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Problems and Solutions in INORGANIC CHEMISTRY for JEE (Main & Advanced)

3e

V. Joshi

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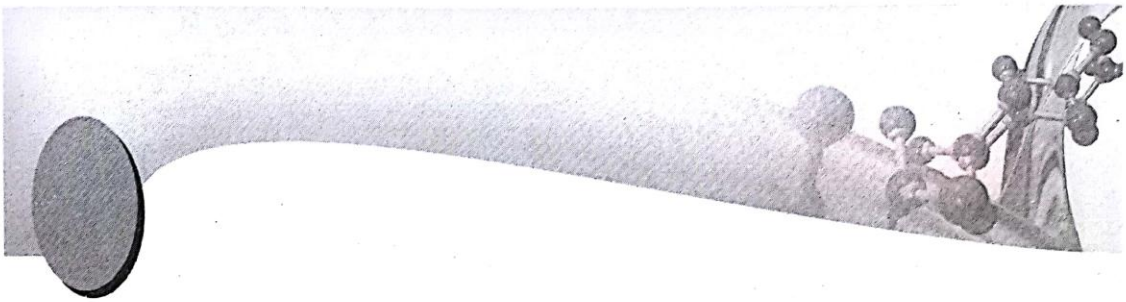
Preface

It is a matter of great pleasure for me to present this edition of *Problems and Solutions in Inorganic Chemistry for JEE (Main & Advanced)* before Joint Entrance Examination (JEE) aspirants. During teaching hours, I felt that the facts may be made more and more clear to the students through problematic approach. Although an ocean of material in inorganic is available with the students, but the approach to design the problems has been changed in recent years and if one tries in this ocean, it will be very difficult task to make the students more familiar with the trends and tricks to solve problems. The present problem book has been presented in the current scenario of stiff competition and is well equipped with the facts of subject, yet the winner is one who knows how to use these equipments with accuracy and efficiency. The book includes the problems based on the latest pattern being followed by JEE.

Most of the chapters in the book have been divided into eight sections, and the problems in each section have been designed such that they fulfill both the requirements of an aspirant, i.e., knowledge of subject and practice.

1. Single Correct Answer Type
2. Multiple Correct Answers Type
3. Comprehension Type
4. Assertion-Reasoning Type
5. Matching Column Type
6. Integer Answer Type
7. NCERT Exemplar Exercises
8. Archives (Previous Years' Questions)

V. JOSHI



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2. **Coordination Compounds** **2.1-2.59**
3. **General Principles of Extraction of Metals** **3.1-3.39**
4. **Qualitative Inorganic Analysis** **4.1-4.66**
5. ***s*-Block Elements** **5.1-5.29**
6. ***p*-Block Elements** **6.1-6.77**
7. ***d*-Block Elements** **7.1-7.34**
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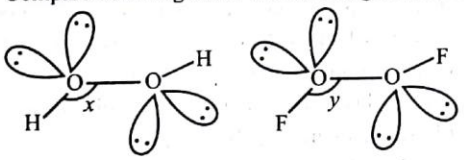
1

Chemical Bonding (Part-A)

JEE (Main) Exercises

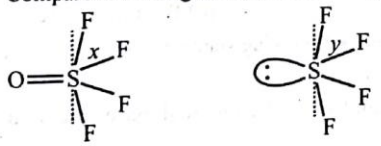
Single Correct Answer Type

1. Compare bond angles for the following molecules:



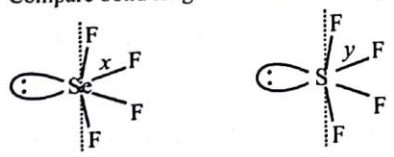
(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

2. Compare bond lengths for the following molecules:



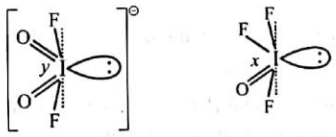
(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

3. Compare bond lengths for the following molecules:



(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

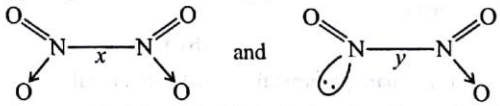
4.



Compare x and y bond lengths for the above given molecules:

(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

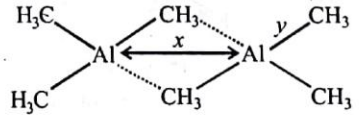
5.



Compare x and y bond lengths for the above given molecules:

(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

6.



Compare x and y bond lengths for the above given molecule:

(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) None of these

7. Which of the following silicate is called pyroxene?

(a) Orthosilicate (b) Pyrosilicate
(c) 2D silicate (d) Single-chain silicate

8. Which of the following silicate is called amphibole?

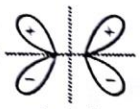
(a) Single-chain silicate (b) Double-chain silicate
(c) 2D silicate (d) Cyclic silicate

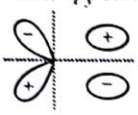
9. Which of the following silicate is called disilicate?

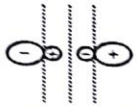
(a) Orthosilicate (b) Pyrosilicate

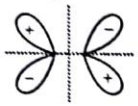
(c) Single-chain silicate (d) None of these

10. Select the correct diagram for the $\pi^{*}2p_y$-orbital:

(a) 

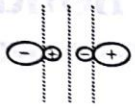
(b) 

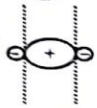
(c) 

(d) 

11. Select the correct diagram for the $\sigma 2p_x$-orbital:

(a)

(b) 

(c) 

(d) None of these

12. Nature of O_2 molecule is:

(a) Paramagnetic (b) Diamagnetic

(c) Both (a) and (b) (d) None of these

13. Which of the following has the highest boiling point?

(a) Ne (b) He

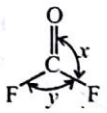
(c) CH_4 (d) Xe

14. The cationic part of solid XeF_6 is having the "_____" shape:

(a) Linear (b) Angular

(c) Square pyramidal (d) Tetrahedral

15. Compare x and y bond angles in the following molecule:



(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

16. A metal oxide is acidic when:

(a) $\sqrt{\varphi} < 2.1$ (b) $\sqrt{\varphi} = 2.1$ to 3.2

(c) $\sqrt{\varphi} > 3.2$ (d) None of these

17. Find out the similarities between I_2Cl_6 and Al_2Cl_6:

(a) Both have 3C — $4e^-$ bond

(b) Both have sp^3-hybridization for the central atom

(c) Both are nonplanar

(d) All are correct

18. Which of the following set has the same bond order?

(a) N_2, O_2^{2+}, NO^+, $\overset{\ominus}{C}N$ (b) N_2^{2-}, O_2, NO^-, NO_2^+

(c) NO, N_2^-, O_2^+, NO^{2+} (d) All are correct

19. In the hydrolysis of ICl, the products are:

(a) HI + HCl (b) HI + HOCl

(c) HCl + HOI (d) HOCl + HOI

20. Which of the following geometry is not possible when the central atom is having sp^3d-hybridization?

(a) TBP (b) Trigonal planar

(c) Linear (d) T-shaped

21. Select the correct statement:

(a) If molecule has any polar bond, then it is always polar

(b) Solubility of noble gases increases in water down the group when their size increases because London dispersion force increases

(c) First ionization energy of Al is greater than that of gallium

(d) $XeF_5^{\oplus}$ has distorted octahedral geometry

22. Which is the correct order for different forces?

(a) E_D (Dipole–induced dipole interaction) > E_K (Dipole–dipole interaction) > E_L (London force)

(b) E_K (Dipole–dipole interaction) > E_D (Dipole–induced dipole interaction) > E_L (London force)

(c) E_D (Dipole–induced dipole interaction) > E_L (London force) > E_K (Dipole–dipole interaction)

(d) All forces are equally strong

23. Which of the following compounds are the common product/s obtained in the hydrolysis of XeF_6 and XeF_4?

(a) XeO_2F_2 (b) HF

(c) XeO_3 (d) Both (b) and (c)

24. Which of the following statement is incorrect for CO molecule?

(a) Intramolecular Lewis acid–base interaction is present

(b) Charge separation is present

(c) σ-bond, π-bond, and back-bond all are present together

(d) Direction of dipole moment is from C to O

25. Find the incorrect match:

(a) Al_2Cl_6 : 3C-4e bond is present

(b) $Al_2(CH_3)_6$: All carbon atoms are sp^3-hybridized

(c) I_2Cl_6 : Nonplanar

(d) Al_2Br_6 : Nonpolar

26. Which the following interaction form nonbonding molecular orbital when z-axis is the bonding axis?

(a) $d_{yz} + d_{z^2}$ (b) $d_{yz} + d_{xy}$

(c) $d_{x^2-y^2} + d_{xy}$ (d) All form N.B.M.O.

27. Which of the following molecule/species is polar?

(a) O_3 (b) NO_2^+

(c) Para-dichlorobenzene (d) None of these

28. Which of the following is most covalent?

(a) CuCl (b) NaCl

(c) AgCl (d) AuCl

29. When NF_3 undergoes hydrolysis at room temperature, then the product will be:

(a) HNO_2 (b) N_2O_3

(c) $NO + NO_2$ (d) None of these

30. Select the incorrect order:

(a) Thermal stability : $LiNO_3 < NaNO_3 < KNO_3$

(b) Solubility : $LiNO_3 < NaNO_3 < KNO_3$

(c) Thermal stability : $Be(OH)_2 < Ca(OH)_2 < Sr(OH)_2$

(d) Solubility : $Be(OH)_2 < Ca(OH)_2 < Sr(OH)_2$

31. Which of the following does not contain three electron bond?

(a) ClO_2 (b) CO_2

(c) O_2^- (d) NO

32. Which of the following ions is diamagnetic?

(a) N_2^+ (b) O_2^-

(c) Be_2^+ (d) NO^+

33. Which of the following is not an electron-deficient compound?

(a) $BeEt_2$ (b) $AlMe_3$

(c) B_2H_6 (d) $Si(CH_3)_4$

34. The BCl_3 is a planar molecule, whereas NCl_3 is a pyramidal because:

(a) N — Cl bond is more covalent bond than B — Cl bond

(b) B — Cl bond is more polar than N — Cl bond

(c) nitrogen atom is similar to boron atom

(d) BCl_3 has no lone pair but NCl_3 has a lone pair or electrons

35. Which of the following molecule has the largest bond angle?

(a) BF_3 (b) NH_3

(c) CO_2 (d) SF_6

36. Which compound possesses the greatest lattice energy?

(a) LiBr (b) LiCl

(c) LiI (d) LiF

37. The common features among the species CN^-, CO, and NO^+ are:

(a) Bond order three and isoelectronic

(b) Bond order three and weak field ligands

(c) Bond order two and π-acceptors

(d) Isoelectronic and weak field ligands

38. Which of the following molecular species has unpaired electron(s)?

(a) N_2 (b) F_2

(c) O_2^- (d) O_2^{2-}

39. Covalent compounds have low melting points because:

(a) Covalent molecules have definite shape

(b) Covalent bond is weaker than ionic bond

(c) Covalent bond is less exothermic

(d) Covalent molecules are held by weak van der Waals' forces of attraction

40. Which of the following has a zero dipole moment?

(a) ClF (b) PCl_3

(c) SiF_4 (d) $CFCl_3$

41. The bond order of O_2^+ is:

(a) 1 (b) 1.5

(c) 2.5 (d) 3

42. In which of the following species is the underline carbon having sp^3-hybridization?

(a) CH_3—$\underline{C}$OOH (b) CH_3—$\underline{C}H_2$—OH

(c) CH_3—$\underline{C}O$—CH_3 (d) CH_2=$\underline{C}H$—CH_3

43. A square planar complex is formed by hybridization of which atomic orbitals?

(a) s, p_x, p_y, d_{yz} (b) $s, p_x, p_y, d_{x^2-y^2}$

(c) s, p_x, p_y, d_{z^2} (d) s, p_x, p_z, d_{xy}

44. Which of the following compound has the smallest bond angle?

(a) SH_2 (b) NH_3

(c) SO_2 (d) OH_2

45. Which of the following statement is not correct for sigma and pi-bonds formed between two carbon atoms?

(a) A sigma bond is stronger than a pi-bond

(b) Bond energies of sigma and pi-bonds are of the same order

(c) Free rotation of atoms about a sigma bond is allowed but not in case of a pi-bond

(d) A sigma bond determines the direction between carbon atoms, but a pi-bond has no primary effect in this regard

46. Number of covalent bonds in MgH_2 is:

(a) Zero (b) 1

(c) 2 (d) 4

47. Only iodine forms heptafluoride IF_7, but chlorine and bromine give pentafluorides. The reason for this is:

(a) Low electron affinity of iodine

(b) Unusual pentagonal bipyramidal structure of IF_7

(c) That the larger iodine atom can accommodate more number of smaller fluorine atom around it

(d) Low chemical reactivity of IF_7

48. Based on lattice energy and other considerations which one of the following alkali metal chloride has the highest melting point?

(a) KCl (b) RbCl

(c) LiCl (d) NaCl

49. Which of the following cannot exist on the basis of M.O. theory?

(a) C_2 (b) He_2^+

(c) H_2^+ (d) He_2

50. Which of the following has fractional bond order?

(a) O_2^{2+} (b) O_2^{2-}

(c) F_2^{2-} (d) H_2^-

51. The correct order of a dipole moment is:

(a) $CH_4 < NF_3 < NH_3 < H_2O$

(b) $NF_3 < CH_4 < NH_3 < H_2O$

(c) $NH_3 < NF_3 < CH_4 < H_2O$

(d) $H_2O < NH_3 < NF_3 < CH_4$

52. In water molecule, oxygen is:

(a) *sp*-hybridized (b) sp^3-hybridized

(c) sp^2-hybridized (d) None of these

53. According to Fajan's rule, ionic character increases for:

(a) Large cation and small anion

(b) Small cation and small charge on cation

(c) Small cation and large charge on cation

(d) Large cation and no charge on cation

54. Which one of the following order is not in accordance with the property stated against it?

(a) F > Cl > Br > I: Electronegativity

(b) $F_2 > Cl_2 > Br_2 > I_2$: Bond dissociation energy

(c) $F_2 > Cl_2 > Br_2 > I_2$: Oxidizing power

(d) HI > HBr > HCl > HF: Acidic property in water

55. The species having octahedral shape is:

(a) SF_6 (b) BF_4^-

(c) PCl_5 (d) BO_3^{3-}

56. Which one of the following sets of ions represent a collection of isoelectronic species?

(a) $K^+, Cl^-, Ca^{2+}, Sc^{3+}$ (b) $Ba^{2+}, Sr^{2+}, K^+, Ca^{2+}$

(c) $N^{3-}, O^{2-}, F^-, S^{2-}$ (d) $Li^+, Na^+, Mg^{2+}, Ca^{2+}$

57. Which of the following molecules/ions are all the bonds not equal?

(a) SF_4 (b) SiF_4

(c) XeF_4 (d) BF_4^-

58. The decreasing values of bond angles from NH_3 (107°) to SbH_3 (91°) down the group-15 of the periodic table is due to:

(a) Increasing *bp–bp* repulsion

(b) Increasing *p*–orbital character in sp^3

(c) Decreasing *lp–bp* repulsion

(d) Increasing electronegativity

59. Arrange the following compounds in order of increasing dipole moment:

(I) Toluene (II) *m*-dichlorobenzene

(III) *o*-dichlorobenzene (IV) *p*-dichlorobenzene

(a) I < IV < II < III (b) IV < I < II < III

(c) IV < I < III < II (d) IV < II < I < III

60. Linear combination of two hybridized orbitals, belonging to two atoms and each having one electron, leads to:

(a) Sigma-bond (b) Double bond

(c) Coordinate covalent bond

(d) Pi-bond

61. In compound *X*, all the bond angles are exactly 109°28′. *X* is:

(a) Chloromethane (b) Iodoform

(c) Carbon tetrachloride (d) Chloroform

62. The correct order of bond angle is:

(a) $PF_3 = PCl_3 = PBr_3 = PI_3$

(b) $PF_3 < PBr_3 < PCl_3 < PI_3$

(c) $PI_3 < PBr_3 < PCl_3 < PF_3$

(d) $PF_3 < PCl_3 < PBr_3 < PI_3$

63. Which compound among the following has more covalent character?

(a) $AlCl_3$ (b) AlI_3

(c) MgI (d) NaI

64. The compound with the maximum dipole moment among the following is:

(a) *p*-Dichlorobenzene (b) *m*-Dichlorobenzene

(c) *o*-Dichlorobenzene (d) Carbon tetrachloride

65. Pauling's electronegativity values of elements are useful in predicting:

(a) Polarity of bonds in molecules

(b) Position of elements in periodic table

(c) Coordination number

(d) Dipole moment of various molecules

66. The structure of ICl_2^- is:

(a) Trigonal (b) Octahedral

(c) Square planar (d) None of these

67. In H_2^- ion, the bond order is:

(a) Zero (b) 1/2

(c) –1/2 (d) 1

68. The shape of ClO_3^- according to VSEPR model is:

(a) Planar triangle (b) Pyramidal

(c) Tetrahedral (d) Square planar

69. The state of hybridization for the transition state of hydrolysis mechanism of BCl_3 and SF_4 are respectively:

(a) sp^2, sp^3d (b) sp^3, sp^3

(c) sp^3, sp^3d^2 (d) sp^3, sp^3d

70. Which of the following molecular species has unpaired electron(s)?

(a) N_2 (b) F_2

(c) O_2^- (d) O_2^{2-}

71. Which of the following two are isostructural?

(a) XeF_2, IF_2^- (b) NH_3, BF_3

(c) CO_3^{2-}, SO_3^{2-} (d) PCl_5, ICl_5

72. According to molecular orbital theory for O_2^+:

(a) Bond order is less than O_2 and O_2^+ is paramagnetic

(b) Bond order is more than O_2 and O_2^+ is paramagnetic

(c) Bond order is less than O_2 and O_2^+ is diamagnetic

(d) Bond order is more than O_2 and O_2^+ is diamagnetic

73. The maximum number of 90° angles between bond pair–bond pair of electron is observed in:

(a) sp^3d^2-hybridization (b) sp^3d-hybridization

(c) dsp^2-hybridization (d) dsp^3-hybridization

74. Which species is diamagnetic in nature?

(a) He_2^+ (b) H_2

(c) H_2^+ (d) H_2^-

75. Which of the following does not contain isoelectronic species?

(a) PO_4^{3-}, SO_4^{2-}, ClO_4^- (b) CN^-, N_2, C_2^{2-}

(c) SO_3^{2-}, CO_3^{2-}, NO_3^- (d) BO_3^{3-}, CO_3^{2-}, NO_3^-

76. The correct increasing covalent nature is:

(a) NaCl < LiCl < $BeCl_2$ (b) $BeCl_2$ < NaCl < LiCl

(c) $BeCl_2$ < LiCl < NaCl (d) LiCl < NaCl < $BeCl_2$

77. Which is expected to show paramagnetism?

(a) ClO_2 (b) SO_2

(c) CO_2 (d) SiO_2

78. Which of the following tetrahalide is not easily hydrolyzed?

(a) CCl_4 (b) $SiCl_4$

(c) $GeCl_4$ (d) $SnCl_4$

79. Which of the following molecule is planar?

(a) $[I(CN)_2]^-$ (b) PCl_3F_2

(c) PCl_5 (d) SF_4

80. Which of the following molecule has sp^3d-hybridization?

(a) SOF_4 (b) SF_4

(c) XeF_3^+ (d) All

81. Which of the following molecule/ion has a zero dipole moment?

(a) ClF_3 (b) ICl_2^-

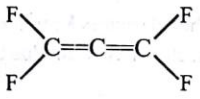
(c) SF_4 (d) None of these

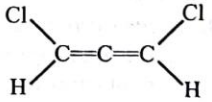
82. Select the correct ionic mobility order in water?

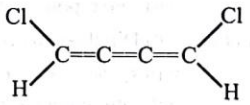
(a) $Be^{2+} > Ba^{2+}$ (b) $Li^+ > Rb^+$

(c) $I^- < Cl^-$ (d) $Na^+ > Mg^{2+} > Al^{3+}$

83. Which of the following molecule is polar as well as planar?

(a) 

(b) 

(c) 

(d) None of these

84. What is the hybridization of Xe in cationic part of solid XeF_6?

(a) sp^3d^3 (b) sp^3d

(c) sp^3d^2 (d) sp^3

85. Which of the following molecule(s)/ion(s) are isoelectronic?

(a) CO_2 and N_2O (b) CO_2 and CN_2^{2-}

(c) C_6H_6 and $B_3N_3H_6$ (d) All are isoelectronic

86. Select the correct order of polarizing power of cation?

(a) $Na^+ < Mg^{2+} < Si^{4+} < Al^{3+}$

(b) $Mg^{2+} > Si^{4+} > Al^{3+} > Na^+$

(c) $Na^+ < Mg^{2+} < Al^{3+} < Si^{4+}$

(d) $Al^{3+} < Si^{4+} < Mg^{2+} < Na^+$

87. Select the correct order of thermal stability of bicarbonates:

(a) $NaHCO_3 > KHCO_3 > RbHCO_3 > CsHCO_3$

(b) $RbHCO_3 > CsHCO_3 > NaHCO_3 > KHCO_3$

(c) $KHCO_3 > RbHCO_3 > CsHCO_3 > NaHCO_3$

(d) $NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3$

88. Identify the correct order of bond angle in following species:

$$\overset{\oplus}{C}H_3,\ CH_4,\ \overset{\ominus}{C}H_3$$

(a) $\overset{\ominus}{C}H_3 > CH_4 > \overset{\oplus}{C}H_3$ (b) $CH_4 > \overset{\ominus}{C}H_3 > \overset{\oplus}{C}H_3$

(c) $\overset{\oplus}{C}H_3 > CH_4 > \overset{\ominus}{C}H_3$ (d) $\overset{\oplus}{C}H_3 = CH_4 = \overset{\ominus}{C}H_3$

89. Which of the following molecule/ion has higher B — O bond length?

(a) H_3BO_3 (b) $[B(OH)_4]^-$

(c) Both (a) and (b) have equal B—O bond length

(d) None of these

90. Which of the following molecule has $3C - 4e^-$ bond?

(a) Al_2Cl_6 (b) Be_2Cl_4

(c) I_2Cl_6

(d) All are having $3C - 4e^-$ bond

91. Which of the following molecule does not exist?

(a) He_2 (b) $H — H^+$

(c) $He — He^+$ (d) Li_2

92. Certain derivatives of phenol such as Kr $(phenol)_2$, Xe $(phenol)_2$, Rn $(phenol)_2$, etc., may result due to which type of interaction?

(a) Dipole–dipole (b) Ion–dipole

(c) Ion–induced dipole (d) Dipole–induced dipole

93. In organic homologous series, the higher members show the higher melting and boiling point due to the:

(a) Dipole–dipole interaction

(b) Ion–dipole interaction

(c) London dispersion forces

(d) Dipole–induced dipole interaction

94. Select the correct order of unpaired e^- of antibonding molecular orbitals in following species:

(a) $O_2 > O_2^{2-} > O_2^-$ (b) $O_2 > O_2^- > O_2^{2-}$

(c) $O_2 > O_2^{2-} \approx O_2^-$ (d) $O_2 \approx O_2^{2-} \approx O_2^-$

95. Select the correct order of the first ionization potential:

(a) $NO > N_2$ (b) $N_2 > NO$

(c) $NO \approx N_2$ (d) None of these

96. Select the correct order of the first ionization potential:

(a) $F_2 > F$ (b) $F_2 \approx F$

(c) $F > F_2$ (d) None of these

97. Which of the following element does not show inert pair effect?

(a) Tl (b) Pb

(c) Bi (d) Sn

98. Which of the following compound is not a strong oxidizing agent?

(a) PbO_2 (b) $PbCl_4$

(c) Pb_2O_3 (d) CCl_4

99. Which of the following does show reducing property?

(a) Ge(II) (b) Sn(II)

(c) Both (a) and (b) (d) None of these

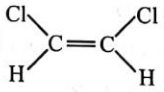
100. Which of the following molecule is not showing zero dipole moment?

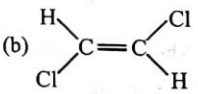
(a) $C_6H_4(NO_2)$ (para) (b) $C_6H_4(CH_3)_2$ (para)

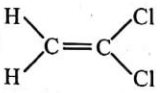
(c) $C_6H_4(OH)_2$ (para)

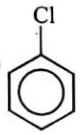
(d) All compounds are showing zero dipole moment

101. Which of the following molecule has almost zero dipole moment?

(a) 

(b) 

(c) 

(d) 

102. Select the correct increasing order of π bond formation tendency from the following:

(a) Si — O > P — O > S — O > Cl — O

(b) Si — O < P — O < S — O < Cl — O

(c) Cl — O < Si — O < P — O < S — O

(d) Si — O < Cl — O < P — O < S — O

103. Choose the correct order of bond strength by overlapping of atomic orbitals:

(a) $1s$-$1s > 1s$-$2s > 1s$-$2p$ (b) $2s$-$2s > 2s$-$2p > 2p$-$2p$

(c) $2s$-$2p > 2s$-$2s > 2p$-$2p$ (d) $1s$-$1s > 1s$-$2p > 1s$-$2s$

JEE (Advanced) Exercises

Single Correct Answer Type

1. Which one of the following bonds has the highest bond energy?
   (a) C – C (b) Si – Si
   (c) Ge – Ge (d) Sn – Sn

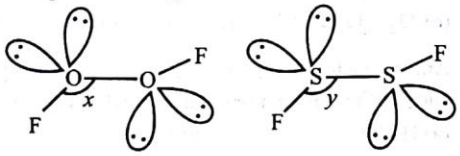
2. Which of the following is incorrect?
   (a) Among Cl, Ar, and K, K has the smallest ionization potential
   (b) Among CH_4, NH_3, and HF, HF has the highest boiling point
   (c) Among Cl_2, Br_2, and I_2, Br_2 has the lowest boiling point
   (d) Among HOI, HOBr, and HOCl, HOI is the weakest acid

3. PCl_5 and PBr_5 exist in sp^3d-hybrid state in gaseous phase. But in solid state, which of the following statement is true?
   (a) P in PCl_5 exists in sp^3-hybridization state, while P in PBr_5 exists in sp^3d^2 and sp^3-hybridization states
   (b) P in PCl_5 and PBr_5 exists in sp^3d^2 and sp^3-hybridization state
   (c) P in PCl_5 exists in sp^3d^2 and sp^3-hybridization states, while P in PBr_5 exists in sp^3-hybridization state
   (d) P in PCl_5 and PBr_5 exists in sp^3-hybridization state

4. Which of the following halide does not exist?
   (a) PbF_4 (b) $PbCl_4$
   (c) PbI_2 (d) PbI_4

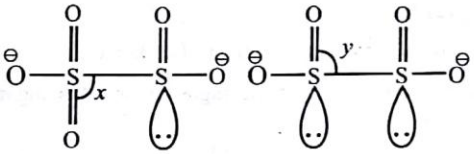
5. If the π-back bonding involves the lone pair of central atom, then bond angle gets opened up due to:
   (a) Increase of *bp/bp* repulsion for the enhanced bond multiplicity
   (b) Decrease of *lp/lp* and *lp/bp* repulsion(s) on the central atom
   (c) Both (a) and (b) (d) None of these

6. Compare bond angles for the following molecules:



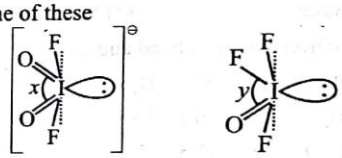
   (a) $x > y$ (b) $y > x$
   (c) $x = y$ (d) None of these

7. Compare S—O bond angle for the following molecules:

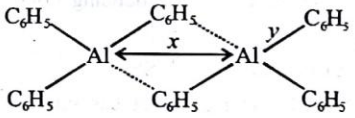


   (a) $x > y$ (b) $y > x$
   (c) $x = y$ (d) None of these

8. Compare $F—\hat{Br}—O$ and $O—\hat{Br}—O$ in $FBrO_3$ molecule:
   (a) $F—\hat{Br}—O > O—\hat{Br}—O$
   (b) $F—\hat{Br}—O < O—\hat{Br}—O$
   (c) $F—\hat{Br}—O = O—\hat{Br}—O$
   (d) None of these

9. 

   Compare x and y bond angles for the above given molecules:
   (a) $x > y$ (b) $y > x$
   (c) $x = y$ (d) None of these

10. 

   Compare x and y bond lengths for the above given molecule:
   (a) $x > y$ (b) $y > x$
   (c) $x = y$ (d) None of these

11. Which of the following reaction(s) is/are not possible?
   (i) $(CH_3)_2O + BF_3 \longrightarrow (CH_3)_2O \rightarrow BF_3$
   (ii) $(SiH_3)_2O + BF_3 \longrightarrow (SiH_3)_2O \rightarrow BF_3$
   (iii) $H_3N + BF_3 \longrightarrow H_3N \rightarrow BF_3$
   (iv) $(CH_3)_2O + BF_4^- \longrightarrow (CH_3)_2O \rightarrow BF_4^-$
   (a) (i) and (ii) (b) (i), (iii), and (iv)
   (c) (ii) and (iv) (d) (ii) and (iii)

12. $Si_6O_{18}^{12-}$ unit is an example of:
   (a) 3D silicate (b) Double chain silicate
   (c) Cyclic silicate (d) 2D silicate

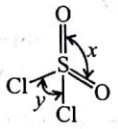
13. Which of the following molecule/ion has higher number of e^- in A.B.M.O.?

(a) O_2^+ (b) O_2^{2-}

(c) O_2^{2+}

(d) All have equal number of unpaired e^-

14. Compare x and y bond angles in the following molecule:



(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

15. Predict the nature of metal oxide if $\phi = 2.1$ for metal cation:

(a) Amphoteric (b) Acidic

(c) Basic (d) Neutral

16. The correct order of bond angle is:

(a) $H_2O > OF_2 > SF_2 > H_2S$

(b) $H_2O > SF_2 > OF_2 > H_2S$

(c) $H_2O > OF_2 > H_2S > SF_2$

(d) $H_2O > H_2S > OF_2 > SF_2$

17. In which of the following molecules all A—X bond lengths are identical?

[A = central atom and X = surrounding atom]

(a) XeF_4 (b) PF_5

(c) Both (a) and (b) (d) SF_4

18. Which of the following species has smallest N—O bond length?

(a) NO (b) NO^-

(c) NO^+ (d) N_2O

19. The compounds in which the mentioned bond angle in parenthesis is found to be greater than expected not due to back bonding is:

(a) H_3SiNCS ($\angle$ Si—N—C) (b) BI_3 ($\angle$ I—B—I)

(c) MeNCS ($\angle$ CNC) (d) None of these

20. Select from each set the molecule or ion having the smallest bond angle:

(i) NH_3, PH_3 or AsH_3 (ii) O_3^+, O_3

(iii) NO_2^- or O_3

(iv) X—S—X angle in $SOCl_2$ and SOF_2

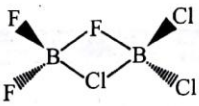
(a) NH_3, O_3^+, O_3, $SOCl_2$

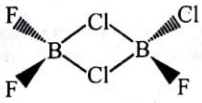
(b) PH_3, O_3^+, NO_2^-, SOF_2

(c) AsH_3, O_3, NO_2^-, SOF_2

(d) AsH_3, O_3^+, O_3, SOF_2

21. What will be the transition state to get BF_2Cl and BCl_2F from the reaction between BF_3 and BCl_3?

(a) 

(b) 

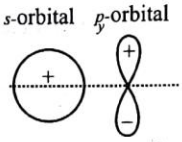
(c) Both (a) and (b) (d) None of these

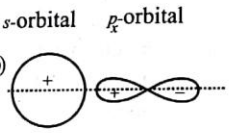
22. Which of the following bond has the highest energy?

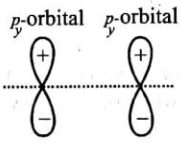
(a) Se—Se (b) Te—Te

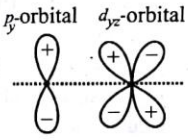
(c) S—S (d) O—O

23. Which of the following overlaps leads to sigma bonding if x is internuclear axis?

(a) 

(b) 

(c) 

(d) 

24. The decreasing order of bond angle is:

(a) $NO_2 > NO_2^+ > NO_2^-$ (b) $NO_2^- > NO_2 > NO_2^+$

(c) $NO_2^+ > NO_2 > NO_2^-$ (d) $NO_2^+ > NO_2^- > NO_2$

25. Which has higher bond energy and stronger bond?

(a) F_2 (b) Cl_2

(c) Br_2 (d) I_2

26. Which of the following is most stable?

(a) Pb^{2+} (b) Ge^{2+}

(c) Si^{2+} (d) Sn^{2+}

27. According to Fajan's rule, polarization is more when:

(a) Small cation and large anion

(b) Small cation and small anion

(c) Large cation and large anion

(d) Large cation and small anion

28. The bond strength in O_2^+, O_2, O_2^-, and O_2^{2-} follows the order:

(a) $O_2^{2-} > O_2^- > O_2 > O_2^+$ (b) $O_2^+ > O_2 > O_2^- > O_2^{2-}$

(c) $O_2 > O_2^- > O_2^{2-} > O_2^+$ (d) $O_2^- > O_2^{2-} > O_2^+ > O_2$

29. Among the following compounds the one that is polar and has the central atom with sp^2-hybridization is:

(a) H_2CO_3 (b) SiF_4

(c) BF_3 (d) $HClO_2$

30. Which pair represents isostructural species?

(a) CH_3^- and CH_3^+ (b) NH_4^+ and NH_3

(c) SO_4^{2-} and BF_4^- (d) NH_2^- and BeF_2

31. Among KO_2, electron, BaO_2, and NO_2^+, unpaired electron is present in:

(a) NO_2^+ and BaO_2 (b) KO_2 and AlO_2^-

(c) KO_2 only (d) BaO_2 only

32. Among LiCl, $BeCl_2$, BCl_3, and CCl_4, the covalent bond character follows the order:

(a) LiCl > $BeCl_2$ > BCl_3 > CCl_4

(b) LiCl < $BeCl_2$ < BCl_3 < CCl_4

(c) LiCl > $BeCl_2$ > CCl_4 > BCl_3

(d) LiCl < $BeCl_2$ < BCl_3 > CCl_4

33. The correct order of decreasing polarisability of ion is:

(a) Cl^-, Br^-, I^-, F^- (b) F^-, I^-, Br^-, Cl^-

(c) I^-, Br^-, Cl^-, F^- (d) F^-, Cl^-, Br^-, I^-

34. The following compounds have been arranged in order of their increasing thermal stabilities. Identify the correct order:

(I) K_2CO_3 (II) $MgCO_3$ (III) $CaCO_3$ (IV) $BeCO_3$

(a) I < II < III < IV (b) IV < II < III < I

(c) IV < II < I < III (d) II < IV < III < I

35. Which has triangular planar shape?

(a) CH_3^+ (b) ClO_2^-

(c) H_3O^+ (d) ClO_3^-

36. Highest covalent character is found in which of the following?

(a) CaF_2 (b) $CaCl_2$

(c) CaI_2 (d) $CaBr_2$

37. C—O—C angle in ether molecule is:

(a) 110° (b) 90°

(c) 180° (d) 109°28′

38. In P_4O_{10} molecule, bridging P–O bond length is:

(a) Larger than that of in P_4O_6

(b) Lesser than that of in P_4O_6

(c) Equal to that of in P_4O_6

(d) Cannot be compared

39. The nodal plane in the π-bond of ethene is located in:

(a) The molecular plane

(b) A plane parallel to the molecular plane

(c) A plane perpendicular to the molecular plane which bisects the carbon–carbon σ-bond at right angle

(d) A plane perpendicular to the molecular plane which contains the carbon–carbon σ-bond

40. The state of hybridization of boron and oxygen atom in boric acid (H_3BO_3) is respectively:

(a) sp^3, sp^3 (b) sp^2, sp^3

(c) sp^3, sp^2 (d) sp^2, sp^2

41. Which of the following has regular tetrahedral shape?

(a) I_3^- (b) SF_4

(c) $[BF_4]^-$ (d) XeF_4

42. The correct order of bond angles is:

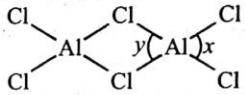
(a) H_2S < NH_3 < BF_3 < SiH_4

(b) NH_3 < H_2S < SiH_4 < BF_3

(c) H_2S < NH_3 < SiH_4 < BF_3

(d) H_2S < SiH_4 < NH_3 < BF_3

43.

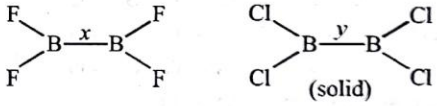


Compare x and y bond angle in above molecule:

(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

44. Compare B—B bond length in following molecules:



(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

45. How many S—S linkage(s) is/are present in sodium tetrathionate?

(a) 4 (b) 3

(c) 2 (d) 1

46. Find the maximum number of atoms that lie in the same plane in PCl_5 molecule:

(a) 3 (b) 5

(c) 4 (d) 2

47. In which of the following cases hydrolysis takes place through S_N2 and S_N1 mechanism, respectively?

(A) P_4O_{10}, $SiCl_4$ (B) NCl_3, NF_3

(C) $SiCl_4$, SiF_4 (D) SF_4, TeF_6

48. What may be the geometry of molecule if AX_3 molecule has non-zero dipole moment?

(a) Trigonal planar (b) Bent T-shape

(c) Pyramidal (d) Both (b) and (c)

49. If Hund's rule is not applicable, then bond order and magnetic behavior of O_2 molecule is:

(a) 2, Paramagnetic (b) 2, Diamagnetic

(c) 2.5, Paramagnetic (d) 2.5, Diamagnetic

50. The existence of intermolecular forces is supported by the facts:

(a) Non ideality of real gases

(b) Liquefaction of gases

(c) Both (a) and (b)

(d) None of these

51. Select the incorrect statement:

(a) On adding one electron in NO^+, the bond length increases

(b) Boron is paramagnetic while carbon is diamagnetic

(c) CO and N_2 both have different bond order

(d) CO and N_2 both have same bond order

52. Select the correct order of first ionization potential:

(a) $N > O_2$ (b) $O_2 > N$

(c) $O_2 = N$ (d) None of these

53. Select the correct order of first ionization potential:

(a) $N > N_2$ (b) $N < N_2$

(c) $N \approx N_2$ (d) None of these

54. Select the correct order of polymerization tendency from the following:

(a) Si — O > P — O > S — O > Cl — O

(b) P — O > S — O > Cl — O > Si — O

(c) Cl — O > S — O > P — O > Si — O

(d) Si — O < P — O < S — O < Cl — O

55. Choose the incorrect statement:

(a) Reducing power in aqueous solution is maximum for lithium metal

(b) Electron affinity order $O^+ > O > O_2^{2-} > O^{2-}$

(c) Order of oxidation number of oxygen $O_3 > KO_2 > BaO_2 > K_2O$

(d) pH of aqueous solution $LiCl > BeCl_2 > MgCl_2 > AlCl_3$

56. Given the species N_2, CO, NO^+, and CN^- which of the following statements are true for this:

(I) All the species are diamagnetic

(II) All the species are isostructural

(III) All the species have identical bond order

(IV) More than one species have zero dipole moment

(a) I, II, and III (b) I, II, III, and IV

(c) III and IV (d) I and II

57. Which is not correctly matched?

(a) XeO_3 : Trigonal bipyramidal

(b) ClF_3 : Bent T-shape

(c) $XeOF_4$: Square pyramidal

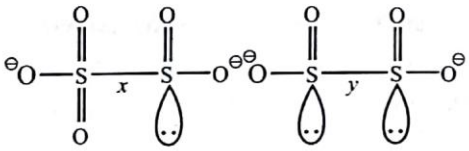
(d) XeF_2 ; Linear shape

58. The bond order of CO molecule on the basis of molecular orbital theory is:

(a) Zero (b) 2

(c) 3 (d) 1

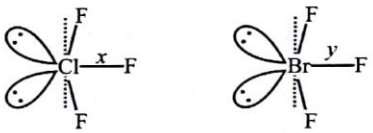
59. Compare S—S bond length from the following molecules:



(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

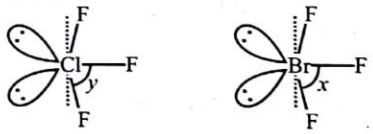
60. Compare bond length from the following molecules:



(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

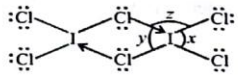
61. Compare bond angle from the following molecules:



(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

62.

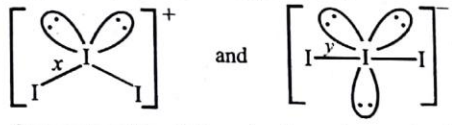


Compare x, y, z bond angle from the above given molecule:

(a) $x > y > z$ (b) $x > z > y$

(c) $y > x > z$ (d) $z > y > x$

63.

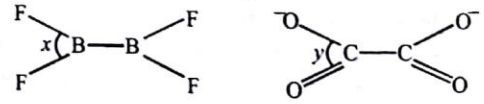


Compare bond length from the above given molecules:

(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

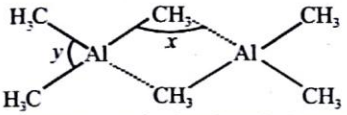
64.



Compare x and y bond angle from the above given molecules:

(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

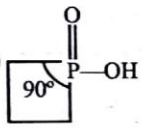
65. 

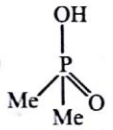
Compare x and y bond angle from the above given molecule:

(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

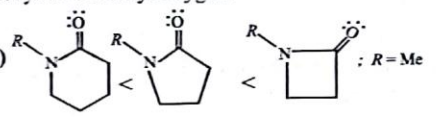
66. Which of the following compound is more basic with respect to exocyclic carbonyl oxygen?

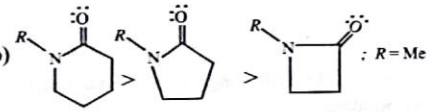
(a) 

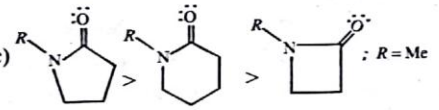
(b) 

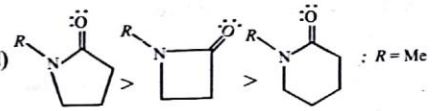
(c) Both are equally basic (d) None of these

67. Select the correct order of Lewis basic strength for exocyclic carbonyl oxygen:

(a) 

(b) 

(c) 

(d) 

68. If the π-back bonding involves the vacant orbital of the central atom, then the bond angle gets widened due to:

(a) The increased *bp/bp* repulsion for the enhanced bond multiplicity

(b) The decreased of *lp/lp* and *lp/bp* repulsion(s)

(c) Both (a) and (b)

(d) None of the above

69. In which of the following structure, the number of shared oxygen atom per tetrahedron is two and half?

(a) 2D silicate (b) 3D silicate

(c) Amphibole (d) Ortho silicate

70. Calculate the % p-character in the orbital occupied by the lone pairs in water molecule:

[Given: $\angle$ HOH is 104.5° and cos (104.5) = – 0.25]

(a) 80% (b) 20%

(c) 70% (d) 75%

71. Correct order for the boiling point between CCl_4 and $SiCl_4$:

(a) $CCl_4 > SiCl_4$ (b) $SiCl_4 > CCl_4$

(c) $SiCl_4 = CCl_4$ (d) None of these

72. Hybridization of central atom is independent of the phase/state of the compound in case of:

(a) BeH_2 (b) N_2O_5

(c) XeF_6 (d) PF_5

73. Select the correct order for I.E.:

(a) $CO > N_2$ (b) $N_2 > CO$

(c) $N_2 < O_2$ (d) $N < O$

74. Which of the following molecules has the weakest bond?

(a) H_2 (b) Li_2

(c) F_2 (d) O_2

75. Which of the following molecule/ion does not contain unpaired electrons?

(a) O_2^{2-} (b) B_2

(c) N_2^+ (d) O_2

76. Among the following species, identify the isostructural pairs:

NF_3, NO_3^-, BF_3, H_3O^+, HN_3

(a) [NF_3, NO_3^-] and [BF_3, H_3O^+]

(b) [NF_3, HN_3] and [NO_3^-, BF_3]

(c) [NF_3, H_3O^+] and [NO_3^-, BF_3]

(d) [NF_3, H_3O^+] and [HN_3, BF_3]

77. Which of the following statement is correct for $CsBr_3$?

(a) It is a covalent compound

(b) It contains Cs^{3+} and Br^- ions

(c) It contains Cs^+, and Br_3^- ions

(d) It contains Cs^+, Br^- and lattice Br_2 molecule

78. Iron is tougher than sodium because:

(a) Iron atom is smaller

(b) Iron atoms are more closely packed

(c) Metallic bonds are stronger in iron

(d) None of these

79. van der Waals' forces are applied to:

(a) Inert gases only (b) Rare gases only

(c) Mixture of gases (d) Elementary gases only

80. The correct order of hybridization of the central atom in the following species NH_3, $[PtCl_4]^{2-}$, PCl_5 and BCl_3 is:

(a) dsp^2, dsp^3, sp^2, sp^3 (b) sp^3, dsp^2, sp^3d, sp^2

(c) dsp^2, sp^2, sp^3, dsp^3 (d) dsp^2, sp^3, sp^2, dsp^3

81. Specify the coordination geometry around and hybridization of N and B atom in a 1 : 1 complex of BF_3 and NH_3:

(a) N : tetrahedral, sp^3; B : tetrahedral, sp^3

(b) N : pyramidal, sp^3; B : pyramidal, sp^3

(c) N : pyramidal, sp^3; B : planar, sp^2

(d) N : pyramidal, sp^3; B : tetrahedral, sp^3

82. The bond order in NO is 2.5 while that in NO^+ is 3. Which statement is true for these two species?

(a) Bond length is unpredictable

(b) Bond length in NO is greater than that in NO^+

(c) Bond length in NO^+ is equal to that in NO

(d) Bond length in NO^+ is greater than that in NO

83. Which of the following acid is not formed during the stepwise hydrolysis of P_4O_{10}?

(a) Tetrameta phosphoric acid

(b) Hypophosphoric acid

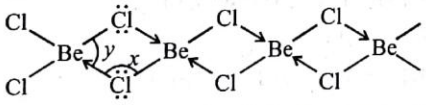
(c) Pyrophosphoric acid

(d) Tetra polyphosphoric acid

84. Which of the following overlapping is used for the formation of $3C - 2e^-$ bond in chain polymer of $BeMe_2$?

(a) sp - sp - sp (b) sp^2 - sp^2 - sp^2

(c) sp^2 - sp^3 - sp^2 (d) sp^3 - sp^3 - sp^3

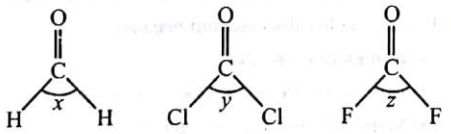
85. 

Compare x and y bond angle in above molecule:

(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

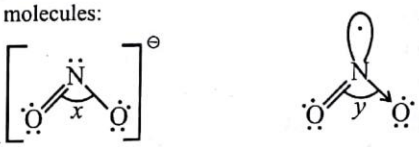
86. Select the correct order of bond angle in following molecules:



(a) $x > z > y$ (b) $x > y > z$

(c) $z > y > x$ (d) $y > x > z$

87. Select the correct order of bond angle in following molecules:



(a) $x < y$ (b) $y < x$

(c) $x = y$ (d) None of these

88. $[Be(OCH_3)_2]_n$ is a high polymer, and is soluble in hydrocarbon solvent. Which type of bond is present in this polymer?

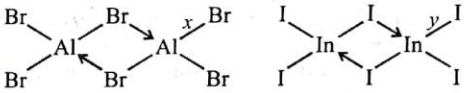
(a) $3C\text{-}2e^-$ (b) $3C\text{-}4e^-$

(c) $2C\text{-}3e^-$ (d) None of these

89. Which type of bond is present in $[BeF_2]_n$ polymer?

(a) $3C - 2e^-$ (b) $3C - 4e^-$

(c) $2C - 3e^-$ (d) None of these

90. 

Compare x and y bond length in above molecules?

(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

91. Which of the following hydrides has the strongest reducing nature?

(a) CH_4 (b) SiH_4

(c) GeH_4 (d) SnH_4

92. Which of the following molecule has intramolecular H-bonding?

(a) Ortho-nitrophenol (b) Ortho-boric acid

(c) Both (a) and (b) (d) None of these

93. If Pauli exclusion principle is not applicable and one orbital has three e^-, then last e^- of N_2 molecule is present in:

(a) $\sigma(2s)$ orbital (b) $\overset{*}{\sigma}(2S)$ orbital

(c) $\overset{*}{\pi}2p_y$ orbital (d) $\pi\, 2p_y$ orbital

94. Select the incorrect statement:

(a) If the orbitals differ largely in energy, the cost of hybridization energy becomes large

(b) The hybridization in phosphorus between $3s$ and $3p$-orbitals may be possible and the participation of $3d$ orbitals in the hybridization with the $3s$ and $3p$-orbitals is not expected because of their (i.e., $3d$ orbital) much higher energy

(c) The d-orbital participation generally requires to bond with highly electronegative elements

(d) PH_5 does not exist but PCl_5, PF_5 exist through the formation of sp^3d^2 hybridization

95. Select the incorrect statement:

(a) $[SiH_6]^{2-}$ has sp^3d^2 hybridization

(b) PF_5 has sp^3d-hybridization

(c) SF_6 has sp^3d^2-hybridization

(d) All are correct statements

96. Given the correct order of initials T or F for following statements. Use T if statement is true and F it is false:

Statement-1: π bond is formed by sideways overlapping of $d_{x^2-y^2}$ and p_y orbital along x-axis.

Statement-2: Zig-zag geometry would be suggested for the $[I(CN)_2]^-$.

(a) T F (b) F T

(c) T T (d) F F

97. Select the correct statement:

(a) The S — F bond length is longer in SF_6 compared to that in SF_2

(b) In PCl_5 axial bonds are smaller than that of equatorial bonds

(c) In IF_7 axial bonds are longer than that of equatorial bonds

(d) All are correct

98. Select the correct order of first ionization potential:

(a) $O_2 > NO$ (b) $O_2 < NO$

(c) $O < NO$ (d) $O \approx NO$

99. Select the correct order of first ionization potential:

(a) $O_2^{2+} > O_2$ (b) $O_2^{2+} < O_2$

(c) $O_2 \approx O_2$ (d) None of these

100. In case of Na metal if the number of Na atom increases, the difference in energy between successive MOs in Na $(Na)_n$ molecule:

(a) Increases (b) Decreases

(c) May increase or decrease

(d) No change

101. Which of the following statement is/are true?

(I) Borazine is aromatic

(II) There are four isomeric disubstituted borazine molecule $B_3N_3H_4X_2$

(III) Borazine is more reactive towards addition reactions than benzene

(IV) Banana bonds in B_2H_6 are longer but stronger than normal B—H bonds

(a) I, II, and III (b) I, II, and IV

(c) I, II, III, and IV (d) only II

102. Which of the following statements are correct for the compound $C_3N_3(N_3)_3$?

(I) It contains three pi bonds

(II) Its structure is planar

(III) C and N atoms are sp^2-hybridized in the ring

(IV) N_3^- groups are attached with N-atoms

Select the correct code:

(a) I, II, and III (b) II and III

(c) I, III, and IV (d) All

103. N_2H_4 (hydrazine) combines with $(CH_3)_3N$ via:

(a) An ionic bond (b) A coordinate bond

(c) A covalent bond

(d) Combination is not possible

Multiple Correct Answers Type

1. Select the correct statements:

(a) The combination of s-orbital and p-orbital, with the increase of p-character, the bond angle decreases

(b) $H—\hat{C}—H$ bond angle > $H—\hat{C}—F$ bond angle in CH_3F molecule

(c) $F—\hat{C}—F$ bond angle > $H—\hat{C}—F$ bond angle in CHF_3 molecule

(d) All are correct statement

2. Which of the following molecule(s) is/are having pyramidal structure?

(a) PH_3 (b) $P(SiH_3)_3$

(c) NH_3 (d) PCl_2^+

3. Select the correct statements:

(a) The hybrid orbitals may be equivalent or not

(b) The hybridization defines a geometry of the molecule

(c) The hybrid orbitals are having much greater bonding strength compared to the pure atomic orbital

(d) The hybrid orbitals are having much lesser bonding strength compared to the pure atomic orbital

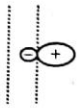
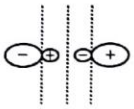
4. Select the correct statement(s) for bond distance:

(a) The bond distance decreases with the increase of bond order

(b) $\equiv C—H < >C—H < -C—H$ (order of C—H bond distance)

(c) $\equiv C—C\equiv < >C—C\equiv < >C—C= < -C—C-$ (order of C — C bond distance)

(d) The bond distance increases with the increase of bond order

5. Bond length depends upon:
   (a) Bond order (b) π-bonding
   (c) State of hybridization (d) None of these
6. Select the correct statements:
   (a) The bond length in BF_3 is shorter than that of BF_4^-
   (b) OCl_2 has $2p_\pi$–$3d_\pi$ back bonding
   (c) $(AlCl_3)_2$ is not electron deficient but $(Al(Me)_3)_2$ is electron deficient
   (d) In B_2H_6, all the hydrogens are not identical
7. Select the correct order of first ionization potential:
   (a) $N_2 > O_2$ (b) $N_2 > O$
   (c) $O > O_2$ (d) $O_2 \approx N_2$
8. Select the correct statements:
   (a) The +1 oxidation state compared to the +3 oxidation state gets gradually more stabilized as we move from top to bottom in III group
   (b) Tl (III) being unstable, acts as a good oxidizing agent to get reduced to Tl (I)
   (c) $SnCl_2$ is a good oxidizing agent
   (d) All are incorrect
9. Which of the following molecule(s) has/have zero dipole moment?
   (a) CH_4 (b) CBr_4
   (c) C_2H_2 (d) None of these
10. Which of the following molecules have zero dipole moment and tetrahedral structure?
   (a) CCl_4 (b) $SnCl_2$
   (c) $SnCl_4$ (d) CO_2
11. Select the correct statements:
   (a) van der Waals' radii is always larger than the covalent radii
   (b) The bond length of a particular bond depends on the state of hybridization of the involved atoms
   (c) When s %-character increases, then bond length increases
   (d) All are incorrect
12. Which of the following silicates are nonplanar?
   (a) Single chain (b) Double chain silicate
   (c) 2D or sheet-like silicate
   (d) Cyclic silicate
13. Select the correct statements:
   (a) $Ca_3Si_3O_9$ is an example of cyclic silicate
   (b) Four corner oxygen atoms per tetrahedron are shared in 3D silicates
   (c) 2D, sheet-like silicates are planar
   (d) Silicate are ionic covalent compound
14. Which of the following molecule(s) is/are planar?
   (a) ICl_3 (b) H_2O
   (c) XeF_2 (d) $I_3^\ominus$
15. Select the correct diagram(s) for anti-bonding molecular orbitals:
   (a)
   (b) 
   (c) 
   (d) None of these
16. If z is internuclear axis, then which type of overlapping is/are not possible?
   (a) s and p_x (b) s and p_y
   (c) $p_x + p_z$ (d) $p_y + p_z$
17. Select the correct statement for non-bonding and anti-bonding orbitals:
   (a) Non-bonding orbitals have same energy than the atomic orbitals from which they are formed
   (b) Anti-bonding orbitals have higher energy than the atomic orbitals from which they are formed
   (c) Non-bonding orbital have higher energy than the atomic orbitals from which they are formed
   (d) Anti-bonding orbital have lower energy than the atomic orbitals from which they are formed
18. Which of the following is/are true for B_2 and C_2 molecules according to M.O.T?
   (a) Both are having 1σ and 1π bond
   (b) Both are having same bond length
   (c) Both are having different bond order
   (d) B_2 is paramagnetic and C_2 is diamagnetic in nature
19. Select the correct statements:
   (a) For a given cation, covalent character increases with increase in the size of the anion
   (b) For a given anion, covalent character increases with decrease in the size of the cation
   (c) Covalent character increases with increasing charge on either ion
   (d) Covalent character is greater for cations with pseudo-inert gas configuration than the noble gas configuration.
20. Which of the following statement(s) is/are correct?
   (a) B_2H_6 is non-planar (b) B_2H_6 is non-polar
   (c) B_2H_6 is e^- deficient
   (d) B_2H_6 has two 3C—$2e^-$ bond

21. Which of the following statement(s) is/are correct?
(a) Dipole moment of diborane is zero
(b) Diborane is a Lewis acid
(c) Diborane has incomplete octet
(d) Di-borane has four 2C—2e^- bond

22. Select the correct statement(s):
(a) In diborane 12 valence e^- are involved in bonding
(b) In diborane, maximum six atoms, two boron and four terminal hydrogen, lie in the same plane.
(c) Diborane has ethane-like structure
(d) In diborane, bridging bonds are stronger and longer than the terminal bonds

23. Select the correct statement for P_4O_{10}:
(a) It has four sp^3-hybridized phosphorous atoms
(b) It has higher s%-character in P—O bond than the P_4O_6
(c) It has a cage-like structure
(d) It has $p_\pi - d_\pi$ bonding

24. Select the correct order of acidic nature of non-metal oxide:
(a) $CO > CO_2$ (b) $CO_2 > CO$
(c) $CO_2 > SiO_2$ (d) $CO_2 < SiO_2$

25. Select the correct order of acidic nature of non-metal oxide:
(a) $SO_2 > SO_3$ (b) $SO_3 > SO_2$
(c) $NO < NO_2$ (d) $NO > NO_2$

26. Select the correct order of acidic nature of metal oxide:
(a) $MnO < Mn_3O_4 < Mn_2O_3 < Mn_2O_7$
(b) $CrO < Cr_2O_3 < CrO_3 < CrO_2$
(c) $MnO < Mn_2O_3 < Mn_3O_4 < Mn_2O_7$
(d) $CrO < Cr_2O_3 < CrO_2 < CrO_3$

27. Select the correct statement(s):
(a) Solubility of alkali metal's chlorate decreases down the group
(b) Solubility of alkali metal's perchlorate decreases down the group
(c) Solubility of alkali metal's nitrate decreases down the group
(d) Solubility of alkali earth metal's sulphate increases down the group

28. In each of the following pairs, select the species having the greater resonance stabilization:
(i) HNO_3 and NO_3^- (pair I)
(ii) $H_2C{=}O$ and $H\underset{\underset{O}{\|}}{C}\!-\!O^{\ominus}$ (pair II)
(a) HNO_3 has greater resonance in pair (I)
(b) NO_3^- has greater resonance in pair (I)
(c) $H_2C{=}O$ has greater resonance in pair (II)
(d) $H\underset{\underset{O}{\|}}{C}\!-\!O^{\ominus}$ has greater resonance in pair (II)

29. Select the correct order of lattice energy:
(a) LiF < LiBr < LiI (b) LiCl > LiBr > LiI
(c) LiCl > NaCl > KCl
(d) $BeCO_3 < MgCO_3 < SrCO_3 < BaCO_3$

30. Which of the following molecule(s) is/are having pyramidal structure?
(a) ClO_3 (b) H_3O^+
(c) NH_3 (d) PCl_3

31. Which of the following is/are paramagnetic in nature?
(a) B_2 (b) O_2
(c) NO^+ (d) O_2^-

32. The species having identical bond order with NO^+ is/are:
(a) CN^- (b) O_2^+
(c) CO (d) N_2

33. Which of the following is/are paramagnetic in nature:
(a) O_2 (b) O_2^+
(c) O_2^- (d) O_2^{2-}

34. Which of the following is/are diamagnetic?
(a) Super oxide ion (b) Oxygen molecule
(c) Carbon molecule (d) Nitrogen molecule

35. Which of the following compounds possesses Lewis acid character?
(a) AlF_3 (b) SiF_4
(c) PF_5 (d) BF_3

36. The species that contain peroxide ions is/are:
(a) KO_2 (b) SrO_2
(c) BaO_2 (d) Na_2O_2

37. Which is/are not correct for B_2H_6 structure?
(a) It has 4B—H terminal bonds and two 3C—2e bonds
(b) It has six B—H terminal bonds and one 3C—2e bond
(c) It has four B—H terminal bonds two 3C—2e bonds and one B—B bond
(d) It has ionic interaction between $[BH_2]^+$ and $[BH_4]^-$

38. Which of the following is/are neutral oxide?

(a) CO (b) ZnO

(c) N_2O (d) SnO_2

39. Which of the following acids contain P in 5+ oxidation state?

(a) Orthophosphoric acid (b) Metaphosphoric acid

(c) Phosphorus acid (d) Pyrophosphoric acid

40. Which of the following can act as Lewis acid?

(a) SiF_4 (b) $SnCl_4$

(c) CCl_4 (d) SF_4

41. Which of the following molecules is/are diamagnetic?

(a) Li_2 (b) B_2

(c) C_2 (d) N_2

42. Which of the fallowing oxides are amphoteric?

(a) HgO (b) ZnO

(c) PbO_2 (d) SnO_2

43. Which of the following is/are paramagnetic?

(a) H_2^+ (b) H_2^-

(c) H_2 (d) He_2^+

44. Select the correct statement(s):

(a) PbI_4, FeI_3 do not exist while $PbCl_4$, $FeCl_3$ exist

(b) $PbCl_4$, $FeCl_3$ do not exist white PbI_4, FeI_3 exist

(c) CO_2 is gaseous while SiO_2 is solid

(d) CO_2 is solid while SiO_2 gaseous

45. Select the correct order (for hydrolysis at room temperature):

(a) $SiCl_4 < CCl_4$ (b) $CCl_4 < SiCl_4$

(c) $NCl_3 > NF_3$ (d) $NCl_3 < NF_3$

46. Select the correct order (for hydrolysis at room temperature):

(a) $SF_4 < SF_6$ (b) $SF_4 > SF_6$

(c) $TeF_6 > SeF_6$ (d) $TeF_6 < SeF_6$

47. Select the correct statement(s):

(a) The e^- cloud of cation will get deformed by that of the anion, but as the electrons in the cation are much more tightly bond due to excess positive charge on cation so distortion is negligible

(b) With the increase of polarization, the degree of covalency increases

(c) With the increase of ionic potential, the polarizing power of the cation increases

(d) With the decrease of ionic potential the polarizing power of the cation increases

48. Select the correct statement(s):

(a) With the decrease of the size of the cation, the polarizing power increases

(b) With the decrease of positive charge on the cation, the polarizing power of cation increases

(c) If the inner electrons are very much efficient to screen the valence electrons, then the effective nuclear charge experienced by outermost electron is less

(d) With the increases of positive charge on the cation, the polarizing power of cation increases

49. Select the correct order of polarizing power of cations when their size are almost same:

(a) $Na^+ > Cu^+$ (b) $Cu^+ > Na^+$

(c) $K^+ < Ag^+$ (d) $Ag^+ < K^+$

50. Select the correct statement(s):

(a) For the same charge and the same size, a pseudo noble gas type cation with 18 e^- in the outermost shell is more polarizing than the cation of noble gas type with 8 e^- in the outermost shell

(b) The degree of covalency increases in descending a group in the transition metal ions for a particular oxidation state

(c) Size increases in descending a group in the transition metal ions for a particular oxidation state

(d) Covalency decreases in descending a group in the transition metal ions for particular oxidation

51. Select the correct statement(s):

(a) The larger anions with more negative charges are more polarizable

(b) The polarizability sequence is $I^- > Br^- > Cl^- > F^-$

(c) The covalency runs in the order $ZnCl_2 < CdCl_2 < HgCl_2$

(d) The polarizing power among the transition series varies as follows: 3*d*-series < 4*d*-series < 5*d*-series

52. Select the incorrect order for the given properties:

(a) Thermal stability : $BaSO_4 > SrSO_4 > CaSO_4$

(b) Solubility : $BaSO_4 > SrSO_4 > CaSO_4$

(c) Thermal stability : $Li_2CO_3 < Na_2CO_3 < K_2CO_3$

(d) Solubility : $Li_2CO_3 > Na_2CO_3 > K_2CO_3$

53. Select the correct order of their thermal stability:

(a) LiF > NaF > KF > RbF > CsF

(b) KF > KCl > KBr > KI

(c) LiCl > NaCl > KCl > RbCl > CsCl

(d) $Li_2O > Na_2O > K_2O > Rb_2O$

54. Which of the following order is /are correct for acidic nature of oxides?

(a) $Li_2O > Na_2O > K_2O > Rb_2O$

(b) MgO > CaO > SrO > BaO

(c) NiO > MgO > SrO > BaO

(d) Al_2O_3 > MgO > SrO > BaO

55. Which of the following oxides are amphoteric?

(a) ZnO (b) BeO

(c) Al_2O_3 (d) Pb_2O_3

56. Select the correct statement(s):

(a) The overlap become better when the overlapping orbitals have comparable energy

(b) The order of increasing tendency of polymerizations $SiO_4^{4-} > PO_4^{3-} > SO_4^{2-} > ClO_4^-$

(c) With the increase in positive oxidation state the energy of the 3*d*-orbitals gradually decreases and it favours the π-bonding interaction

(d) The system where the π bonding is not effective, the stabilization is attained through the single bonded structure, i.e., through the polymerization

57. Which of the following moelcule(s) gives only acid(s) on hydrolysis?

(a) PCl_3 (b) SF_4

(c) NCl_3 (d) P_4O_6

58. Which of the following species have the same bond order?

(a) $\bar{C}N$, N_2 (b) N_2^{2+}, N_2^{2-}

(c) N_2^{2-}, O_2 (d) NO, N_2^{2+}

59. Which of the following conversions does not represent the process of dimerization?

(a) $BeH_2 \longrightarrow BeH_2$ (solid)

(b) $S_2O_3^{2-} \longrightarrow S_4O_6^{2-}$

(c) $NO \longrightarrow N_2O_2$ (d) $ClO_3 \longrightarrow Cl_2O_6$

60. Select the correct options for following statement(s):

(a) sp^3-hybrid orbitals are at 90° to one another

(b) sp^3d^2 adjacent hybrid orbitals are at 90° to one another

(c) sp^2-hybrid orbitals are at 120° to one another

(c) Bond order of N—O bond in NO_3^- is $1\frac{1}{3}$

61. Which of the following species/molecules have the same shape but different hybridization?

(a) XeF_2, CO_2 (b) I_3^-, $HgCl_2$

(c) OCl^-, CO (d) SO_2, OCl_2

62. Select the correct statement(s):

(a) The crystal structure of $NaHCO_3$ and $KHCO_3$ both show hydrogen bonding, but are different. In $NaHCO_3$ the HCO_3^- ions are linked into an infinite chain, while in $KHCO_3$ a dimeric anion is formed

(b) The BeX_2 molecules polymerize to form chains containing bridging halogen groups; for example, in $(BeF_2)_n$ and $(BeCl_2)_n$, each halogen forms one normal covalent bond and uses a lone pair to form a coordinate bond

(c) $[Be(Me_2)_n]$ has essentially the same structure as $(BeCl_2)_n$ but the bonding in the methyl compound is best regarded as three center two electron bonds covering one Me and Be atoms

(d) Beryllium salts are acidic when dissolved in pure water because the hydrated ion hydrolyzed producing H_3O^+

63. Select the correct order for the given properties:

(a) $MgC_2O_4 > CaC_2O_4 > SrC_2O_4 > BaC_2O_4$: Solubility order

(b) $BeS_2O_3 < MgS_2O_3 < CaS_2O_3 < SrS_2O_3$: Solubility order

(c) $KO_3 < RbO_3 < CsO_3$: Thermal stability order

(d) $LiNO_3 < NaNO_3 < KNO_3 < CsNO_3$: Thermal stability order

64. Select the correct statements:

(a) More electronegative atom prefers the hybrid orbital of the central atom in which the *s*-character is less

(b) More electronegative atom prefers the hybrid orbital of the central atom in which the *s*-character is more

(c) Lone pair prefers to stay with that hybrid orbital which has less *s*-character

(d) Lone pair prefers to stay with that hybrid orbital which has more *s*-character

65. Select the correct order:

(a) Bond strength : $NO^- < NO < NO^+$

(b) N—O bond angle : $NO_2^+ < NO_2^- < NO_3^-$

(c) Thermal stability : LiF > NaF > KF > RbF > CsF

(d) Hydrated size : $Be^{2+}(aq) < Mg^{2+}(aq) < Ca^{2+}(aq) < Sr^{2+}(aq) < Ba^{2+}(aq)$

66. Select the correct statements:

(a) XeF_2 is linear and XeF_6 is capped octahedral

(b) Xe can only form compounds with the highly electronegative elements

(c) SF_6 and SH_6 both have sp^3d^2-hybridization

(d) All are correc

67. Select the correct statements:

(a) The symmetrical molecules such as CH_4, CCl_4, CO_2, CS_2, C_6H_6 do not have any dipole moment

(b) SO_2, H_2O, and H_2S being angular in geometry possess the net dipole moment

(c) Direction of dipole moment of hybrid lone pair moment is away from the central atom

(d) All are incorrect

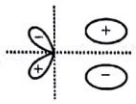
68. Which of the following is/are an example of orthosilicate?

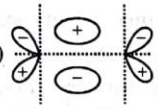
(a) $ZrSiO_4$ (b) Mg_2SiO_4

(c) $Zn_3Si_2O_7$ (d) Asbestos

69. Select the correct diagram for bonding molecular orbitals which are formed by sideways overlapping:

(a)

(b) 

(c) 

(d) None of these

70. If x is internuclear axis, then which type of overlapping is/are responsible for the formation of N.B.M.O.?

(a) $d_{xy} + p_x$ (b) $d_{xy} + s$

(c) $s + p_y$ (d) $s + p_z$

71. Which of the following species are paramagnetic in nature?

(a) F_2 (b) OF

(c) NO (d) B_2

72. Select the incorrect statements:

(a) Peroxide ion has longer bond length than O_2

(b) Superoxide ion has longer bond length than peroxide ion

(c) Dioxygenyl ion (O_2^+) has longer bond length than O_2

(d) Dioxygenyl ion (O_2^+) has smaller bond length than O_2

73. Select the correct order of bond angle:

(a) $OsF_2 < OsCl_2 < OsBr_2$ (b) $SbCl_3 < SbBr_3 < SbI_3$

(c) $PI_3 > AsI_3 > SbI_3$ (d) $PI_3 < AsI_3 < SbI_3$

74. Select the correct statement(s):

(a) Solubility of alkaline earth metal's thiosulphate decreases down the group

(b) Solubility of alkaline earth metal's carbonate increases down the group

(c) Solubility of alkali metal's carbonate increases down the group

(d) Solubility of alkali metal's carbonate decreases down the group

75. In which of the following compounds, S is in +6 oxidation state?

(a) H_2SO_5 (b) $H_2S_2O_8$

(c) $Na_2S_4O_6$ (d) H_2SO_4

76. Which of the following metal carbonates decompose on heating?

(a) Li_2CO_3 (b) Na_2CO_3

(c) K_2CO_3 (d) $MgCO_3$

77. Which of the following oxoanions contain S—S bond?

(a) $S_2O_3^{2-}$ (b) $S_2O_4^{2-}$

(c) $S_2O_6^{2-}$ (d) $S_2O_7^{2-}$

78. Which of the following statement(s) is/are correct for PCl_5?

(a) P atom is sp^3d-hybridized and has trigonal bipyramidal geometry.

(b) It acts as a Lewis acid

(c) On hydrolysis it forms phosphoric acid

(d) Axial Cl atoms are closer to equatorial Cl atoms

79. Which are the correct statements for NO_2?

(a) It is paramagnetic and dimerizes to N_2O_4

(b) N_2O_4 is planar and diamagnetic

(c) NO_2 is linear containing an odd number of electrons

(d) N—O bonds in NO_2 are of different lengths

80. According to M.O. theory for the atomic species "C_2" which is not correct?

(a) Bond order is zero and it is paramagnetic

(b) Bond order is zero and it is diamagnetic

(c) Bond order is two and it is paramagnetic

(d) Bond order is two and it is diamagnetic

81. Which of the following does not contain O—O bond?

(a) $S_2O_8^{2-}$ (b) $S_4O_6^{2-}$

(c) SO_5^{2-} (d) $S_2O_7^{2-}$

82. Which of the following compound/ion is/are having pyramidal geometry?

(a) ClO_3^- (b) $(SiH_3)_3N$

(c) $(CH_3)_3N$ (d) CH_3^+

83. Select the correct statement(s):

(a) Para-dihydroxy benzene is polar while para-dimethyl benzene is non-polar

(b) Dipole moment of NH_3 is larger than that of NF_3

(c) The direction of dipole moment in CO is from C to oxygen

(d) All are incorrect

84. Select the correct statement(s):

(a) The transition metal ion is more polarizing compared to the alkali and alkaline earth metal ions of comparable size for a particular oxidation state

(b) The solubility of silver halides in water runs as AgF > AgCl > AgBr > AgI

(c) LiCl is soluble in organic solvents while NaCl is insoluble in such solvents

(d) All are incorrect

85. Select the correct statement(s):

(a) CH_3NCS is angular while SiH_3NCS is linear

(b) Both CH_3NCS and SiH_3NCS are linear

(c) CH_3NCS is linear while SiH_3NCS is bent

(d) The Lewis acid strength of boron halides runs as $BF_3 < BCl_3 < BBr_3 < BI_3$

86. Select the correct statement(s):

(a) The rate of hydrolysis of SiH_4 is higher than that of CH_4

(b) The hydrolytic products of NCl_3, NF_3, and PCl_3 are of different types

(c) The hydrolytic products of NCl_3 and BCl_3 are of same type

(d) The hydrolytic products of NCl_3, NF_3, and PCl_3 are of same type

87. Select the correct statement(s):

(a) Diamond is hard while graphite is soft and slippery

(b) The degree of covalency in the following compounds runs as $HgX_2 > CdX_2 > ZnX_2$

(c) Zns is white, CdS is yellow, while HgS is black

(d) Diamond is soft while graphite is hard

88. Select the correct order for the given properties:

(a) Thermal stability : $BeCO_3 < MgCO_3 < CaCO_3$

(b) Solubility : $BeCO_3 > MgCO_3 > CaCO_3$

(c) Thermal stability : $Li_2SO_4 < Na_2SO_4 < K_2SO_4$

(d) Solubility : $Li_2O > Na_2O > Cs_2O$

89. Select the incorrect order for the given properties:

(a) $Li^+(aq) > Na^+(aq) > K^+(aq) > Rb^+(aq) > Cs^+(aq)$: Ionic mobility

(b) $Li^+(aq) < Na(aq) > K^+(aq) > Rb^+(aq) > Cs^+(aq)$: Hydrated size of ion

(c) $F^-(aq) > Cl^-(aq) > Br^-(aq) > I^-(aq)$: Hydrated size of ion

(d) $F(aq) < Cl^-(aq) < Br^-(aq) < I^-(aq)$: Ionic mobility

90. Select the correct statements:

(a) *s*-block metal oxides are basic in nature, except BeO which is amphoteric

(b) *p*-block metal oxides are acidic in nature, except NO, N_2O, CO, H_2O

(c) *d*-block metal oxides are basic, acidic, and amphoteric in nature

(d) *d*-block metal oxides are only basic in nature

91. Choose the incorrect statement:

(a) All S — F bond lengths are identical in SF_4

(b) All Cl — F bond length are identical in ClF_3

(c) All $\angle$ FClF angles are identical in ClF_3

(d) All possible angle in BF_2Cl are 120°

92. Select the correct statement(s):

(a) When $d_{x^2-y^2}$ or d_{xy} orbitals combine in parallel planes, then δ or δ^* molecular orbitals are formed

(b) When $d_{x^2-y^2}$ and d_{xy} orbitals combine in parallel planes, then N.B.M.O. are formed

(c) When d_{yz} and d_{xz} orbitals combine in along the *y*-axis, then N.B.M.O. orbitals are formed

(d) No interaction is possible when p_z and d_{xz} orbitals overlap with collinear *z*-axis

93. The dipole moment of AX_3, BX_3, and CY_3 are 4.97×10^{-30}, 0.60×10^{-30}, and 0.00 C.M. respectively, then the shape of molecules may be:

(a) Pyramidal, T-shape, trigonal planar

(b) Pyramidal, trigonal planar, T-shape

(c) T-shape, pyramidal, trigonal planar

(d) Pyramidal, T-shape, linear

94. Select the correct statement(s) for following molecules:

(I) $PF_2(CH_3)_3$ (II) $PF_2(CF_3)_3$

(a) Both have trigonal bipyramidal structure

(b) Both have the same dipole moment

(c) P—F bond length is longer in $PF_2(CH_3)_3$ than in $PF_2(CF_3)_3$

(d) P—F bond length is longer in $PF_2(CF_3)_3$ than in $PF_2(CH_3)_3$

95. Select the incorrect statement for adjacent bond angle:

(a) In CF_2 and OF_2, OF_2 has higher bond angle

(b) In PF_4^+ and PF_4^-, PF_4^- has higher bond angle

(c) In ClF_3 and BF_3, ClF_3 has lower bond angle

(d) Both NH_3 and PH_3 have the same bond angle

96. Which of the following statement is correct in the context of the allene molecule C_3H_4?

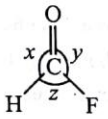
(a) The central carbon is *sp*-hybridized

(b) The terminal carbon atoms are sp^2-hybridized

(c) The planes containing the CH_2 groups are mutually perpendicular to permit the formation of two separate π-bonds

(d) Central atom is sp^2-hybridized

97. Which of the following relationship is correct for the following figure:



(a) $x = y = z$ (b) $x = y > z$

(c) $x > 120°$ (d) $z < 120°$

98. Which of the following are correct statements about white phosphorus (P_4)?

(a) Each P atom has one lone pair of electrons in a molecule of P_4

(b) It has tetrahedral structure with 109°28' bond angle

(c) There are six P—P linkages in a molecule of P_4

(d) It undergoes disproportionation on reaction with alkalies

99. Select the correct order for the given properties:

(a) NaF > KF > LiF > RbF > CsF: Melting point order

(b) CuCl > NaCl: Covalent character

(c) $BeSO_4 < CaSO_4 < SrSO_4 < BaSO_4$: Thermal stability order

(d) LiI > NaI > KI > RbI > CsI: Solubility order

100. Which of the respective orders are correct?

(a) $NH_3 > SbH_3 > AsH_3 > PH_3$: Thermal stability order

(b) Liquid hydrogen < liquid helium: boiling point order

(c) $BeCO_3 > SrCO_3 > BaCO_3$: K_p value order during their thermal dissociation in closed container

(d) $O_2 > KO_2 > K_2O_2$: Magnetic moment order

101. Select the correct statements:

(a) The alkali metal salts of azide and cyanate are isomorphous

(b) The lone pairs and multiple bonds preferably occupy the equatorial positions in trigonal bipyramidal

(c) In PCl_3F_2, the fluorine preferably occupy the axial positions of the trigonal bipyramidal

(d) All the bond angles in CH_4 are identical but these are not identical in CH_2F_2

102. Select the correct statements:

(a) The colors of halogens (X_2) are: F_2 (pale yellow), Cl_2 (yellowish green), Br_2 (reddish brown), I_2 (violet)

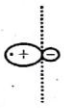
(b) Halogen molecules are diamagnetic

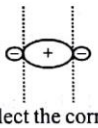
(c) The bond length of the peroxo-linkage (O — O) in F_2O_2 is remarkably shorter compared to that in other peroxo compound, e.g., H_2O_2, Ba_2O_2

(d) All are incorrect

103. Select the correct diagram for bonding molecular orbitals which are formed by axial overlapping:

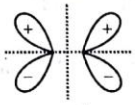
(a)

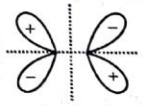
(b) 

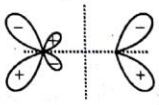
(c) 

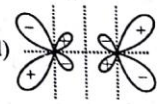
(d) None of these

104. Select the correct diagram for anti-bonding molecular orbitals which are formed by side-ways overlapping:

(a) 

(b) 

(c) 

(d) 

105. Which of the following is/are incorrect about solubility trend in group I and II?

	Least soluble in water	Most soluble in water
(a) Thiosulphate :	BaS_2O_3	BeS_2O_3
(b) Oxalate :	BaC_2O_4	BeC_2O_4
(c) Chromate :	$BeCrO_4$	$BaCrO_4$
(d) Bicarbonate :	$NaHCO_3$	$CsHCO_3$

106. Select the correct statement(s):

(a) Solubility of alkali earth metal's oxide decreases down the group

(b) Solubility of alkaline earth metal's sulphide increases down the group

(c) Solubility of alkali metal's hydroxide increases down the group

(d) Solubility of alkali metal's fluorides increases down the group

107. Select the correct statement(s):

(a) Solubility of alkaline earth metal's chromate decreases down the group

(b) Solubility of alkaline earth metal's chromate increases down the group

(c) Solubility of alkaline earth metal's hydroxide decreases down the group

(d) Solubility of alkaline earth metal's hydroxide increases down the group

108. Which is/are correct representation of boranes?

(a) $B_n H_{n+4}$ (b) $B_n H_{n+6}$

(c) $B_n H_{2n+2}$ (d) None of these

109. Which of the following compound(s) is/are peroxy-acids?

(a) $HClO_4$ (b) H_2SO_5

(c) $H_2S_2O_8$ (d) H_3PO_5

110. Which of the following species do not exist?

(a) XeF_3 (b) XeF_4

(c) XeF_5 (d) XeF_6

111. Select the correct statement(s):

(a) $SnCl_4$ hydrolyzes more readily than $SnCl_2$

(b) $BeCO_3$ is thermally more unstable compared to $MgCO_3$

(c) $PbCl_2$ is white while PbI_2 is colored

(d) PbI_2 is white while $PbCl_2$ is colored

112. Select the correct statement(s):

(a) Compared to Me_3N, $(SiH_3)_3N$ has got almost no basicity

(b) The molecular formulas of nitrogen and phosphorus are N_2 and P_4, respectively; similarly, oxygen exists as O_2 while sulphur exists as S_8

(c) The dipole moment of R_3NO is much greater compared to that of R_3PO

(d) All the B—O bond lengths are not identical in polyborates

113. Select the correct statement(s):

(a) The tendency of polymerization of the oxyanions lies in the sequence

$$SiO_4^{4-} > PO_4^{3-} > SO_4^{2-} > ClO_4^-$$

(b) The molecular structure of $S_4N_4H_4$ and $S_4N_4F_4$ are different

(c) The bond strength of P—O linkage is maximum in OPF_3 compared to all other analogous halogen compound

(d) The structural geometries of NO_2^- and NO_2 are different

114. Select the correct order of bond angle:

(a) $H-\hat{P}-H\,(PH_3) < F-\hat{P}-F\,(PF_3)$

(b) $F-\hat{N}-F\,(NF_3) < H-\hat{N}-H\,(NH_3)$

(c) $F-\hat{O}-F\,(OF_2) < H-\hat{O}-H\,(H_2O)$
$< Cl-\hat{O}-Cl\,(OCl_2)$

(d) $H-\hat{P}-H\,(PH_3) > F-\hat{P}-F\,(PF_3)$

115. Select the correct order of bond angle:

(a) $Br-\hat{P}-Br\,(OPBr_3) > Cl-\hat{P}-Cl\,(OPCl_3) > F-\hat{P}-F\,(OPF_3)$

(b) $H-\hat{C}-H(CH_4) > H-\hat{N}-H(NH_3)$

(c) $H-\hat{C}-H(CH_4) < H-\hat{N}-H(NH_3)$

(d) $Br-\hat{P}-Br\,(OPBr_3) < Cl-\hat{P}-Cl\,(OPCl_3) < F-\hat{P}-F\,(OPF_3)$

116. Which of the following molecule(s) has/have $d_\pi - p_\pi$ bonding?

(a) $H_2S_2O_3$ (b) P_4O_{10}

(c) SO_3 (d) P_4S_{10}

117. Select the correct order of polarizing power of cation:

(a) $Li^+ > K^+ > Na^+$ (b) $Li^+ > Na^+ > K^+$

(c) $Ba^{2+} > Ca^{2+} > Be^{2+}$ (d) $Be^{2+} > Mg^{2+} > Ca^{2+}$

118. Select the correct order of polarizing powers of cations when their sizes are almost same:

(a) $Cd^{2+} > Ca^{2+}$ (b) $Ca^{2+} > Cd^{2+}$

(c) $Au^+ < Rb^+$ (d) $Au^+ > Rb^+$

119. Select the correct order for the given properties:

(a) Thermal stability order : $NaNO_3 < KNO_3 < RbNO_3$

(b) Solubility in water : $NaNO_3 > KNO_3 > RbNO_3$

(c) Melting point order : NaF > KF > RbF

(d) Covalent character order : NaF > KF > RbF

120. Which of the following metal oxide(s) gives metal and oxygen on heating?

(a) $NaNO_3$ (b) KNO_3

(c) $Hg(NO_3)_2$ (d) $AgNO_3$

121. Select the correct order of their thermal stability:

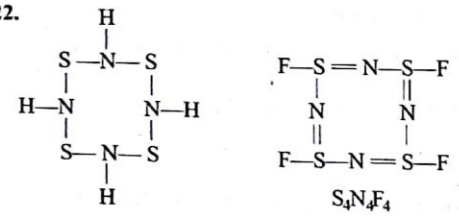
(a) LiOH < NaOH < KOH < RbOH < CsOH

(b) $Na_2O_2 < K_2O_2 < Rb_2O_2 < Cs_2O_2$

(c) $NaO_2 < KO_2 < RbO_2 < CsO_2$

(d) $NaO_2 > KO_2 < RbO_2 < CsO_2$

122.



$S_4N_4H_4$ (Tetrasulphur tetramide) $S_4N_4F_4$ (Tetrathiazyl tetrafluoride)

Select the correct statement(s) for the above given structures:

(a) In $S_4N_4H_4$, the hydrogens never go on sulphurs while in $S_4N_4F_4$, fluorines get preferably attached with sulphur atoms

(b) The highly electronegative fluorines on being placed on sulphur atoms can appreciably contract the 3*d*-orbital of S to facilitate $N(2p_\pi) \longrightarrow S(3d_\pi)$ π–bonding

(c) If in $S_4N_4H_4$, hydrogens go to the sulphurs, no effective π–bonding occurs through the 3*d*-orbitals of S

(d) N—H bond is stronger than the S—H bond

123. Select the correct statement for thiazyl trifluoride (NSF_3):

(a) S—N bond length is 141.5 pm, probably the shortest one between S and N

(b) The three highly electronegative fluorine substituents contract the 3*d*-orbitals of sulphur sufficiently to effect the strong π-bonding with the half-filled *p*-orbitals of nitrogen

(c) The bond angle $F-\hat{S}-F = 94°$ indicates the involvement of almost pure *p*-orbitals of S in binding the fluorine atoms

(d) The very strong bonding (due to multiple bond formation) between N and S demands the participation of *s*-character enriched orbitals of sulphur

124. Select the correct statement(s):

(a) $BeCl_2$ tends to dimerize to a 3-coordinate structure in vapor phase, but linear monomer is also known at high temperature

(b) BeF_2 has $3C - 4e^-$ bond

(c) Bond lengths in all the boron trihalides are shorter than expected for single bonds

(d) BeF_2 is analogous to CO_2 and BF_3 analogous to SO_3

125. Select the correct statement(s):

(a) $CH_3 - C - CH_3$ angle in $(CH_3)_2C = CH_2$ is smaller and the $CH_3 - C = CH_2$ angle is larger than the trigonal 120°

(b) O — I — F angle is less than 90° (89°) in $IOF_4^{\ominus}$

(c) In $SeOCl_2$, Cl — Se — Cl angle is less than the Cl—Se—O angle

(d) $POCl_3$ is tetrahedral with a double bond between P and O. There is no lone pair on central atom

126. Select the correct statement(s):

(a) Two ions isoelectronic with carbon suboxide C_3O_2 are $N_5^{\oplus}$ and $OCNCO^+$

(b) C_3O_2 is linear, both $N_5^{\oplus}$ and $OCNCO^+$ are bent at the central nitrogen

(c) C_3O_2 is formed by dehydration of malonic acid by P_2O_5

(d) C_3O_2 has 4σ and 4π bond in its structure

127. Correct statement(s) about NH_3 and PH_3 is/are:

(a) μ_D of $PH_3 < \mu_D$ of NH_3

(b) PH_3 is stronger Lewis base than NH_3

(c) $\angle H-N-H > \angle H-P-H$

(d) Both have sp^3-hybridization

128. Select the correct statement(s):

(a) Due to the absence of vacant orbital of N-atom, NCl_3 does not undergo hydrolysis

(b) Order of rate of hydrolysis in SF_6, SeF_6, and TeF_6, is $SF_6 < SeF_6 < TeF_6$

(c) Only proton donor acids are formed as final hydrolyzed product of SF_4

(d) Hybridization of central atom in transition state changes during hydrolysis of BCl_3

129. Select the correct properties for the following molecules:

(I) CH_2F_2 (II) CHF_3 (III) CH_3F

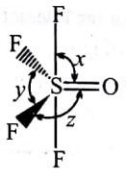
(a) C — F bond length order: $CH_3F > CH_2F_2 > CHF_3$

(b) C — H bond length order: $CH_3F > CH_2F_2 > CHF_3$

(c) Shape is not perfect tetrahedral for given compounds

(d) Dipole moment is non-zero for given compounds

130. The incorrect order of bond angle in the following molecule is/are:



(a) $y = z > x$ (b) $z > y > x$
(c) $y > x > z$ (d) $x > y > z$

131. The planar compounds are:

(a) $\ddot{N}(SiH_3)_3$ (with respect to N)

(b) IF_4^-

(c) BF_3 (d) BrF_3

132. Select the correct statement(s):

(a) Solubility of group IA fluorides and carbonates increases down the group

(b) LiF is insoluble or very less soluble in water, whereas other alkali metals fluorides are soluble

(c) Hydrogen peroxide acts as a reducing agent in the presence of other oxidizing agent. This is because it can take up an atom of oxygen to give water and oxygen gas

(d) All the carbonates and bicarbonates of alkali metals are soluble except $NaHCO_3$ and solubility increases down the group but Li_2CO_3 is sparingly soluble

133. Select the correct order of acidic strength:

(a) $BF_3 > Me_3B$

(b) $HC{\equiv}C - H$ (*sp* carbon) $< H_2C{=}CH - H$ (sp^2carbon) $< H_3C - CH_2 - H$ (sp^3carbon)

(c) $BF_3 < Me_3B$

(d) $HC{\equiv}C - H$ (*sp* carbon) $> H_2C{=}CH - H$ (sp^2carbon) $> H_3C - CH_2 - H$ (sp^3carbon)

134. Correct order of bond energy for PH_3, NH_3 and NF_3, PF_3:

(a) $B.D.E._{N-H} > B.D.E._{P-H}$

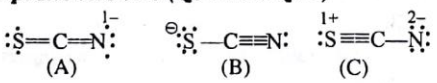
(b) $B.D.E._{N-H} < B.D.E._{P-H}$

(c) $B.D.E._{N-F} > B.D.E._{P-F}$

(d) $B.D.E._{N-F} < B.D.E._{P-F}$

Comprehension Type

Comprehension-1: (Q. 1 and Q. 2)



In the thiocyanate ion, SCN^-, three resonance structures are consistent with the electron-dot method. Structure A has only one negative formal charge on the nitrogen atom, the most electronegative atom in the ion. Structure B has a single negative charge on the S, which is less electronegative than N. Structure *C* has charges of –2 on N and +1 on S, consistent with the relative electronegativities of the atoms but with a larger charge and greater charge separation than the first.

1. Predict the hybridization of atom which is bonded with H in structure of HNCS:

(a) *sp* (b) sp^2
(c) sp^3 (d) No hybridization

2. HNCs is isostructural with:

(a) HN_3 (b) NH_3
(c) CO_2 (d) None of these

Comprehension-2: (Q. 3 to Q. 5)

Many bond angles can be explained by either electronegativity or size arguments. Molecules with larger difference in electronegativity values between central and outer atoms have smaller bond angles. As the size of outer atom increases, the angle increases. The size of central atom can also be used to determine the bond angles in the series.

3. Consider the following molecules:

(I) H_2O (II) H_2S
(III) H_2Se (IV) H_2Te

Arrange these molecules in increasing order of bond angle:

(a) I < II < III < IV (b) IV < III < II < I
(c) I < II < IV < III (d) II < IV < III < I

4. Consider the following hydrides and arrange them in increasing order of bond angles:

(I) NH_3 (II) PH_3
(III) AsH_3 (IV) SbH_3

(a) I < II < III < IV (b) IV < III < II < I
(c) I < III < II < IV (d) IV < II < III < I

5. Which has the smallest bond angle ($X - S - X$) in the given molecules?

(a) OSF_2 (b) $OSCl_2$
(c) $OSBr_2$ (d) OSI_2

Comprehension-3: (Q. 6 to Q. 8)

The simplest phosphoric acid (H_3PO_4) contains three replaceable H-atom and is tribasic.

6. The basicity of $H_4P_2O_7$ is:

(a) 1 (b) 2
(c) 3 (d) 4

7. The oxidation state of P in H_3PO_5 is:
(a) +3 (b) +5
(c) +7 (d) None of these

8. Which of the following is known as glacial phosphoric acid?
(a) HPO_3 (b) H_3PO_3
(c) H_3PO_3 (d) H_3PO_4

Comprehension-4: (Q. 9 to Q. 11)

Polarization is an important phenomenon which is helpful in determination of covalent nature of compound. With the help of Fajan's rule one can easily predict the nature of compound.

9. Which of the following halide possess the highest covalent character?
(a) LiF (b) LiCl
(c) LiBr (d) LiI

10. Which of the following possess the least covalent character?
(a) LiCl (b) NaCl
(c) KCl (d) CsCl

11. The correct increasing covalent nature is:
(a) NaCl < LiCl < $BeCl_2$ (b) $BeCl_2$ < NaCl < LiCl
(c) $BeCl_2$ < LiCl < NaCl (d) LiCl > NaCl > $BeCl_2$

Comprehension-5: (Q. 12 to Q. 14)

Bond order is associated with the strength of bond and bond length. The higher the bond order, the smaller will be the bond length and stronger will be the bond.

12. Arrange O_2, O_2^+, O_2^- and O_2^{2-} in order of increasing bond order:
(a) $O_2 < O_2^- < O_2^{2-} < O_2^{2+}$ (b) $O_2^{2-} < O_2^- < O_2 < O_2^+$
(c) $O_2^- < O_2^{2-} < O_2^+ < O_2$
(d) $O_2^{2-} < O_2^+ < O_2^- < O_2$

13. Which of the following species has the longest O—O bond?
(a) O_2 (b) O_2^+
(c) O_2^- (d) O_2^{2-}

14. Which of the following has the highest O—O bond energy?
(a) O_2 (b) O_2^{2-}
(c) O_2^- (d) O_2^{2-}

Comprehension-6: (Q. 15 to Q. 18)

The rule governing the transition from ionic to covalent bonding are called Fajan's rules. They are based on the deformation of the interacting ions in the bond $A^+B^{\ominus}$ (polarization of ions).

15. Select the correct statement:
(a) Solubility of hydroxides of group I A increases down the group, while for group II A it decreases down the group
(b) Solubility of hydroxides of *s*-block metal cations increases down the group
(c) Solubility of carbonates of *s*-block metal cation decreases down the group
(d) Solubility of carbonates of *s*-block metal cation increases down the group

16. Select the correct statement:
(a) Solubility of bicarbonates of Na^+, K^+, Rb^+, Cs^+ decreases down the group
(b) Thermal stability of nitrates of group I A cations decreases down the group
(c) Solubility of chromates of group II A cation increases down the group
(d) Melting point of fluorides of Na^+, K^+, Rb^+, Cs^+ decreases down the group

17. Which of the following compound has the highest thermal stability?
(a) NaCl (b) CsCl
(c) KCl (d) RbCl

18. Which of the following is most covalent?
(a) CuCl (b) NaCl
(c) AgCl (d) AuCl

Comprehension-7: (Q. 19 to Q. 21)

The molecule in which an atom is associated with more than 8 electrons is known as hypervalent molecule and less than 8 electrons is known as hypovalent molecule. All hypervalent molecules must have $d\pi$–$p\pi$ bonding but the molecules having back bonding need not always have $d\pi$–$p\pi$ bonding.

19. Which of the molecule is not hypovalent but complete its octet?
(a) $AlCl_3$ (b) $AlBr_3$
(c) AlF_3 (d) BF_3

20. Which of the following molecule is having complete octet?
(a) $BeCl_2$ (dimer) (b) BeH_2 (dimer)
(c) $BeH_2(s)$ (d) $BeCl_2(s)$

21. Which of the following molecule is not having $d\pi$–$p\pi$ bonding?
(a) BCl_3 (b) P_4O_{10}
(c) PF_3 (d) $B_3N_3H_6$

Comprehension-8: (Q. 22 to Q. 24)

NO has 11 valence electrons. It is impossible for all to be paired, and hence this is an odd electron molecule and the gas is paramagnetic.

22. Which of the following is the correct decreasing bond order for NO, NO^+, and NO^-?

(a) $NO > NO^- > NO^+$ (b) $NO^- > NO^+ > NO$

(c) $NO^- > NO > NO^+$ (d) $NO^+ > NO > NO^-$

23. Which of the following species has the smallest N—O bond length?

(a) NO (b) NO^-

(c) NO^+ (d) N_2O

24. Which of the following is diamagnetic?

(a) NO (b) NO^-

(c) NO^+ (d) NO_2

Comprehension-9: (Q. 25 to Q. 28)

NO is a colorless gas and an important intermediate in the manufacture of nitric acid by catalytic oxidation of ammonia.

25. Which of the following is a neutral oxide?

(a) NO (b) NO_2

(c) N_2O_3 (d) N_2O_5

26. Which of the following is known as anhydride of nitric acid?

(a) N_2O_3 (b) N_2O_4

(c) N_2O_5 (d) N_2O

27. Which of the following is/are isoelectronic and isostructural with CO_2?

(a) NO_2 (b) NO_2^+

(c) NO_2^- (d) NO_3^-

28. In which of the following the O—N—O bond angle is the highest?

(a) NO_2 (b) NO_2^+

(c) NO_2^- (d) NO_3^-

Comprehension-10: (Q. 29 to Q. 31)

I_2 has less solubility in water so its solubility increases on adding KI solution when KI and I_2 react, then a species X is formed and solubility of I_2 solution increases.

29. Hybridization of anionic part of X is:

(a) sp^2 (b) sp^3

(c) sp^3d (d) sp^3d^2

30. Geometry of anionic part of X is:

(a) Linear (b) T-shape

(c) Pyramidal (d) See-saw

31. Anionic part of X is:

(a) Non-planar (b) Planar

(c) Both (a) and (b) (d) None of these

Comprehension-11: (Q. 32 to Q. 34)

Bent's rule is consistent with VSPER theory. According to Bent's rule, the more electronegative substituent attaches itself to hybrid orbital that contains more p-character or less s-character.

32. The molecule/ion in which bond angle is less than 109°:

(a) $\overset{+}{N}F_4$ (b) CCl_4

(c) ClO_4^- (d) None of these

33. Select pair of compounds in which both have different hybridization but have the same molecular geometry:

(a) BF_3, BrF_3 (b) ICl_2^-, $BeCl_2$

(c) BCl_3, PCl_3 (d) PCl_3, NCl_3

34. Find the species which is not perfectly planar:

(a) $\dot{C}H_3$ (b) $\dot{C}HF_2$

(c) $:CH_2$ (d) $\dot{N}O_2$

Comprehension-12: (Q. 35 to Q. 37)

Hybridization is the measure to express the molecular shapes reasonably. Hybridization, although theoretical, but is highly correlated with molecular shapes or inter orbital angles. If there is any departure in geometry (on the basis of VSEPR theory), the apparent departure in hybridization can be observed and the following characteristic relationship is the easiest way to interpret that departure. Any hybrid orbital made by s and p-orbitals is characterized by the following relationship.

$$f_s = \frac{1}{i+1} \text{ or } f_p = \frac{i}{i+1} \text{ and } i = \frac{f_p}{f_s}$$

For sp^3, $i = 3$ and sp^2, $i = 2$; for an orbital $f_s + f_p = 1$ while all the s-p hybrids of gien atom must satisfy the condition,

$$\Sigma f_s = 1.00$$

d and the inter orbital angle between two equivalent (same f_s and same f_p) hybrid orbitals is given by

$$\cos\theta = \frac{-1}{i}$$

35. VSEPR theory suggests a small departure from 109° 28' for NH_3 molecule. The H — N — H bond angle has been found to be 107°. What kind of hybrid orbital will be occupied by the non-bonding pair of electron?

(a) sp^3 (b) $sp^{3.4}$

(c) $sp^{2.13}$ (d) sp^2

36. What s-character is used by the carbon atom in the orbitals directed to hydrogen atom in CH_2F_2 molecule? [H — C — H bond angle in CH_2F_2 is 111.9° (cos 111.9° = – 0.3729)]
(a) 27.1% (b) 37.29%
(c) 29% (d) 29.99%

37. In BFClBr molecule the minimum % s-character provided from the central atom is in the bond:
(a) B — F (b) B — Cl
(c) B—Br (d) Cannot be predicted

Comprehension-13: (Q. 38 to Q. 40)

When two compounds ACl_3 and DCl_3 of two elements A and D are mixed together a compound $ADCl_6$ is formed. Structural analysis showed that $ADCl_6$ is an ionic compound. Given that DCl_3 is trigonal planar and ACl_3 is trigonal pyramidal, predict the shape of the anion.

38. If anion has see-saw shape, then the shape of cation formed is:
(a) Linear (b) Bent
(c) Pentagonal bipyramidal
(d) Trigonal planar

39. If shape of anion is tetrahedral, then the shape of cation formed is:
(a) Tetrahedral (b) Bent
(c) Linear (d) Trigonal planar

40. Shape of DCl_4^- is:
(a) See-saw (b) Perfect tetrahedral
(c) Square planar (d) none of these

Comprehension-14: (Q. 41 to Q. 43)

Lewis concept of covalency of an element involves octet rule. Later on it was found that many elements in their compounds, e.g., BeF_2, BF_3 etc. have incomplete octet whereas PCl_5, SF_6, etc. have expanded octet. This classical concept also failed in predicting the geometry of molecules. Modern concept of covalence was proposed in terms of valence bond theory. Hybridization concept along with valence bond theory successfully explained the geometry of various molecules but failed in many molecules. The geometry of such molecules was explained by VSEPR concept. Finally molecular orbital theory was proposed to explain many other molecules.

41. Which are true statements among the following?
(I) I_3^+ has bent structure
(II) p_π-p_π bonds are present in SO_2
(III) SeF_4 and CH_4 has same shape
(IV) XeF_2 and CO_2 has same shape
(V) SF_4 is sea-saw structure whereas ICl_3 is T-shaped.
(a) I, II, IV, V (b) I, II, III, IV
(c) II, III, IV, V (d) I, III, IV, V

42. The bond angle NO_2^+, NO_2, and NO_2^- are, respectively:
(a) 180°, 134°, 115° (b) 115°, 134°, 180°
(c) 134°, 180°, 115° (d) 115°, 180°, 130°

43. Which statements are correct for CO and N_2 according to molecular orbital theory?
(I) Bond order of CO and N_2 are 3 and 3
(II) Bond order of CO and N_2 are same
(III) During the formation of N_2^+ from N_2 bond length increases
(IV) During the formation of CO^+ from CO, the bond length decreases
(a) II, IV, I (b) I, II, III, IV
(c) I, III (d) I, II, III

Assertion-Reasoning Type

1. **Statement-1:** XeF_4 exists while XeH_4 does not exist.
Statement-2: In XeH_4 d-orbital contraction is absent.
(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

2. **Statement-1:** PH_3 exists but PH_5 does not exist while both PCl_3 and PCl_5 exist.
Statement-2: PH_3 has sp^3-hybridization.
(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

3. **Statement-1:** B and C form their stable halides as BX_3 and CX_4, while Tl and Pb produce their stable halides as TlX and PbX_2.
Statement-2: Both PbX_4 and TlX_3 are strong oxidizing agent.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

4. **Statement-1:** The two —CH_2 groups in C_2H_4 do not rotate freely around the bond connecting them, although the two — CH_3 groups in C_2H_6 have almost an unhindered rotation around the C — C bond.

Statement-2: C_2H_4 has π bond and the overlap of the atomic *p*-orbitals making up this bond would be destroyed if the — CH_2 groups rotate.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

5. **Statement-1:** Carbonates and silicates are isostructural.

Statement-2: Carbon and silicon have the same number of valence shell electrons.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

6. **Statement-1:** SiF_4 undergoes partial hydrolysis.

Statement-2: Back bonding from F to Si increases the bond order of Si — F bond.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

7. **Statement-1:** $FeCl_3$ and $FeCl_2$ exist in dimer form in vapor phase.

Statement-2: In dimer form, they have (3C—4e^-) bond.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

8. **Statement-1:** The number of bonding electrons in N_2 and N_2^- is same.

Statement-2: The bond order and bond length of N_2^+ and N_2^- are same.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

9. **Statement-1:** In peroxy disulphuric acid central atoms are sp^3 hybridized.

Statement-2: Peroxy disulphuric acid contains one peroxy (— O — O —) linkage.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

10. **Statement-1:** The O — O bond length in H_2O_2 is shorter than that of O_2F_2.

Statement-2: H_2O_2 has an open book-type structure.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

11. **Statement-1:** The B — F bond lengths in BF_3 and BF_4^- are different.

Statement-2: In BF_3, B — F bond aquires some double bond character.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

12. **Statement-1:** Boiling point of HF is lesser than water.

Statement-2: Hydrogen bonding in water is weaker than HF.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

13. **Statement-1:** The molar conductance of the following aqueous ion is

$$Cs^+ > Rb^+ > Na^+ > K^+ > Li^+$$

Statement-2: The more the hydration of cation the lesser the conductivity.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

14. **Statement-1:** Superoxides of alkali metals are paramagnetic.

Statement-2: Superoxides contain the O_2^- ion which has one unpaired electron in its antibonding orbital.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

15. **Statement-1:** The ionic character exist in H_2 molecule but no dipole moment or bond moment exists permanently.

Statement-2: It arises so, as the two ionic forms having bond moments in opposite directions contribute equally to nullify the effect.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

16. **Statement-1:** When the unshared pairs house in the hybrid orbitals, its consideration becomes accountable and it is referred to as hybrid lone pair moment.

Statement-2: The hybrid orbital concentrated the electron cloud in some particular directions and the electron cloud remains under the control of a single nucleus.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

17. **Statement -1:** The central carbon-carbon bond in butane is larger than that in 1,3-butadiene.

Statement -2: The more is *s*-character in hybridization, the lesser is the bond length.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

18. **Statement-1:** $(CH_3)_3Si$ — OH is more acidic than $(CH_3)_3C$ — OH.

Statement-2: $(CH_3)_3Si$ — OH has back bonding.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

19. **Statement-1:** The S — O bond distance in SO_2F_2 is identical with that in SO_2.

Statement-2: S and O are double bonded in both molecules.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

20. Statement-1: Bond order for both NO^+ and NO^- is 2.5.

Statement-2: NO^+ is more stable than NO^-.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

21. Statement-1: The bond angle of PBr_3 is greater than that of PH_3, but bond angle of NBr_3 is less than that of NH_3.

Statement-2: Electronegativity of phosphorus atom is less than that of nitrogen.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

22. Statement-1: F_2 has higher bond energy than the Cl_2.

Statement-2: Electronegativity of fluorine is more than that of chlorine.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

23. Statement-1: The acidic strength sequence $BMe_3 < B(MeO)_3$

Statement-2: The acidic strength can also be explained by considering the existing back bonding.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

24. Statement-1: NO^+ is more stable than the NO, and CO^+ is also more stable than the CO.

Statement-2: NO^+ formed when NO has lost an anti-bonding electron, and CO^+ formed when CO has lost N.B.M.O. e^- having anti-bonding character.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

25. Statement-1: Ag_2S is much less soluble in water than Ag_2O.

Statement-2: S^{2-} is much larger than O^{2-}; so polarization of S^{2-} is higher than O^{2-}.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

26. Statement-1: Oxyacids of group VI A elements: H_2SO_4, H_2SeO_4, H_6TeO_6.

Statement-2: The lighter member where $O(2p) \longrightarrow X(3d, 4d)$ π bonding is significant forms strong π-bonds to give XO_4^{2-}.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

27. Statement-1: The order of π bond formation tendency is Si—O < P—O < S—O< Cl—O.

Statement-2: On moving from left to right along a period, the effective nuclear charge generally increases and consequently the energy of the $3d$-orbital decreases from $Si \rightarrow P \rightarrow S \rightarrow Cl$.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

28. **Statement-1:** $p_\pi - p_\pi$ bonding is much more significant than the $p_\pi - d_\pi$ bonding.

Statement-2: In $p_\pi - p_\pi$ bonding, the overlapping lobes are parallel, and as a result there occurs a pure sideways (~ at 180°) overlap; on the other hand, in p_π–d_π bonding the lobes of the overlapping *d* orbitals are at an angle < 180° to the lobes of the *p*-orbital.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

29. **Statement-1:** CCl_4 is stable while $PbCl_4$ is powerful oxidizing agent.

Statement-2: Due to inert pair effect the stability of the 2+ state increases on moving down the group from carbon to lead.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

30. **Statement-1:** The calculated value of dipole moment of LiI = 11.5 D in the gaseous state is more than its experimental value (3.25D).

Statement-2: In LiI the electron charge cloud of I^- ion is polarized by Li^+ ion; hence the flow of electric charge occurs from I^- to Li^+ ion.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

31. **Statement-1:** Borazole is more reactive than benzene.

Statement-2: Electrophiles attacks at nitrogen and not at boron atom in inorganic benzene.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

32. **Statement-1:** $FeCl_3$ is stable but FeI_3 is unstable

Statement-2: I^- is a strong reductant and Fe^{3+} is oxidant and thus I^- reduces Fe^{3+} to Fe^{2+}; on the other hand, Cl^- is weak reductant.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

33. **Statement-1:** The C—O bond in CO^+ is longer than in CO.

Statement-2: In changing from CO to CO^+, the electron is removed from nonbonding molecular orbital having anti-bonding character.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

34. **Statement-1:** The canonical forms in which the negative charge resides on the electronegative atoms contribute more, but in BF_3 the $p_\pi - p_\pi$ back bonding places a positive charge on F which is more electronegative than B.

Statement-2: This disfavor is compensated due to the formation of an additional π-bond.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

Matching Column Type

1. Match the column:

Column-I	Column-II
(a) BCl_3	(p) Proton donor oxyacid is formed as a final hydrolyzed product

(b) NCl_3	(q) sp^3d^2-hybridized central atom in transition state during hydrolysis
(c) SF_4	(r) Orthophosphoric acid is formed as final hydrolyzed product
(d) PCl_5	(s) Weak monobasic Lewis acid is formed as hydrolyzed product

2. Match the column:

Column-I	Column-II
(a) BF_3	(p) Intra Lewis acid base interaction
(b) $B_3N_3H_6$	(q) $2p_\pi - 2p_\pi$ back bonding
(c) $N(SiH_3)_3$ (with respect to N)	(r) Planar
(d) BCl_3	(s) sp^2-hybridization
	(t) Non-polar

3. Match the column:

Column-I	Column-II
(a) $\overset{\ominus}{C}Cl_3$	(p) $2p_\pi - 3d_\pi$ back bonding
(b) CCl_2	(q) Planar
(c) $B_3N_3H_6$	(r) Direction of back bonding is Cl to central atom
(d) BCl_3	(s) $2p_\pi - 3p_\pi$ back bonding
	(t) $\mu = 0$

4. Match the column:

Column-I	Column-II
(a) $(BeCl_2)_2$	(p) 3C—$2e^-$ bond
(b) $(BeH_2)_2$	(q) 3C—$4e^-$ bond
(c) $(ICl_3)_2$	(r) sp^3-hybridization w.r.t. central atom (Be, Al, I)
(d) $(AlH_3)_2$	(s) Non-planar
	(t) Planar

5. Match the column:

Column-I	Column-II
(a) CH_2F_2	(p) $H-\hat{C}-H$ bond angle is greater than 109.5°
(b) CH_3F	(q) $F-\hat{C}-F$ bond angle is less than 109.5°
(c) CHF_3	(r) Perfect tetrahedral structure
(d) CF_4	(s) sp^3-hybridization
	(t) Non-planar

6. Match the column:

Column-I	Column-II
(a) SF_4	(p) L.P. present in axial position
(b) PCl_3F_2	(q) L.P. present in equatorial position
(c) XeF_4	(r) F atoms are present in axial position
(d) XeF_5^-	(s) μ (dipole moment) = 0
	(t) Non-planar

7. Match the column:

Column-I	Column-II
(a) $XeOF_2$	(p) Two lone pairs are present in equatorial position
(b) $ClOF_3$	(q) One lone pair is present in equatorial position
(c) SOF_4	(r) sp^3d-hybridization
(d) SF_4	(s) Bent T-shape
	(t) See-saw shape

8. Match the column:

Column-I	Column-II
(a) sp-hybridization	(p) CO_2
(b) sp^2-hybridization	(q) CS_2
(c) sp^3-hybridization	(r) $SnCl_4$
(d) sp^3d-hybridization	(s) NO_3^-
	(t) AsF_5

9. Match the column:

Column-I	Column-II
(a) $Cr_2O_7^{2-}$	(p) Species having X—O—X linkage
(b) Pyroxene chain silicate	(q) Only one corner per tetrahedron is shared
(c) Thiosulphite ion	(r) All X-atom(s) is/are sp^3-hybridized

Note: All X-atoms are considered as central atom

(d) $B_3O_6^{3-}$	(s) Overall species is planar
	(t) Six number of X—O bonds are identical in length

10. Match the column:

Column-I	Column-II
(a) $BeCl_2$	(p) 3C—$4e^-$ bond is present in dimer
(b) BCl_3	(q) Having sp^3-hybridization in hydrolyzed product from central atom in basic medium
(c) $AlCl_3$	(r) Planar in its formation
	(s) Change in hybridization of the central atom during dimerization

11. Match the following:

Column-I	Column-II (Dominating force)
(a) Xenon–H_2O	(p) Dipole–dipole interaction
(b) Ethanol–H_2O mixture	(q) London forces
(c) Liquid He	(r) Ion–dipole interaction
(d) Liquid HCl	(s) Dipole–induced dipole interaction

12. Match the following:

Column-I	Column-II (Nodal plane)
(a) $\sigma 2s$	(p) 0
(b) $\overset{*}{\sigma} 2p_z$	(q) 1
(c) $\overset{*}{\pi} 2p_x$	(r) 2
(d) $\overset{*}{\pi} 2p_y$	(s) 3

13. Match the column:

Column-I	Column-II (Dominating force)
(a) Dipole–dipole interaction	(p) Na^+ ..... Cl — H
(b) Ion–dipole interaction	(q) CH_4 ..... CH_4
(c) Dipole–induced dipole interaction	(r) Cl — H ..... CH_4
(d) Instantaneous dipole–induced dipole	(s) H — Cl ..... H — Cl
	(t) H — H ..... H — H

14. Match the column:

Column-I	Column-II (Dominating force)
(a) Ion–dipole interaction	(p) H — F .... H — F
(b) Dipole–dipole interaction	(q) F^- .... H — F
(c) H–bonding	(r) Na^+ .... H — F
	(s) HCl .... HCl

15. Match the column:

Column-I	Column-II
(a) BF_3	(p) Intra Lewis acid–base interaction
(b) $H_3N: \longrightarrow BF_3$	(q) Inter Lewis acid–base interaction
(c) PF_3	(r) Planar
(d) SiF_4	(s) $2p_\pi - 3d_\pi$ back bonding
	(t) $2p_\pi - 2p_\pi$ back bonding

16. Match the column:

Column-I	Column-II
(a) BeH_2 (Solid)	(p) 3C—$2e^-$ bond
(b) $BeCl_2$	(q) 3C—$4e^-$ bond
(c) $(AlBr_3)_2$	(r) Incomplete octet
(d) $(GaH_3)_2$	(s) sp^3-hybridization
	(t) Non-planar

17. Match the column:

Column-I	Column-II
(a) B_2H_6	(p) Can act as Lewis acid
(b) BF_3	(q) Intramolecular Lewis acid–base interaction
(c) ICl_3	(r) Non-polar
(d) SiF_4	(s) Non-planar
	(t) Can undergo dimerization

18. Match the column:

Column-I	Column-II
(a) XeO_3F_2	(p) The species / compound is regular octahedral
(b) $SF_2(CH_3)_2$	(q) 5 number of atoms may lie in the same plane within the species/compound
(c) XeO_6^{4-}	(r) The species/compound utilizes $d_{x^2-y^2}$ orbital in its formation.
(d) $[I(CN)_2]^-$	(s) The species/compound utilizes d_{z^2} orbital in its formation.
	(t) The dipole moment of the compound/species is zero.

19. Match the column:

Column-I	Column-II
(a) ICl_3	(p) Hybridization of central atom is similar in both dimer and monomer forms
(b) $AlCl_3$	(q) Both monomer and dimer forms are planar
(c) AlF_3	(r) In dimer form all atoms are sp^3-hybridized
(d) NO_2	(s) Does not exist in dimer form

20. Match the column:

Column-I	Column-II
(a) BF_3	(p) $3p_\pi - 2p_\pi$
(b) P_4O_{10}	(q) $2p_\pi - 3d_\pi$

(c) $B_3N_3H_6$ (r) $2p_\pi - 2p_\pi$
(d) BCl_3 (s) Cage like structure
(t) Planar

21. Match the column:

Column-I	Column-II
(a) Linear shape	(p) CS_2
(b) *sp*-hybridization	(q) XeF_2
(c) sp^3d-hybridization	(r) C_2H_2
(d) CO_2 is isostructural to	(s) NCO^-
	(t) $HgCl_2$

22. Match the column:

Column-I	Column-II
(a) XeO_4	(p) Pyramidal
(b) XeO_3F_2	(q) Tetrahedral
(c) XeO_6^{4-}	(r) Trigonal bipyramidal
(d) XeO_3	(s) Octahedral

23. Match the column:

Column-I	Column-II
(a) $[Al(CH_3)_3]_2$	(p) 3C—$2e^-$ bonds
(b) $[Be(CH_3)_2]_2$	(q) 3C—$4e^-$ bonds
(c) $BeCl_2$ (solid)	(r) Vacant orbital participate in hybridization
(d) $(AlCl_3)_2$	(s) sp^3-hybridization w.r.t. central atom (Be, Al)
	(t) sp^2-hybridization w.r.t. central atom (Be, Al)
	(t) Non-planar

24. Match the column:

Column-I	Column-II
(a) CH_3NCS	(p) Bent structure with respect to central atom like (N, B or I)
(b) H_3SiNCS	(q) Planar structure with respect to central atom like (N, B, or I)
(c) BF_2^-	(r) $C-\hat{N}-X$ bond angle > 120° where X is C or Si atom
(d) I_3^+	(s) *sp*-hybridized N atom in stable resonating structure

25. Column-I contains some chemical species and Column-II contains the type of hydride orbitals used in the formation of such species. Match the items of Column-I with those of Column-II and select the correct answer using the codes:

Column-I	Column-II
(a) CrO_4^{2-}	(p) sp^3d^2
(b) BF_4^-	(q) sp^3
(c) ICl_4^-	(r) d^3s
(d) $PtCl_4^{2-}$	(s) dsp^2

Integer Answer Type

1. Find out the number of species showing $H-\hat{C}-H > 109°28'$:
CH_3F, CH_2F_2, CH_4, $CH_3C{\equiv}CH$, $\overset{+}{C}H_3$

2. Find the number of molecule(s) having octahedral geometry from the following:
S_2F_{10}, XeO_6^{4-}, PCl_6^-, $[SiF_6]^2$, SeF_6, TeF_6, SF_6, PO_4^{3-}

3. Find the number of corner shared per tetrahedron for pyro-silicate.

4. How many $d_\pi - p_\pi$ bonds are present in ClO_3^-?

5. Find the sum of oxidation state of phosphorus in H_3PO_4 and H_3PO_3.

6. How many atom(s) of $BeCl_2$ lie in the same plane?

7. How many atom(s) of BF_3 lie in the same plane?

8. How many atoms of PCl_5 lie in the same plane and find the number of such plane in PCl_5 molecule?

9. A cyclic silicate anion is represented as $[Si_3O_9]^{n-}$; find the value of *n*.

10. How many atom(s) of H_2O lie in the same plane?

11. In P_4O_{10}, find the number of oxygen atoms bonded to each phosphorous atom.

12. How many atom(s) of $SF_2(CH_3)_2$ may lie in equatorial plane?

13. How many corner oxygen atoms are shared in 2D silicate?

14. Find the number of σ bond and π bond in 1, 3-butadiene.

15. Find the sum of bond order and number of π-bonds in C_2 molecule on the basis of molecular orbital theory.

16. Find the number of amphoteric oxide(s) from the following:
NiO, Al_2O_3, B_2O_3, PbO_2, ZnO, MgO.

17. How many nodal plane is/are present in σ^*_{3-x} anti-bonding molecular orbital?

18. Find out the total number of all 2C—$2e^-$ and 3C—$4e^-$ bonds in $BeCl_2$.

19. Predict the basicity of final product (having sulphur) obtained when SF_4 undergoes hydrolysis.

20. Find the number of nonbonding molecular orbital(s) from the following (If x is internuclear axis):
$s + p_y$, $p_y + p_y$, $p_x + p_x$, $d_{xy} + s$, $d_{xy} + p_x$, $p_y + p_x$
21. How many unpaired electron(s) is/are present in O_2 molecule if Hund's rule is violated?
22. Find the sum of bond order and number of π bonds in B_2 molecule.
23. How many unpaired electron(s) is/are present in highest occupied molecular orbital (H.O.M.O.) of O_2 molecule?
24. What is the bond order of NO^+?
25. Find the number of unpaired e^- in dioxygenylion (O_2^+).
26. Find the bond order of peroxide ion.
27. Find the number of acid(s) from the following in which X — H bond is/are present. Given X is central atom:
H_3PO_2, $H_4P_2O_7$, $H_4P_2O_5$, $H_2S_2O_6$, H_3PO_3, H_3BO_3, H_2SO_4
28. How many σ bonds are present in C_2 (vap.)?
29. How many π bonds are present in B_2 molecule according to M.O.T?
30. Calculate the ratio of σ bonding electrons and π bonding electrons in B_2 molecule.
31. Calculate the ratio of σ bonding electrons and π bonding electrons in C_2 molecule.
32. Find the number of water molecules required to get the complete hydrolysis product of P_4O_6.
33. Find the number of water molecules required to get the complete hydrolysis product of $H_2S_2O_8$.
34. Find the number of parent acid formed from complete hydrolysis of P_4O_{10}.
35. Find the number of HCl molecule formed from complete hydrolysis of $SiCl_4$.
36. If Hund's rule is not applicable, then how many unpaired electrons are present in NO molecule?
37. When oleum ($H_2S_2O_7$) is completely hydrolyzed, then how many acidic hydrogens are present in the final product?
38. Find the number of molecule(s) having trigonal planar geometry from the following:
$OCCl_2$, $\overset{+}{C}H_3$, $\overset{-}{C}H_3$, ClF_3, I_3^-
39. Find the number of molecule(s)/ion(s) having tetrahedral geometry from the following:
OPF_3, $S_2O_3^{2-}$, XeO_4, SF_4, $TeCl_4$, NH_4^+
40. How many atom(s) of CH_4 lie in same plane?
41. Find out the total sum of B.A. of < 72° and 90° in pentagonal pyramidal shape.
42. How many same atoms of PCl_3F_2 lie in the same plane?
43. What is the basicity of the final hydrolyzed product (oxyacid) of P_4S_{10}?
44. How many atom(s) of BF_2^- lie in the same plane?
45. How many atom(s) of $S(CH_2)F_4$ may lie in the equatorial plane?
46. How many nodal plane is/are present in σ_{p-p} bonding molecular orbital?
47. Find the sum of nodal plane of π^*_{d-d} anti-bonding molecular orbital and π^*_{p-d} anti-bonding molecular orbital.
48. Find the number of delta bonding molecular orbital from the following set if z is the inter-nuclear axis:
$d_{x^2-y^2}$ and d_{xz}, $d_{x^2-y^2}$ or d_{xz}
49. Find the number of corner of O-atom shared per tetrahedron in 3D-silicate.
50. Find the ratio of bond order of N_2^{2+} to N_2^{2-}.
51. Find the ratio of the total number of electron(s) in bonding molecular orbital of O_2 to the total number of electrons in bonding molecular orbital of N_2 molecule.
52. Find the ratio of σ-bonds to π-bonds in $P_5O_{16}^{7-}$.
53. How many nodal plane(s) is/are present in $\overset{*}{\pi}_{2p_y}$?
54. If Hund's rule is not applicable, then how many unpaired e^- are present in B_2 molecule?
55. Find the ratio between σ-bond and π-bond in $C_3N_3Cl_3$.
56. Find the ratio between π bonds and lone pairs of sp^2-hybrid orbitals in $C_3N_3(NH_2)_3$.
57. Find the number of molecule(s) is/are having zero dipole moment and linear shape from the following:
ClF_3, I_3^-, CO_2, $HgCl_2$, ICl_2^-, XeF_2
58. In XeF_5^- and XeF_5^+ find the sum of axial d-orbital which are used in hybridization of both species.
59. How many atoms of XeO_6^{4-} lie in the same plane?
60. How many maximum atoms of IF_7 are present in the same plane?
61. How many atom(s) of $S(CH_2)F_4$ may lie in the axial plane?
62. How many P — O — P linkage(s) is/are present in $P_4O_{12}^{4-}$?
63. The compound MX_6 is octahedral. Find the number of $X-\hat{M}-X$ angles in the compound.
64. Find the sum of nodal plane of σ^*_{s-s} anti-bonding molecular orbital and σ_{s-p} bonding molecular orbital.

65. How many nodal plane is/are present in π^*_{p-p} anti-bonding molecular orbital?

66. Find the sum of nodal plane of $\delta_{d_{xy}-d_{xy}}$ molecular orbital and $\delta^*_{d_{xy}-d_{xy}}$ anti-bonding molecular orbital.

67. Find the number of non-bonding molecular orbital from the following if z is the internuclear axis:

$d_{z^2}+s$, $d_{x^2-y^2}+s$, p_z+d_{xz} , $s+d_{yz}$

68. Find the number of non-bonding molecular orbital from the following set if z is the internuclear axis:

d_{yz} and d_{z^2} , d_{yz} and d_{xz} , $d_{x^2-y^2}$ and d_{xy}, d_{xz} or $d_{x^2-y^2}$

69. Calculate the number of molecules of HF which are contained in gaseous form due to hydrogen bonding if the density of HF in gaseous phase at 1 atm, 300 K is 3.248 g/l?

70. Find the number of pi bonding molecular orbital from the following set if z is the internuclear axis:

p_z and d_{z^2} , p_x and d_{xz} , d_{xz} or d_{yz} , d_{xz} and d_{yz}

71. How many nodal planes are present in $\pi 2p_y$ bonding molecular orbital?

72. How many nodal planes are present in δ bonding molecular orbital?

73. Find the ratio of the total number of σ bonds to lone pair of sp^2-hybrid orbitals in $C_3N_3(N_3)_3$.

74. Find the ratio of lone pairs to π bond (present in ring) in $C_3N_3(NH_2)_3$.

75. Find the ratio of the total number of bonds to the total number of lone pairs in $C_3N_3Cl_3$.

76. Find the ratio of lone pairs present on Cl atoms to sp^2-hybrid orbital in $C_3N_3Cl_3$ molecule.

NCERT Exemplar Exercises

Single Correct Answer Type

1. Isostructural species are those which have the same shape and hybridization. Among the given species identify the isostructural pairs.
   (a) [NF_3 and BF_3] (b) [$BF_4^{\ominus}$ and NH_4^+]
   (c) [BCl_3 and $BrCl_3$] (d) [NH_3 and NO_3^-]

2. Polarity in a molecule and hence the dipole moment depends primarily on electronegativity of the constituent atoms and shape of a molecule. Which of the following has the highest dipole moment?
   (a) CO_2 (b) HI
   (c) H_2O (d) SO_2

3. The types of hybrid orbitals of nitrogen in NO_2^+, NO_3^- and NH_4^+ respectively are expected to be
   (a) sp, sp^3, and sp^2 (b) sp, sp^2, and sp^3
   (c) sp^2, sp, and sp^3 (d) sp^2, sp^3, and sp

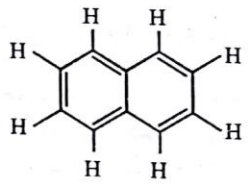
4. Hydrogen bonds are formed in many compounds e.g., H_2O, HF, NH_3. The boiling point of such compounds depends to a large extent on the strength of hydrogen bond and the number of hydrogen bonds. The correct decreasing order of the boiling points of above compounds is:
   (a) $HF > H_2O > NH_3$ (b) $H_2O > HF > NH_3$
   (c) $NH_3 > HF > H_2O$ (d) $NH3 > H_2O > HF$

5. In PO_4^{-3} ion the formal charge on the oxygen atom of P–O bond is:
   (a) +1 (b) −1
   (c) −0.75 (d) +0.75

6. In NO_3^- ion, the number of bond pairs and lone pairs of electrons on nitrogen atom are:
   (a) 2, 2 (b) 3, 1
   (c) 1, 3 (d) 4, 0

7. Which of the following species has tetrahedral geometry?
   (a) BH_4^- (b) NH_2^-
   (c) CO_3^{2-} (d) H_3O^+

8. Number of π bonds and σ bonds in the following structure is:



   (a) 6, 19 (b) 4, 20
   (c) 5, 19 (d) 5, 20

9. In which of the following molecule/ion all the bonds are not equal?
   (a) XeF_4 (b) BF_4^-
   (c) C_2H_4 (d) SiF_4

10. In which of the following substances will hydrogen bond be strongest?
   (a) HCl (b) H_2O
   (c) HI (d) H_2S

11. If the electronic configuration of an element is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$, the four electrons involved in chemical bond formation will be _____.

(a) $3p^6$ (b) $3p^6, 4s^2$
(c) $3p^6, 3d^2$ (d) $3d^2, 4s^2$

12. Which of the following angle corresponds to sp^2 hybridization?
(a) 90° (b) 120°
(c) 180° (d) 109°

Comprehension

The electronic configurations of three elements, A, B, and C are given below. Answer the questions 13 to 16 on the basis of these configurations.

A	$1s^2$	$2s^2$	$2p^6$	Ne		
B	$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^3$	P
C	$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^5$	Cl

13. Stable form of A may be represented by the formula:
(a) A (b) A_2
(c) A_3 (d) A_4

14. Stable form of C may be represented by the formula:
(a) C (b) C_2
(c) C_3 (d) C_4

15. The molecular formula of the compound formed from B and C will be:
(a) BC (b) B_2C
(c) BC_2 (d) BC_3

16. The bond between B and C will be:
(a) Ionic (b) Covalent
(c) Hydrogen (d) Coordinate

17. The electronic configuration of the outer most shell of the most electronegative element is:
(a) $2s^22p^5$ (b) $3s^23p^5$
(c) $4s^24p^5$ (d) $5s^25p^5$

18. Amongst the following elements whose electronic configurations are given below, the one having the highest ionisation enthalpy is:
(a) $[Ne]3s^23p^1$ (b) $[Ne]3s^23p^3$
(c) $[Ne]3s^23p^2$ (d) $[Ar]3d^{10}4s^24p^3$

Multiple Correct Answers Type

In the following questions two or more options may be correct.

1. Which of the following attain the linear structure:
(a) $BeCl_2$ (b) NCO^-
(c) NO_2 (d) CS_2

2. CO is isoelectronic with:
(a) NO^+ (b) N_2
(c) $SnCl_2$ (d) NO_2^-

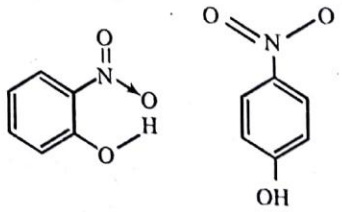
3. Which of the following species have the same shape?
(a) CO_2 (b) CCl_4
(c) O_3 (d) NO_2^-

4. Which of the following statements are correct about CO_3^{2-}?
(a) The hybridization of central atom is sp^3.
(b) Its resonance structure has one C–O single bond and two C=O double bonds
(c) The average formal charge on each oxygen atom is 0.67 units
(d) All C–O bond lengths are equal

5. Which of the following statements are not correct?
(a) NaCl being an ionic compound is a good conductor of electricity in the solid state
(b) In canonical structures there is a difference in the arrangement of atoms
(c) Hybrid orbitals form stronger bonds than pure orbitals
(d) VSEPR Theory can explain the square planar geometry of XeF_4

Short Answer Type

1. Explain the nonlinear shape of H_2S and nonplanar shape of PCl_3 using valence shell electron pair repulsion theory.
2. Explain the shape of BrF_5.
3. Structures of molecules of two compounds are given below:



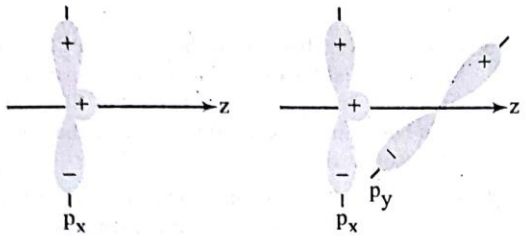
(I) (II)

(a) Which of the two compounds will have intermolecular hydrogen bonding and which compound is expected to show intramolecular hydrogen bonding?

(b) The melting point of a compound depends on, among other things, the extent of hydrogen bonding. On this basis explain which of the above two compounds will show higher melting point.

(c) Solubility of compounds in water depends on power to form hydrogen bonds with water. Which of the above compounds will form hydrogen bond with water easily and be more soluble in it.

4. Which type of overlap given in the following figure do not result in bond formation?



5. Explain why PCl_5 is trigonal bipyramidal whereas IF_5 is square pyramidal.

6. In both water and dimethyl ether ($CH_3-\ddot{\underset{..}{O}}-CH_3$), oxygen atom is central atom, and has the same hybridization, yet they have different bond angles. Which one has greater bond angle? Give reason.

7. Write Lewis structure of the following compounds and show formal charge on each atom. HNO_3, NO_2, H_2SO_4

8. Give reasons for the following:

(a) Covalent bonds are directional bonds while ionic bonds are nondirectional.

(b) Water molecule has bent structure whereas carbon dioxide molecule is linear.

(c) Ethyne molecule is linear.

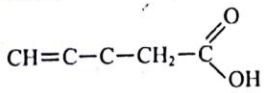
9. What is an ionic bond? With two suitable examples explain the difference between an ionic and a covalent bond?

10. Arrange the following bonds in order of increasing ionic character, give reason.

N–H, F–H, C–H, and O–H

11. Explain why CO_3^{2-} ion cannot be represented by a single Lewis structure. How can it be best represented?

12. Predict the hybridization of each carbon in the molecule of organic compound given below. Also indicate the total number of sigma and pi bonds in this molecule.



13. Group the following as linear and nonlinear molecules:

H_2O, HOCl, $BeCl_2$, Cl_2O

14. Elements X, Y, and Z have 4, 5, and 7 valence electrons respectively. (a) Write the molecular formula of the compounds formed by these elements individually with hydrogen. (b) Which of these compounds will have the highest dipole moment?

15. Draw the resonating structure of

(a) Ozone molecule

(b) Nitrate ion

16. Predict the shapes of the following molecules on the basis of hybridization.

BCl_3, CH_4, CO_2, NH_3

17. All the C–O bonds in carbonate ion (CO_3^{2-}) are equal in length. Explain.

18. What is meant by the term average bond enthalpy? Why is there difference in bond enthalpy of O–H bond in ethanol (C_2H_5OH) and water?

Matching Column Type

1. Match the species in Column-I with the type of hybrid orbitals in Column-II.

Column-I	Column-II
(a) SF_4	(p) sp^3d^2
(b) IF_5	(q) d^2sp^3
(c) NO_2^+	(r) sp^3d
(d) NH_4^+	(s) sp^3
	(t) sp

2. Match the species in Column-I with the geometry/shape in Column-II.

Column-I	Column-II
(a) H_3O^+	(p) Linear
(b) HC≡CH	(q) Angular
(c) ClO_2^-	(r) Tetrahedral
(d) NH_4^+	(s) Trigonal bipyramidal
	(t) Pyramidal

3. Match the items given in Column-I with examples given in Column-II.

Column-I	Column-II
(a) Hydrogen bond	(p) C
(b) Resonance	(q) LiF
(c) Ionic solid	(r) H_2
(d) Covalent solid	(s) HF
	(t) O_3

4. Match the shape of molecules in Column-I with the type of hybridisation in Column-II.

Column-I	Column-II
(a) Tetrahedral	(p) sp^2
(b) Trigonal	(q) sp
(c) Linear	(r) sp_3

Assertion-Reasoning Type

In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

1. **Assertion (A):** Sodium chloride formed by the action of chlorine gas on sodium metal is a stable compound.

   Reason (R): This is because sodium and chloride ions acquire octet in sodium chloride formation.

   (a) A and R both are correct, and R is the correct explanation of A.
   (b) A and R both are correct, but R is not the correct explanation of A.
   (c) A is true but R is false.
   (d) A and R both are false.

2. **Assertion (A):** Though the central atom of both NH_3 and H_2O molecules are sp^3 hybridized, yet H–N–H bond angle is greater than that of H–O–H.

   Reason (R): This is because nitrogen atom has one lone pair and oxygen atom has two lone pairs.

   (a) A and R both are correct, and R is the correct explanation of A.
   (b) A and R both are correct, but R is not the correct explanation of A.
   (c) A is true but R is false.
   (d) A and R both are false.

3. **Assertion (A):** Among the two O–H bonds in H_2O molecule, the energy required to break the first O–H bond and the other O–H bond is the same.

   Reason (R): This is because the electronic environment around oxygen is the same even after breakage of one O–H bond.

   (a) A and R both are correct, and R is the correct explanation of A.
   (b) A and R both are correct, but R is not the correct explanation of A.
   (c) A is true but R is false.
   (d) A and R both are false.

Long Answer Type

1. (a) Discuss the significance/applications of dipole moment.
   (b) Represent diagrammatically the bond moments and the resultant dipole moment in CO_2, NF_3, and $CHCl_3$.

2. Briefly describe the valence bond theory of covalent bond formation by taking an example of hydrogen. How can you interpret energy changes taking place in the formation of dihydrogen?

3. Describe hybridization in the case of PCl_5 and SF_6. The axial bonds are longer as compared to equatorial bonds in PCl_5 whereas in SF_6 both axial bonds and equatorial bonds have the same bond length. Explain.

4. (a) Discuss the concept of hybridization. What are its different types in a carbon atom.
   (b) What is the type of hybridization of carbon atoms marked with star.

   (a) $\overset{*}{C}H_2{=}CH{-}\overset{*}{C}(=O){-}O{-}H$
   (b) $CH_3{-}\overset{*}{C}H_2{-}OH$
   (c) $CH_3{=}CH_2{-}\overset{*}{C}(=O){-}H$
   (d) $\overset{*}{C}H_3{-}CH{=}CH{-}CH_3$
   (e) $\overset{*}{C}H_3{-}C{\equiv}CH$

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. In which of the following species the inter-atomic bond angle is 109°28?
   (a) NH_3 and $(BF_4)^{-1}$
   (b) $(NH_4)^+$ and $(BF_4)^{-1}$
   (c) NH_3 and BF_3
   (d) $(NH_2)^{-1}$ and BF_3

   (AIEEE, 2002)

2. Which of the following is arranged in an increasing order of their bond strengths?
   (a) $O_2^- < O_2 < O_2^+ < O_2^{2-}$
   (b) $O_2^{2-} < O_2^- < O_2 < O_2^+$
   (c) $O_2^- < O_2^{2-}\ O_2 < O_2^+$
   (d) $O_2^+ < O_2 < O_2^- < O_2^{2-}$

   (AIEEE, 2002)

3. Hybridization of the underlines atom changes in
   (a) $\underline{Al}H_3$ changes to $\underline{Al}H_4^-$

(b) H_2O changes to H_3O^+
(c) NH_3 changes to NH_4
(d) All of these

(AIEEE, 2002)

4. An ether is more volatile than an alcohol having the same molecular formula. This is due to
(a) Alcohols having resonance structures
(b) Inter-molecular hydrogen bonding in ethers
(c) Inter-molecular hydrogen bonding in alcohols
(d) Dipolar characteristics of ethers

(AIEEE, 2003)

5. Which one of the following pairs of molecules will have permanent dipole moments for both members?
(a) NO_2 and CO_2 (b) NO_2 and O_3
(c) SiF_4 and CO_2 (d) SiF_4 and NO_2

(AIEEE, 2003)

6. Which one of the following compounds has the smallest bond angle in the molecule?
(a) OH_2 (b) SH_2
(c) NH_3 (d) SO_2

(AIEEE, 2003)

7. The pair of species having identical shapes for molecules of both species is
(a) XeF_2 and CO_2 (b) BF_3 and PCl_3
(c) PF_5 and IF_5 (d) CF_4 and SF_4

(AIEEE, 2003)

8. The correct order of bond angles (smallest first) in H_2S, NH_3, BF_3 and SiH_4 is:
(a) $H_2S < NH_3 < SiH_4 < BF_3$
(b) $NH_3 < H_2S < SiH_4 < BF_3$
(c) $H_2S < SiH_4 < NH_3 < BF_3$
(d) $H_2S < NH_3 < BF_3 < SiH_4$

(AIEEE, 2004)

9. The bond order in NO is 2.5 while that in NO^+ is 3. Which of the following statements is true for these two species?
(a) Bond length in NO^+ is equal to that in NO.
(b) Bond length in NO is greater than in NO^+.
(c) Bond length in NO^+ is greater than in NO.
(d) Bond length is unpredictable.

(AIEEE, 2004)

10. The states of hybridization of boron and oxygen atoms in boric acid (H_3BO_3) are, respectively,
(a) sp^3 and sp^2 (b) sp^2 and sp^3
(c) sp^2 and sp^2 (d) sp^3 and sp^3

(AIEEE, 2004)

11. Which one of the following has the regular tetrahedral structure?
(a) BF_4^- (b) SF_4
(c) XeF_4 (d) $[Ni(CN)_4]^{2-}$

(AIEEE, 2004)

12. The maximum number of 90° angles between bond pair–bond pair of electrons is observed in:
(a) dsp^2 hybridization
(b) sp^3d hybridization
(c) dsp^3 hybridization
(d) sp^3d^2 hybridization

(AIEEE, 2004)

13. Lattice energy of an ionic compound depends upon:
(a) Charge on the ion and size of the ion
(b) Packing of ions only
(c) Charge of ions only
(d) Size of the ion only

(AIEEE, 2005)

14. Which of the following molecules or ions does not contain unpaired electrons?
(a) N_2^+ (b) O_2
(c) O_2^{2-} (d) B_2

(AIEEE, 2006)

15. In which of the following molecules or ions is all the bonds not equal?
(a) XeF_4 (b) BF_4^-
(c) SF_4 (d) SiF_4

(AIEEE, 2006)

16. The decreasing values of bond angles from NH_3 (106°) to SbH_3 (91°) down group-15 of the periodic table is due to:
(a) Decreasing lp-bp repulsion
(b) Decreasing electronegativity
(c) Increasing bp–bp repulsion
(d) Increasing p-orbital character in sp^3

(AIEEE, 2006)

17. Which of the following species exhibits the diamagnetic behavior?
(a) NO (b) O_2^{2-}
(c) O_2^+ (d) O_2

(AIEEE, 2007)

18. The charge to size ratio of a cation determines its polarizing power. Which one of the following sequences represents the increasing order of the

polarizing power of the cationic species K^+, Ca^{2+}, Mg^{2+}, and Be^{2+}?

(a) $Ca^{2+} < Mg^{2+} < Be^+ < K^+$
(b) $Mg^{2+} < Be^{2+} < K^+ < Ca^{2+}$
(c) $Be^{2+} < K^+ < Ca^{2+} < Mg^{2+}$
(d) $K^+ < Ca^{2+} < Mg^{2+} < Be^{2+}$

(AIEEE, 2007)

19. In which of the following ionization processes, the bond order has increased and the magnetic behaviour has changed?

(a) $N_2 \rightarrow N_2^+$ (b) $C_2 \rightarrow C_2^+$
(c) $NO \rightarrow NO^+$ (d) $O_2 \rightarrow O_2^+$

(AIEEE, 2007)

20. Which of the following hydrogen bonds is the strongest?

(a) O–H---F (b) O–H---H
(c) F–H---F (d) O–H---O

(AIEEE, 2008)

21. Which one of the following pairs of species has the same bond order?

(a) CN^- and NO^+ (b) CN^- and CN^+
(c) O_2^- and CN^- (d) NO^+ and CN^+

(AIEEE, 2008)

22. The bond dissociation energy of B–F in BF_3 is 646 J mol^{-1}, whereas that of C–F in CF_4 is 515 kJ mol^{-1}. The correct reason for higher B–F bond dissociation energy as compared with that of C–F is:

(a) Stronger σ bond between B and F in BF_3 as compared with that between C and F in CF_4
(b) Significant $p\pi$–$p\pi$ interaction between B and F in BF_3, whereas there is no possibility of such interaction between C and F ions in CF_4
(c) Lower degree of $p\pi$–$p\pi$ interaction between B and F in BF_3 than that between C and F in CF_4
(d) Smaller size of B-atom as compared with that of C-atom.

(AIEEE, 2008)

23. Using MO theory, predict which of the following species has the shortest bond length?

(a) O_2^+ (b) O_2^-
(c) O_2^{2-} (d) O_2^{2+}

(AIEEE, 2008)

24. Among the following, the maximum covalent character is shown by the compound:

(a) $FeCl_2$ (b) $SnCl_2$
(c) $AlCl_3$ (d) $MgCl_2$

(AIEEE, 2011)

25. The hybridization of orbitals of N atom in NO_3^-, NO_2^+, and NH_4^+ are respectively

(a) sp, sp^2, and sp^3 (b) sp^2, sp and sp^3
(c) sp, sp^3, and sp^2 (d) sp^2, sp^3, and sp

(AIEEE, 2011)

26. The structure of IF_7 is a:

(a) Square pyramid
(b) Trigonal bipyramid
(c) Octahedral
(d) Pentagonal bipyramid

(AIEEE, 2011)

27. The number of types of bonds between two carbon atoms in calcium carbide is:

(a) One sigma and one pi
(b) Two sigma and one pi
(c) Two sigma and two pi
(d) One sigma and two pi

(AIEEE, 2011)

28. Ortho-nitrophenol is less soluble in water than p- and m-nitrophenols because:

(a) o-Nitrophenol is more volatile steam than those of m- and p-isomers
(b) o-Nitrophenol shows intramolecular H-bonding
(c) o-Nitrophenol shows intermolecular H-bonding
(d) Melting point of o-nitrophenol is lower than those of m- and p-isomers

(AIEEE, 2012)

29. In which of the following pairs the two species are not isostructural?

(a) CO_3^{2-} and NO_3^- (b) PCl_4^+ and $SiCl_4$
(c) PF_5 and BrF_5 (d) AlF_6^{3-} and SF_6

(AIEEE, 2012)

30. Which one of the following molecules is expected to exhibit diamagnetic behaviour?

(a) C_2 (b) N_2
(c) O_2 (d) S_2

(JEE Main, 2013)

31. Which of the following is the wrong statement?

(a) ONCl and ONO^- are not isoelectronic

(b) O_3 molecule is bent
(c) Ozone is violet-black in solid state
(d) Ozone is diamagnetic gas

(JEE Main, 2013)

32. In which of the following pairs of molecules/ions, both the species are not likely to exist?
(a) H_2^+, He_2^{2-} (b) H_2^-, He_2^{2-}
(c) H_2^{2+}, He_2 (d) H_2^-, He_2^{2+}

(JEE Main, 2013)

33. Which of the following exists as covalent crystals in the solid state?
(a) Iodine (b) Silicon
(c) Sulphur (d) Phosphorus

(JEE Main, 2013)

34. Stability of the species Li_2, Li_2^-, and Li_2^+ increases in the order of:
(a) $Li_2 < Li_2^+ < Li_2^-$ (b) $Li_2^- < Li_2^+ < Li_2$
(c) $Li_2 < Li_2^- < Li_2^+$ (d) $Li_2^- < Li_2 < Li_2^-$

(JEE Main, 2013)

35. Which one of the following properties is **not** shown by NO?
(a) It combines with oxygen to form nitrogen dioxide
(b) Its bond order is 2.5
(c) It is diamagnetic in gaseous state
(d) It is a neutral oxide

(JEE Main, 2014)

36. The correct statement for the molecule, CsI_3, is:
(a) It contains Cs^{3+} and I^- ions
(b) It contains Cs^+, I^- and lattice I^2 molecule
(c) It is a covalent molecule
(d) It contains Cs^+ and I_3^- ions

(JEE Main, 2014)

37. The number and type of bonds in C_2^{2-} ion in CaC_2 are:
(a) Two σ bonds and one π – bond
(b) Two σ bonds and two π – bonds
(c) One σ bond and two π – bonds
(d) One σ bond and one π – bond

(JEE Main, 2014)

38. For the compounds
CH_3Cl, CH_3Br, CH_3I and CH_3F,
the correct order of increasing C-halogen bond length is:
(a) $CH_3F < CH_3Br < CH_3Cl < CH_3I$
(b) $CH_3F < CH_3Cl < CH_3Br < CH_3I$
(c) $CH_3Cl < CH_3Br < CH_3F < CH_3I$
(d) $CH_3F < CH_3I < CH_3Br < CH_3Cl$

[JEE Main, 2014]

39. Which of the following has unpaired electron(s)?
(a) O_2^- (b) N_2^{2+}
(c) O_2^{2-} (d) N_2

[JEE Main, 2014]

JEE (Advanced) Exercises

Fill in the Blanks-Type

1. The angle between two covalent bonds is maximum in _____ (CH_4, H_2O, CO_2).

(IIT-JEE, 1981)

2. The pair of molecules which forms the strongest intermolecular hydrogen bonds is _____
(SiH_4 and SiF_4, $CH_3-\underset{\underset{O}{\|}}{C}-CH_3$ and $CHCl_3$, $\underset{\underset{O}{\|}}{HC}-OH$ and $CH_3-\underset{\underset{O}{\|}}{C}-OH$).

(IIT-JEE, 1981)

3. There are _____ π-bonds in a nitrogen molecule.

(IIT-JEE, 1982)

4. _____ hybrid orbitals of nitrogen atom are involved in the formation of ammonium ion.

(IIT-JEE, 1982)

5. The shape of $[CH_3]^+$ is _____.

(IIT-JEE, 1990)

6. The two types of bonds present in B_2H_6 are covalent and _____.

(IIT-JEE, 1994)

7. When N_2 goes to N_2^+, the N—N bond distance _____, and when O_2 goes to O_2^+ the O—O bond distance _____.

(IIT-JEE, 1996)

8. Among N_2O, SO_2, I_3^+, and I_3^-, the linear species are _____ and _____.

(IIT-JEE, 1997)

True/False Type

1. Linear overlap of two atomic *p*-orbitals leads to a σ-bond.

(IIT-JEE, 1983)

2. All molecules with polar bonds have dipole moment.

(IIT-JEE, 1985)

3. $SnCl_2$ is a non-linear molecule.

(IIT-JEE, 1985)

4. In benzene, carbon uses all the three p-orbitals for hybridization.
(IIT-JEE, 1987)

5. sp^3-hybrid orbitals have equal s and p characters.
(IIT-JEE, 1987)

6. The presence of polar bonds in a polyatomic molecule suggests that the molecule has non-zero dipole moment.
(IIT-JEE, 1990)

7. H_2O molecule is linear.
(IIT-JEE, 1993)

Single Correct Answer Type

1. The octet rule is not valid for which of the following molecules?
(a) CO_2 (b) H_2O
(c) O_2 (d) NO
(IIT-JEE, 1979)

2. The compound which contains both ionic and covalent bonds is:
(a) CH_4 (b) H_2
(c) KCN (d) KCl
(IIT-JEE, 1979)

3. The total number of electrons that take part in forming the bond in N_2 is:
(a) 2 (b) 4
(c) 6 (d) 10
(IIT-JEE, 1980)

4. Element X is strongly electropositive and element Y is strongly electronegative. Both are univalent. The compound formed would be:
(a) X^+Y^- (b) X^-Y^+
(c) $X-Y$ (d) $X \rightarrow Y$
(IIT-JEE, 1980)

5. Which of the following compounds is covalent?
(a) H_2 (b) CaO
(c) KCl (d) Na_2S
(IIT-JEE, 1980)

6. If a molecule MX_3 has zero dipole moment, the σ-bonding orbitals used by M (atomic number < 21) are:
(a) pure p (b) sp-hybridized
(c) sp^2-hybridized (d) sp^3-hybridized
(IIT-JEE, 1981)

7. The ion that is isoelectronic with CO is:
(a) CN^- (b) O_2^+
(c) O_2^- (d) N_2^+
(IIT-JEE, 1982)

8. Carbon tetrachloride has no net dipole moment because of:
(a) Its planar structure
(b) Its regular tetrahedral structure
(c) Similar sizes of carbon and chlorine atoms
(d) Similar electron affinities of carbon and chlorine
(IIT-JEE, 1983)

9. Which of the following does not have hydrogen bond?
(a) Phenol (b) Liquid NH_3
(c) Water (d) HCl
(IIT-JEE, 1983)

10. On hybridization of one s- and one p-orbital, we get:
(a) Two mutually perpendicular orbitals
(b) Two orbitals at 180°
(c) Four orbitals directed tetrahedrally
(d) Three orbitals in a plane
(IIT-JEE, 1984)

11. The molecule having one unpaired electron is:
(a) NO (b) CO
(c) CN^- (d) O_2
(IIT-JEE, 1985)

12. The hybridization of sulphur in sulphur dioxide is:
(a) sp (b) sp^3
(c) sp^2 (d) dsp^2
(IIT-JEE, 1986)

13. The bond between two identical non-metal atoms has a pair of electrons:
(a) Unequally shared between the two
(b) Transferred fully from one atom to another
(c) With identical spins
(d) Equally shared between them
(IIT-JEE, 1986)

14. Which of the following compounds has a zero dipole moment?
(a) 1,1-Dichloroethylene
(b) *cis*-1,2-Dichloroethylene
(c) *trans*-1,2-Dichloroethylene
(d) None of the above
(IIT-JEE, 1987)

15. The species in which the central atom uses sp^2-hybrid orbitals in its bonding is:
(a) PH_3 (b) NH_3
(c) CH_3^+ (d) SbH_3
(IIT-JEE, 1988)

16. The molecule that has a linear structure is:
(a) CO_2 (b) NO_2
(c) SO_2 (d) SiO_2
(IIT-JEE, 1988)

17. The Cl—C—Cl angles in 1,1,2,2-tetrachloroethene and tetrachloromethane, respectively, will be about:
(a) 120° and 109.5° (b) 90° and 109.5°
(c) 109.5° and 90° (d) 109.5° and 120°
(IIT-JEE, 1988)

18. The molecule which has a pyramidal shape is:
(a) PCl_3 (b) SO_3
(c) CO_3^{2-} (d) NO_3^-
(IIT-JEE, 1989)

19. Which of the following is paramagnetic?
(a) O_2^- (b) CN^-
(c) CO (d) NO^+
(IIT-JEE, 1989)

20. The molecule which has zero dipole moment is:
(a) CH_2Cl_2 (b) BF_3
(c) NF_3 (d) ClO_3
(IIT-JEE, 1989)

21. The type of hybrid orbitals used by the chlorine atom in ClO_2^- is:
(a) sp^3 (b) sp^2
(c) sp (d) None of these
(IIT-JEE, 1992)

22. The maximum possible number of hydrogen bonds a water molecule can form is:
(a) 2 (b) 4
(c) 3 (d) 1
(IIT-JEE, 1992)

23. Which of the following molecules is planar?
(a) NF_3 (b) NCl_3
(c) PH_3 (d) BF_3
(IIT-JEE, 1996)

24. The number and type of bonds between two carbon atoms in CaC_2 are:
(a) One σ-and one π-bond
(b) One σ-and two π-bonds
(c) One σ-and one-half π-bond
(d) One σ-bond **(IIT-JEE, 1996)**

25. Among the following species, identify the isostructural pairs:
NF_3, NO_3^-, BF_3, H_3O^+, N_3H
(a) [NF_3, NO_3^-] and [BF_3, H_3O^+]
(b) [NF_3, N_3H] and [NO_3^-, BF_3]
(c) [NF_3, H_3O^+] and [NO_3^-, BF_3]
(d) [NF_3, H_3O^+] and [N_3H, BF_3]
(IIT-JEE, 1996)

26. Arrange the following compounds in the order of increasing dipole moment: toluene (I), *m*-dichlorobenzene (II), *o*-dichlorobenzene (III), *p*-dichlorobenzene (IV):
(a) I < IV < II < III (b) IV < I < II < III
(c) IV < I < III < II (d) IV < II < I < III
(IIT-JEE, 1996)

27. The cyanide ions CN^- and N_2 are isoelectronic, but in contrast to CN^-, N_2 is chemically inert because of:
(a) Low bond energy
(b) Absence of bond polarity
(c) Unsymmetrical electron distribution
(d) Presence of more number of electrons in bonding orbitals
(IIT-JEE, 1997)

28. Among KO_2, AlO_2^-, BaO_2, and NO_2^+, unpaired electron is present in:
(a) NO_2^+ and BaO_2 (b) KO_2 and AlO_2^-
(c) KO_2 only (d) BaO_2 only
(IIT-JEE, 1997)

29. Which of the following compounds has sp^2-hybridization?
(a) CO_2 (b) SO_2
(c) N_2O (d) CO
(IIT-JEE, 1997)

30. Among the following compounds the one that is polar and has the central atom with sp^2-hybridization is:
(a) H_2CO_3 (b) SiF_4
(c) BF_3 (d) $HClO_2$
(IIT-JEE, 1993)

31. Which of the following contains both polar and non-polar bonds?
(a) NH_4Cl (b) HCN
(c) H_2O_2 (d) CH_4
(IIT-JEE, 1997)

32. The correct order of increasing C—O bond length in CO, CO_3^{2-}, CO_2 is:
(a) $CO_3^{2-} < CO_2 < CO$ (b) $CO_2 < CO_3^{2-} < CO$
(c) $CO < CO_3^{2-} < CO_2$ (d) $CO < CO_2 < CO_3^{2-}$
(IIT-JEE, 1999)

33. The geometry of H_2S and its dipole moment are:
(a) Angular and non-zero
(b) Angular and zero

(c) Linear and non-zero
(d) Linear and zero

(IIT-JEE, 1999)

34. The molecular shape of SF_4, CF_4, and XeF_4 are:
(a) The same, with 2, 0, and 1 lone pair of electrons, respectively
(b) The same, with 1, 1, and 1 lone pair of electrons, respectively
(c) Different, with 0, 1, and 2 lone pair of electrons, respectively
(d) Different, with 1, 0, and 2 lone pair of electrons, respectively

(IIT-JEE, 2000)

35. The hybridization of atomic orbitals of nitrogen in NO_2^+, NO_3^-, and NH_4^+ are:
(a) sp, sp^3, and sp^2, respectively
(b) sp, sp^2, and sp^3, respectively
(c) sp^2, sp, and sp^3, respectively
(d) sp^2, sp^3, and sp, respectively

(IIT-JEE, 2000)

36. The correct order of hybridization of the central atom in the following species NH_3, $[PtCl_4]^{2-}$, PCl_5, and BCl_3 is:
(a) dsp^2, dsp^3, sp^2, and sp^3
(b) sp^3, dsp^2, sp^3d, and sp^2
(c) dsp^2, sp^2, sp^3, and dsp^3
(d) dsp^2, sp^3, sp^2, and dsp^3

(IIT-JEE, 2001)

37. The common features among the species CN^-, CO, and NO^+ are:
(a) Bond order three and isoelectronic
(b) Bond order three and weak field ligands
(c) Bond order two and π-acceptors
(d) Isoelectronic and weak field ligands

(IIT-JEE, 2001)

38. Specify the coordination geometry around and hybridization of N and B atoms in a 1 : 1 complex of BF_3 and NH_3.
(a) N: tetrahedral, sp^3; B: tetrahedral, sp^3
(b) N: pyramidal, sp^3; B: pyramidal, sp^3
(c) N: pyramidal, sp^3; B: planar, sp^2
(d) N: pyramidal, sp^3; B: tetrahedral, sp^3

(IIT-JEE, 2002)

39. Identify the least stable ion among the following:
(a) Li^- (b) Be^-
(c) B^- (d) C^-

(IIT-JEE, 2002)

40. Which of the following molecular species has unpaired electron(s)?
(a) N_2 (b) F_2
(c) O_2^- (d) O_2^{2-}

(IIT-JEE, 2002)

41. Which of the following are isoelectronic and isostructural?

$NO_3^-, CO_3^{2-}, ClO_3^-, SO_3$

(a) NO_3^-, CO_3^{2-} (b) SO_3, NO_3^-
(c) ClO_3^-, CO_3^{2-} (d) CO_3^{2-}, SO_3

(IIT-JEE, 2003)

42. Which of the following has —O—O— linkage?
(a) $H_2S_2O_6$ (b) $H_2S_2O_8$
(c) $H_2S_2O_3$ (d) $H_2S_4O_6$

(IIT-JEE, 2004)

43. According to MO theory:
(a) O_2^+ is paramagnetic and bond order is greater than O_2
(b) O_2^+ is paramagnetic and bond order is less than O_2
(c) O_2^+ is diamagnetic and bond order is less than O_2
(d) O_2^+ is diamagnetic and bond order is more than O_2

(IIT-JEE, 2004)

44. The number of lone pair(s) in $XeOF_4$ is:
(a) 0 (b) 1
(c) 2 (d) 3

(IIT-JEE, 2004)

45. Which species has the maximum number of lone pair of electrons on the central atom?
(a) $[ClO_3^-]$ (b) XeF_4
(c) SF_4 (d) $[I_3^-]$

(IIT-JEE, 2005)

46. The species having bond order different from that in CO is:
(a) NO^- (b) NO^+
(c) CN^- (d) N_2

(IIT-JEE, 2007)

47. Among the following, the paramagnetic compound is:
(a) Na_2O_2 (b) O_3
(c) N_2O (d) KO_2

(IIT-JEE, 2007)

48. The percentage of p-character in the orbitals forming P—P bonds in P_4 is:
(a) 25 (b) 33
(c) 50 (d) 75

(IIT-JEE, 2007)

49. The species having pyramidal shape is:
(a) SO_3 (b) BrF_3
(c) SiO_3^{2-} (d) OSF_2
(IIT-JEE, 2010)

50. Which ordering of compounds is according to the decreasing order of the oxidation state of nitrogen?
(a) HNO_3, NO, NH_4Cl, N_2
(b) HNO_3, NO, N_2, NH_4Cl
(c) HNO_3, NH_4Cl, NO, N_2
(d) NO, HNO_3, NH_4Cl, N_2
(IIT-JEE, 2012)

51. In allene (C_3H_4), the type(s) of hybridization of the carbon atoms is(are):
(a) *sp* and sp^3 (b) *sp* and sp^2
(c) Only sp^3 (d) sp^2 and sp^3
(IIT-JEE, 2012)

52. Assuming 2s–2p mixing is NOT operative, the paramagnetic species among the following is:
(a) Be_2 (b) B_2
(c) C_2 (d) N_2
(JEE Advanced, 2014)

Multiple Correct Answers Type

1. CO_2 is isostructural with:
(a) $HgCl_2$ (b) C_2H_2
(c) $SnCl_2$ (d) NO_2
(IIT-JEE, 1986)

2. The linear structure is assumed by:
(a) $SnCl_2$ (b) CS_2
(c) NO_2^+ (d) NCO^-
(e) SO_2 **(IIT-JEE, 1991)**

3. The molecule(s) that will have dipole moment is/are:
(a) 2,2-dimethyl propane
(b) *trans*-2-pentene
(c) *cis*-3-hexene
(d) 2,2,3,3-tetramethyl butane
(IIT-JEE, 1992)

4. Which of the following has/have identical bond orders?
(a) CN^- (b) O_2^-
(c) NO^+ (d) CN^+
(IIT-JEE, 1992)

5. Pick out the isoelectronic structure from the following:
(I) CH_3^+ (II) H_3O^+ (III) NH_3 (IV) CH_3^-
(a) I and II (b) III and IV
(c) I and III (d) II, III, and IV
(IIT-JEE, 1993)

6. The critical temperature of water is higher than that of O_2 because the H_2O molecule has:
(a) Fewer electrons than O_2
(b) Two ionic bonds
(c) Two covalent bonds
(d) Dipole moment
(IIT-JEE, 1997)

7. The geometry and type of hybrid orbital present about the central atom in BF_3 are:
(a) Linear, *sp* (b) Trigonal planar, sp^2
(c) Tetrahedral, sp^3 (d) Pyramidal, sp^3
(IIT-JEE, 1998)

8. The nitrogen oxide(s) containing N—N bond is/are:
(a) N_2O (b) N_2O_3
(c) N_2O_4 (d) N_2O_5
(IIT-JEE, 2010)

9. Hydrogen bonding plays a central role in the following phenomena:
(a) Ice floats in water
(b) Higher Lewis basicity of primary amines than tertiary amines in aqueous solutions
(c) Formic acid is more acidic than acetic acid
(d) Dimerisation of acetic acid in benzene
(JEE Advanced, 2014)

Matching Column Type

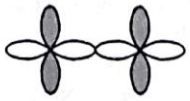
1. Match each of the diatomic molecules in Column-I with its property/properties in Column-II.

Column-I	Column-II
(a) B_2	(p) Paramagnetic
(b) N_2	(q) Undergoes oxidation
(c) O_2^-	(r) Undergoes reduction
(d) O_2	(s) Bond order ≥ 2
	(t) Mixing of *s*- and *p*-orbitals

(IIT-JEE, 2009)

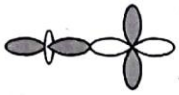
2. Match the orbital overlap figures shown in **List-I** with the description given in **List-II** and select the correct answer using the code given below the lists.

List-I **List-II**

(a)  (p) p-d σ antibonding

(b) (q) d-d σ bonding

(c) (r) p-d π bonding

(d)  (s) d-d σ antibonding

Code:

	p	q	r	s
(a)	2	1	3	4
(b)	4	3	1	2
(c)	2	3	1	4
(d)	4	1	3	2

(JEE Advanced, 2014)

Integer Answer Type

1. Based on VSEPR theory, the number of 90° F—Br—F angles in a molecule of BrF_5 is _____. **(IIT-JEE, 2010)**
2. Among the following, the number of compounds that can react with PCl_5 to give $POCl_3$ is
O_2, CO_2, SO_2, H_2O, H_2SO_4, P_4O_{10}
(IIT-JEE, 2011)
3. The total number of lone-pairs of electrons in melamine is _____.
(JEE Advanced, 2013)
4. A list of species having the formula XZ_4 is given below:
XeF_4, SF_4, SiF_4, BF_4^-, BrF_4^-, $[Cu(NH_3)_4]^{2+}$, $[FeCl_4]^{2-}$, $[CoCl_4]^{2-}$ and $[PtCl_4]^{2-}$.
Defining shape on the basis of the location of X and Z atoms, the total number of species having a square planar shape is _____.
(JEE Advanced, 2014)

Subjective Type

1. State four major physical properties that can be used to distinguish between covalent and ionic compounds. Mention the distinguishing features in each case.
(IIT-JEE, 1978)
2. Write the Lewis dot structural formula for each of the following. Also give the formula of a neutral molecule which has the same geometry and the same arrangement of the bonding electrons as in each of the following.
(i) O_2^{2-} (ii) CO_3^{2-}
(iii) CN^- (iv) NCS^-
(IIT-JEE, 1983)
3. How many σ-molecules and how many π-bonds are present in a benzene molecule?
(IIT-JEE, 1985)
4. Arrange the following as stated.
"Increasing strength of hydrogen bonding (X—H—X)".
O, S, F, Cl, N
(IIT-JEE, 1991)
5. Given reasons in two or three sentences only for the following:
"Hydrogen peroxide acts as an oxidising as well as a reducing agent".
(IIT-JEE, 1992)
6. The dipole moment of KCl is 3.336×10^{-29} C m which indicates that it is a highly polar molecule. The inter atomic distance between K^+ and Cl^- in this molecule is 2.6×10^{-10} m. Calculate the dipole moment of KCl molecule if there were opposite charges of one fundamental unit located at each nucleus. Calculate the percentage ionic character of KCl.
(IIT-JEE, 1993)
7. Explain the difference in the nature of bonding in LiF and LiI.
(IIT-JEE, 1996)
8. Using the VSEPR theory, identify the type of hybridization and draw the structure of OF_2. What are the oxidation states of O and F?
(IIT-JEE, 1997)
9. Interpret the non-linear shape of H_2S molecule and non-planar shape of PCl_3 using valence shell electron pair repulsion (VSEPR) theory. (Atomic number of H is 1, P is 15, Cl is 17.)
(IIT-JEE, 1998)
10. Write the MO electron distribution of O_2. Specify its bond order and magnetic property.
(IIT-JEE, 2000)
11. Which one is more stable in diethyl ether: anhydrous $AlCl_3$ or hydrous $AlCl_3$? Explain in terms of bonding.
(IIT-JEE, 2003)
12. Using VSEPR theory, draw the shape of PCl_5 and BrF_5.
(IIT-JEE, 2003)
13. Draw the shape of XeF_4 and OSF_4 according to VSEPR theory. Show the lone pair of electrons on the central atom.
(IIT-JEE, 2004)
14. On the basis of ground electronic configuration, arrange the following molecules in the order of increasing O—O bond lengths. KO_2, O_2, $O_2[AsF_6]$
(IIT-JEE, 2004)
15. Predict whether the following molecules are iso-structural or not. Justify your answer.
$N(Me)_3$ and $N(SiMe_3)_3$
(IIT-JEE, 2005)

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

1. (a) Bond angle $\propto \dfrac{1}{\text{electronegativity of surrounding atom}}$

Electronegativity of F is higher than the H; hence $x > y$.

2. (b) $x = 153.9$ pm; $y = 154.5$ pm

Lone pair has more s%-character than the multiple bond; hence orbital having lone pair has more s%-character and other orbital has less s%-character. s% ↓ bond length ↑.

3. (a) $x = 168$ pm; $y = 153.9$ pm

With increase in the size of central atom, the bond length increases.

4. (b) $y = 193$ pm; $x = 182$ pm

5. (b) $x = 175$ pm; $y = 186.4$ pm

6. (a) Bridge bond lengths are longer than the terminal bonds

9. (b) Orthosilicate has SiO_4^{4-} unit.

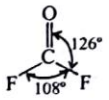
Pyrosilicate has $Si_2O_7^{2-}$ unit.

13. (d) All Xe molecules are non-polar; however, Xe has the greatest van der Waals' forces because it has higher boiling point.

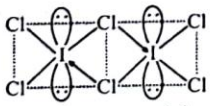
14. (c) $XeF_6 \longrightarrow XeF_5^+ + F^-$

Square pyramidal

15. (a)



17. (a)

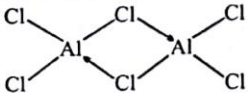


Hybridization of each I : sp^3d^2

Planar structure

2 bonds are of 3C—$4e^-$

4 bonds are of 2C—$2e^-$



Hybridization of each Al : sp^3

Non-planar structure

2 bonds are of 3C—$4e^-$

4 bonds are of 2C—$2e^-$

18. (d) M.O. configuration up to $14\bar{e}$

$$\sigma 1s^2 < \overset{*}{\sigma} 1s^2 < \sigma 2s^2 < \overset{*}{\sigma} 2s^2 < \pi 2py^2 = \pi 2pz^2 < \sigma 2px^2 < \overset{*}{\pi} 2py^0 = \overset{*}{\pi} 2pz^0$$

Example: For N_2, CN^-:

N_2, B.O. = 3.0 N_2^- : B.O. = 2.5

CN^-, B.O. = 3.0 N_2^{2-} B.O. = 2.0

M.O. configuration for more than $14e^-$

$$\sigma 1s^2 < \overset{*}{\sigma} 1s^2 < \sigma 2s^2 < \overset{*}{\sigma} 2s^2 < \sigma 2px^2 < \pi 2py^2 = \pi 2pz^2 < \overset{*}{\pi} 2pz^1 = \overset{*}{\pi} 2py^1$$

Example: For O_2, NO:

O_2, B.O. = 2.0

O_2^+, B.O. = 2.5 NO^+, B.O. = 3.0

O_2^{2+}, B.O. = 3.0 NO^-, B.O. = 2.0

NO^{2+}, B.O. = 2.5

B.O. of N—O bond in NO_2^+ is 2

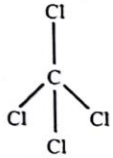
$$O = \overset{+}{N} = O$$

19. (c) $ICl + H_2O \xrightarrow{\text{room temp.}} HCl + HOI$

During the hydrolysis of interhalogen compounds, oxyacid of less electronegative or large sized halogen is formed, and other halogen forms halogen acid.

20. (b) From sp^3d-hybridization trigonal planar geometry is not possible, because in trigonal planar geometry lone pair electrons will be placed at the axial position, which violates VSEPR theory or Bent's rule.

21. (d) (a) Example:



$\mu_{C-Cl} \neq 0$

$\mu_{\square} = 0$

(b) Inert gas dissolves in water due to dipole–induced dipole, not by London dispersion force

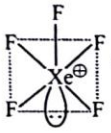
(c) Al = [Ne] $3s^2\,3p^1$

Ga = [Ar] $3d^{10}\,4s^2\,4p^1$ and $I.E._{Ga}$ = $I.E._{Al}$

5.999 eV/atom 5.987 eV/atom

due to d-orbitals in Ga having weak shielding effect.

(d) $XeF_5^{\oplus}$



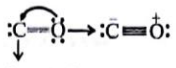
distorted square pyramidal

Xe is sp^3d^2-hybridization $\left.\begin{matrix}\text{5 bond pair}\\ \text{1 lone pair}\end{matrix}\right\}$

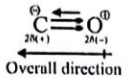
23. (d) $\overset{6+}{Xe}F_6 + 3H_2O \longrightarrow \overset{6+}{Xe}O_3 + 6HF$ (No redox)

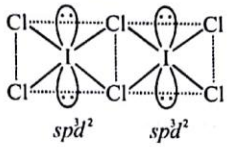
disprop.

$$3XeF_4 + 6H_2O \longrightarrow 2Xe + XeO_3 + 12HF + \frac{3}{2}O_2$$

24. (d) 

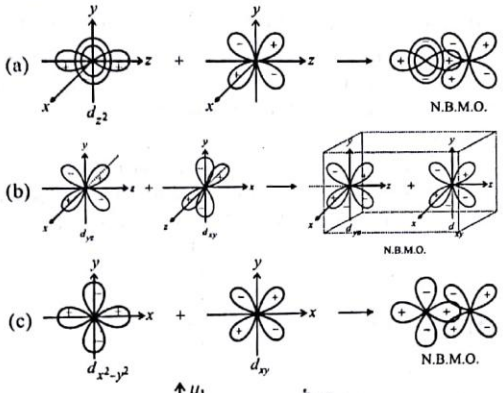
Incomplete octet

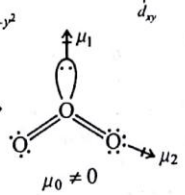


25. (c) 

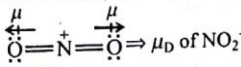
Square planar geometry for individual I-atoms, and to minimize the repulsion of lone pair on I-atoms overall molecule must be planar.

26. (d)



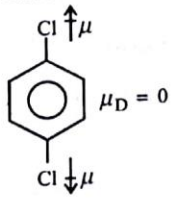
27. (a) (a) → 

Central oxygen atom is surrounded by two oxygen atoms and a lone pair, hence in such unsymmetrical distribution μ_D of $O_3 \neq 0$.



sp Linear

Because both bond dipole moments of N—O bond cancel each other.



28. (d) Increasing covalent character NaCl < CuCl < AgCl < AuCl.

Au^+ [Xe] $4f^{14}5d^{10}$; due to very poor shielding of 4*f* and 5*d* electrons, Au^+ has very high z_{eff} value in comparision to Na^+, Cu^+, Ag^+. Hence, AuCl is most covalent.

29. (d) Due to absence of vacant orbital at N in NF_3 it does not undergo hydrolysis at room temperature.

49. (d) Bond order for He_2 is zero.

50. (d) Bond order for H_2^- = + 1/2

51. (a) Dipole moment of CH_4 = 0.

52. (b) O is sp^3-hybridized and H_2O is of V shape due to the presence of two lone pair of electrons in oxygen.

53. (a) The more is polarization of anion, the more is covalent character.

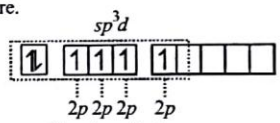
54. (a) Bond dissociation energy order:

Cl_2	> Br_2	> F_2	> I_2	
242.6	192.8	158.8	151.1 in kJ mol^{-1}	

55. (a) S-atom in SF_6 is in sp^3d^2-hybridized state and shows octahedral shape.

56. (a) Each possesses 18 electrons.

57. (a) In SF_4, S has sp^3d-hybridization. Thus, it contains two axial and two equatorial bonds to give a see-saw structure.



58. (d) It is a reason for given fact.

59. (b) *o*-, *m*-, *p*-derivatives has α = 60°, 120°, and 180°, respectively and thus resultant vector has zero dipole moment in *p*-derivative. Also dipole moment of *m*-dichlorobenzene is more than toluene.

60. (a) Head on overlapping gives rise to σ-bond formation.

61. (c) CCl_4 has sp^3-hybridization giving regular tetrahedron geometry. In others the geometry is little distorted inspite of sp^3-hybridization due to different atoms on the vertices of tetrahedron.

62. (d) $PF_3 < PCl_3 < PBr_3 < PI_3$, the bond angle order is explained in terms of increasing electronegativity of halogens.

63. (b) Follow Fajan's rule.

64. (c) In *o*-dichlorobenzene, $\alpha = 60°$

∴ $\cos\alpha = +$ ve,

$$\mu = \sqrt{\mu_1^2 + \mu_2^2 + 2\mu_1\mu_2\cos\alpha}$$

65. (a) Electronegativity difference in two atoms involved in bonding is a measure of polarity in molecule.

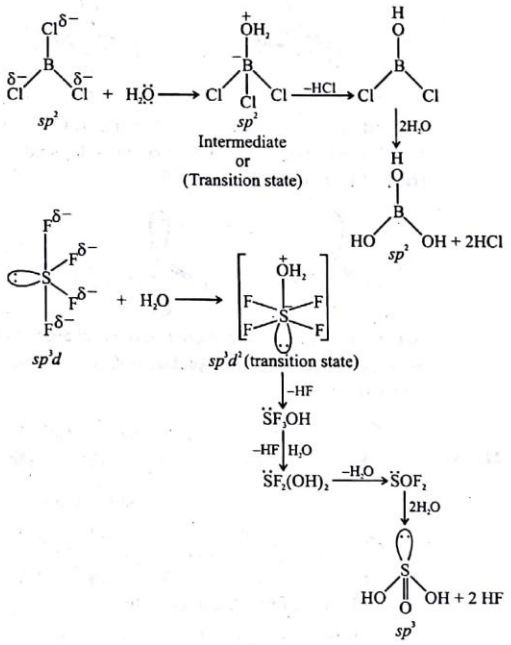
66. (d) ICl_2^- has sp^3d-hybridization and has three bond pairs and three lone pairs of electrons.

Geometry of $ICl_2^{\ominus}$ is a bent T shape.

67. (b) Bond order = $\frac{1}{2}$ [number of bonding electrons – number of antibonding electrons]

68. (b) ClO_3^- has sp^3-hybridization with one lone pair of electron.

69. (c)



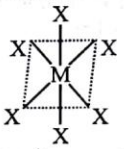
70. (c) O_2^- has one unpaired electron in its antibonding molecular orbital.

71. (a) Both are linear.

72. (b) Bond order for $O_2 = 2$ and for $O_2^+ = 2.5$

Both are paramagnetic (O_2 has 2 unpaired electrons; O_2^+ has one unpaired electron).

73. (a) sp^3d^2-hybridization leads for octahedral geometry having in all three bonds at 180° and 12 bonds at 90°.



74. (b) He_2^+ have three electrons, of which one must be unpaired. He_2^+ has one unpaired electron; H_2 has two (paired) electrons.

75. (c) SO_3^{2-} has 42 electrons, CO_3^{2-} has 32 electrons. NO_3^- has 32 electrons.

76. (a) Follow Fajan's rule.

77. (a) ClO_2 has 33 electrons, i.e., one unpaired.

94. (b) $O_2 = \sigma^2(1s)\ \sigma^{*2}(1s)\sigma^2(2s)\ \sigma^{*2}(2s)\sigma^2 2p_x\ \pi 2p_y^2$

$= \pi 2p_z^2\ \pi^* 2p_y^1 = \pi^* 2p_z^1$

Hence number of unpaired e^- in A.B.M.O. = 2

$O_2^- = \sigma^2(1s)\ \sigma^{*2}(1s)\sigma^2(2s)\ \sigma^{*2}(2s)\sigma^2 2p_x\ \pi 2p_y^2$

$= \pi 2p_z^2\ \pi^* 2p_y^2 = \pi^* 2p_z^1$

Hence number of unpaired e^- in A.B.M.O. = 1

$O_2^2 = \sigma^2(1s)\ \sigma^{*2}(1s)\sigma^2(2s)\ \sigma^{*2}(2s)\sigma^2 2p_x\ \pi 2p_y^2$

$= \pi 2p_z^2\ \pi^* 2p_y^2 = \pi^* 2p_z^2$

Hence number of unpaired e^- in A.B.M.O. = 0

100. (a) A serious deviation has been noticed for para-$C_6H_5(OH)_2$ for which the observed value is 1.64 D.

This deviation arises probably due to the lack of planarity of OH group with respect to the plane of ring. Thus, the two —OH links are probably remaining inclined to the plane of the ring.

101. (b) Generally, the trans compounds show zero dipole moment.

102. (b) Increasing order of π bond formation tendency:

Si — O < P — O < S — O < Cl — O

because Cl has the smallest size atom among Si, P, and S; hence due to less internuclear distance, sideways overlapping is most effective in case of Cl.

103. (d) When n is less, then overlapping is stronger.

Therefore, $1s$–$1s$ is strongest.

When one set is totally non-directional and n is also different, then directional nature of orbitals is seen:

$1s$–$2p > 1s$–$2p$

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a) Bond energy order:

$C\overset{\sigma}{—}C > Si\overset{\sigma}{—}Si > Ge\overset{\sigma}{—}Ge > Sn\overset{\sigma}{—}Sn$

$2p-2p \quad 3p-3p \quad 4p-4p \quad 5p-5p$

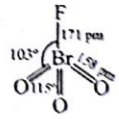
Extent of overlapping decreases in the order:

$2p-2p > 3p-3p > 4p-4p > 5p-5p$

6. (a) Bond angle α electronegativity of central atom.

7. (a) $x = 105°$; $y = 99°$

8. (b) According to Bent's rule

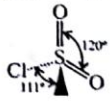


9. (a) $x = 100°$; $y = 98°$

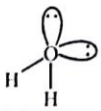
According to Bent's rule

10. (a) $x = 270$ pm; $y = 196$ pm

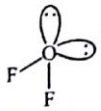
14. (a)



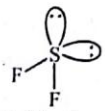
16. (a)



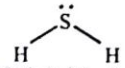
Hybridization: sp^3



Hybridization: sp^3



Hybridization: sp^3



No hybridization according to Drago's rule

Bond angle between H_2O and OF_2 is compared on the basis of Bent's rule.

$\angle$ FSF in SF_2 > $\angle$ HSH in H_2S

From Drago's rule,

$\angle$ FOF in OF_2 > $\angle$ FSF in SF_2

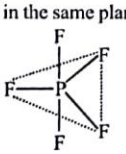
On descending in a group for same substituents, bond angle decreases.

17. (a)

Hybridization of Xe: sp^3d^2

All four Xe — F bonds are of equal lengths as they lie in the same plane and are at 90° apart from each other.

(b)

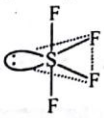


Hybridization: sp^3d

$(P — F)_{axial} > (P — F)_{equatorial}$

(1.58 Å) (1.53 Å)

(c)



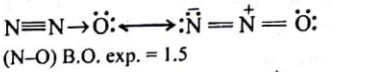
Hybridization: sp^3d

$(S — F)_{axial} > (S — F)_{equatorial}$

18. (c) (a) NO : B.O. = 2.5

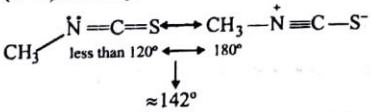
(b) NO^- : B.O. = 2.0

(c) NO^+ : B.O. = 3.0



(N–O) B.O. exp. = 1.5

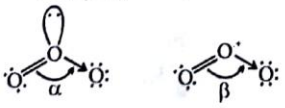
19. (c)



20. (c) (i) According to Drago's rule, the trend of decreasing bond angle in NH_3, PH_3, and AsH_3 is:

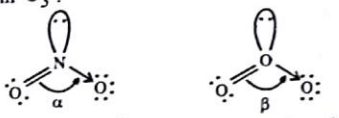
$NH_3 > PH_3 > AsH_3$

(ii)



$\alpha < \beta$ because lone pair–double bond repulsion in O_3 is greater than single electron–double bond in O_3^+. Also, lone pair–single bond (electron pair) repulsion in O_3 is greater than single electron–single bond repulsion in O_3^+.

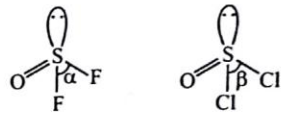
(iii)



Hybridization of N: sp^2 Hybridization of O: sp^2

According to Bent's rule, N — O bond (B.O. = 1.5) in NO_2^- has more p character than O — O bond (B.O. = 1.5) in O_3. Hence $\alpha < \beta$.

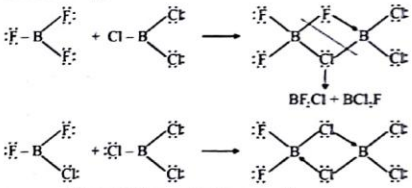
(iv)



According to Bent's rule, there is more p-character in S—F bond than in S—Cl bond in $SOCl_2$.

Hence $\alpha < \beta$.

21. (a)



$BF_2Cl + BCl_2F$

does not form due to crowding at B-atom due to large size of Cl-atoms.

25. (b) Bond energy of Cl_2 is highest among all halogen molecules. Bond energy of F_2, Cl_2, Br_2, I_2 are 37, 58, 46, and 36 kcal mol^{-1}, respectively.

26. (a) The tendency to show lower ionic state increases down the group due to inert pair effect.

27. (a) Small cation causes more polarization in anion. Also, larger anions are easily polarized by a cation.

28. (b) The bond order for O_2^{2-}, O_2^-, O_2, O_2^+ are 1.0, 1.5, 2.0, 2.5, respectively. The higher is bond order, the more is bond energy.

29. (a) Carbon in H_2CO_3 has sp^2-hybridization and also polar. BF_3 has sp^2-hybridized but is non-polar. SiF_4 has sp^3-hybridization. $HClO_2$ has sp^3-hybridization.

30. (c) Both SO_4^{2-} and BF_4^- have sp^3-hybridization and are tetrahedral.

31. (c) KO_2 has $K^+ O_2^-$ structure having one unpaired electron.

32. (b) Smaller cation causes more polarization of anion.

33. (c) The larger is anion, the more is its polarization.

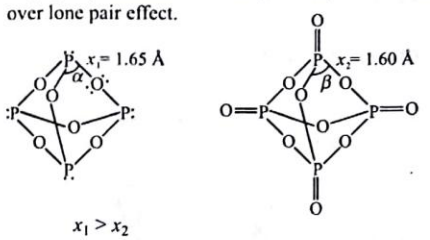
34. (b) The stability of carbonates increases with increasing electropositive character of metal.

35. (a) CH_3^+ possesses sp^2-hybridization.

36. (c) Larger anion is polarized more (Fajan's rule).

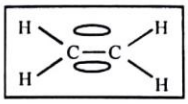
37. (a) In ether, sp^3-hybridized oxygen molecule shows a little larger angle than 109° 28′ due to steric effect of alkyl groups on two sides of it, which predominates over lone pair effect.

38. (b)



$x_1 > x_2$

39. (a) A π-bond has a nodal plane passing through the two bonded nuclei, i.e., molecular plane.



Nodal plane, i.e., molecular plane.

40. (d) Boric acid is HO—B(:OH)—OH; boron has sp^2 and oxygen has sp^2-hybridization because of back bonding.

41. (c) Boron in $[BF_4]^-$ has regular tetrahedral geometry because of sp^3-hybridization on boron atom.

42. (c) The bond angles are

H_2S	NH_3	SiH_4	BF_3
92.6°	107°	109°28	120°

43. (a) $x = 118°$; $y = 79°$

44. (b) $x = 172$ pm; $y = 175$ pm

51. (c) CO and N_2 both have same (B.O. = 3) bond order.

54. (a) Increasing order of π bond formation tendency: Si — O < P — O < S — O < Cl — O

because Cl is the small size atom among Si, P, and S, hence due to less internuclear distance, sideways overlapping is most effective in case of Cl.

When π bond formation tendency increases, then polymerization tendency decreases.

58. (c) Bond order

$= \frac{1}{2}$ [bonding electrons – antibonding electrons]

59. (b) $x = 217$ pm; $y = 239$ pm

61. (b) Bond angle ∝ Electronegativity of central atom

Electronegativity of Cl is higher than Br, hence $y > z$

62. (b) $x = 94°$; $y = 84°$; $z = 91°$

Terminal chlorine has three lone pairs so repulsion is more between two terminal chlorine, but bridging chlorine has two lone pairs so repulsion between one terminal and one bridging chlorine is less than the terminal chlorine.

63. (c) $x = 266$ pm; $y = 293$ pm

In $I_3^{\oplus}$, there is sp^3 hybridization so $s\% < 25\%$ in bonded orbitals.

However, there is an sp^3d hybridization in I_3^-; so $s\% = 0$ in axial orbitals. When $s\% \uparrow$ bond length $\downarrow$

64. (b) $x = 120$; $y = 126°$

According to Bent's rule

70. (c) $\cos\theta = \frac{-1}{i}$

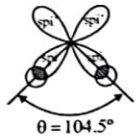
$\cos(104.5°) = \frac{-1}{i} = -0.25$

$\Rightarrow \quad i = 4$

Applying $\quad \Sigma f_p = 3$

$\frac{2 \times i}{i+1} + 2f_p' = 3$

$\frac{2 \times 4}{5} + 2f_p' = 3$



where f_p' = fraction of p-character in lone pair.

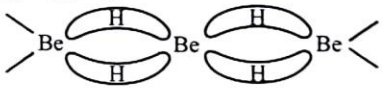
$$f_p' = \frac{7}{10}$$

$$f_p'\% = 70\%$$

71. (a) The magnitude of negative charge developed at chlorine atoms in $SiCl_4$ is more in comparison to negative charge developed at chlorine atoms in CCl_4, it is due to more electronegativity difference between Si and Cl than that of between C and Cl.

72. (d) $nBeH_{2(g)} \longrightarrow (BeH_2)_{n(s)}$

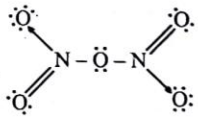
H — Be — H



Hybridization of Be: sp^3 (solid)

Hybridization of Be: sp (gas)

(b)



$[NO_2]^+ [NO_3]^+$

Hybridization of N in NO_2^+ : sp

Hybridization of N in NO_3^- : sp^2

(N_2O_5 in solid state)

Hybridization of each N: sp^2 (gaseous state)

(c) XeF_6

Gaseous state

Hybridization: sp^3d^3

$[XeF_5]^+ F^-$

Solid state

Hybridization: sp^3d^2

(d) PF_5

Gaseous state

Hybridization: sp^3d

PF_5

Solid state

Hybridization: sp^3d

73. (b) N_2 and CO are isoelectronic. To convert $N_2 \rightarrow N_2^+$, electron is removed from bonding M.O. evidenced by decrease in bond order. While the conversion $CO \rightarrow CO^+$ requires less energy than in case of N_2, because bond order of CO increases.

$CO_{(g)} \rightarrow CO^+_{(g)} + e$, I.E. = 1352 kJ/mol

$N_{2(g)} \rightarrow N_2^+{}_{(g)} + e$, I.E. = 1503 kJ/mol

$NO_{(g)} \rightarrow NO^+_{(g)} + e$, I.E. = 894 kJ/mol

$O_{2(g)} \rightarrow O_2^+{}_{(g)} + e$, I.E. = 1164 kJ/mol

75. (a) O_2 has two unpaired electron but are paired in O_2^{2-}.

76. (c) NF_3 and H_3O^+ have sp^3-hybridization; NO_3^- and BF_3 have sp^2-hybridization.

77. (c) $CsBr_3 \longrightarrow Cs^+ + Br_3^-$

78. (c) Electronegativity difference in two atoms involved in bonding is a measure of polarity in molecule.

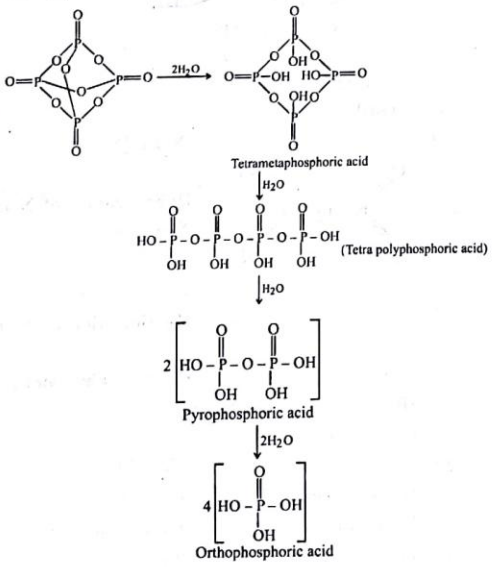
79. (c) Operates in each gaseous molecule.

80. (b) NH_3, $[PtCl_4]^{2-}$, PCl_5, and BCl_3 have sp^3, dsp^2, sp^3d, and sp^2-hybridization, respectively.

81. (a) No doubt NH_3 and BF_3 have sp^3 (pyramidal) and sp^2 (coplanar) hybridization, respectively, having one lone pair of electron on N atom which is responsible for pyramidal shape of NH_3 inspite of sp^3-hybridization. However, as soon as it is coordinated to BF_3, both attain tetrahedral geometry and acquire sp^3 hybridization.

82. (b) The larger is bond order, the smaller is bond length.

83. (b)



85. (b) $y = 98°$; $x = 82°$

86. (b) According to Bent's rule.

87. (a) $x = 115°$; $y = 132°$

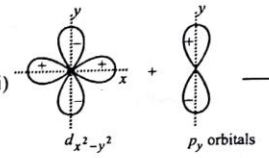
90. (b) $y = 2.644$ Å $\quad x = 2.21$ Å

93. (d) $\sigma 1s^3 < \overset{*}{\sigma}(1s)^3 < \sigma 2s^3 < \overset{*}{\sigma}(2s)^3 < \pi 2py^2$

94. (d) PF_5 and PCl_5 exist through the formation of sp^3d-hybridization.

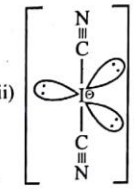
95. (a) $[SiH_6]^{2-}$ does not exist because of the absence of d-orbital contraction.

96. (d) (i)



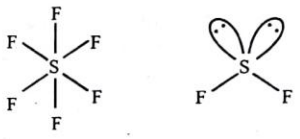
→ N.B.M.O. is formed

(ii)



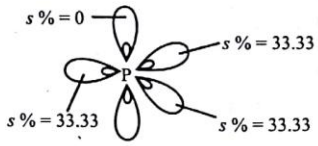
$[I(CN)_2]^-$ has linear geometry and sp^3d-hybridization.

97. (a)



s % character ↑ $\quad$ bond length ↓

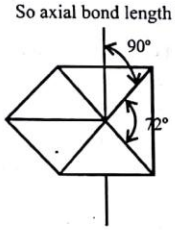
(b)



s %↑ $\quad$ bond length ↓

So axial bond length is longer than the

(c)



For axial position	For equatorial position
$\cos 90° = \frac{s}{s-1}$	$\cos 72° = \frac{s}{s-1}$
$s\% = 0$	$s\% = -$ive

s% ↑ $\quad$ bond length ↓

So equatorial bond lengths are longer than axial bond lengths.

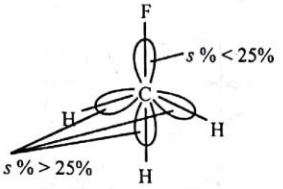
Multiple Correct Answers Type

1. (a), (b)

(a) $\cos\theta = \dfrac{p-1}{p}$

$\theta\uparrow \quad p\downarrow$

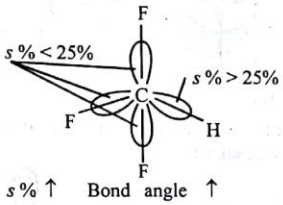
(b)



$s\,\% \uparrow$ Bond angle $\uparrow$

Hence $H-\hat{C}-H > F-\hat{C}-H$

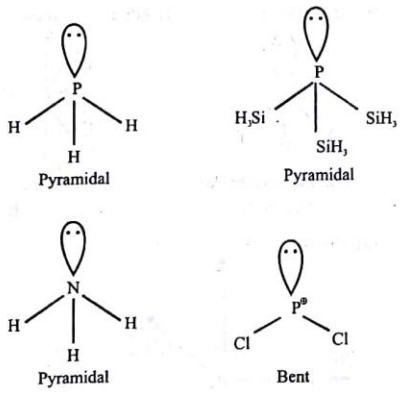
(c)



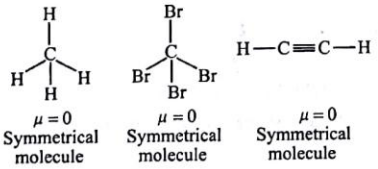
$s\,\% \uparrow$ Bond angle $\uparrow$

Hence $H-\hat{C}-F > F-\hat{C}-F$

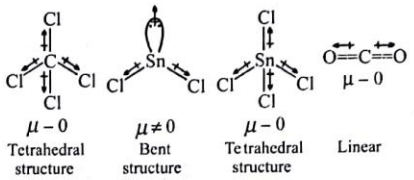
2. (a), (b), (c)



9. (a), (b), (c)



10. (a), (c)



12. (a), (b), (c), (d)

All silicates are non-planar because SiO_4^{4-} unit is tetrahedral.

27. (a), (b), (c)

Solubility of alkali earth metal's sulphate decrease down the group: $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$

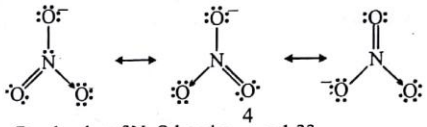
35. (b), (c), (d)

AlF_3 is ionic so it has complete octet.

60. (b), (c), (d)

(a) sp^3-hybrid orbitals are at 109°28' to each other

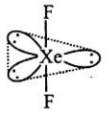
(d)



Bond order of N–O bond $= \dfrac{4}{3} = 1.33$

61. (a), (b), (c), (d)

(a)

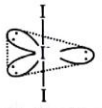


Hybridization: sp^3d
shape: linear

O = C = O

Hybridization: sp
shape: linear

(b)

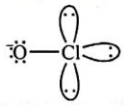


Hybridization: sp^3d
shape: linear

Cl – Hg – Cl

Hybridization: sp
shape: linear

(c)

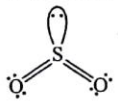


Hybridization of Cl: sp^3
shape: linear

:C ⇇ O:

Hybridization of C: sp
shape: linear

(d)



Hybridization: sp^2

shape: V-shape/bent/angular

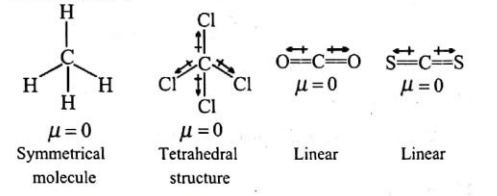
Hybridization of O: close to sp^3

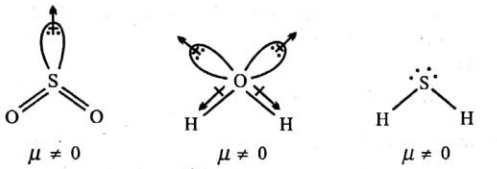
shape: V-shape/bent/angular

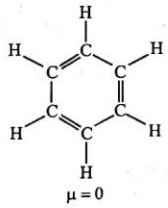
66. (a), (b)

SH_6 does not exist due to the absence of *d*-orbital contraction.

67. (a), (b), (c)

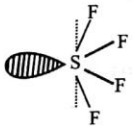






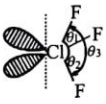
91. (a), (b), (c), (d)

s → sp^3d-hybridized



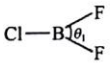
Axial bond length is greater than equatorial bond length (see-saw).

Cl → sp^3d-hybridized.



Axial and equatorial; bond length are different (nearly T-shape)

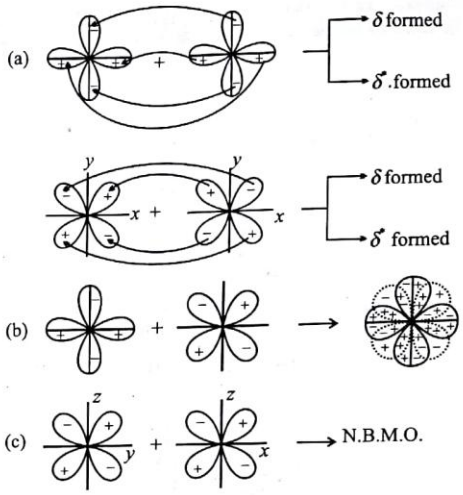
$\theta_1 = \theta_2 \neq \theta_3$



$\theta_1 < 120°$

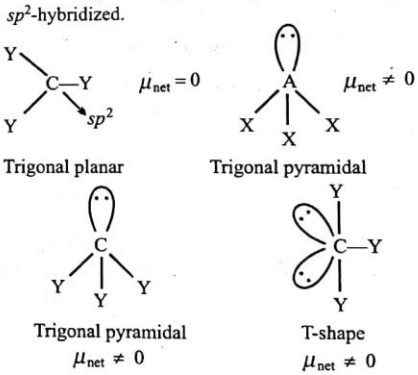
as per Bent's rule

92. (a), (b), (c), (d)

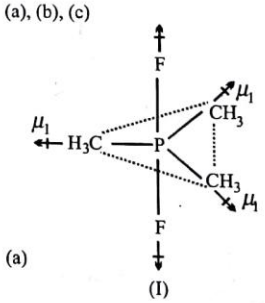


93. (a), (c)

Since the dipole moment of $CY_3 = 0$. It means C in CY_3 is sp^2-hybridized.



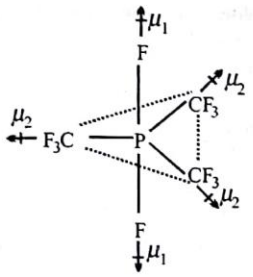
94. (a), (b), (c)



(a) (I)

Hybridization of P: sp^3d

Hence, shape: trigonal bipyramidal



(II)

Hybridization of P: sp^3d

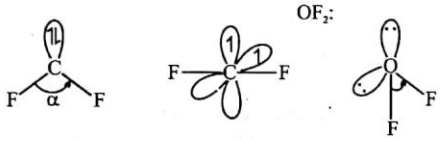
Hence, shape: trigonal bipyramidal

(b) μ_D of both I and II is equal to zero as all substituents are symmetrically arranged.

(c) According to Bent's rule, P – F bond length in PF_2Me_3 is longer than $PF_2(CF_3)_3$, because as a whole group CF_3 is more electronegative than CH_3 group by which polarity of P–F bond increases in $PF_2(CF_3)_3$ and P–F bond length decreases.

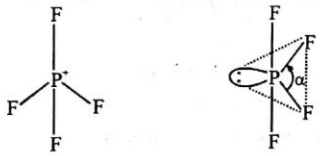
95. (a), (b), (d)

(a)



Singlet hybridization of C : sp^2	Triplet hybridization of C : sp	Hybridization of O : sp^3
$\alpha \approx 120°$	$\angle FCF = 180°$	$\angle FOF = 103°$

(b)



Hybridization of P: sp^3

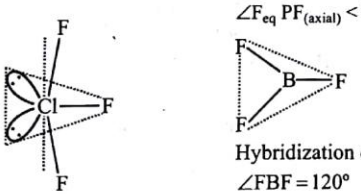
$\angle = 109°28'$

Hybridization of P: sp^3d

$\angle FPF$ (eq.) < 120°

$\angle F_{eq}\ PF_{(axial)} < 90°$

(c)



Hybridization of B: sp^2

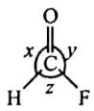
$\angle FBF = 120°$

Hybridization of Cl: sp^3d

$\angle FClF = 87.5°$

(d) In NH_3, $\angle HNH = 107°$; In PH_3, $\angle HPH = 93.8°$

97. (c), (d)



Due to $-I$ effect of F (which is more compared to $+R$ effect of F-atom), the % p-character in C–F increases and consequently % s-character increases in C–H bond. Hence the bond angle order is $x > y > z$.

$x > 120°$; $z < 120°$

100. (c), (d)

(a) $NH_3 > PH_3 > AsH_3 > SbH_3$

As we move down the group, the size of the central atom increases and therefore its tendency to form stable covalent bond with small hydrogen atom decreases. Consequently, the strength of M—H bond and hence the thermal stability goes on decreasing as we move from NH_3 to BiH_3.

(b) The boiling point of liquid hydrogen is greater than liquid helium due to large surface area of hydrogen than Helium.

(c) According to Fajan rule, as ionic potential (ϕ) of cation increases thermal stability of metal carbonate decreases; hence k_p increases because reaction moves in the forward direction, so

$$MCO_3 \xrightleftharpoons{k_p} MO + CO_2$$

$BeCO_3 > SrCO_3 > BaCO_3$

(d) Magnetic moment = $\sqrt{n(n+2)}$ (where n = unpaired electron)

O_2 = 2 unpaired electron $\sqrt{2(2+2)} = \sqrt{8}$

$KO_2\ K^+ \cdots O_2^-$ = 1 unpaired electron

$\sqrt{1(1+2)} = \sqrt{3}$

$K_2O_2\ 2K^+ \cdots O_2^{2-}$ = 0 unpaired electron

$\sqrt{0(0+2)} = \sqrt{0}$

So magnetic moment order: $O_2 > KO_2 > K_2O_2$

106. (b), (c), (d)

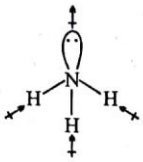
Solubility of alkaline earth metal's oxide increases down the group: BeO < MgO < CaO < SrO < BaO

120. (c), (d)

$$AgNO_3 \xrightarrow{\Delta} Ag + \frac{1}{2}O_2 + NO_2$$

$$Hg(NO_3)_2 \xrightarrow{\Delta} Hg + O_2 + 2NO_2$$

127. (a), (c)

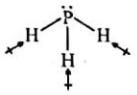


NH_3

Hybridization of N: sp^3

Bond angle H $\hat{N}$ H less than 109°

Lone pair exists in hybrid orbitals.



PH_3

Hybridization of P: No hybridization according to Drago's rule

$\angle HPH$ is close to 90°.

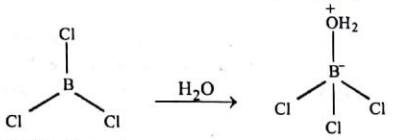
Lone pair exists in *s*-orbital.

Dipole moment of pure orbital is zero.

128. (b), (c), (d)

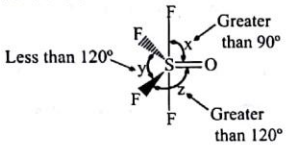
NCl_3 undergoes hydrolysis and H_2O attacks at Cl-atoms.

$$SF_4 + 3H_2O \xrightarrow{\text{room temp.}} \underbrace{H_2SO_3 + 4HF}_{\text{Proton donor acids}}$$



Hybridization: sp^2 Hybridization: sp^3 (Transition state)

130. (a), (c), (d)



134. (a), (d)

B.D.E.$_{N-H}$ > B.D.E.$_{P-H}$ because NH_3 has sp^3-hybridization, so N – H bond has more *s* % character.

When *s* % ↑ B.D.E.↑

Note: In PH_3 hybridization is not possible according to Drago's rule.

But both NF_3 and PF_3 have sp^3 hybridization.

B.D.E.$_{P-F}$ > B.D.E.$_{N-F}$ because PF_3 has back bonding.

Comprehension Type

15. (b) (a) Solubilities of hydroxides of alkali metals and alkaline earth metals increase downward because in both groups L.E. of hydroxides decreases at a faster rate than their hydration energies.

(b) Solubilities of carbonates of alkali metals increase downward while those of alkaline earth metals decrease downward.

Decreasing solubilities of alkaline earth metals carbonates: $BeCO_3 > MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$ (based on $r^+ << r^-$)

Increasing solubilities of alkali metals carbonates $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$ (exception to $r^+ << r^-$)

16. (d) (a) **Solubilities of bicarbonates:** $NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3$ because the extent of association of HCO_3^- by intermolecular H bonding decreases from $NaHCO_3$ to $CsHCO_3$.

(b) **Thermal stability:** $LiNO_3 < NaNO_3 < KNO_3 < RbNO_3 < CsNO_3$. Thermal stability of an ionic compound having polyatomic anion such as NO_3^- inversely is proportional to polarization.

(c) Solubilities of chromates of II A cations: $BeCrO_4 > MgCrO_4 > CaCrO_4 > SrCrO_4 > BaCrO_4$ (based on $r^+ << r^-$)

(d) Melting point of fluorides of alkali metals: NaF > KF > RbF > CsF (decided by L.E.)

17. (a) Thermal stability of an ionic compound having monoatomic anion ∝ lattice energy.

Hence, NaCl is the most thermally stable.

18. (d) Increasing covalent character: NaCl < CuCl < AgCl < AuCl.

Au^+ [Xe] $4f^{14}5d^{10}$; due to very poor shielding of $4f$ and $5d$ electrons, Au^+ has very high z_{eff}. value in comparision to Na^+, Cu^+, Ag^+. Hence, AuCl is most covalent.

31. (b) $KI + I_2 \longrightarrow KI_3$

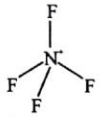
(*X*)

Anionic part of *X* is I_3^-

I_3^- has sp^3d-hybridization and linear geometry

I_3^- is planar

32. (d)

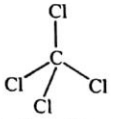


Hybridization of N: sp^3

$\angle FNF = 109.5°$

As all substituents are same.

(b)

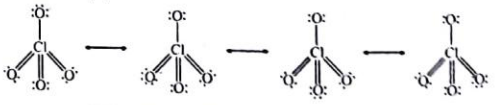


Hybridization of C: sp^3

$\angle ClCCl = 109.5°$

As all substituents are same.

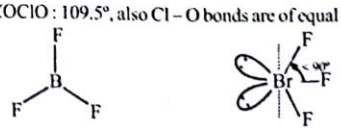
(c)



Hybridization of Cl: sp^3

$\angle OClO$: 109.5°, also Cl – O bonds are of equal length.

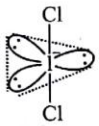
33. (b)



Hybridization of B: sp^2
Shape: trigonal planar

Hybridization of Br: sp^3d
Shape: bent T shape.

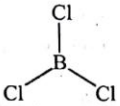
(b)

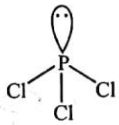


Hybridization: sp^3d
Shape: linear

Hybridization: sp
Shape: linear

(c)

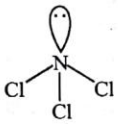


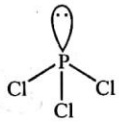


Hybridization of N: sp^3
Shape: trigonal planar

Hybridization of P: sp^3
Shape: triangular pyramidal

(d)

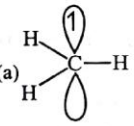




Hybridization of N: sp^3
Shape: triangular pyramidal

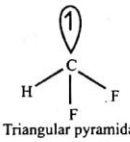
Hybridization of P: sp^3
Shape: triangular pyramidal.

34. (b) (a)



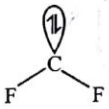
Planar

(b)



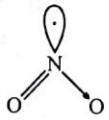
Triangular pyramidal (non-planar)

(c)



Planar (singlet carbene)

(d)



Planar

35. (c) $f_p = 3 \times \left(\frac{i}{i+1}\right) + \left(\frac{i'}{1+i'}\right) = \frac{3}{i}$

For sp^3

$\cos\theta\,(107) = \frac{-1}{i}$

$\cos 107° = 0.292$

$-0.292 = \frac{-1}{i}$

$i = 3.4$

$f_s = 3 \times \frac{i}{3.4+1} + \frac{1}{1+i'} = 1$

$i' = 2.13$

$sp^3 / sp^2 / sp^1$

$\Sigma f_s = 1$

$\Sigma f_p = 3$

36. (a) $\cos\theta = \frac{s}{(s-1)}$

$-0.3729 = \frac{s}{(s-1)} \quad \Rightarrow \quad \% = 27.1\%$

37. (a) F is more electronegative.

40. (b) As DCl_3 is trigonal planar; hence D belongs to boron family.

As ACl_3 is trigonal pyramidal; hence A belongs to nitrogen family.

$DCl_3 + ACl_3 \longrightarrow [DCl_2]^+[ACl_4]^-$ or $[ACl_2]^+[DCl_4]^-$

If anionic part is $[ACl_4]^-$ which has a see-saw structure, then cationic part will be $[DCl_2]^+$ where hybridization of D will be sp and hence shape will be linear.

If anionic part is DCl_4^- i.e., it is of tetrahedral shape, then cationic part will be ACl_2^+ which will be bent.

Assertion-Reasoning Type

2. (c) (i) PH_5 does not exist due to the absence of d-orbital contraction.

(ii) In PH_3 hybridization is absent according to Drago's rule.

3. (b) $Pb^{4+} + 2e^- \longrightarrow Pb^{2+}$

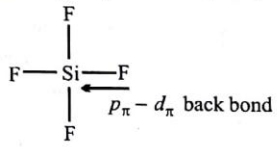
$Pb^{2+} > Pb^{4+}$ (due to inert pair effect).

$Tl^{3+} + 2e^- \longrightarrow Tl^+$

$Tl^+ > Tl^{3+}$ (due to inert pair effect).

6. (b) $3SiF_4 + 4H_2O \longrightarrow H_4SiO_4 + 2H_2\,[SiF_6]$

Out of three molecules of SiF_4, only one molecule becomes hydrolyzed. Hence, it is partial hydrolysis.



8. (c) M.O. configuration of

$N_2: \sigma 1s^2 < \overset{*}{\sigma}_{1s}{}^2 < \sigma 2s^2 < \overset{*}{\sigma}_{2s}{}^2 < \pi 2py^2 = \sigma 2pz^2 < \overset{*}{\sigma} 2px^2$

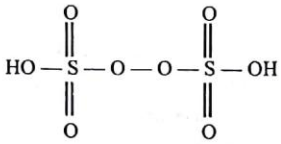
Number of bonding electrons in $N_2 = 10$

Number of bonding electrons in $N_2^- = 10$

Bond order of $N_2^+ = 2.5$; B.E. of $N_2^+ > N_2^-$ and B.E. of $N_2^+ > N_2^-$

Bond order of $N_2^- = 2.5$

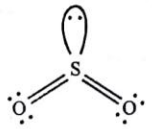
9. (b)



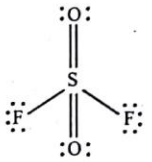
15. (a) $H_A^+\ H_B^- \leftrightarrow H_A^-\ H_B^+ \leftrightarrow H_A : H_B$

H_2 has ionic character (2%) due to instantaneous dipole.

19. (d)



Hybridization: sp^2



Hybridization: sp^3

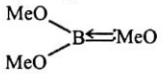
S – O bond distance in SO_2F_2 is not identical with that in SO_2.

24. (a) According to Coulson model.

25. (a) When size increases then polarization of ion increases and covalent character also increases and hence solubility in polar solvent decreases.

33. (d) According to Coulson model.

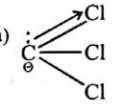
34. (a) $B(Me)_3 > B(MeO)_3$ due to back bonding.



Matching Column Type

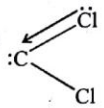
3. (a) p, q; (b) q, r, s; (c) q, t; (d) q, r, s, t

(a)



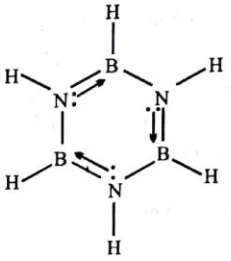
(i) $2p_\pi - 3d_\pi$ back bonding
(ii) $\mu \neq 0$
(iii) Polar
(iv) Non-planar

(b)



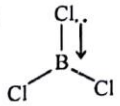
(i) $2p_\pi - 3p_\pi$ back bonding
(ii) Planar
(iii) $\mu \neq 0$, polar
(iv) Planar

(c) $B_3N_3H_6$



(i) $2p_\pi - 2p_\pi$ back bonding
(ii) $\mu = 0$
(iii) Non-polar
(iv) Planar

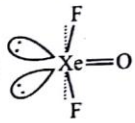
(d)



(i) $2p_\pi - 3p_\pi$ back bonding
(ii) $\mu = 0$
(iii) Non-polar
(iv) Direction of back bonding is from Cl to central atom
(v) Planar

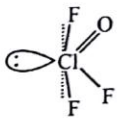
7. (a) p, r, s; (b) q, r, t; (c) r; (d) q, r, t

(a)



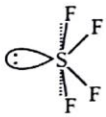
(i) sp^3d-hybridization
(ii) Bent T shape
(iii) Two lone pairs are present in equatorial position

(b)



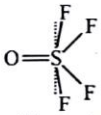
(i) sp^3d hybridization
(ii) See-saw shape
(iii) One lone pair is present in equatorial position

(c)



(i) sp^3d hybridization
(ii) See-saw shape
(iii) One lone pair is present in equatorial position

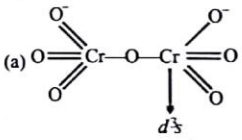
(d)



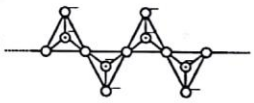
(i) sp^3d-hybridization
(ii) Trigonal bipyramidal shape

9. (a) p, q, t; (b) p, r; (c) r; (d) p, s, t

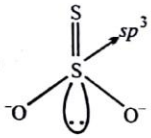
(a)



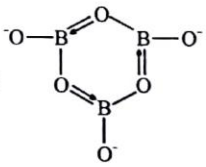
(b)



(c)



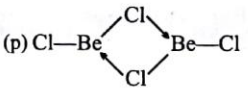
(d)



Aromatic, planar

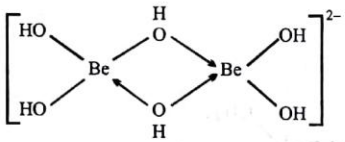
10. (a) p, q, r, s; (b) q, r; (c) p, q, r, s

(a) $BeCl_2$

(p) 

Dimer of $BeCl_2$ having two 3C – 4*e* bonds.

(q) $BeCl_2 \xrightarrow{H_2O}$



Polyhydroxy compound

$\downarrow$ NaOH

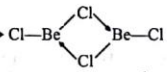
$[Be(OH)_4]^{2-}$

II

Hybridization of Be : sp^3

(r) Cl – Be – Cl ⇒ Planar molecule.

(s)

2Cl– Be– Cl $\xrightarrow{\text{dimerization}}$ 

Hybridization of Be: *sp*

Hybridization of Be : sp^3

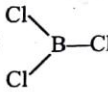
(b) BCl_3

(p) Due to $p\pi$–$p\pi$ back bonding and large size of Cl atom, BCl_3 does not undergo dimerization. Hence 3C–4$\bar{e}$ bonds cannot be formed.

(q) $BCl_3 \xrightarrow{H_2O} H_3BO_3$

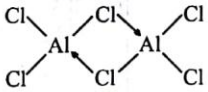
$\xrightarrow{OH^-} B(OH)_4^-$

Hybridization of B : sp^3

(r)  Hybridization of B: sp^2 ⇒ Planar

(c) $AlCl_3$

(p) $2AlCl_3$

$\xrightarrow{\text{dimerization}}$ 

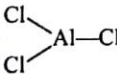
It has two 3C — 4$\bar{e}$ bonds.

(q) $AlCl_3 \underset{}{\overset{\text{Water}}{\rightleftharpoons}} Al^{3+}_{(aq.)} + 3Cl^-_{(aq.)}$

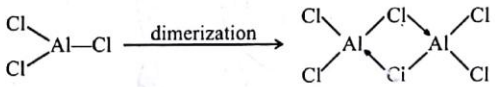
$\downarrow OH^-$

$[Al(OH)_4]^-$

Hybridization of Al: sp^3

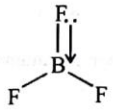
(r)  → Hybridization of Al: sp^2, hence planar

(s) 2

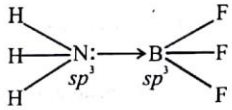


Hybridization of Al : sp^2 Hybridization of Al : sp^3

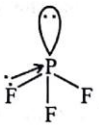
15. (a) p, r, t; (b) q; (c) p, s; (d) p, s

(a) 

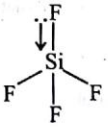
(i) $2p_\pi - 2p_\pi$ back bonding
(ii) Planar
(iii) $\mu = 0$
(iv) Inter Lewis acid–base interaction

(b) 

(i) Inter Lewis acid–base interaction
(ii) Non-planar
(iii) Back bonding absent because of the absence of vacant orbital on B-atom

(c) 

(i) $2p_\pi - 3d_\pi$ back bonding
(ii) Non-planar
(iii) Intra Lewis acid–base interaction.

(d) 

(i) $2p_\pi - 3d_\pi$ back bonding
(ii) Non-planar
(iii) Intra Lewis acid–base interaction

17. (a) p, r, s; (b) p, q, r; (c) p, t; (d) p, q, r, s

(a) B_2H_6

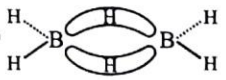
(p) B_2H_6 can act as Lewis acid

$B_2H_6(g) + 2NH_3 \xrightarrow{\Delta} [BH_2.2NH_3]^+ [BH_4]^-$

Lewis acid Lewis base

$\xrightarrow{\Delta} B_3N_3H_6$

Borazine

(s) 

Hybridization of each B: sp^3; hence non-planar.

(r) As molecule is symmetrical; therefore $\mu_D = 0$.

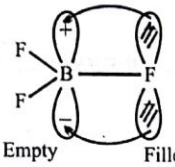
(b) BF_3

(p) BF_3 can act as Lewis acid due to vacant orbital at B in spite of $p\pi$–$p\pi$ back bonding.

$BF_3 + \ddot{N}H_3 \rightarrow F_3B{\cdot}NH_3$

Lewis acid Lewis base Adduct

(q)



Due to $p\pi$–$p\pi$ back bonding, intramolecular Lewis acid–base interaction occurs.

(s) BF_3: Planar

(r) μ_D of $BF_3 = 0$

(t) Does not undergo dimerization.

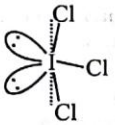
(c) ICl_3

(p) Due to vacant $5d$ orbitals at I atom, it can act as Lewis acid.

$$\underset{\text{Lewis acid}}{ICl_3} + \underset{\text{Lewis base}}{Cl^-} \rightarrow ICl_4^-$$

(q) Due to large size of I-atom, no back bonding is possible, i.e., no Lewis acid–base interaction internally occurs.

(s) Although ICl_3 exists in dimer form, but ICl_3 itself is planar.



Hybridization: sp^3d.
Shape: bent T shape

(r) μ_D of $ICl_3 = 0$

(t) It undergoes dimerization.

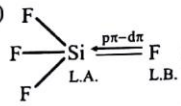
$$2ICl_3 \rightleftharpoons I_2Cl_6$$

(d) SiF_4

(p) Can act as Lewis acid

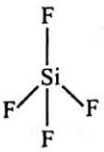
$$\underset{\text{Lewis acid}}{SiF_4} + \underset{\text{Lewis base}}{2F^-} \rightarrow [SiF_6]^{2-}$$

(q)



Due to $p\pi$–$p\pi$ back bonding in SiF_4 there is internal Lewis acid–base interaction.

(r)



Hybridization of Si: sp^3

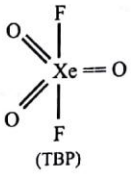
Shape: Regular tetrahedral; hence μ_D of $SiF_4 = 0$

(s) Non-planar

(t) Cannot undergo dimerization.

18. (a) s, t; (b) q, s; (c) p, q, r, s, t; (d) q, s, t

(a)

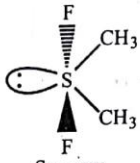


(TBP)

Xe is sp^3d-hybridized and d used is d_{z^2}

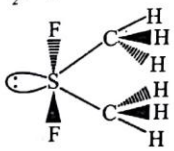
$\mu_{net} = 0$

(b)



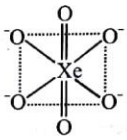
See-saw

S is $sp^3\ d_{z^2}$ hybridized.



Bold atoms are lying in the same plane

(c)

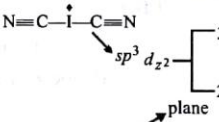


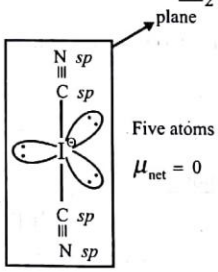
$sp^3\ d_{x^2-y^2}\ d_{z^2}$ or sp^3d^2-octahedral

5 atoms in plane.

$\mu_{net} = 0$, d used are — $d_{x^2-y^2}$, d_{z^2}

(d)



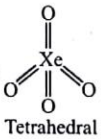


Five atoms are in plane

$\mu_{net} = 0$

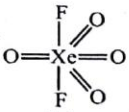
22. (a) q; (b) r; (c) s; (d) p

(a)



Tetrahedral

(b)

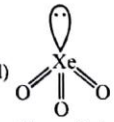


Trigonal bipyramidal

(c)

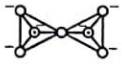
Octahedral

(d)



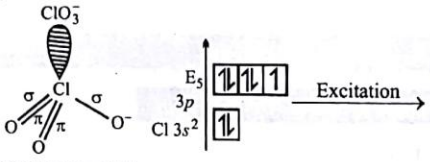
Pyramidal

Integer Answer Type

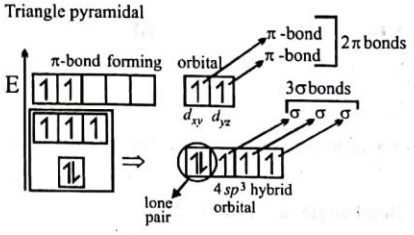
3. (1)  ⇒ pyrosilicate

Number of corner shared per tetrahedron = 1

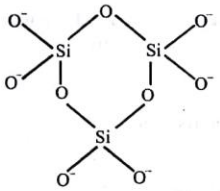
4. (2)



Triangle pyramidal



There are two $d_\pi - p_\pi$ bond.

9. (6)  $[Si_3O_9]^{6-}$

10. (3) 9σ and 2π-bonds

Butadiene is $CH_2 = CH - CH = CH_2$.

18. (2) Cl – Be – Cl

No. of 2C – $2e^-$ bonds = 2
No. of 3C – $4e^-$ bonds = 0
⇒ Total no. of 2C – $2e^-$ and 3C – $2e^-$ bonds = 2

19. (2)

$$SF_4 + 3H_2O \longrightarrow H_2SO_3 + 4HF$$

Basicity = 2 Basicity = 1

28. (0) C_2 (solid) does not exist but C_2 (vapor) has 2π bonds according to M.O.T.

29. (1) B_2 has 1π bond, according to M.O.T.

30. (2) $B_2 = \sigma^2_{(1s)}\ \overset{*}{\sigma}{}^2_{(1s)}\ \sigma^2_{(2s)}\ \overset{*}{\sigma}{}^2_{(2s)}\ \pi^1_{2p_y} = \pi^1_{2p_z}$

$$\text{Ratio} = \frac{\text{Number of } \sigma \text{ bonding } e^-}{\text{Number of } \pi \text{ bonding } e^-} = \frac{4}{2} = 2$$

31. (3) $C_2 = \sigma^2(1s)\,\overset{*}{\sigma}{}^2(1s)\sigma^2(2s)\overset{*}{\sigma}{}^2(2s)\,\pi 2p_y^2 = \pi 2p_z^2$

$$\text{Ratio} = \frac{\text{Number of } \sigma \text{ bonding electrons}}{\text{Number of } \pi \text{ bonding electrons}} = \frac{4}{4} = 1$$

32. (6) $P_4O_6 + 6H_2O \longrightarrow 4H_3PO_3$

33. (2) $H_2S_2O_8 + 2H_2O \longrightarrow 2H_2SO_4 + H_2O_2$

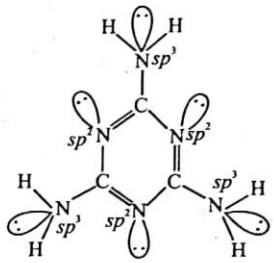
34. (4) $P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$

35. (5) $SiCl_4 + 4H_2O \longrightarrow H_4SiO_4 + 4HCl$

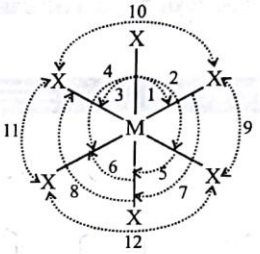
37. (2) $H_2S_2O_7 + H_2O \longrightarrow 2H_2SO_4$

55. (3) $\frac{9}{3} = 3$

56. (1) $\frac{3}{3} = 1$



63. (12)



64. (1) 01 + 0 = 1

69. (4) If vapor state of HF be $(HF)_n$

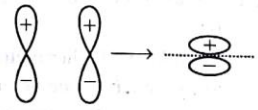
$P \times$ Mol. wt. $= dRT$

$1 \times$ Mol. wt. $= 3.248 \times 0.0821 \times 300$

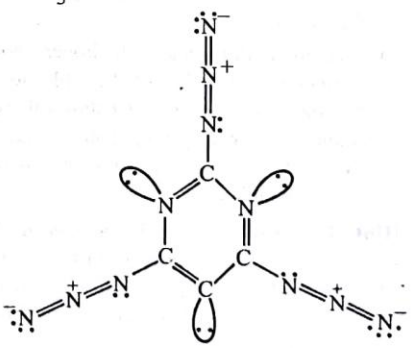
$n\,(20) =$ Mol. wt. $= 79.9 \simeq 80$

$n = 4$

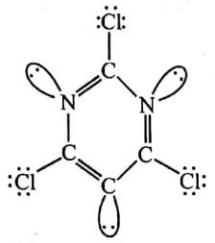
Hence, vapor state is represented as $(HF)_4$

71. (1)  Nodal plane

73. (5) $\frac{15}{3} = 5$



75. (1) $\frac{12}{12} = 1$

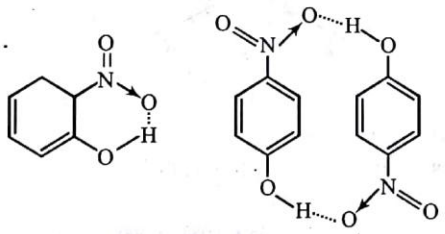


76. (3) $\frac{9}{3} = 3$

NCERT Exemplar Exercises

Short Answer Type

3.



(I) (II)

(a) Compound (I) will form intramolecular hydrogen bond because NO_2 and OH group are close together in comparison to that in compound (II).

(b) Compound (II) will have higher melting point because it forms intermolecular hydrogen bonds. Thus, more and more molecules are joined together through hydrogen bond formation.

(c) Due to intramolecular hydrogen bonding compound (I) will not be able to form hydrogen bonds with water thus will be less soluble in it while compound (II) can form hydrogen bond with water more easily and will be soluble in water.

6. [**Hint:** Dimethyl ether will have larger bond angle. There will be more repulsion between bond pairs of CH_3 groups attached in ether than between bond pairs of hydrogen atoms attached to oxygen in water. The carbon of CH_3 in ether is attached to three hydrogen atoms through bonds and electron pairs of these bonds add to the electronic charge density on carbon atom. Hence, repulsion between two $-CH_3$ groups will be more than that between two hydrogen atoms.]

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (b)

NH_3	BF_3
No. of σ bond = 3	No. of σ bond = 3
No. of lp = 1	No. of l-p = 0
No. of hybrid orbitals = 4	No. of hybrid orbitals = 3

Bond angle nearly $109° 28^1$

BF_4^-	sp^2
No. of σ bond = 4	Bond angle exactly 120°

No. of lp = 0

No. of hybrid orbitals = 4

sp^3 hybridization

Bond angle exactly $109° 28^1$

2. (b) Bond strength $\propto$ bond order

$O_2 \rightarrow \sigma_{1s}^2 < \sigma_{1s}^* < \sigma_{2s}^2 < \sigma_{2s}^{*2}\sigma_{2pz}^2 < \pi_{2px}^{1\downarrow} = \pi_{2py}^{1\downarrow} < \pi_{2px}^{*1} = \pi_{2py}^{*1}$

$$BO = \frac{10-6}{2} = 2$$

$$O_2^+ \Rightarrow BO = \frac{10-5}{2} = 2.5$$

$$O_2^- \Rightarrow BO = \frac{10-7}{2} = 1.5$$

$$O_2^{2-} \Rightarrow BO = \frac{10-8}{2} = 1$$

3. (a)

AlH_4	AlH_4^-	H_2O
No. of σ bond = 3	No. of σ bond = 4	No. of σ bond = 2
No. of lp = 0	No. of lp = 0	No. of lp = 2

No. of hybrid orbitals = 4

sp^2	sp^3	sp^3
H_3O^+	NH_3	NH_4^+
No. of σ bond = 3	No. of σ bond = 3	No. of σ bond = 4

No. of $lp = 1$	No. of $lp = 1$	No. of $lp = 0$
sp^3	sp^3	sp^3

4. (c) Condition for hydrogen bonding

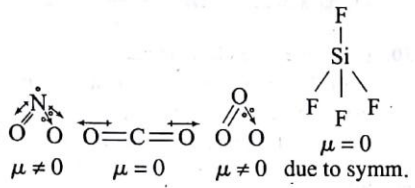
X—H-----Y

X = F, O, N

Y = F, O, N

In case of ether, there is no hydrogen bonding because hydrogen is directly attached with oxygen by covalent bond.

5. (b)



$\mu \neq 0$ $\mu = 0$ $\mu \neq 0$ $\mu = 0$ due to symm.

6. (b)

H_2O	(bond angle is 105°) sp^3
H_2S	(bond angle is 90°) no hybridization
NH_3	(bond angle is 107°) sp^3
SO_2	(bond angle is 120°) sp^2

7. (a)

XeF_2	**CO_2**	**BF_3**
No. of σ bond = 2	No. of σ bond = 2	No. of σ bond = 3
No. of $lp = 3$	No. of $lp = 0$	No. of $lp = 0$
sp^3d	sp	sp^3
Linear	Linear	Trigonal planar
PCl_3	**PF_5**	**IF_5**
No. of σ bond = 3	No. of σ bond = 5	No. of σ bond = 5
No. of $lp = 1$	No. of $lp = 0$	No. of $lp = 1$
sp^3	sp^3d	sp^3d^2
Trigonal pyramidal	Trigonal bipyramidal	Square pyramidal

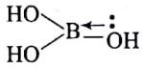
CF_4	**SF_4**
No. of σ bond = 4	No. of σ bond = 4
No. of $lp = 0$	No. of $lp = 1$
sp^3	sp^3d
Tetrahedral	See-Saw

8. (a)

H_2S	(Nearly 90°)
NH_3	(= 107°)
SiH_4	(109°28′)
BF_3	(120°)

9. (b) Bond length $\propto \dfrac{1}{\text{Bond order}}$

10. (b)

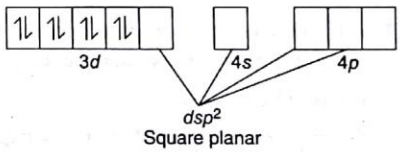


For boron	**For oxygen**
No. of σ bond = 3	No. of σ bond = 2
No. of $lp = 0$	No. of $lp = 1$
sp^2	sp^3

Because one lp involves in back bonding, so oxygen has sp^2 hybridisation.

11. (a)

BF_4^-	**SF_4**
[No. of σ bond = 4] sp^3	No. of σ bond = 4
No. of $lp = 0$	No. of $lp = 1$
All surrounding atoms are same	sp^3d
Perfect tetrahedral	See-Saw
XeF_4	**$[Ni(CN)_4]^{2-}$**
No. of σ bond = 4	$Ni \rightarrow 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^8\,4s^2$
No. of $lp = 2$	$Ni^{+2} \rightarrow 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^8\,4s^2$
sp^3d^2	CN^- S.F.L. Co. no. 4
Square planar	



12. (d)

dsp^2	squre planar	No. of 90° angles = 4
dsp^3/sp^3d	trigonal bipyramidal	No. of 90° angles = 6
sp^3d^2	square bipyramidal	No. of 90° angles = 12

13. (a) L.E. $\propto \dfrac{q_1 q_2}{d}$

q_1 and q_2 are magnitude of charge on the ions. d is the distance between ions.

14. (c)

N_2^+: $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \pi 2px^{1\downarrow} = \sigma 2py^{1\downarrow} < \sigma 2pz^1$

O_2: $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2a^2 < \sigma 2pz^2 < \pi 2px^{1\downarrow} = \pi 2py^{1\downarrow} < \pi^* 2px^1 = \pi^* 2py^1$

O_2^{2-}: $\sigma_{1s}^2 < \sigma_{1s}^{*2} < \sigma_{2s}^2 < \sigma_{2s}^{*2} < \sigma 2pz^2 < \pi 2px^{1\downarrow}$
$= \pi 2py^{1\downarrow} < \sigma^* 2px^{1\downarrow} = \sigma^* 2py^{1\downarrow}$

B_2: $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \pi 2px^1$
$= \pi 2py^1 < \sigma 2pz$

15. (d) **Note:** In sp^3d hybridization, all bond lengths are not equal. The three equatorial bonds are equivalent, while the two axial bonds are longer than equatorial bonds. This is due to the fact that the axial bond pairs suffer more repulsion as compared to equatorial bond pairs.

XeF_4	**BF_4^-**
No. of σ bond = 4	No. of σ bond = 4
No. of lp = 2	No. of lp = 0
sp^3d^2	sp^3
All bond lengths are equal	All bond lengths are equal
SF_4	**SiF_4**
No. of σ bond = 4	No. of σ bond = 4
No. of lp = 1	No. of lp = 0
sp^3d	sp^3
SF_4	**SiF_4**
See-Saw	All bond lengths are equal

Axial bond lengths are greater than equatorial.

16. (b) There is no hybridisation in SbH_3 due to Drago's rule.

17. (b) NO has 15 electrons; species having odd electrons are always paramagnetic.

O_2^+ has 15 electrons.

O_2: $\sigma_{1s}^2 < \sigma_{1s}^{*2} < \sigma_{2s}^2 < \sigma_{2s}^{*2} < \sigma_{2pz}^2 < \pi_{2px}^{1\downarrow}$
$= \pi_{2px}^{1\downarrow} < \pi_{2px}^{*\uparrow} < \pi_{2py}^{*\uparrow}$

O_2^{2-}: $\sigma_{1s}^2 < \sigma_{1s}^{*2} < \sigma_{2s}^2 < \sigma_{2s}^{*2} < \sigma_{2pz}^2 < \pi_{2px}^{1\downarrow}$
$= \pi_{2py}^{1\downarrow} < \pi_{2px}^{*1\downarrow} < \pi_{2py}^{*1\downarrow}$

18. (d) Smaller the cation and larger the positive charge on it more will be its polarizing power.

19. (c) N_2: $\sigma_{1s}^2 < \sigma_{1s}^{*2} < \sigma_{2s}^2 < \sigma_{2s}^{*2} < \pi_{2px}^{1\downarrow} = \pi_{2py}^{*1\downarrow} = \pi_{2pz}^2$

Diamagnetic BO $= \dfrac{10-4}{2} = 3$

N^{2+} paramagnetic BO $= \dfrac{9-4}{2} = 2.5$

C_2 diamagnetic BO $= \dfrac{8-4}{2} = 2.5$

C_2^+ paramagnetic BO $= \dfrac{7-4}{2} = 1.5$

NO: $\sigma_{1s}^2 < \sigma_{1s}^{*2} < \sigma_{2s}^2 < \sigma_{2s}^{*2} < \sigma_{2pz}^2 < \pi_{2px}^{1\downarrow}$
$= \pi_{2py}^{*\uparrow} < \pi_{2px}^{*\uparrow} = \sigma_{2py}^*$

Paramagnetic BO $= \dfrac{10-5}{2} = 2.5$

NO^+ diamagnetic BO $= \dfrac{10-4}{2} = 3$

O_2 paramagnetic BO $= \dfrac{7-5}{2} = 2$

O_2^+ paramagnetic BO $= \dfrac{10-5}{2} = 2.5$

20. (c) Higher the electronegativity of atoms attached with H, more will the charge on H and the electronegative atom therefore, more will be electrostatic force of attraction.

21. (a)

CN^-	No. of electrons = 14	B – O = 3
NO^+	No. of electrons = 14	B – O = 3
CN^+	No. of electrons = 13	B – O = 2.5
O_2^-	No. of electrons = 17	B – O = 1.5

22. (b) BF_3 is a Lewis acid due to incomplete octet of boron. Among BF_3, BCl_3, BBr_3, and so on, BF_3 is the weakest Lewis acid due to back bonding of lp electron of F to vacant P-orbital of boron.

Therefore, the bond strength of B–F bond is stronger than single bond between boron and fluorine, that is, in BF_4^-

23. (d)

O_2: $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2pz^2$
$< \pi 2px^{1\downarrow} = \pi 2py^{1\downarrow} < \pi^* 2px^1 = \pi^* 2py^1$

B.O. $= \dfrac{10-4}{2} = 2$

O_2^+: $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2pz^2$
$< \pi 2px^{1\downarrow} = \pi 2py^{1\downarrow} < \pi^* 2px^1 = \pi^* 2py$

B.O. $= \dfrac{10-5}{2} = 2.5$

O_2^-: $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2pz^2$
$< \pi 2px^{1\downarrow} = \pi 2py^{1\downarrow} < \pi^* 2px^{1\downarrow} = \pi^* 2py^1$

B.O. $= \dfrac{10-7}{2} = 1.5$

O_2^{2-}: $\sigma_{1s}^2 < \sigma_{1s}^{*2} < \sigma_{2s}^2 < \sigma_{2s}^{*2} < \sigma 2pz^2 < \pi 2px^{1\downarrow}$
$= \pi 2py^{1\downarrow} < \pi^* 2px^{1\downarrow} = \pi^* 2py^{1\downarrow}$

$$\text{B.O.} = \frac{10-8}{2} = 1$$

$$\left[\text{Bond length} \propto \frac{1}{\text{Bond order}}\right]$$

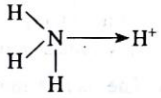
24. (c) If the anion is same, then the ionic character or covalent character depends on the size and charge on cation. Smaller the size and larger the charge on cation, more will be its polarizing power.

Fe^{2+} Sn^{+2} Al^{+3} Mg^{+2}

Polarizing power of Al^{+3} will be higher than other ions.

25. (b)

NO_3^- $O=N-O^-$ NO_2^+

No. of σ bonds = 3	$O=\overset{+}{N}=O$
No. of lp = 0	No. of σ bond = 2
No. of hybrid orbital = 3	No. of lp = 0
	No. of hybrid orbitals = 2
sp^2	sp
NH_4^+	
No. of σ bond = 4	
No. of lp = 0	
No. of hybrid orbital = 4	
sp^3	

26. (d) IF_7

No. of σ bond = 7

No. of hybrid orbitals = 7

sp^3d^3

Pentagonal bipyramidal

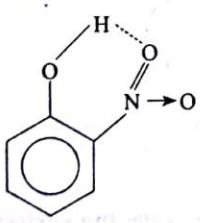
27. (d) $CaC_2 \Rightarrow Ca^{+2}\,C_2^{2-}$

$\bar{C} \equiv \bar{C}$

σ bond = 1

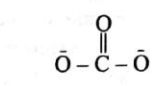
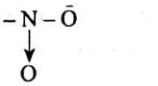
π bond = 2

28. (b)



In o-nitrophenol, there is intramolecular hydrogen bonding, whereas in *m*-nitrophenol and *p*-nitrophenol, there is no intramolecular hydrogen bonding. *o*-Nitrophenol has less tendency for hydrogen bonding with water than *m*- and *p*-nitrophenol

29. (c)

CO_3^{2-}	NO_3^-	PCl_4^+
		
No. of σ bond = 3	No. of σ bond = 3	No. of σ bond = 4
No. of lp = 0	No. of lp = 0	No. of lp = 0
sp^2	sp^2	sp^3
Trigonal planar	Trigonal planar	Tetrahedral
$Si(CH_3)_4$	**PF_5**	**BrF_5**
No. of σ bond = 4	No. of σ bond = 5	No. of σ bond = 5
No. of lp = 0	No. of lp = 0	No. of lp = 1
sp^3	sp^3d	sp^3d^2
Tetrahedral	Trigonal bipyramidal	Square pyramidal
AlF_6^{3-}	**SF_6**	
No. of σ bond = 6	No. of σ bond = 6	
No. of lp = 0	No. of lp = 0	
sp^3d^2	sp^3d^2	
Octahedral	Octahedral	

30. (b) $C_2 = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2$

$$\begin{cases}\pi 2p_y^2 \\ \pi 2p_z^2\end{cases} \text{(Diagmanetic)}$$

$N_2 = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2$

$$\begin{cases}\pi 2p_y^2 \\ \pi 2p_z^2\end{cases} \sigma 2p_x^2 \text{ (Diamagnetic)}$$

$O_2 = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2,$

$$\begin{cases}\pi 2p_y^2 \\ \pi 2p_z^2\end{cases}, \begin{cases}\pi^* 2p_y^1 \\ \pi^* 2p_z^1\end{cases} \text{(Paramagnetic)}$$

$S_2 = KK, LL, \sigma 3s^2, \sigma^* 3s^2,$

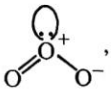
$$\begin{cases}\pi 3p_y^2 \\ \pi 3p_z^2\end{cases}, \begin{cases}\pi^* 3p_y^1 \\ \pi^* 3p_z^1\end{cases} \text{(Paramagnetic)}$$

C_2 and N_2 both are diamegnatic actully, but according to the language of question, **expected to be diamegnatic.**

If we consider energy leval diagram of C_2 and N_2 similar to O_2 then C_2 becomes paramagnetic and N_2 remains diamegnatic so best answer of question is N_2.

31. (a)

(i) Some times, two species having same valence shell electrons are considered as isolectronic species. Accordingly ONCl and ONO^- are isoelectronic to each other. **[Otherwise all four statements are correct and no answer is available in the given options].**

(ii)  , bent shaped

(iii) O_3 (g) = Blue

O_3 (l) = Dark blue

O_3 (s) = Violet-black

(iv) All electrons are paired in structure of O_3. Hence it is diamagnetic.

32. (c) According to M.O.T. species which has zero B.O., they do not exist.

Energy order of M.O. in H_2 and He_2 = $\sigma 1s$, σ^*_{1s}

$\Rightarrow$ H_2^{2+} have zero electron; B.O. = zero

$\Rightarrow$ He_2 have two bonding electron and two antibonding electrons; B.O. = zero

33. (b)

(i) I_2 is molecular solid in which I2 molecules are interacted by weak London forces.

(ii) Silicon exists in diamond like structure in which atoms of Si are bonded by covalent bond. Hence it is a covalent solid.

(iii) Sulphur is molecular solid in which S8 molecules are interacted by London force.

(iv) White phosphorous is a molecular solid in which P4 molecules are interacted by London force.

34. (b) Stability depends upon bond order

B.O. of Li_2, Li_2^+ and Li_2^- are 1, 0.5 and 0.5 respectively.

Hence $Li_2 > Li_2^+$

$Li_2 > Li_2^-$

while $Li_2^+ > Li_2^-$ due to higher interelectronic repulsion in Li_2^- which makes it least stable. Hence the order is $Li_2 > Li_2^+ > Li_2^-$

35. (c)

(1) $\underset{\text{(Colourless)}}{NO} + \underset{\text{(Air)}}{\frac{1}{2}O_2} \rightarrow \underset{\text{(Brown)}}{NO_2}$ (Correct statement)

(2) NO is odd e^- molecule which have B.O. = 2.5 (correct statement)

(3) NO has an unpaired e^- in its antibonding M.O. That is, it is paramagnatic compound (given statement in the question is incorrect)

(4) It is neutral towards litmus (correct statement)

36. (d) CsI_3 is an ionic compound and consisting of Cs^+ and I_3^-.

37. (c) $Ca^{+2}[C\equiv C]^{-2}$

38. (b) As the radius of halogen increase C—halogen bond length increased.

39. (a) O_2^- has one unpaired electron is π^* MO.

JEE (Advanced) Exercises

Fill in the Blanks Type

1. The angle between two covalent bonds is maximum in $\mathbf{CO_2}$.
It is a linear molecule and has 180° angle.

2. The pair of molecules which forms the strongest intermolecular hydrogen bonds is

$$\mathbf{HC-\underset{\underset{O}{\|}}{C}OH \text{ and } CH_3-\underset{\underset{O}{\|}}{C}-OH.}$$

These are two carboxylic acids and form strong hydrogen bonds.

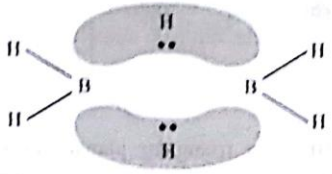
3. There are **two** π-bonds in a nitrogen molecule.
There is a triple bond which has one σ-bond and two π-bonds.

4. sp^3-Hybrid orbitals of nitrogen atom are involved in the formation of ammonium ion.

5. The shape of $[CH_3]^+$ is **triangular planar.**

CH_3^+, sp^2 carbon
In carbocations, carbon atom is sp^2-hybridized and they have a triangular planar shape.

6. The two types of bonds present in B_2H_6 are covalent and **three-center two-electron bonds.**



7. When N_2 goes to N_2^+, the N—N bond distance **increases**, and when O_2 goes to O_2^+, the O—O bond distance **decreases**.
The electron is removed from a bonding molecular orbital in nitrogen and from an antibonding molecular orbital in oxygen.

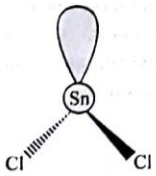
8. Among N_2O, SO_2, $I_3^{\oplus}$, and $I_3^{\ominus}$, the linear species are $\mathbf{N_2O}$ and $\mathbf{I_3^-}$.

True/False Type

1. **True.**
The linear overlap of two atomic *p*-orbitals leads to a σ-bond.

2. **False.**
All molecules with polar bonds do not have dipole moment. Sometimes due to regular shapes, dipole moment vectors cancel out each other and the molecule becomes non-polar.

3. **True.**
$SnCl_2$ is a non-linear molecule. It is V-shaped.

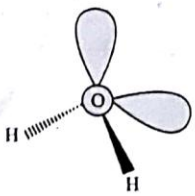


4. **False.**
In benzene, carbon uses only two *p*-orbitals for hybridization because it is sp^2-hybridized.

5. **False.**
sp^3-Hybrid orbitals have 25% *s* and 75% *p* characters.

6. **False.**
All molecules with polar bonds do not have dipole moment. Sometimes due to regular shapes, dipole moment vectors cancel out each other and the molecule becomes non-polar.

7. **False.**
H_2O molecule is V-shaped.



Single Correct Answer Type

1. (d) In NO, the octet is not complete:

2. (c) $K^+[C{\equiv}N]^-$
KCN consists of potassium ions and cyanide ions. In cyanide ion, there are also three covalent bonds.

3. (c) Six, because a triple covalent bond is formed between two nitrogen atoms.

4. (a) X^+Y^-
Ionic bond is expected to be formed between a highly electropositive and a highly electronegative element.

5. (a) H_2 is a covalent compound because it is formed by the sharing of electrons or in other words when the difference in electronegativities is less, then covalent bond is formed as in H_2.

6. (c)

Zero dipole moment means a triangular planar molecule is formed. And this shape is formed by sp^2-hybridization.

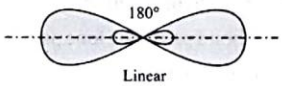
7. (a) In CO, there are 6 + 8 = 14 electrons.
In CN^-, there are 6 + 7 + 1 = 14 electrons.
CO is isoelectronic with CN^-.

8. (b)

In carbon tetrachloride, there is regular tetrahedral shape. All the dipole moment vectors cancel each other so that the resultant dipole moment comes out to be zero.

9. (d) HCl does not form hydrogen bonds because chlorine is not electronegative enough, and it has larger size, so hydrogen bonds are not formed. They are generally formed with fluorine, oxygen, and nitrogen.

10. (b)



Two *sp*-hybrid orbitals

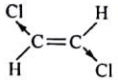
11. (a) In NO, there are 7 + 8 = 15 electrons. Definitely it has an unpaired electron.

12. (c)

The sulphur atom in sulphur dioxide is sp^2-hybridized, and it is a V-shaped molecule.

13. (d) The bond between two identical non-metal atoms has a pair of electrons equally shared between them.
They form a covalent bond which is totally non-polar because of the similar electronegativity.

14. (c)



In *trans*-1,2-dichloroethylene, net dipole moment is zero because the two dipole moment vectors are equal and opposite, and they cancel each other as shown.

15. (c)

CH_3^+, sp^2 carbon

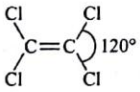
In carbocations, carbon atom is sp^2-hybridized and they have a triangular planar shape.

16. (a) CO_2 molecule is a linear molecule.

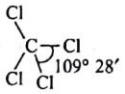
O=C=O

Central carbon is *sp*-hybridized.

17. (a)



Tetrachloroethene
sp^2-hybridized carbon



Tetrachloromethane
sp^3-hybridized carbon

18. (a)

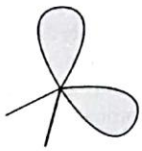
PCl_3 : sp^3-hybridization
Three bond pairs, one lone pair
Pyramidal shape

19. (a) O_2^- has 8 + 8 + 1 = 17 electrons. It must have at least one unpaired electron which makes it paramagnetic.

20. (b)

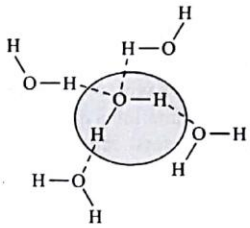
BF_3 is a triangular planar molecule where the resultant of three dipole moment vectors is equal to zero.

21. (a)



ClO_2^- : sp^3-hybridization
Two bond pairs, two lone pairs
Angular shape, V-shaped

22. (b)



Every water molecule can form a maximum of four hydrogen bonds. Two hydrogen bonds are formed through oxygen atom and one each from the two hydrogen atoms.

23. (d)

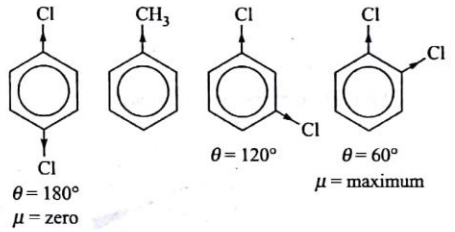
BF_3 has triangular planar molecule due to sp^2-hybridization.

24. (b) $Ca^{2+}[C{\equiv}C]^{2-}$
There is a triple bond between two carbon atoms which means that there is one σ-bond and there are two π-bonds.

25. (c) NF_3 and H_3O^+ are pyramidal structures with three bond pairs and two lone pairs due to sp^3-hybridization.

NO^-_3 are BF_3 triangular planar structures with three bond pairs and no lone pair due to sp^2-hybridization.

26. (b)



p-Dichlorobenzene < Toluene < *m*-Dichlorobenzene < *o*-Dichlorobenzene

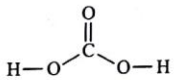
27. (b) The cyanide ions, CN^- and N_2 are isoelectronic, but in contrast to CN^-, N_2 is chemically inert because of the absence of polarity of bond.

28. (c) KO_2 is potassium superoxide. It contains one unpaired electron due to the presence of superoxide ion (O^-_2 ion) in it, which is paramagnetic.

29. (b)

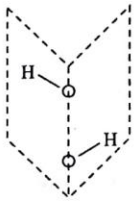
The sulphur atom in sulphur dioxide is sp^2-hybridized, and it is a V-shaped molecule.

30. (a)



H_2CO_3 is polar and the central carbon atom is sp^2-hybridized.

31. (c)



In hydrogen peroxide, O—O bond is non-polar, and O—H bonds are polar.

32. (d) Bond orders:

CO^{2-}_3 :1.33

CO_2 :2

CO:3

The higher the bond order, the lesser the bond length. So, the order of bond length of C—O is $CO < CO_2 < CO^{2-}_3$.

33. (a)

H_2S: sp^3-hybridization

Two bond pairs, two lone pairs

Angular shape, V-shaped

34. (d) $SF_4 \rightarrow sp^3d$, one lone pair, see-saw shape

$CF_4 \rightarrow sp^3$, no lone pair, tetrahedral

$XeF_4 \rightarrow sp^3d^2$, two lone pairs, square planar

35. (b) NO^+_2:

NO^+_2:

sp linear

Angle 180°

NO^-_3:

sp^2 triangular planar

Angle 120°

NH^+_4:

sp^3 tetrahedral

Angle 109°28'

36. (b) NH_3:sp^3; Pyramidal

$[PtCl_4]^{2-}$: dsp^2; Square planar

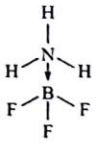
PCl_5: sp^3d; Trigonal bipyramidal

BCl_3: sp^2; Triangular planar

37. (a) CN^-, CO, and NO^+ have 14 electrons each, so they are isoelectronic.

Bond order in all of them is three according to molecular orbital theory.

38. (a)

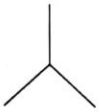


Both ammonia and BF_3 are tetrahedral and have sp^3-hybridization of the central atom.

39. (b) Be^-: $1s^2 2s^2 2p^1$ is the least stable of these ions.

40. (c) O_2^- has 8 + 8 + 1 = 17 electrons. It must have at least one unpaired electron which makes it paramagnetic.

41. (a)



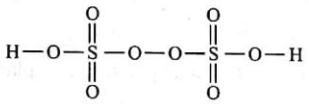
NO_3^{3-} and CO_3^{2-} ions are isoelectronic and isostructural.

CO_3^{2-}: 32 electrons

NO_3^-: 32 electrons

In both of these, the central atom is sp^2-hybridized with triangular planar shape.

42. (b)



$H_2S_2O_8$

43. (a)

	O_2^{2-}	O_2^-	O_2	O_2^+
Bond order	1	1.5	2	2.5
	Dia	Para	Para	Para

44. (b)

$XeOF_4$

sp^3d^2 hybridization

Five bond pairs, one lone pair

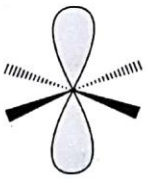
Square pyramidal shape

45. (d) ClO_3^-: sp^3

Three bond pairs, one lone pair

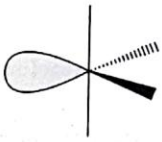
XeF_4: sp^3d^2

Four bond pairs, two lone pairs



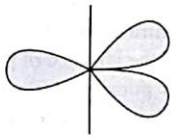
SF_4: sp^3d

Four bond pairs, one lone pair



I_3^-: sp^3d

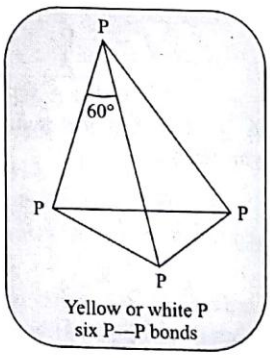
Two bond pairs, three lone pairs



46. (a) In NO^+, CN^-, and N_2, there are 14 electrons each, such as in CO, therefore the bond order would be similar (i.e., 3). In NO^-, there are 16 electrons and a different bond order, i.e., 2.

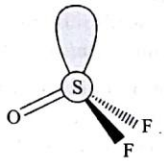
47. (d) KO_2 is potassium superoxide. It contains one unpaired electron due to the presence of superoxide ion, O_2^-, in it, which is paramagnetic.

48. (d)



sp^3-hybridization and 75% p-character.

49. (d)



OSF_2

sp^3-hybridization

Three bond pairs, one lone pair

Pyramidal shape

50. (b) $HNO_3 = +5$

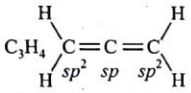
$NO = +2$

$NH_4Cl = -3$

$N_2 = 0$

So the correct order will be

HNO_3, NO, N_2, NH_4Cl

51. (b) 

52. (c) If 2s–2p mixing is not operative, then the energy sequence of molecular orbitals is

$\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \sigma^*_{2s} < \sigma_{2p_x} < \pi_{2p_y} = \pi_{2p_z} < \pi^*_{2p_y} = \pi^*_{2p_z} < \sigma^*_{2p_x}$

$Be_2(8e^-)$: 2 2 2 2 ⇒ Diamagnetic

$B_2(10e^-)$: 2 2 2 2 2 ⇒ Diamagnetic

$C_2(12e^-)$: 2 2 2 2 2 1 ⇒ Paramagnetic

$N_2(14e^-)$: 2 2 2 2 2 2 ⇒ Diamagnetic

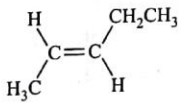
Multiple Correct Answers Type

1. (a), (b) Carbon dioxide is a linear molecule. $HgCl_2$ and C_2H_2 are linear molecules.

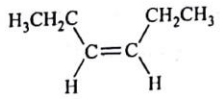
2. (b), (c), (d) $[O{=}N{=}O]^+, [N{\equiv}C{-}O]^-, S{=}C{=}S$

All these are linear molecules.

3. (b), (c)



trans-Pent-2-ene has dipole moment because on one side there is methyl group and on the other side there is ethyl group, so dipole moment vectors do not cancel out each other completely.

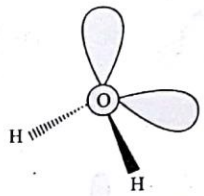


Hex-3-ene has dipole moment because dipole moment vectors do not cancel out each other .

4. (a), (c) CN^- and NO^+ have 14 electrons each and an identical bond order of three.

5. (b), (d) H_3O^+, NH_3, and CH_3^- have 10 electrons each, so they are isoelectronic.

6. (c), (d) Critical temperature of water is higher than that of O_2 because H_2O molecule has dipole moment. Its two covalent bonds are at an angle to each other and the dipole moment vectors do not cancel each other.



7. (b)

BF_3 has triangular planar molecule due to sp^2-hybridization.

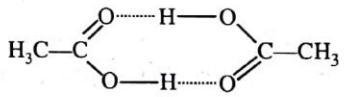
8. (a), (b), (c)

$N{\equiv}N \rightarrow O$

9. (b), (c), (d) **Hint:**

⇒ Ice floats in water due to the low density of ice as compare to water which is due to open cage like structure (formed by intermolecular H-bonding)

⇒ Dimerisation of acetic acid in benzene is due to intermolecular hydrogen bonding



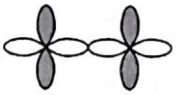
⇒ Basic strength of $RNH_2 > R_3N$ it also explained by hydrogen bonding.

Matching Column Type

1. (a) → (p, q, r, t); (b) → (q, r, s, t); (c) → (p, q, r); (d) → (p, q, r, s)

On the basis of molecular orbital theory, these conclusions can be made.

2. (c)

(a) 

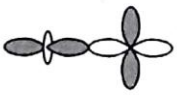
(1) d-d interaction produce bonding molecular orbital (due to addition of wave function)

(b)

(2) Lateral overlapping produce π bonding molecular orbital (addition of wave function)

(c)

(3) p-d interaction produce π antibonding molecular. Orbital (Substitution of wave function)

(d) 

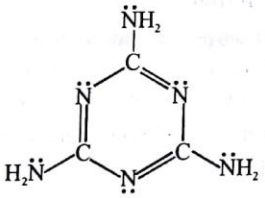
(4) d-d interaction produce antibonding molecular. Orbital (Substitution of wave function)

Integer Answer Type

1. (0)

2. (5)

3. (6) $C_3N_3(NH_2)_3$



Total six L.P.

4. (d) XeF_4, BrF_4^-, $[Cu(NH_3)_4]^{2+}$, $[PtCl_4]^{2-}$ are square planar

SF_4 – Sea-saw

SiF_4, BrF_4^-, $[FeCl_4]^{2-}$, $[CoCl_4]^{2-}$ are tetrahedral

Subjective Type

1. **Properties of covalent compounds:** When the difference in electronegativities of elements is lesser, covalent bond is formed.

Due to weaker forces of attraction, they have low melting and boiling points.

They are generally soft and waxy.

They are usually insoluble in polar solvents but soluble in non-polar solvents.

Properties of ionic compounds: When there is a large difference between the electronegativities of elements, then ionic bond is formed.

Due to stronger forces of attraction, they have high melting and boiling points

Generally they are hard and brittle.

As they are polar molecules, so are easily soluble in polar solvents.

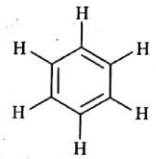
2. (i) $\left[:\ddot{\underset{..}{O}}:\ddot{\underset{..}{O}}:\right]^{2-}$ $\left[:\ddot{\underset{..}{F}}:\ddot{\underset{..}{F}}:\right]$

(ii) $\left[\begin{array}{c}:\ddot{\underset{..}{O}}:\underset{..}{C}:\ddot{\underset{..}{O}}:\\ \ddot{\underset{..}{O}}:\end{array}\right]^{2-}$ $\left[\begin{array}{c}:\ddot{\underset{..}{O}}:\underset{..}{S}:\ddot{\underset{..}{O}}:\\ \ddot{\underset{..}{O}}:\end{array}\right]$

(iii) $\left[:C:::N:\right]^{-}$ $\left[:N:::N:\right]$

(iv) $\left[:\ddot{N}::C::\ddot{S}:\right]^{-}$ $\left[:\ddot{O}::C::\ddot{O}:\right]$

3.



12 σ- and 3 π-bond:

4. S < Cl < N < O < F

The larger the electronegativity, the stronger the hydrogen bonding. It decreases with increasing size of the atom. Sulphur does not form any hydrogen bonds.

5. In H_2O_2, the oxidation number of oxygen is –1, so it can be increased up to 0 and decreased up to –2. Hence, it acts as a reducing as well as an oxidizing agent.

As oxidizing agent:

$$H_2O_2 + 2e^- \rightarrow 2OH^-$$

$$2Cr(OH)_3 + 4NaOH + 3H_2O_2 \rightarrow 2Na_2CrO_4 + 8H_2O$$

The oxidation number of chromium increases from +3 to +6.

As reducing agent:

$$H_2O_2 + 2OH^- \rightarrow O_2 + 2H_2O + 2e^-$$

$$2K_3[Fe(CN)_6] + 2KOH + H_2O_2 \rightarrow 2K_4[Fe(CN)_6] + 2H_2O + O_2$$

The oxidation number of iron decreases from +3 to +2.

6. Assuming 100% ionic character in KCl:

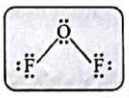
Calculated dipole moment = $e \times d$

$$\mu_{cal} = 1.6\times10^{-19} \times 2.6\times10^{-10} \text{ cm}$$
$$= 4.1\times10^{-29} \text{ cm}$$

$$\text{Percentage ionic character} = \frac{\mu_{observed}}{\mu_{calculated}} \times 100$$
$$= \frac{3.336\times10^{-29} \times 100}{4.1\times10^{-29}}$$
$$= 81.36\%$$

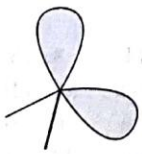
7. According to Fajan rules, the larger the anion, the more the polarizability power and therefore more is the polarization of the bond. Hence, more is the covalent character. Iodide ion is larger than fluoride ion, so lithium iodide is more covalent than lithium fluoride.

8. In OF_2, there are two lone pairs on oxygen atom and three lone pairs on each of the F atoms. Also, there are two bond pairs of electrons.



In OF_2, oxidation state of oxygen is +2, while the oxidation state of fluorine is −1. It is known as oxygen difluoride and not as oxide.

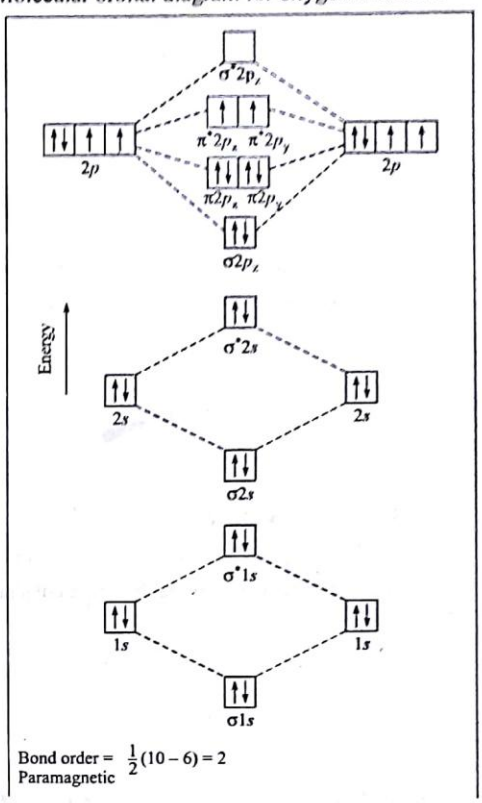
9.



H_2S: Four electron pairs around central atom; two bond pairs and two lone pairs tetrahedrally arranged; angular shape, V-shaped.

PCl_3: Four electron pairs around central atom; three bond pairs and one lone pair tetrahedrally arranged; pyramidal shaped.

10. Molecular orbital diagram for oxygen molecule



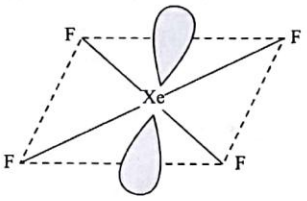
11. Anhydrous aluminium chloride is more soluble in diethyl ether because the oxygen atom of ether has lone pairs of electrons which can be donated into vacant *p*-orbitals of aluminium for interaction.

12.

PCl_5: Five electron pairs around central atom; five bond pairs, no lone pairs; trigonal bipyramidal shape.

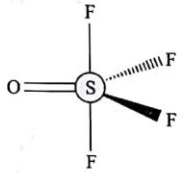
BrF_5: Six electron pairs around central atom; five bond pairs, one lone pair, octahedrally arranged; square pyramidal shape

13.



XeF_4: sp^3d^2-hybridization

Six electron pairs around central atom; four bond pairs, two lone pairs; square planar shape.



OSF_4: sp^3d-hybridized

Five electron pairs around central atom; four bond pairs, one lone pair; trigonal bipyramidal shape.

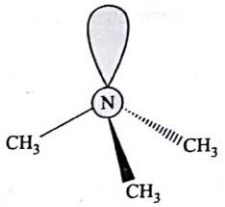
14.

	O_2^{2-}	O_2^-	O_2	O_2^+
Bond order	1	1.5	2	2.5
	Dia	Para	Para	Para

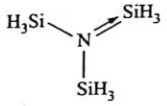
The larger the bond order, the smaller the bond length.

Therefore, $O_2^+[AsF_6]^- < O_2 < K^+O_2^-$

15.



$N(Me)_3$ is pyramidal in shape due to sp^3-hybridization.



$N(SiMe_3)_3$ is trigonal planar. Nitrogen atom shows sp^2-hybridization. The structure is stabilized by the donation of a lone pair of electrons from nitrogen into vacant *d*-orbitals of silicon.

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (a)	**2.** (b)	**3.** (a)	**4.** (b)	**5.** (b)	**6.** (a)	**7.** (d)	**8.** (b)	**9.** (b)	**10.** (d)
11. (c)	**12.** (a)	**13.** (d)	**14.** (c)	**15.** (a)	**16.** (c)	**17.** (a)	**18.** (d)	**19.** (c)	**20.** (b)
21. (d)	**22.** (b)	**23.** (d)	**24.** (d)	**25.** (c)	**26.** (d)	**27.** (a)	**28.** (d)	**29.** (d)	**30.** (b)
31. (b)	**32.** (d)	**33.** (d)	**34.** (d)	**35.** (c)	**36.** (d)	**37.** (a)	**38.** (c)	**39.** (d)	**40.** (c)
41. (c)	**42.** (b)	**43.** (b)	**44.** (a)	**45.** (b)	**46.** (a)	**47.** (c)	**48.** (d)	**49.** (d)	**50.** (d)
51. (a)	**52.** (b)	**53.** (a)	**54.** (b)	**55.** (a)	**56.** (a)	**57.** (a)	**58.** (b)	**59.** (b)	**60.** (a)
61. (c)	**62.** (d)	**63.** (b)	**64.** (c)	**65.** (a)	**66.** (d)	**67.** (b)	**68.** (b)	**69.** (c)	**70.** (c)
71. (a)	**72.** (b)	**73.** (a)	**74.** (b)	**75.** (c)	**76.** (a)	**77.** (a)	**78.** (a)	**79.** (a)	**80.** (d)
81. (b)	**82.** (d)	**83.** (b)	**84.** (c)	**85.** (d)	**86.** (c)	**87.** (d)	**88.** (c)	**89.** (b)	**90.** (d)
91. (a)	**92.** (d)	**93.** (c)	**94.** (b)	**95.** (b)	**96.** (c)	**97.** (d)	**98.** (d)	**99.** (c)	**100.** (c)
101. (b)	**102.** (b)	**103.** (d)							

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a)	**2.** (c)	**3.** (c)	**4.** (d)	**5.** (c)	**6.** (a)	**7.** (a)	**8.** (b)	**9.** (a)	**10.** (a)

11. (c)	12. (c)	13. (b)	14. (a)	15. (c)	16. (a)	17. (a)	18. (c)	19. (c)	20. (c)
21. (a)	22. (c)	23. (b)	24. (c)	25. (b)	26. (a)	27. (a)	28. (b)	29. (a)	30. (c)
31. (c)	32. (b)	33. (c)	34. (b)	35. (a)	36. (c)	37. (a)	38. (b)	39. (a)	40. (d)
41. (c)	42. (c)	43. (a)	44. (b)	45. (b)	46. (c)	47. (b)	48. (d)	49. (b)	50. (c)
51. (c)	52. (a)	53. (b)	54. (a)	55. (b)	56. (a)	57. (a)	58. (c)	59. (b)	60. (b)
61. (b)	62. (b)	63. (b)	64. (b)	65. (b)	66. (b)	67. (b)	68. (a)	69. (c)	70. (c)
71. (a)	72. (d)	73. (b)	74. (b)	75. (a)	76. (c)	77. (c)	78. (c)	79. (c)	80. (b)
81. (a)	82. (b)	83. (b)	84. (d)	85. (b)	86. (b)	87. (a)	88. (b)	89. (b)	90. (b)
91. (d)	92. (a)	93. (d)	94. (d)	95. (a)	96. (d)	97. (a)	98. (a)	99. (a)	100. (b)
101. (c)	102. (b)	103. (d)							

Multiple Correct Answers Type

1. (a), (b)	2. (a), (b), (c)	3. (a), (b), (c)	4. (a), (b), (c)	5. (a), (b), (c)
6. (a), (b), (c), (d)	7. (a), (b), (c)	8. (a), (b)	9. (a), (b), (c)	10. (a), (c)
11. (a), (b)	12. (a), (b), (c), (d)	13. (a), (b), (d)	14. (a), (b), (c), (d)	15. (a), (b), (c)
16. (a), (b), (c), (d)	17. (a), (b)	18. (c), (d)	19. (a), (b), (c), (d)	20. (a), (b), (c), (d)
21. (a), (b), (c), (d)	22. (a), (b), (d)	23. (a), (b), (c), (d)	24. (b), (c)	25. (b), (c)
26. (a), (d)	27. (a), (b), (c)	28. (b), (d)	29. (b), (c)	30. (a), (b), (c), (d)
31. (a), (b), (d)	32. (a), (c), (d)	33. (a), (b), (c)	34. (c), (d)	35. (b), (c), (d)
36. (b), (c), (d)	37. (b), (c)	38. (a), (c)	39. (a), (b), (d)	40. (a), (b), (d)
41. (a), (c), (d)	42. (b), (c), (d)	43. (a), (b), (d)	44. (a), (c)	45. (b), (c)
46. (b), (c)	47. (a), (b), (c)	48. (a), (c), (d)	49. (b), (c)	50. (a), (b)
51. (a), (b), (c), (d)	52. (b), (d)	53. (a), (b), (c), (d)	54. (a), (b), (c), (d)	55. (a), (b), (c), (d)
56. (a), (b), (c), (d)	57. (a), (b), (d)	58. (a), (b), (c), (d)	59. (a), (b)	60. (b), (c), (d)
61. (a), (b), (c), (d)	62. (a), (b), (c), (d)	63. (c), (d)	64. (a), (d)	65. (a), (c)
66. (a), (b)	67. (a), (b), (c)	68. (a), (b)	69. (a), (b), (c)	70. (a), (b), (c), (d)
71. (b), (c), (d)	72. (b), (c)	73. (a), (b), (c)	74. (a), (c)	75. (a), (b), (d)
76. (a), (d)	77. (a), (b), (c)	78. (a), (b), (c)	79. (a), (b)	80. (a), (b), (c)
81. (b), (d)	82. (a), (c)	83. (a), (b)	84. (a), (b), (c)	85. (a), (d)
86. (a), (b)	87. (a), (b), (c)	88. (a), (b), (c)	89. (a), (b)	90. (a), (b), (c)
91. (a), (b), (c), (d)	92. (a), (b), (c), (d)	93. (a), (c)	94. (a), (b), (c)	95. (a), (b), (d)
96. (a), (b), (c)	97. (c), (d)	98. (a), (c), (d)	99. (a), (b), (c)	100. (c), (d)
101. (a), (b), (c), (d)	102. (a), (b), (c)	103. (a), (b), (c)	104. (b), (c), (d)	105. (b), (c)
106. (b), (c), (d)	107. (a), (d)	108. (a), (b)	109. (b), (c), (d)	110. (a), (c)
111. (a), (b), (c)	112. (a), (b), (c), (d)	113. (a), (b), (c), (d)	114. (a), (b), (c)	115. (a), (b)
116. (a), (b), (c), (d)	117. (b), (d)	118. (a), (d)	119. (a), (b), (c), (d)	120. (c), (d)
121. (a), (b), (c)	122. (a), (b), (c), (d)	123. (a), (b), (c), (d)	124. (a), (c), (d)	125. (a), (b), (c), (d)
126. (a), (b), (c), (d)	127. (a), (c)	128. (b), (c), (d)	129. (a), (b), (c), (d)	130. (a), (c), (d)
131. (a), (b), (c), (d)	132. (a), (b), (c), (d)	133. (a), (d)	134. (a), (d)	

Comprehension Type

Comprehension-1	1. (b)	2. (a)	
Comprehension-2	3. (b)	4. (b)	5. (a)
Comprehension-3	6. (d)	7. (b)	8. (a)

Comprehension-4	**9.** (d)	**10.** (d)	**11.** (a)	
Comprehension-5	**12.** (b)	**13.** (d)	**14.** (b)	
Comprehension-6	**15.** (b)	**16.** (d)	**17.** (a)	**18.** (d)
Comprehension-7	**19.** (c)	**20.** (d)	**21.** (d)	
Comprehension-8	**22.** (d)	**23.** (c)	**24.** (c)	
Comprehension-9	**25.** (a)	**26.** (c)	**27.** (b)	**28.** (b)
Comprehension-10	**29.** (c)	**30.** (a)	**31.** (b)	
Comprehension-11	**32.** (d)	**33.** (b)	**34.** (b)	
Comprehension-12	**35.** (c)	**36.** (a)	**37.** (a)	
Comprehension-13	**38.** (a)	**39.** (b)	**40.** (b)	
Comprehension-14	**41.** (a)	**42.** (a)	**43.** (b)	

Assertion-Reasoning Type

1. (a)	**2.** (c)	**3.** (b)	**4.** (a)	**5.** (d)	**6.** (b)	**7.** (b)	**8.** (c)	**9.** (b)	**10.** (d)
11. (a)	**12.** (b)	**13.** (a)	**14.** (a)	**15.** (a)	**16.** (a)	**17.** (a)	**18.** (a)	**19.** (d)	**20.** (d)
21. (b)	**22.** (d)	**23.** (d)	**24.** (a)	**25.** (a)	**26.** (a)	**27.** (a)	**28.** (d)	**29.** (a)	**30.** (a)
31. (b)	**32.** (a)	**33.** (d)	**34.** (a)						

Matching Column Type

1. (a) s; (b) p; (c) p, q; (d) p, q, r
2. (a) p, q, r, s, t; (b) p, q, r, s, t; (c) p, r, s, t; (d) p, r, s, t
3. (a) p, q; (b) q, r, s; (c) q, t; (d) q, r, s, t
4. (a) q, t; (b) p, t; (c) q, t; (d) p, r, s
5. (a) p, q, s, t; (b) p, s, t; (c) q, s, t; (d) r, s, t
6. (a) q, r, t; (b) r, s, t; (c) s; (d) p, s
7. (a) p, r, s; (b) q, r, t; (c) r; (d) q, r, t
8. (a) p, q; (b) s; (c) r; (d) t
9. (a) p, q, t; (b) p, r; (c) r; (d) p, s, t
10. (a) p, q, r, s; (b) q, r; (c) p, q, r, s
11. (a) s; (b) p; (c) q; (d) p
12. (a) p; (b) q; (c) r; (d) r
13. (a) s; (b) p; (c) r; (d) q, t
14. (a) q, r; (b) p, s; (c) p, q
15. (a) p, r, t; (b) q; (c) p, s; (d) p, s
16. (a) p, r, s, t; (b) r; (c) q, s, t; (d) p, r, s, t
17. (a) p, r, s; (b) p, q, r; (c) p, t; (d) p, q, r, s
18. (a) s, t; (b) q, s; (c) p, q, r, s, t; (d) q, s, t
19. (a) q; (b) r; (c) s; (d) p, q
20. (a) r, t; (b) q, s; (c) r, t; (d) p, t
21. (a) p, q, r, s, t; (b) p, r, s, t; (c) q; (d) p, q, r, s, t
22. (a) q; (b) r; (c) s; (d) p
23. (a) p, r, s; (b) p, r, t; (c) q, r, s; (d) q, r, s
24. (a) p, q, r, s; (b) q, r, s; (c) p, q; (d) p, q
25. (a) r; (b) q; (c) p; (d) s

Integer Answer Type

1. (4)	2. (7)	3. (1)	4. (2)	5. (8)	6. (3)	7. (4)	8. (4,4)	9. (6)	10. (3)
11. (4)	12. (5)	13. (3)	14. (9 and 2)		15. (4)	16. (3)	17. (1)	18. (2)	19. (2)
20. (4)	21. (0)	22. (2)	23. (2)	24. (3)	25. (1)	26. (1)	27. (3)	28. (0)	29. (1)
30. (2)	31. (1)	32. (6)	33. (2)	34. (4)	35. (5)	36. (1)	37. (2)	38. (2)	39. (4)
40. (3)	41. (5)	42. (3)	43. (3)	44. (3)	45. (4)	46. (0)	47. (4)	48. (1)	49. (4)
50. (1)	51. (1)	52. (4)	53. (2)	54. (0)	55. (3)	56. (1)	57. (5)	58. (4)	59. (5)
60. (6)	61. (6)	62. (4)	63. (12)	64. (1)	65. (2)	66. (5)	67. (3)	68. (3)	69. (4)
70. (2)	71. (1)	72. (2)	73. (5)	74. (2)	75. (1)	76. (3)			

NCERT Exemplar Exercises

Single Correct Answer Type

1. (b)	2. (c)	3. (b)	4. (b)	5. (b)	6. (d)	7. (a)	8. (c)	9. (c)	10. (b)
11. (d)	12. (b)	13. (a)	14. (b)	15. (d)	16. (b)	17. (a)	18. (b)		

Multiple Correct Answers Type

1. (a), (b), (d)
2. (a), (b)
3. (c), (d)
4. (c), (d)
5. (a), (b)

Matching Column Type

1. (a) → (c); (b) → (a); (c) → (e); (d) → (d)
2. (a) → (e); (b) → (a); (c) → (b); (d) → (c)
3. (a) → (d); (b) → (e); (c) → (b); (d) → (a)
4. (a) → (c); (b) → (a); (c) → (b)

Assertion-Reasoning Type

1. (a)
2. (a)
3. (d)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (b)	2. (b)	3. (a)	4. (c)	5. (b)	6. (b)	7. (a)	8. (a)	9. (b)	10. (b)
11 (a)	12 (d)	13 (a)	14 (c)	15 (d)	16. (b)	17. (b)	18 (d)	19. (c)	20. (c)
21. (a)	22. (b)	23. (d)	24. (c)	25. (b)	26. (d)	27. (d)	28. (b)	29. (c)	30. (b)
31. (a)	32. (c)	33. (b)	34. (b)	35. (c)	36. (d)	37. (c)	38. (b)	39. (a)	

JEE (Advanced) Exercises

Single Correct Answer Type

1. (d)	2. (c)	3. (c)	4. (a)	5. (a)	6. (c)	7. (a)	8. (b)	9. (d)	10. (b)
11. (a)	12. (c)	13. (d)	14. (c)	15. (c)	16. (a)	17. (a)	18. (a)	19. (a)	20. (b)

21. (a) **22.** (b) **23.** (d) **24.** (b) **25.** (c) **26.** (b) **27.** (b) **28.** (c) **29.** (b) **30.** (a)
31. (c) **32.** (d) **33.** (a) **34.** (d) **35.** (b) **36.** (b) **37.** (a) **38.** (a) **39.** (b) **40.** (c)
41. (a) **42.** (b) **43.** (a) **44.** (b) **45.** (d) **46.** (a) **47.** (d) **48.** (d) **49.** (d) **50.** (b)
51. (b) **52.** (c)

Multiple Correct Answers Type

1. (a), (b) **2.** (b), (c), (d) **3.** (b), (c) **4.** (a), (c) **5.** (b), (d)
6. (c), (d) **7.** (b) **8.** (a), (b), (c) **9.** (a, b, d)

Matching Column Type

1. (a) → (p,q,r,t); (b) → (q,r,s,t); (c) → (p,q,r); (d) → (p,q,r,s) **2.** (c)

Integer Answer Type

1. (8) **2.** (5) **3.** (6) **4.** (d)

2

Coordination Compounds

JEE (Main) Exercises

Single Correct Answer Type

1. Ligand with two or more points of attachment to single metal atoms are called:
   (a) Monodentate ligand
   (b) Chelating ligand
   (c) Ambidentate ligand
   (d) None of these
2. Select the correct I.U.P.A.C. name for $[Cr(NH_3)_3Cl_3]$ complex:
   (a) Triamminetrichloridochromate(III)
   (b) Triamminetrichloridochromium(III)
   (c) Trichloridotriamminechromium(III)
   (d) Trichloridotriamminechromate(III)
3. Select the correct I.U.P.A.C. name for $[Cu(NH_3)_4][PtCl_4]$:
   (a) Tetraamminecopper(II) tetrachloridoplatinum(II)
   (b) Tetraamminecopper(II) tetrachloridoplatinum(IV)
   (c) Tetraamminecopper(II) tetrachloridoplatinate(II)
   (d) Tetraamminecuprate(II) tetrachloridoplatinate(II)
4. Select the correct I.U.P.A.C. name for $Cr(C_6H_6)(CO)_3$:
   (a) (η^6-benzene) tricarbonylchromate (0)
   (b) Tricarbonyl (η^6-benzene)chromate (0)
   (c) Tricarbonyl (η^6-benzene)chromium (0)
   (d) (η^6-benzene) tricarbonylchromium (0)
5. I.U.P.A.C. name for complex $[Mn(\pi\text{–}C_5H_5)(CO)_3]$:
   (a) Tricarbonyl (η^5–cyclopentadiene)manganese(I)
   (b) Tricarbonyl (η^5–cyclopentadiene)mangate(I)
   (c) Tricarbonyl (η^5-cyclopentadienyl)manganese(I)
   (d) (η^5-cyclopentadienyl) tricarbonyl manganese(I)
6. Select the correct order of E.A.N:
   (a) $[Cr(CO)_6] > [Cr(CO)_6]^{\ominus} > [Cr(CO)_6]^{\oplus}$
   (b) $[Cr(CO)_6]^{+} > [Cr(CO)_6]^{\ominus} > [Cr(CO)_6]$
   (c) $[Cr(CO)_6]^{\ominus} > [Cr(CO)_6] > [Cr(CO)_6]^{\oplus}$
   (d) $[Cr(CO)_6]^{\ominus} = [Cr(CO)_6] > [Cr(CO)_6]^{+}$
7. Which of following complex has higher Δ_o value?
   (a) $[Fe(H_2O)_6]^{3+}$ (b) $[Fe(H_2O)_6]^{2+}$
   (c) $[Fe(CN)_6]^{3-}$ (d) All have equal
8. Among the following ions which one has the highest paramagnetism?
   (a) $[Cr(H_2O)_6]^{3+}$ (b) $[Fe(H_2O)_6]^{2+}$
   (c) $[Cu(H_2O)_6]^{2+}$ (d) $[Zn(H_2O)_6]^{2+}$
9. The calculated value of magnetic moment of $_{22}Ti^{3+}$ is:
   (a) 1.73 μ_B (b) 2.83 μ_B
   (c) 3.87 μ_B (d) 4.9 μ_B
10. The I.U.P.A.C. name for $[Fe(CN)_6]^{3-}$ ion is:
   (a) Hexacyanidoferrate(II) ion
   (b) Hexacyanidoferrate(III) ion
   (c) Hexacyanideiron(II) ion
   (d) Iron(III) hexacyanide ion

11. The I.U.P.A.C. name for $[Ni(CO)_4]$ is:
(a) Tetracarbonylnickel(II)
(b) Tetracarbonylnickel(0)
(c) Tetracarbonylnickelate(II)
(d) Tetracarbonylnickelate(0)

12. The number of ions produced by the complex $[Co(NH_3)_4Cl_2]Cl$ is:
(a) 2 (b) 3
(c) 4 (d) 6

13. The I.U.P.A.C. name for $[Ni(CN)_4]^{2-}$ is:
(a) Tetracyanidonickel (II) ion
(b) Tetracyanidonickel (0) ion
(c) Tetracyanidonickelate (II) ion
(d) Tetracyanidonickelate (0) ion

14. The I.U.P.A.C. name for $K_3[Co(NO_2)_6]$ is:
(a) Potassium(I) hexanitrocobaltate (II)
(b) Potassium(I) hexanitrocobaltate (IV)
(c) Potassium hexanitrocobalt (0)
(d) Potassium hexanitrocobaltate (III)

15. Which of the following complex is diamagnetic?
(a) $[CoF_6]^{3-}$ (b) $[NiCl_4]^{2-}$
(c) $[Ni(NH_3)_6]^{2+}$ (d) $[Ni(CN)_4]^{2-}$

16. Which of the following is a tridentate ligand?
(a) NO_2^- (b) Oxalate ion
(c) Glycinate ion (d) Dien

17. How many ions are produced from $[Co(NH_3)_6]Cl_3$ in the solution?
(a) 3 (b) 4
(c) 5 (d) 6

18. A complex involving dsp^2-hybridization has:
(a) A square planar geometry
(b) A tetrahedral geometry
(c) An octahedral geometry
(d) Trigonal planar geometry

19. A complex involving d^2sp^3-hybridization is:
(a) A square planar geometry
(b) A tetrahedral geometry
(c) An octahedral geometry
(d) Trigonal planar geometry

20. Zeise's salt is:
(a) $Fe(\eta^5 - C_5H_5)_2$
(b) $Cr(\eta^6 - C_6H_6)_2$
(c) $K[Pt(\eta^2 - C_2H_4)Cl_3]$
(d) $K[Pt(\eta^2 - C_2H_4)_2Cl_2]$

21. Which of the following complex ion possesses d^2sp^3 hybridization?
(a) $[Ni(NH_3)_6]^{2+}$ (b) $[CoF_6]^{3-}$
(c) $[Co(NH_3)_6]^{3+}$ (d) $[FeF_6]^{3-}$

22. Which of the following complex ion possesses dsp^2 hybridization?
(a) $[Ni(CN)_4]^{2-}$ (b) $[Ni(CO)_4]$
(c) $[NiCl_4]^{2-}$ (d) $[Ni(PF_3)_4]$

23. Which of the following complex ion possesses sp^3d^2 hybridization?
(a) $[Cr(NH_3)_6]^{3+}$ (b) $[FeF_6]^{3-}$
(c) $[Co(NO_2)_6]^{3-}$ (d) $[TiF_6]^{3-}$

24. Which of the following complex is paramagnetic?
(a) $K_2[Ni(CN)_4]$ (b) $K_4[Fe(CN)_6]$
(c) $[Co(NH_3)_6]Cl_3$ (d) $[Cr(H_2O)_6]SO_4$

25. The color of a complex compound is due to:
(a) Promotion of 3*d*-electrons of the central atom/ion to 4*s*-orbital
(b) Promotion of 3*d*-electrons of the central atom/ion to 4*p*-orbitals
(c) Promotion of 3*d*-electrons of the central atom/ion within *d*-orbitals
(d) Promotion of 4*s*-electrons of the central atom/ion to 4*p*-orbitals

26. Relative to the average energy in the spherical crystal field, the t_{2g} orbitals in tetrahedral field is:
(a) Raised by $(2/5)\Delta_t$ (b) Lowered by $(2/5)\Delta_t$
(c) Raised by $(3/5)\Delta_t$ (d) Lowered by $(1/5)\Delta_t$

27. Which is the pair of ambident ligands?
(a) CN^-, NO_2^- (b) NO_3^-, SCN
(c) N_3^-, NO_2^- (d) NCS^-, $C_2O_4^{2-}$

28. The closed ring compounds formed by bidentate ligands, on binding to a metal or metal ions, are called:
(a) Monodentate (b) Chelates
(c) Ambidentate (d) None of these

29. Coordination number of Cu^{2+} is ..... in $CuSO_4 \cdot 5H_2O$:
(a) 5 (b) 4
(c) 3 (d) 2

30. Coordination number of calcium is six in:
(a) $[Ca(EDTA)]^{2-}$ (b) CaC_2O_4
(c) $[Ca(C_2O_4)_2]^{2-}$ (d) $CaSO_4 . 4H_2O$

31. Increasing order of EAN of the metals in $[Ni(CN)_4]^{2-}$, $[Fe(CN)_6]^{3-}$ and $[Cu(CN)_4]^{3-}$ is:
(a) $[Ni(CN)_4]^{2-} < [Fe(CN)_6]^{3-} < [Cu(CN)_4]^{3-}$
(b) $[Ni(CN)_4]^{2-} < [Fe(CN)_6]^{3-} = [Cu(CN)_4]^{3-}$

(c) $[Ni(CN)_4]^{2-} < [Cu(CN)_4]^{3-} < [Fe(CN)_6]^{3-}$

(d) $[Cu(CN)_4]^{3-} < [Fe(CN)_6]^{3-} < [Ni(CN)_4]^{2-}$

32. $[Co(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_6][Co(CN)_6]$ are:

(a) Linkage isomers (b) Ionization isomers

(c) Coordination isomers (d) None of these

33. The crystal field splitting energy for octahedral (Δ_o) and tetrahedral (Δ_t) complexes is related as:

(a) $\Delta_t = \frac{4}{9}\Delta_o$ (b) $\Delta_t = \frac{1}{2}\Delta_o$

(c) $\Delta_o = -2\Delta_t$ (d) $\Delta_o = -\frac{4}{9}\Delta_t$

34. Which has maximum coordinating (donor) points?

(a) DMG (b) EDTA

(c) en (d) py

35. Which is used in cancer chemotherapy?

(a) *cis*-platin (b) Zeisse's salt

(c) Both (a) and (b) (d) None of these

36. In which of the following compounds, transition metal may have zero oxidation state?

(a) $[Fe(CO)_5]$ (b) $[Ni(CN)_4]^{2-}$

(c) Fe_2O_3 (d) CrO_5

37. A square planar complex is formed by hybridization of which atomic orbitals?

(a) s, p_x, p_y, d_{yz} (b) $s, p_x, p_y, d_{x^2-y^2}$

(c) s, p_x, p_y, d_{z^2} (d) s, p_y, p_z, d_{xy}

38. The type of isomerism present in pentaammine nitro chromium(III) chloride is:

(a) Optical (b) Linkage

(c) Hydrate (d) Polymerization

39. Which one of the following has the largest number of isomers?

(a) $[Co(en)_2Cl_2]^+$ (b) $[Co(NH_3)_5Cl]^{2+}$

(c) $[Ir(PR_3)_2H(CO)]^{2+}$ (d) $[Ru(NH_3)_4Cl_2]^+$

40. The correct order of magnetic moment (spin values in B.M.) is:

(Atomic no. Mn = 25, Fe = 26, Co = 27)

(a) $[Fe(CN)_6]^{4-} > [CoCl_4]^{2-} > [MnCl_4]^{2-}$

(b) $[MnCl_4]^{2-} > [Fe(CN)_6]^{4-} > [CoCl_4]^{2-}$

(c) $[Fe(CN)_6]^{4-} > [MnCl_4]^{2-} > [CoCl_4]^{2-}$

(d) $[MnCl_4]^{2-} > [CoCl_4]^{2-} > [Fe(CN)_6]^{4-}$

41. Which one of the following has the regular tetrahedral structure?

(a) $[Ni(CN)_4]^{2-}$ (b) SF_4

(c) BF_4^- (d) XeF_4

42. The I.U.P.A.C. name of the coordination compound $K_3[Fe(CN)_6]$ is:

(a) Potasssium hexacyanidoferrate(II)

(b) Potassium hexacyanidoferrate(III)

(c) Potassium hexacyanidoiron(II)

(d) Tripotassium hexacyanidoiron(II)

43. Which one of the following has the lowest value of paramagnetic behavior:

(a) $[Cr(CN)_6]^{3-}$ (b) $[Mn(CN)_6]^{3-}$

(c) $[Fe(CN)_6]^{3-}$ (d) $[Co(CN)_6]^{3-}$

44. The species having tetrahedral shape is:

(a) $[PdCl_4]^{2-}$ (b) $[Ni(CN)_4]^{2-}$

(c) $[Pt(CN)_4]^{2-}$ (d) $[NiCl_4]^{2-}$

45. $[Cr(H_2O)_6]Cl_3$ (atomic number of Cr = 24) has a magnetic moment of 3.83 B.M. The correct distribution of 3*d*-electrons in the chromium present in the complex is:

(a) $3d^1_{xy}, 3d^1_{yz}, 3d^1_{zx}$ (b) $3d^1_{xy}, 3d^1_{yz}, 3d^1_{z^2}$

(c) $3d^1_{(x^2-y^2)}, 3d^1_{z^2}, 3d^1_{zx}$ (d) $3d^1_{xy}, 3d^1_{(x^2-y^2)}, 3d^1_{xz}$

46. A complex compound in which the oxidation number of metal is zero:

(a) $[Ni(CO)_4]$ (b) $[Pt(NH_3)_4]Cl_2$

(c) $K_4[Fe(CN)_6]$ (d) $K_3[Fe(CN)_6]$

47. $[Co(NH_3)_5NO_2]Cl_2$ and $[Co(NH_3)_5ONO]Cl_2$ are related to each other as:

(a) Geometrical isomers

(b) Linkage isomers

(c) Coordination isomers

(d) Ionization isomers

48. Which one of the following will be able to show geometrical isomerism if complexes are square planar?

(a) Ma_4 (b) Ma_3b

(c) *Mabcd* (d) $[M(AA)_2]$

49. $K_4[Fe(CN)_6]$ is called:

(a) Potassium hexacyanidoferrate(II)

(b) Potassium ferricyanate

(c) Potassium ferricyanide

(d) Prussian blue

50. Among the following ions which one has the highest paramagnetism?

(a) $[Cr(H_2O)_6]^{3+}$ (b) $[Fe(H_2O)_6]^{2+}$

(c) $[Cu(H_2O)_6]^{2+}$ (d) $[Zn(H_2O)_4]^{2+}$

51. The number of geometrical isomers of $[Co(NH_3)_3(NO_3)_3]$ is:

(a) 0 (b) 2
(c) 3 (d) 4

52. Some salts, although containing two different metallic elements, give test for one of them in solution. Such salts are:
(a) Complex salt (b) Double salt
(c) Normal salt (d) None of these

53. Coordination number of Ni in $[Ni(C_2O_4)_3]^{4-}$ is:
(a) 3 (b) 6
(c) 4 (d) 5

54. Both geometrical and optical isomerisms are shown by:
(a) $[Co(en)_2Cl_2]^+$ (b) $[Co(NH_3)_5Cl]^{2+}$
(c) $[Co(NH_3)_4Cl_2]^+$ (d) $[Cr(OX)_3]^{3-}$

55. In $[Cr(C_2O_4)_3]^{3-}$, the isomerism shown is:
(a) Ligand (b) Optical
(c) Geometrical (d) Ionization

56. The hypothetical complex chlorido diaquatriammine cobalt (III) chloride can be represented as:
(a) $[Co(NH_3)_3(H_2O)_2Cl]Cl_2$
(b) $[Co(NH_3)_3H_2OCl_3]$
(c) $[Co(NH_3)_3(H_2O)Cl]$
(d) $[Co(NH_3)_3(H_2O)_3Cl_3]$

57. In the coordination compound $K_4[Ni(CN)_4]$, the oxidation state of Ni is:
(a) –1 (b) 0
(c) +1 (d) +2

58. Which of the following octahedral complex does not show geometrical isomerism (*A* and *B* are monodentate ligands)?
(a) $[MA_3B_3]$ (b) $[MA_4B_2]$
(c) $[MA_5B]$ (d) $[MA_2B_4]$

59. The geometry of $[Ni(CN)_4]^{2-}$ and $[NiCl_4]^{2-}$ ions are:
(a) Tetrahedral (b) Square planar
(c) Square planar, tetrahedral, respectively
(d) Tetrahedral and square planar, respectively

60. The complex used as an anticancer agent is:
(a) *mer*-$[Co(NH_3)_3Cl_3]$ (b) *cis*-$[PtCl_2(NH_3)_2]$
(c) *cis*-$K_2[PtCl_2Br_2]$ (d) $Na_2[CoCl_4]$

61. The ligand called π-acid is:
(a) CO (b) NH_3
(c) $C_2O_4^{2-}$ (d) Ethylene diamine

62. The effective atomic number of cobalt in the complex $[Co(NH_3)_6]^{3+}$ is:
(a) 36 (b) 33
(c) 24 (d) 30

63. Facial-meridional isomers is associated with which one of the following complex? (M = central metal)
(a) $[M(AA)_2]$ (b) $[MA_3B_3]$
(c) $[M(AA)_3]$ (d) $[MABCD]$

64. Which one of the following is a tridenate ligand?
(a) NO_2^- (b) Oxalate ion
(c) Glycinate ion (d) Dien

65. Assign the hybridization, shape, and magnetic moment of $K_2[Cu(CN)_4]$ are:
(a) sp^3, tetrahedral, 1.73 B.M.
(b) dsp^2, square planar, 1.73 B.M.
(c) sp^3, tetrahedral, 2.44 B.M.
(d) dsp^2, square planar, 2.44 B.M.

66. Hardness of water is estimated by simple complex formation titration. Complex formed by cation in hard water during estimation of hardness is:
(a) $Na_2[Ca(PO_3)_6]$ (b) $Na_2[Mg(EDTA)]$
(c) $Na_2[Pb(EDTA)]$ (d) $[Ca(SO_4)_2]^{2-}$

67. The I.U.P.A.C. name for $[Ni(NH_3)_4][NiCl_4]$ is:
(a) Tetrachloridonickel(II)-tetraamminenickel(II)
(b) Tetraamminenickel (II)-tetrachloridonickel (II)
(c) Tetraamminenickel (II)-tetrachloridonickelate (II)
(d) Tetrachloridonickel (II)-tetraamminenickelate (II)

68. In which of the following coordination entities, the magnitude of Δ_0[CFSE in octahedral field] will be maximum?
(a) $[Co(CN)_6]^{3-}$ (b) $[Co(NO_2)_6]^{3-}$
(c) $[CoF_6]^{3-}$ (d) $[Co(NH_3)_6]^{3+}$

69. Hybridization, shape, and magnetic moment of $K_3[Co(CO_3)_3]$ are:
(a) d^2sp^3, octahedral, 4.9 B.M.
(b) sp^3d^2, octahedral, 4.9 B.M.
(c) dsp^2, square planar, 4.9 B.M.
(d) sp^3, tetrahedral, 4.9 B.M.

70. Geometry, hybridization, and magnetic moment of the ions $[Ni(CN)_4]^{2-}$, $[MnBr_4]^{2-}$ and $[FeF_6]^{3-}$, respectively are:
(a) Tetrahedral, square planar, octahedral: sp^3, dsp^2, sp^3d^2: 5.9, 0, 4.9
(b) Tetrahedral, square planar, octahedral: dsp^2, sp^3, sp^3d^2: 0, 5.9, 4.9
(c) Square planar, tetrahedral, octahedral: dsp^2, sp^3, d^2sp^3: 5.9, 4.9, 0
(d) Square planar, tetrahedral, octahedral: dsp^2, sp^3, sp^3d^2: 0, 5.9, 4.9

71. In Cu-ammonia complex, the state of hybridization of Cu^{2+} is:

(a) sp^3 (b) d^3s

(c) sp^2 (d) dsp^2

72. The total number of possible coordination isomer for the given compound $[Pt(NH_3)_4Cl_2][PtCl_4]$ is:

(a) 2 (b) 4

(c) 5 (d) 3

73. E.A.N. of $K[PtCl_3(\eta^2\text{-}C_2H_4)]$ is:

(a) 86 (b) 78

(c) 84 (d) 34

74. Ag^+ forms many complexes, some of these are $[Ag(NH_3)_2]^+$, $[Ag(CN)_2]^-$, $[Ag(S_2O_3)_2]^{3-}$. Which of the following statements is true?

(a) In these complexes, Ag^+ is a Lewis base

(b) The hybridization of Ag^+ is sp^2

(c) The Ag^+ complexes are good reducing agents

(d) These complexes are all linear

75. The following complexes are given:

(1) *trans*-$[Co(NH_3)_4Cl_2]^+$ (2) *cis*-$[Co(NH_3)_2(en)_2]^{3+}$

(3) *trans*-$[Co(NH_3)_2(en)_2]^{3+}$

(4) $[NiCl_4]^{2-}$

(5) $[TiF_6]^{2-}$

(6) $[CoF_6]^{3-}$

Choose the correct code:

(a) 1, 2 are optically active; 3 optically inactive

(b) 2 is optically active; 1, 3 are optically inactive

(c) 4, 5 are colored; 6 is colorless

(d) 4 is colored; 5, 6 are colorless

76. The number of σ and π - bonds in $Fe_2(CO)_9$, respectively are:

(a) 22σ and 15π (b) 23σ and 15π

(c) 22σ and 16π (d) 15σ and 8π

77. In which of the following configurations will there be the possibility of both para and diamagnetism, depending on the nature of the ligands?

(a) d^7 (b) d^3

(c) d^6 (d) d^5

78. An aqueous solution of titanium chloride, when subjected to magnetic measurement, measured zero magnetic moment. Assuming the complex as octahedral in aqueous solution, the formula of the complex is:

(a) $[Ti(H_2O)_6]Cl_2$ (b) $[Ti(H_2O)_6]Cl_4$

(c) $[TiCl_6]^{3-}$ (d) $[Ti(H_2O)_4Cl_2]$

79. Which of the following statements is correct?

(a) With d^2sp^3 hybridization $[FeCl(CN)_4(O_2)]^{4-}$ complex is diamagnetic

(b) $[NiCl_4]^{2-}$ complex is more stable than $[Ni(dmg)_2]$ due to higher C.F.S.E. value

(c) $[V(CO)_6]$ is not very stable and easily reduces to $[V(CO)_6]^-$

(d) Ligands such as CO, CN^-, NO^+ are π e^- donor due to the presence of filled π-molecular orbital

80. Select the correct I.U.P.A.C. name for $[Pt(NH_3)_4][PtCl_4]$:

(a) Tetraammineplatinum(II) tetrachloridoplatinate(II)

(b) Tetraammineplatinate(II) tetrachloridoplatinate(II)

(c) Tetraammineplatinate(II) tetrachloridoplatinum(II)

(d) All are correct

81. Select the correct I.U.P.A.C. name for $[Co(NH_3)_6][Co(ONO)_6]$:

(a) Hexaamminecobalt(II) hexanitrito-O cobalt(II)

(b) Hexaamminecobalt(III) hexanitrito-N cobaltate(III)

(c) Hexaamminecobaltate(III) hexanitrito-O cobaltate(II)

(d) Hexaamminecobalt(III) hexanitrito-O cobaltate(III)

82. Select the correct I.U.P.A.C. name for $[PtCl_2(NH_3)_4][PtCl_4]$:

(a) Tetraamminedichloridoplatinate(IV) tetrachloridoplatinate(II)

(b) Tetraamminedichloridoplatinate(II) tetrachloridoplatinate(IV)

(c) Tetraamminedichloridoplatinum(IV) tetrachloridoplatinate(II)

(d) All are correct

83. Select the correct I.U.P.A.C. name for $Na[Co(CO)_4]$:

(a) Sodium tetracarbonylcobalt (–I)

(b) Sodium tetracarbonylcobalt (0)

(c) Sodium tetracarbonylcobaltate (0)

(d) Sodium tetracarbonylcobaltate (–I)

84. Select the correct I.U.P.A.C. name for $Fe(\pi\text{–}C_5H_5)_2$:

(a) bis(η^6-cyclopentadienyl) iron(II)

(b) bis(η^5-cyclopentadienyl) ferrate(II)

(c) bis(η^5-cyclopentadienyl) iron(0)

(d) bis(η^5-cyclopentadienyl) iron(II)

85. Select the correct I.U.P.A.C. name for $[Cr(C_6H_6)_2]$:

(a) bis(η^5-benzene) chromium(0)

(b) bis(η^6-benzene) chromate(0)

(c) bis(η^6-benzene) chromate(0)

(d) bis(η^6-benzene) chromium(0)

JEE (Advanced) Exercises

Single Correct Answer Type

1. Select the correct I.U.P.A.C. name for $[Co(CO)_3(\pi\text{-}C_3H_5)]$:
   (a) (η^3-Allyl) tricarbonyl cobalt(I)
   (b) (Tricrbonyl) (η^3-allyl) cobalt(I)
   (c) Tricarbonyl (η^3-allyl) cobaltate(I)
   (d) Tricarbonyl (η^3-allyl) tricarbonylcobalt(I)
2. E.A.N. of $[Fe(\eta^5\text{–}C_5H_5)(CO)_2Cl]$:
   (a) 36 (b) 35
   (c) 37 (d) 34
3. For Mn^{3+} ion, the electron pairing energy P is about 28,000 cm^{-1}, Δ_o values for the complexes $[Mn(H_2O)_6]^{3+}$ and $[Mn(CN)_6]^{3-}$ are 15,800 cm^{-1} and 38,500 cm^{-1}, respectively, which of the following complex is high spin:
   (a) $[Mn(CN)_6]^{3-}$ (b) $[Mn(H_2O)_6]^{3+}$
   (c) Both are high spin (d) None of these
4. If a transition-metal compound absorbs violet-indigo radiation in the visible region. Its color would be:
   (a) Green (b) Yellow
   (c) Orange (d) Blue
5. Transition metal compounds are usually colored. This is due to the electronic transition:
   (a) From *p*-orbital to *s*-orbital
   (b) From *d*-orbital to *s*-orbital
   (c) From *d*-orbital to *p*-orbital
   (d) Within the *d*-orbitals
6. A substance which is not paramagnetic is:
   (a) $Cr(ClO_4)_3$ (b) $KMnO_4$
   (c) $TiCl_3$ (d) $VOBr_2$
7. The following represents a pair of enantiomers:
   (a) *trans*-$[CrCl_2\,en_2]^+$ (b) *cis*-$[CrCl_2\,en_2]^+$
   (c) *trans*-$[CrCl_2(NH_3)_4]^+$ (d) *cis*-$[CrCl_2(NH_3)_4]^+$
8. The compound $[PtCl_2(NH_3)_2]$ can form:
   (a) Geometrical isomers (b) Coordination isomers
   (c) Linkage isomers (d) Optical isomers
9. The compound $[CoCl_2(NH_3)_2\,(en)]$ can form:
   (a) Linkage isomers
   (b) Coordination isomers
   (c) Optical isomers
   (d) Linkage as well as optical isomers
10. Which of the following complexes has magnetic moment of 2.83 Bohr magneton?
   (a) $[Ni(NH_3)_6]^{2+}$ (b) $[Ni(CN)_4]^{2-}$
   (c) $TiCl_4$ (d) $[CoCl_6]$
11. According to crystal field theory, octahedral splitting and tetrahedral splitting of *d* orbitals caused by the same ligands are related through the expression:
   (a) $\Delta_o = \Delta_t$ (b) $4\Delta_o = 9\Delta_t$
   (c) $9\Delta_o = 4\Delta_t$ (d) $\Delta_o = 2\Delta_t$
12. Relative to the average energy in the spherical crystal field, the t_{2g} orbitals in octahedral field is:
   (a) Raised by $(2/5)\Delta_o$ (b) Lowered by $(2/5)\Delta_o$
   (c) Raised by $(1/5)\Delta_o$ (d) Lowered by $(3/5)\Delta_o$
13. Which of the following ligands are correctly represented in an spectrochemical series?
   (a) $SCN^- < F^- < CN^-$ (b) $SCN^- < CN^- < F^-$
   (c) $F^- < SCN^- < CN^-$ (d) $F^- < CN^- < SCN^-$
14. In the complex $[Pt(O_2)\,(en)_2\,(Br)]^{2+}$, coordination number and oxidation number of platinum are:
   (a) 4, 3 (b) 4, 5
   (c) 4, 6 (d) 6, 4
15. Coordination number of Cr is six. A complex with $C_2O_4^{2-}$, en and superoxide O_2^- will be in the ratio to make complex $[Cr(C_2O_4)_x\,(en)_y\,(O_2)_z]^-$:

	x	y	z
(a)	1	1	1
(b)	1	1	2
(c)	1	2	2
(d)	2	1	1

16. EAN of Fe is ... in $[Fe(C_2O_4)_3]^{3-}$:
   (a) 27 (b) 24
   (c) 35 (d) 29
17. EAN of cobalt is 36 in $[Co(NH_3)_2O_2(en)Cl]$. Thus, O_2 is:
   (a) Dioxide (b) Superoxide ion
   (c) Peroxide ion (d) Oxide
18. EAN of Mg is ... in $[Mg(EDTA)]^{2-}$:
   (a) 16 (b) 20
   (c) 22 (d) 18
19. Which has maximum EAN of the underlined atoms? (Cr = 24, Co = 27, Fe = 26, Ni = 28)
   (a) $[\underline{Cr}(EDTA)]^-$ (b) $[\underline{Co}(en)_3]^{3+}$
   (c) $[\underline{Fe}(C_2O_4)_3]^{3-}$ (d) $[\underline{Ni}(CN)_4]^{2-}$

20. Arrange the following in order of decreasing number of unpaired electrons:

I: $[Fe(H_2O)_6]^{2+}$ II: $[Fe(CN)_6]^{3-}$

III: $[Fe(CN)_6]^{4-}$ IV: $[Fe(H_2O)_6]^{3+}$

(a) IV, I, II, III (b) I, II, III, IV

(c) III, II, I, IV (d) II, III, I, IV

21. Among $[Ni(CO)_4]$, $[Ni(CN)_4]^{2-}$ and $[NiCl_4]^{2-}$ species, the hybridization state of Ni atoms are respectively:

(a) sp^3, ds^2p, dsp^2 (b) sp^3, dsp^2, sp^3

(c) sp^3, sp^3, dsp^2 (d) dsp^2, sp^3, sp^3

22. The most stable ion is:

(a) $[Fe(C_2O_4)_3]^{3-}$ (b) $[Fe(Cl)_6]^{3-}$

(c) $[Fe(SCN)_6]^{3-}$ (d) $[Fe(H_2O)_6]^{3+}$

23. One mole of complex compound $Co(NH_3)_5Cl_3$ gives 3 moles of ions on dissolution in water. One mole of the same complex reacts with two moles of $AgNO_3$ to yeild two moles of $AgCl_{(s)}$. The complex is:

(a) $[Co(NH_3)_4Cl_2]Cl \cdot NH_3$

(b) $[Co(NH_3)_4Cl]Cl_2 \cdot NH_3$

(c) $[Co(NH_3)_5Cl]Cl_2$ (d) $[Co(NH_3)_3Cl_3] \cdot 2NH_3$

24. Which of the following will show optical isomerism?

(a) $[Cu(NH_3)_4]^{2+}$ (b) $[ZnCl_4]^{2-}$

(c) $[Cr(C_2O_4)_3]^{3-}$ (d) $[Co(CN)_6]^{3-}$

25. The bond length of C—O bond in carbon monoxide is 1.128 Å. The C—O bond in $Fe(CO)_5$ is:

(a) 1.115 Å (b) 1.128 Å

(c) 1.178 Å (d) 1.150 Å

26. In which of the following pairs both the complexes show optical isomerism?

(a) *cis*-$[Cr(C_2O_4)_2Cl_2]^{3-}$, *cis*-$[Co(NH_3)_4Cl_2]$

(b) $[Co(en)_3]Cl_3$, *cis*-$[Co(en)_2Cl_2]Cl$

(c) [Pt Cl (en)Cl], $[NiCl_2Br_2]^{2-}$

(d) $[Co(NO_3)_3(NH_3)_3]$, *cis*-$[Pt(en)_2Cl_2]$

27. The oxidation number of Pt in $[Pt(C_2H_4)Cl_3]^{\ominus}$ is:

(a) +1 (b) +2

(c) +3 (d) +4

28. Which of the following gives the maximum number of isomers?

(a) $[Co(NH_3)_4Cl_2]$ (b) $[Ni(en)(NH_3)_4]^{2+}$

(c) $[Ni(C_2O_4)(en)_2]$ (d) $[Cr(SCN)_2(NH_3)_4]^+$

29. Consider the following complex:

$$[Co(NH_3)_5CO_3]ClO_4$$

the coordination number, oxidation number, number of *d*-electrons, and number of unpaired *d*-electrons of the metal are respectively:

(a) 6, 3, 6, 0 (b) 7, 2, 7, 1

(c) 7, 1, 6, 4 (d) 6, 2, 7, 3

30. The common features among the species CN^-, CO, and NO^+ are:

(a) Bond order three and isoelectronic

(b) Bond order three and weak field ligands

(c) Bond order two and π-acceptors

(d) Isoelectronic and weak field ligands

31. The possible number of optical isomers in $[Co(en)_2Cl_2]^+$ are:

(a) 2 (b) 3

(c) 4 (d) 6

32. Which of the following does not have optical isomers?

(a) $[Co(en)_3]Cl_3$ (b) $[Co(NH_3)_3Cl_3]$

(c) $[Co(en)_2Cl_2]Cl$ (d) $[Co(en)(NH_3)_2Cl_2]Cl$

33. Which of the following has a square planar geometry?

(a) $[PtCl_4]^{2-}$ (b) $[CoCl_4]^{2-}$

(c) $[FeCl_4]^{2-}$ (d) $[NiCl_4]^{2-}$

34. Which of the following will give a pair of enantiomorphs?

(a) $[Cr(NH_3)_6][Co(CN)_6]$ (b) $[Co(en)_2Cl_2]Cl$

(c) $[Pt(NH_3)_4][PtCl_6]$ (d) $[Co(NH_3)_4Cl_2]NO_2$

35. Both Co^{3+} and Pt^{4+} have a coordination number of 6. Which of the following pairs of complexes will show approximately the same electrical conductance for their 0.001M aqueous solutions?

(a) $CoCl_3 \cdot 4NH_3$ and $PtCl_4 \cdot 4NH_3$

(b) $CoCl_3 \cdot 3NH_3$ and $PtCl_4 \cdot 5NH_3$

(c) $CoCl_3 \cdot 6NH_3$ and $PtCl_4 \cdot 5NH_3$

(d) $CoCl_3 \cdot 5NH_3$ and $PtCl_4 \cdot 6NH_3$

36. The increasing order of the crystal field splitting power of some common ligands is:

(a) $H_2O < NO_2^- < \overset{\ominus}{C}N < NH_3$

(b) $NH_3 < NO_2^- < \overset{\ominus}{C}N < H_2O$

(c) $H_2O < NH_3 < NO_2^- < \overset{\ominus}{C}N$

(d) $H_2O < NH_3 < \overset{\ominus}{C}N < NO_2$

37. The EAN of Fe atom in $(CO)_3Fe(CO)_3$ $Fe(CO)_3$ is:

(a) 34 (b) 35

(c) 36 (d) 37

38. Which of the pair of complex compounds are tetrahedral as well as diamagnetic?

(a) $[CoCl_4]^-$ and $[Co(CO)_4]^-$

(b) $[Ag(SCN)_4]^{2-}$ and $[NiCl_4]^{2-}$

(c) $[Co(CO)_4]^-$ and $[Ni(CN)_4]^{4-}$

(d) $[PdCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$

39. If $H_x[Pt\ y_6]$, y is a monodentate negatively charged ligand then find out the value of x:

(a) 5 (b) 3

(c) 6 (d) None of these

40. Select the correct IUPAC name of $K_2[Cd(CN)_4]$:

(a) Potassium tetracyanidocadmate (II)

(b) Potassium tetracyanidocadmate (2–)

(c) Both (a) and (b) (d) None of these

41. Select the correct order of magnetic moment (in B.M.) from the following options:

(a) $[MnCl_4]^{2-} > [CoCl_4]^{2-} > [Fe(CN)_6]^{4-}$

(b) $[Fe(CN)_6]^{4-} > [MnCl_4]^{2-} > [CoCl_4]^{2-}$

(c) $[Fe(CN)_6]^{2-} > [CoCl_4]^{2-} > [MnCl_4]^{2-}$

(d) $[MnCl_4]^{2-} > [Fe(CN)_6]^{4-} > [CoCl_4]^{2-}$

42. When $K_4[Fe(CN)_6]$ is treated with $FeCl_3$, a blue color is obtained. It is due to the formation of:

(a) $Fe^{II}[Fe^{III}(CN)_6]^-$ (b) $Fe^{III}[Fe^{II}(CN)_6]^-$

(c) Both (a) and (b) (d) None of these

43. In isolated condition C—C bond length of C_2H_4 is x, than the bond length of C—C bond of C_2H_4 in Zeise's salt is:

(a) Greater than x (b) Less than x

(c) Equal to x (d) None of these

44. The correct I.U.P.A.C. name for $H_2[PtCl_6]$ complex:

(a) Hexachloridoplatinic(IV) acid

(b) Hexachloridoplatinate(IV) acid

(c) Hydrogenhexachloridoplatinate(IV)

(d) Di hydrogenhexachloridoplatinate(IV)

45. Select the correct I.U.P.A.C. name for $Fe_4[Fe(CN)_6]_3$:

(a) Iron(III) hexacyanidoferrate(II)

(b) Iron(III) hexacyanidoferrate(III)

(c) Iron(III) hexacyanidoiron(III)

(d) Iron(II) hexacyanidoiron(II)

46. Select the correct I.U.P.A.C. name for $[Ti\ (\pi - C_5H_5)_2(\sigma - C_5H_5)_2]$:

(a) Bis (cyclopentadienyl) bis (η^5 - cyclopentadienyl) titanate(IV)

(b) Bis (η^5-cyclopentadienyl) bis (cyclopentadienyl) titanium(IV)

(c) Bis (η^5-cyclopentadiene) bis (cyclopentadiene) titanium(IV)

(d) Bis (η^5-cyclopentadiene) bis (cyclopentadiene) titanate(IV)

47. Select the correct I.U.P.A.C name for $Mo(\sigma\text{-}C_3H_5)(\pi\text{-}C_5H_5)(CO)_3$:

(a) Allytricarbonyl (η^5 – cyclopentadiene) molybdenum(II)

(b) Allyltricarbonyl (η^5-cyclopentadienyl) molybdate(II)

(c) Tricarbonyl (η^5-cyclopentadienyl) allyl molybdate(II)

(d) Allyl tricarbonyl (η^5-cyclopentadienyl) molybdenum(II)

48. I.U.P.A.C. name for $Fe(CO)_2(\sigma\text{-}C_5H_5)(\pi\text{-}C_5H_5)$ complex:

(a) Dicarbonyl (η^5-cyclopentadienyl) (cyclopentadienyl)ferrate(II)

(b) Dicarbonyl (η^5-cyclopentadiene) (cyclopentodiencyl)iron(II)

(c) Dicarbonyl (η^5-cyclopentadienyl) (η^5-cyclopentadienyl)iron(II)

(d) Dicarbonyl (η^5-cyclopentadienyl) (cyclopentadienyl)iron(II)

49. Select the correct I.U.P.A.C. name for $[Pt(C_5H_5N)_4][PtCl_4]$:

(a) Tetrapyridineplatinate(II) tetrachloridoplatinate(II)

(b) Tetrapyridineplatinate(II) tetrachloridoplatinate(II)

(c) Tetrapyridineplatinate(II) tetrachloridoplatinum(II)

(d) Tetrapyridineplatinum(II) tetrachloridoplatinate(II)

50. Select the correct I.U.P.A.C. name for $C_4H_4Fe(CO)_3$ complex:

(a) η^4-cyclobutadiene tricarbonyliron(0)

(b) Tricarbonyl (η^4-cyclobutadienyl) iron(0)

(c) Tricarbonyl (η^4-cyclobutadiene) iron(I)

(d) Tricarbonyl (η^4-cyclobutadiene) iron(0)

51. Among the following, the lowest degree of paramagnetism per mole of the compound at 298 K will be shown by:

(a) $MnSO_4 \cdot 4H_2O$ (b) $FeSO_4 \cdot H_2O$

(c) $CuSO_4 \cdot 5H_2O$ (d) $NiSO_4 \cdot 6H_2O$

52. The color of Cu^+ compounds is:

(a) White (b) Blue

(c) Orange (d) Yellow

53. Dimethylglyoxime is coordinated to Ni^{2+} through:
(a) Two oxygen toms
(b) Two nitrogen atoms
(c) Two oxygen and one nitrogen atoms
(d) Two oxygen and two nitrogen atoms

54. Ferrocene is:
(a) $Fe(\eta^2\text{-}C_6H_5)_2$ (b) $Fe(\eta^5\text{-}C_5H_5)_2$
(c) $Fe(\eta^6\text{-}C_6H_6)_2$ (d) $Fe\ (\eta^3\text{-}C_3H_3)_2$

55. Relative to the average energy in the spherical crystal field, the e_g orbitals in octahedral field is:
(a) Raised by $(2/5)\Delta_o$ (b) Lowered by $(4/5)\Delta_o$
(c) Raised by $(3/5)\Delta_o$ (d) Lowered by $(3/5)\Delta_o$

56. Relative to the average energy in the spherical crystal field, the e_g orbitals in tetrahedral field is:
(a) Raised by $(2/5)\Delta_t$ (b) Lowered by $(4/5)\Delta_t$
(c) Raised by $(3/5)\Delta_t$ (d) Lowered by $(3/5)\Delta_t$

57. In the complex $[Pt\,(O_2)\,(en)_2\,(Br)]^{2+}$, nature of (O_2) is:
(a) Oxide ion (b) Peroxide ion
(c) Superoxide ion (d) Oxygen molecule

58. Among the properties (a) reducing, (b) oxidizing, (c) complexing, the set of properties shown by CN^- ion towards metal species is:
(a) *a, b, c* (b) *b, c*
(c) *c, a* (d) *a, b*

59. The value of "spin only" mgnetic moment for one of the following configuration is 2.84 B.M. The correct one is:
(a) d^4 (in strong field ligand)
(b) d^7 (in weak field ligand)
(c) d^3 (in weak as well as in strong field ligand)
(d) d^5 (in strong field ligand)

60. The complex ion which has no *d* electron in the central metal atom is:
(a) $[MnO_4]^-$ (b) $[Co(NH_3)_6]^{3+}$
(c) $[Fe(CN)_6]^{3-}$ (d) $[Cr(H_2O)_6]^{3+}$

61. Ths spin magnetic moment of cobalt in $Hg[Co(SCN)_4]$ is:
(a) $\sqrt{3}$ (b) $\sqrt{8}$
(c) $\sqrt{15}$ (d) $\sqrt{24}$

62. The pair in which both species have same magnetic moment (spin only value) is:
(a) $[Cr(H_2O)_6]^{2+}$, $[CoCl_4]^{2-}$
(b) $[Cr(H_2O)_6]^{2+}$, $[Fe(H_2O)_6]^{2+}$
(c) $[Mn(H_2O)_6]^{2+}$, $[Cr(H_2O)_6]^{2+}$
(d) $[CoCl_4]^{2-}$, $[Fe(H_2O)_6]^{2+}$

63. Which of the following compound is not colored?
(a) $Na_2[CuCl_4]$ (b) $Na_2[CdCl_4]$
(c) $K_4[Fe(CN)_6]$ (d) $K_3[Fe(CN)_6]$

64. What is the shape of $Fe(CO)_5$ molecule and which of the following *d*-orbitals involved in hybridization?
(a) Tetrahedral $d_{x^2-y^2}$
(b) Trigonal bipyramidal, $d_{x^2-y^2}$
(c) Trigonal bipyramidal, d_{z^2}
(d) Square pyramidal

65. Mg is an important component of which biomolecule occurring extensively in living world?
(a) Hemoglobin (b) Chlorophyll
(c) Florigen (d) ATP

66. Atomic numbers of Cr and Fe are, respectively, 24 and 26. Which of the following is paramagnetic with spin of electron?
(a) $Cr(CO)_6$ (b) $[Fe(CO)_5]$
(c) $[Fe(CN)_6]^{4-}$ (d) $[Cr(NH_3)_6]^{3+}$

67. Among the following, which is not the π-bonded organometallic compound?
(a) $(CH_3)_4Pb$ (b) $[Cr(\eta^6\text{-}C_6H_6)_2]$
(c) $[Fe(\eta^5\text{-}C_5H_5)_2]$ (d) $K[PtCl_3(\eta^2-C_2H_4)]$

68. According to the I.U.P.A.C. nomenclature, sodium nitroprusside is named as:
(a) Sodium nitro-ferrocyanide
(b) Sodium pentacyanidonitrosoniumferrate(II)
(c) Sodium nitroferricyanide
(d) Sodium pentacyanonitrosylferrate(III)

69. Which of the following is not considered as an organo-metallic compound?
(a) Ferrocene (b) *cis*-platin
(c) Zeise's salt (d) Grignard reagent

70. The *d*-electron configurations of Mn^{2+}, Fe^{2+}, Co^{3+}, and Ni^{2+} are $3d^5$, $3d^6$, $3d^6$, $3d^8$, respectively. Which of the following aqua complexes will exhibit the minimum paramagnetic behavior?
(a) $[Fe(H_2O)_6]^{2+}$ (b) $[Co(H_2O)_6]^{3+}$
(c) $[Ni(H_2O)_6]^{2+}$ (d) $[Mn(H_2O)_6]^{2+}$

71. The hybridization and geometry of $[Fe(CO)_4]^{2-}$ are:
(a) sp^3d, TBP (b) sp^3, tetrahedral
(c) dsp^2, square planar (d) sp^3, TBP

72. Which of the following statements is correct for the complex K_4 $[Fe(CN)_5\ O_2]$ having t_{2g}^6, e_g^0 electronic configuration?

(a) d^2sp^3 hybridized and diamagnetic

(b) sp^3d^2 hybridized and paramagnetic

(c) sp^3d^2 hybridized and diamagnetic

(d) d^2sp^3 hybridized and paramagnetic

73. Which of the following statements is correct for the $[Fe(H_2O)_5NO]SO_4$ complex?

(a) The E.A.N. value of Fe in this complex depends on the charge of NO ligand

(b) The E.A.N. value of Fe in this complex does not depend on the charge of NO ligand

(c) The hybridization of the central atom is d^2sp^3

(d) It is paramagnetic with $\mu = 1.73$ B.M.

74. Which of the following complex can act as an oxidizing agent as well as reducing agent?

(a) $Ti(CO)_6$ (b) $Mn(CO)_5$

(c) $Mn(CO)_6$ (d) None of these

75. Select the correct statement for $[M(AB)b_2cd]$:

(a) All geometrical isomers are optically active

(b) It has four *trans* isomer with respect to *b*

(c) It has seven geometrical isomers

(d) It has three *cis* and two *trans* isomers with respect to *b*

76. Which of the following complex is inner orbital as well as low spin complex?

(a) $[Cr(H_2O)_6]^{3+}$ (b) $[Fe(CN)_6]^{3-}$

(c) $[Cu(CN)_4]^{3-}$ (d) $[Mn(NH_3)_6]^{2+}$

77. The magnetic moment of a certain complex (*A*) of Co was found to be 4.89 B.M. and the EAN as 36. Co also forms complex (*B*) with magnetic moment 3.87 B.M. and EAN 37, and complex (*C*) with EAN as 36 but diamagnetic. Which of the following statements is true regarding the above observation?

(a) The oxidation states of Co in (*A*), (*B*), and (*C*) are +3, +2, and +3, respectively

(b) Complexes (*A*) and (*B*) have sp^3d^2 hybridization state while (*C*) has dsp^3 hybridization state

(c) The spin multiplicities of Co in (*A*), (*B*), and (*C*) are 4, 3, and 1, respectively

(d) The oxidation states of Co in (*A*), (*B*), and (*C*) are +6, +8, and +1, respectively

78. Oxidation state of "V" in $Rb_4Na[HV_{10}O_{28}]$ is:

(a) +5 (b) +6

(c) $+\frac{7}{5}$ (d) +4

79. Which of the following organometallic compound is σ and π-bonded?

(a) $[Fe(\eta^5 - C_5H_5)_2]$ (b) $K[PtCl_3(\eta^2 - C_2H_4)]$

(c) $[Co(CO)_5NH_3]^{2+}$ (d) $Fe(CH_3)_3$

80. Spin only magnetic moments of a d^8 ion in octahedral, square planar, and tetrahedral complexes, respectively, are:

(a) 2.8 B.M., 0, and 2.8 B.M.

(b) 2.8, 2.8, and 2.8 B.M.

(c) 0, 0, and 0 B.M. (d) None of these

81. Compare C — C bond length (*x*) of C_2H_4 in Zeise's salt and C — C bond length (*y*) of $C_2(CN)_4$ in $K[PtCl_3C_2(CN)_4]$:

(a) $x > y$ (b) $y > x$

(c) $x = y$ (d) None of these

82. Select the correct order of C — O bond order in mixed phosphine carbonyl complex:

(a) $[(Ph_3P)_3Mo(CO)_3] > [(Ph_2PCl)_3\ Mo(CO)_3] > (PhPCl_2)_3\ Mo\ (CO)_3]$

(b) $[(Ph_3P)_3Mo(CO)_3] < [(Ph_2PCl)_3\ Mo(CO)_3] < (PhPCl_2)_3\ Mo\ (CO)_3]$

(c) $[(Ph_3P)_3Mo(CO)_3] = [(Ph_2PCl)_3\ Mo(CO)_3] > (PhPCl_2)_3\ Mo\ (CO)_3]$

(d) $[(Ph_3P)_3Mo(CO)_3] < [(Ph_2PCl)_3\ Mo(CO)_3] > (PhPCl_2)_3\ Mo\ (CO)_3]$

83. Which bond properties are consistent with one another?

	Bond order	Bond length	Vibrational frequency
(a)	Higher	shorter	higher
(b)	Higher	longer	lower
(c)	Lower	shorter	lower
(d)	Lower	longer	higher

84. Which of the following statement(s) is/are true or false?

S_1: In organometallic compounds, carbon is bonded to metals directly

S_2: Complexes having d^0 or d^{10} configuration of metal ions are always diamagnetic

S_3: Extra stability of metal carbonyls is explained by synergic bonding

S_4: In $Fe(CO)_5$, the Fe—C bond possesses both σ and π characteristics

(a) T T T T (b) T T F F

(c) F T F T (d) F T T T

85. Which of the following is **incorrect** about Wilkinson's catalyst?

(a) It is a non-ionic complex
(b) It is a diamagnetic complex
(c) It is a tetrahedral complex
(d) It is very effective for selective hydrogenation of organic molecule at room temperature and pressure

Multiple Correct Answers Type

1. Select the correct I.U.P.A.C. name from following:
(a) Diamminesilver(I) chloride: $[Ag(NH_3)_2]Cl$
(b) Potassium hexacyanidoferrate(III): $K_3[Fe(CN)_6]$
(c) Tetraamminecopper(II) sulphate: $[Cu(NH_3)_4]SO_4$
(d) Hexamminecobalt(III) chloride: $[Co(NH_3)_6]Cl_3$

2. Select the correct I.U.P.A.C. name for $[Pt(NH_3)_4]^{2+}$ complex ion:
(a) Tetraammineplatinum(II) ion
(b) Tetraammineplatinum(2+) ion
(c) Tetraammineplatinate(II) ion
(d) Tetraammineplatinate(2+) ion

3. Select the correct I.U.P.A.C. name for $[PtCl_4]^{2-}$:
(a) Tetrachloridoplatinum(II) ion
(b) Tetrachloridoplatinum(2–) ion
(c) Tetrachloridoplatinate(II) ion
(d) Tetrachloridoplatinate(2–) ion

4. Select the correct I.U.P.A.C. name for $[PtCl_6]^{2-}$:
(a) Hexachloridoplatinate(IV) ion
(b) Hexachloridoplatinum(II) ion
(c) Hexachloridoplatinate(2–) ion
(d) Hexachloridoplatinum(2–) ion

5. Select the correct statement(s) for double salt:
(a) Double salts are stable in solid state but loose their identity in aqueous solution
(b) In double salt the properties of constituent ions are not changed in their aqueous solution
(c) Double slats are stable in solid state and do not loose their identity in aqueous solution
(d) In double salt the properties of constituent ions are changed in their aqueous solution

6. Select the paramagentic complex compound:
(a) $K_4[Fe(CN)_5O_2]$ (b) $Fe(CO)_5$
(c) $[Cr(NH_3)_6]^{3+}$ (d) $[Ni(CN)_6]^{4-}$

7. Which of the following ligand(s) is/are ambidentate?
(a) $NOS^{\ominus}$ (b) $\overset{\ominus}{S}CN$
(c) $NO_2^{\ominus}$ (d) $CH_3COO^{\ominus}$

8. Select the correct I.U.P.A.C. name for $[CoCl_2(en)_2]_2SO_4$:
(a) Dichloridobis (ethylenediamine)cobalt(III) sulphate
(b) Dichloridobis (ethane-1, 2-diamine) cobalt(III) sulphate
(c) bis{dichloridoethylenediaminecobalt(III)} sulphate
(d) bis{di(chlorido)ethylenediaminecobalt(III)} sulphate

9. Which of the following complex (s) is/are high spin?
(a) $[CoF_6]^{3-}$ (b) $[Co(H_2O)_3F_3]$
(c) $[Co(H_2O)_6]^{3+}$ (d) $[Co(H_2O)_6]^{2+}$

10. Which of the following complex (s) is/are paramagnetic in nature?
(a) $K_2[NiF_6]$ (b) $K_3[CoF_6]$
(c) $K_3[Fe(CN)_6]$ (d) $[Co(H_2O)_6]^{3+}$

11. Which of the following complex ion(s) are paramagnetic?
(a) $[Ni(CN)_4]^{2-}$ (b) $[NiCl_4]^{2-}$
(c) $[CoF_6]^{3-}$ (d) $[Co(NH_3)_6]^{3+}$

12. Bidentate ligands are:
(a) $C_2O_4^{2-}$ (oxalate) (b) en (ethylenediamine)
(c) DMG (dimethyl glyoxime)
(d) Gly (glycine)

13. Which of the following complex(s) is/are having correct name?
(a) $K[Pt(NH_3)Cl_5]$ – Potassium amminepentachloridoplatinate(IV)
(b) $[Ag(CN)_2]^-$ – Dicyanidoargentate(I) ion
(c) $K_3[Cr(C_2O_4)_3]$ – Potassium trioxalatochromate(III)
(d) $Na_2[Ni(EDTA)]$–Sodium ethylenediaminetetraacetatonickel(II)

14. $d_{x^2-y^2}$ orbital is involved in which of the following hybridization?
(a) sp^3d (sq. pyramidal) (b) dsp^2
(c) sp^3d^2 (d) sp^3d^3

15. Which of the following statement(s) is/are correct?
(a) The stability constant of $[Co(NH_3)_6]^{3+}$ is larger than that of $[Co(NH_3)_6]^{2+}$
(b) The cyano complexes are more stable than those formed by halide ions
(c) The stability of halide complexes follows the order $I^- < Br^- < Cl^-$

(d) The stability constant of $[Cu(NH_3)_4]^{2+}$ is larger than that of $[CuCl_4]^{2-}$

16. The complexes $[CoNO_2(NH_3)_5]Cl_2$ and $[Co(ONO)(NH_3)_5]Cl_2$ are not the examples of:

(a) Geometrical isomers (b) Optical isomers

(c) Coordination isomers (d) Linkage isomers

17. The complexes $[Cr(NH_3)_6]$ $[Co(CN)_6]$ and $[Co(NH_3)_6]$ $[Cr(CN)_6]$ are not the examples of:

(a) Geometrical isomers (b) Optical isomers

(c) Coordination isomers (d) Linkage isomers

18. Which of the following statement(s) is/are true?

(a) $Ni(CO)_4$ is paramagnetic

(b) $[Fe(CN)_6]^{3-}$ contains one unpaired electron

(c) $[FeF_6]^{3-}$ involves sp^3d^2-hybridization

(d) $[Ni(CN)_4]^{2-}$ is square planar and diamagnetic

19. In the complex $[Fe(NH_3)_6]^{3+}$:

(a) Fe^{3+} is a Lewis acid (b) NH_3 is a Lewis base

(c) NH_3 is Lewis acid (d) Fe^{3+} is a Lewis base

20. Which can form chelates?

(a) Ethylene diamine (b) Oxalate

(c) Glycinate (d) Cyanide

21. In which case geometrical isomer *cis* possible with *M* as metal ion if complexes are square planar having C.N. = 4?

(a) MX_2Y_2 (b) MX_2Y_4

(c) $MX_2Y_2Z_2$ (d) Ma_4

22. Ethylenediamine is/are not an example of a ..... ligand:

(a) Monodentate (b) Bidentate

(c) Tridentate (d) Hexadentate

23. Which of the following statement(s) is/are correct?

(a) $Ni(CO)_4$—Tetrahedral, paramagnetic

(b) $[Ni(CN)_4]^{2-}$—Square planar, diamagnetic

(c) $[Ni(CO)_4]$—Tetrahedral, diamagnetic

(d) $[NiCl_4]^{2-}$—Tetrahedral, paramagnetic

24. Which of the following statements(s) is/are correct?

(a) The complexes $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ differ in state of hybridization of nickel

(b) The complexes $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ differ in geometry

(c) The complexes $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ differ in the magnetic properties

(d) The complexes $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ differ in primary valencies of nickel

25. Both geometrical and optical isomerisms are not shown by:

(a) dichlorobis (ethylenediamine) cobalt(III) ion

(b) triamminetrichloro cobalt(III) ion

(c) tetraamminedichloro cobalt(III) ion

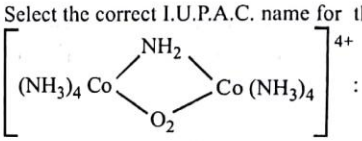
(d) trioxalatochromate(III) ion

26. Which of the following moelcule(s) is/are showing optical isomerism?

(a) $[Co(NH_3)_3Cl_3]$ (b) $[Co(en)Cl_2(NH_3)_2]^+$

(c) $[Co(en)_3]^{3+}$ (d) $[Co(en)_2Cl_2]^+$

27. Select the correct I.U.P.A.C. name for the following



:

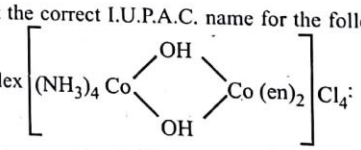
(a) Tetramminecobalt(III)-μ-amido-μ-superoxido-tetraamminecobalt(III) ion

(b) μ-Amido-μ-superoxidobis(tetraammine)dicobalt(III) ion

(c) μ-Amido-μ-superoxidobis(tetraamminecobalt(III)) ion

(d) μ-Amido-μ-superoxidooctaamminedicobalt(III) ion

28. Select the correct I.U.P.A.C. name for the following complex



:

(a) Tetraamminecobalt (III)-μ-dihydroxidobis (ethylenediamine)cobalt(III) chloride

(b) μ-Dihydroxidotetraamminebis(ethylenediamine) dicobalt(III) chloride

(c) Tetraammine cobalt (III)-μ-dihydroxidobis (ethane-1,2-diamine)cobalt(III) chloride

(d) Tetraamminecobalt (III)-μ-dihydroxidobis (ethylenediamine)cobalt(III) tetrachloride

29. Select the correct I.U.P.A.C. name for $Mn(CO)_5$ $(\sigma\text{–}C_3H_5)$:

(a) Allylpentacarbonylmanganese(I)

(b) Cyclopropylpentacarbonylmanganese(I)

(c) Pentacarbonylcyclopropylmanganese(I)

(d) Pentacarbonyl allylmanganese(I)

30. Which of the following molecules have E.A.N. = 36?

(a) $[Fe(CO)_4]^{2-}$ (b) $[Co(\eta^5\text{-}C_5H_5)_2]^+$

(c) Co_2CO_8 (d) $Mn_2(CO)_{10}$

31. The aqueous solution of the following salts will be colored in the case of:

(a) $Zn(NO_3)_2$ (b) $LiNO_3$

(c) $Co(NO_3)_2$ (d) $CrCl_3$

32. In which of the following cases, the synergic bonding takes place at the π-orbital of the ligand?

(a) $[PtCl_3(C_2H_4)]^-$ (b) $[Ni(PF_3)_4]$

(c) $[Cr(C_6H_6)_2]$ (d) $[Fe(\pi\text{-}C_5H_5)_2]$

33. Which of the following complexes are diamagnetic:

(a) $[AuCl_4]^-$ (b) $[Co(H_2O)_6]^{3+}$

(c) $[CoF_6]^{3-}$ (d) $[Co(CO)_4]^-$

34. Which of the following is/are represent the correct sequence of indicated property?

(a) $Mn^{2+} < Ni^{2+} < Co^{2+} < Fe^{2+}$: magnetic moment

(b) FeO > CoO > NiO: basic character

(c) Sc < Ti < Cr < Mn: number of oxidation states

(d) 1.73 μ: one unpaired $e^{\ominus}$

35. Which of the following statement(s) is/are correct?

(a) Primary valency of the central metal of a complex is always satisfied by anions

(b) Secondary valency of the central metal of a complex may be satisfied by either negative ions or neutral molecules

(c) Species which show primary valencies in a complex compound can be precipitated out

(d) None of these

36. Select correct statements:

(a) $[Ni(en)_3]^{2+}$ is less stable than $[Ni(NH_3)_6]^{2+}$

(b) Increase in stability of the complexes due to the presence of multidentate cyclic ligand is called macro-cyclic effect

(c) $[Ni(en)_3]^{2+}$ is more stable than $[Ni(NH_3)_6]^{2+}$

(d) For a given ion and ligand, the greater the charge on the metal ion, the greater is the stability

37. The complex $[Fe(H_2O)_5NO]^{2+}$ is formed in the brown ring test for nitrates when freshly prepared $FeSO_4$ solution is added to aqueous solution of NO_3^- followed by addition of conc. H_2SO_4. Select correct statements about this complex:

(a) Color change is due to charge transfer

(b) It has iron in +1 oxidation state and nitrosyl as NO^+

(c) It has magnetic moment of 3.87 B.M. confirming three unpaired electrons in Fe

(d) In complex Fe has d^2sp^3 hybridization

38. Which of the following complex ion(s) is/are not expected to absorb visible light?

(a) $[Ti(en)_2(NH_3)_2]^{4+}$ (b) $[Cr(NH_3)_6]^{3+}$

(c) $[Zn(NH_3)_6]^{2+}$ (d) $[Sc(H_2O)_3(NH_3)_3]^{3+}$

39. Which of the following molecule(s) is/are not showing optical isomerism?

(a) $[Co(NH_3)_3Cl]^+$ (b) $[Co(en)(NH_3)_2]^{2+}$

(c) $[Co(H_2O)_4(en)]^{3+}$ (d) $[Co(en)_2(NH_3)_2]^{3+}$

40. Colorless, tetrahedral complexes among the following are:

(a) $K_3[Cu(CN)_4]$ (b) $Na_2[NiCl_4]$

(c) $K[BF_4]$ (d) $Ni(CO)_4$

41. Which of the following statement is correct regarding metal carbonyl?

(a) In $Mn_2(CO)_{10}$, bond order of Mn—Mn is 0

(b) In $Fe_2(CO)_9$, number of Fe—Fe bonds is 1

(c) In $Ni(CO)_4$, all bond length are same

(d) $Fe(CO)_5$ is diamagnetic

42. Select the correct I.U.P.A.C. name for $[(NH_3)_4Co(OH)(NH_2)Co(NH_3)_4]^{4+}$:

(a) μ-Amido-μ-hydroxidobis {tetraammine cobalt(4+)} ion

(b) μ-Amido-μ-hydroxidobis {tetraammine cobalt(III)} ion

(c) μ-Amido-μ-hydroxidobis {tetraammine cobaltate(4+)} ion

(d) μ-Amido-μ-hydroxidobis {tetraammine cobaltate(III)} ion

43. The compound(s) that exhibit(s) geometrical isomerism is(are):

(a) $[Pt(en)Cl_2]$ (b) $[Pt(en)_2]Cl_2$

(c) $[Pt(en)_2Cl_2]Cl_2$ (d) $[Pt(NH_3)_2Cl_2]$

44. Select the correct I.U.P.A.C. name for $[(C_6H_5)_3PCl\,Pd\,Cl_2\,Pd\,Cl(C_6H_5)_3P]$:

(a) Chloridotriphenylphosphinepalladium(II) μ-dichloridochloridotriphenylphosphinepalladium(II)

(b) μ-Dichloridodichloridobis(triphenylphosphine) dipalladium(II)

(c) μ-Dihloridobis(chloridotriphenylphosphinepalladium)(II)

(d) Bis (μ-chloridochloridotriphenylphosphinepalladium)(II)

45. $[(Cl_3Sn)_2Rh\,Cl_2\,Rh\,(SnCl_3)_2]^{4-}$as:

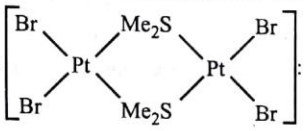
(a) Bis (trichlorostannito) rhodate(I)-μ-dichloridobis (trichlorostannito)rhodate(I) ion

(b) μ-Dichloridotetrakis (trichlorostannito) dirhodate(I)ion

(c) μ-Dichloridobis{bis (trichlorido stannito) rhodate(I)ion}

(d) μ-Dichloridotetrakis (trichloro stannito) dirnodium(I) ion

46. Select the correct I.U.P.A.C name for the following complex



(a) Di bromidoplatinum(II) bis-μ-(dimethylthioether) dibromidoplatinum(II)

(b) Bis{μ (dimethylthioether) dibromidoplatinum(II)}

(c) Bis-μ-dimethylthioethertetrabromidodiplatinum(II)

(d) Bis-μ-dimethylthioethertetrabromidodiplatinate(II)

47. Select the correct I.U.P.A.C. name for $Na_2[Fe(CN)_5NO]$ complex:

(a) Sodiumpentacyanidonitrosoniumferrate(II)

(b) Sodiumpentacyanidonitrosyliumferrate(II)

(c) Sodiumpentacyanidonitrosyl ferrate(II)

(d) Sodiumpentacyanidonitrosyliron(II)

48. Select the correct I.U.P.A.C. name for $[Fe(H_2O)_5(NO)]SO_4$:

(a) Pentaaquanitrosonium iron(I) sulphate

(b) Pentaaquanitrosyliumiron(I) sulphate

(c) Pentaaquanitrosyliron(II) sulphate

(d) Pentaaquanitrosoniumferrate(II) sulphate

49. Select the correct I.U.P.A.C. name for $[(NH_3)_4CoNH_2NO_2Co(NH_3)_4](NO_3)_4$:

(a) Tetraamminecobalt(III)-μ-amido-μ-nitrito-*n* tetraamminecobalt(III) nitrate

(b) μ-Amido-μ-nitrito-N-octaamminedicobalt(III) nitrate

(c) μ-Amido-μ-nitrito-N-bis (tetraammine) dicobalt(III) nitrate

(d) μ-Amido-μ-nitrito-O-octaamminedicobaltate(III) nitrate

50. $[Co(H_2O)_6]^{3+}$ complex is:

(a) High spin complex

(b) Having d^2sp^3-hybridization

(c) Low spin complex

(d) Having octahedral structure

51. Select the correct statement:

(a) $[Co(H_2O)_6]^{3+}$ is Co(III), low spin, 0 unpaired electron, diamagnetic

(b) $[CoF_6]^{3-}$ is Co(III), high spin d^6, 4 unpaired electron, paramagnetic

(c) $[RhF_6]^{3-}$ is Rh(III), low spin d^6, 0 unpaired electrons diamagnetic

(d) $[Fe(CN)_6]^{4-}$ is high spin d^6, 0 unpaired electron diamagnetic

52. Which of the following is/are example(s) of σ-bonded organometallic compound?

(a) $Al_2(CH_3)_6$ (b) $Pb(CH_3)_4$

(c) $Zn(C_2H_5)_2$ (d) Ferrocene

53. Which of the following is an example of π-bonded organometallic complex?

(a) Ferrocene (b) Dibenzenechromium

(c) $Zn(C_2H_5)_2$ (d) $Pb(C_2H_5)_4$

54. Which of the following statement(s) is/are incorrect?

(a) Metal carbonyls are the examples of only σ-bonded organometallic complexes

(b) Metal carbonyls are the examples of only π-bonded organometallic complexes

(c) Metal carbonyls are the examples of organometallic complexes which involve both σ- and π-bonds between metal and carbon of the carbonyl group

(d) Metal carbonyls involve both σ- and π-bonds between metal and oxygen of the carbonyl group

55. The coordination number of a central metal atom in a complex(s) is/are not determined by:

(a) The number of only anionic ligands bonded to the metal ion

(b) The number of ligands around a metal ion bonded by π-bonds

(c) The number of ligands around a metal ion bonded by both σ and π-bonds

(d) The number of ligands around a metal ion bonded by σ-bonds

56. Which of the following complex(s) is/are an example of homoleptic complex?

(a) $[Co(NH_3)_6]^{3+}$ (b) $[Cr(H_2O)_6]^{3+}$

(c) $[Ni(NH_3)_6]^{2+}$ (d) $[Ni(NH_3)_4Cl_2]$

57. The complex $K_4[Zn(CN)_4(O_2)_2]$ is oxidized into $K_2[Zn(CN)_4(O_2)_2]$, then which of the following is/are correct:

(a) Zn(II) is oxidized into Zn(IV)

(b) Paramagnetic moment decreases
(c) O — O bond length decreases
(d) Paramagnetic moment increases

58. Which of the folloiwng is/are characteristic of a tetrahedral complex?
(a) $d_{x^2-y^2}$ and d_{z^2} orbitals are low energy orbitals
(b) Most tetrahedral complexes are high spin
(c) Crystal field splitting is found double in octahedral complexes
(d) Splitting pattern in tetrahedral complex is just opposite of that in octahedral complexes

59. A *d*-block element forms octahedral complex, but its spin magnetic moment remains same either in strong field or in weak field ligand. Which of the following is /are correct?
(a) Element always forms colorless compound
(b) Number of electrons in t_{2g} orbitals are higher than in e_g orbitals
(c) It can have either d^3 or d^8 configuration
(d) It can have either d^7 or d^8 configuration

Comprehension Type

Comprehension-1: (Q. 1 to Q. 3)

(A) When $CuSO_4$ solution is treated with aqueous ammonia solution in 1 : 4 molar ratio, species formed, no longer, gives test of Cu^{2+}.

(B) When $FeSO_4$ solution is treated with $(NH_4)_2SO_4$ solution, species formed gives test of Fe^{2+}, NH_4^+, and SO_4^{2-}.

1. Species formed in experiment (A) does not give test of Cu^{2+}. It is due to the formation of:
(a) $[Cu(NH_3)_4]Cl$ (b) $[Cu(NH_3)_4]SO_4$
(c) $Cu(OH)_2$ (d) Cu

2. Species formed in experiment (B) is:
(a) Complex (b) Double salt
(c) Liquid crystal (d) None of these

3. EAN of copper formed in (A) is:
(a) 26 (b) 35
(c) 36 (d) 38

Comprehension-2: (Q. 4 to Q. 6)

One cationic complex has two isomers *A* and *B*. Each has one Co^{3+}, five NH_3, one Br^-, and one SO_4^{2-} stoichiometrically. *A* gives white ppt with $BaCl_2$ while *B* give yellow ppt with $AgNO_3$.

4. *A* can be:
(a) $[Co(NH_3)_5]BrSO_4$ (b) $[Co(NH_3)_5SO_4]Br$
(c) $[Co(NH_3)_5Br]SO_4$ (d) $[Co(NH_3)_4SO_4]Br \cdot NH_3$

5. *B* can be:
(a) $[Co(NH_3)_5SO_4]Br$ (b) $[Co(NH_3)_5Br]SO_4$
(c) $[Co(NH_3)_3Br(SO_4)] \cdot 2NH_3$
(d) None of these

6. Complexes *A* and *B* have similarity in which type of isomerism?
(A) Hydrate (B) Ionization
(C) Linkage (D) Coordination

Comprehension-3: (Q. 7 and Q. 8)

The atoms or ions with available low-energy orbitals can attract loosely bonded pair of electrons from other molecules. A higher amount of positive charge on the side atom or ion makes its orbitals even more attractive for the loosely bonded electron pairs. The molecules with loosely bonded pairs also have different polarizabilities. The higher size of surrounding molecules and lower size of atom offering low energy orbitals increases crowding and diminishes the tendency of bonding.

7. Which is most stable?
(a) $[NiCl_4]^{2-}$ (b) $[Ni(CN)_4]^{2-}$
(c) $[Pd(CN)_4]^{2-}$ (d) $[Pt(CN)_4]^{2-}$

8. Which is strongest donor?
(a) Cl^- (b) ^-OH
(c) NH_3 (d) ^-CN

Comprehension-4: (Q. 9 to Q. 11)

A metal complex having composition $Cr(NH_3)_4Cl_2Br$ has been isolated in two forms, (*X*) and (*Y*). The form (*X*) reacts with $AgNO_3$ to give a white precipitate readily soluble in dilute aqueous ammonia, whereas (*Y*) gives a pale yellow precipitate soluble in concentrate ammonia.

9. Choose the true statement regarding compounds *X* and *Y*:
(a) Both compounds *X* and *Y* have different magnetic moment (spin only)
(b) Both complexes *X* and *Y* have same magnetic moment (spin only)
(c) Magnetic moment of both *X* and *Y* is calculated by assuming they are low-spin complex
(d) Both compounds *X* and *Y* have different primary valency

10. The hybridization of compound *X* and *Y* is respectively:

(a) sp^3d^2, d^2sp^3 (b) sp^3d^2, sp^3d^2

(c) d^2sp^3, d^2sp^3 (d) d^2sp^3, sp^3d^2

11. Choose the correct statement regarding the complexes *X* and *Y*:

(I) Both complexes have the same six geometrical isomer.

(II) Both complexes have nearly the same conductivity in H_2O.

(III) In both complexes, NH_3 is involved only to secondary valency.

(IV) In both complexes, electronic configuration of t_{2g} is same.

(a) I, II, and III (b) I, II, III, and IV

(c) II, III, and IV (d) I, III, and IV

Comprehension-5: (Q. 12 to Q. 14)

Square planar complexes are formed by d^8 ions with strong field ligands. The crystal field splitting Δ_o is larger for the second and third row transition elements and for more highly charged species. All the complexes having $4d^8$ and $5d^8$ configurations are mostly square planar including those with weak field ligands such as halide ions. Square planar complexes can show geometrical isomerism but they do not show optical isomerism due to the presence of plane of symmetry.

12. Which of the following complex is low spin?

(a) $[Ni(NH_3)_6]^{2+}$ (b) $[Ni(CO)_4]$

(c) $[Pt(NH_3)_4]^{2+}$ (d) All are low spin complex

13. Among the following complex which has a square planar geometry?

(a) $[RhCl(CO)(PPh_3)_2]$ (b) $K_3[Cu(CN)_4]$

(c) $K_2[Zn(CN)_4]$ (d) $[Ni(CO)_4]$

14. Which of the following molecule has synergic bonding?

(a) $[Fe(Phen)_3]^{3+}$

(b) $[Fe(\pi\text{-}C_5H_5)_2]$

(c) $[RhCl(PPh_3)_3]$

(d) all are having synergic bonding

Comprehension-6: (Q. 15 to Q. 18)

The pi acceptor ligand are those which posses vacant π-orbitals in addition to the lone pairs of $e^{\ominus}$:

15. Which of the following complex/ion has highest C—O bond length?

(a) $[V(CO)_6]^{\ominus}$ (b) $Fe(CO)_5$

(c) $Ni(CO)_4$ (d) $[Mn(CO)_6]^+$

16. Which of the following complex/ion has lowest C—O bond order?

(a) $[V(CO)_6]^{\ominus}$ (b) $Fe(CO)_5$

(c) $Ni(CO)_4$ (d) $[Mn(CO)_6]^+$

17. Which of the following complex/ion has highest M—C bond order?

(a) $[V(CO)_6]^{\ominus}$ (b) $Fe(CO)_5$

(c) $Ni(CO)_4$ (d) $[Mn(CO)_6]^+$

18. Which of the following complex/ion has lowest M—C bond length?

(a) $[V(CO)_6]^{\ominus}$ (b) $Fe(CO)_5$

(c) $Ni(CO)_4$ (d) $[Mn(CO)_6]^+$

Comprehension-7: (Q. 19 to Q. 21)

The π acid ligands donate their lone pairs to the metal to form a normal σ bond with the latter in addition to it, the vacant orbitals accept $e^{\ominus}$ from the filled metal orbitals to form a type of π-bond which suppliments the σ bond.

19. Which of the following has lowest *M*—C bond order?

(a) $[Ni(CO)_4]$ (b) $[Co(CO)_4]^{\ominus}$

(c) $[Fe(CO)_4]^{2-}$ (d) $[Mn(CO)_6]^+$

20. Which of the following has lowest *M*—C bond length?

(a) $[Ni(CO)_4]$ (b) $[Co(CO)_4]^{\ominus}$

(c) $[Fe(CO)_4]^{2-}$ (d) $[Mn(CO)_6]^+$

21. Which of the following has lowest C—O bond length?

(a) $[Ni(CO)_4]$ (b) $[Co(CO)_4]^{\ominus}$

(c) $[Fe(CO)_4]^{2-}$ (d) $[Mn(CO)_6]^+$

Comprehension-8: (Q. 22 to Q. 24)

Most of the metal carbonyls obey inert gas rule which states that the compounds in which the central metal atom appears to have attained the configuration of a noble gas either by the sharing or by the transfernce of electrons tend to be more stable.

22. Which of the following has highest C—O bond length?

(a) $[Ni(CO)_4]$ (b) $[CoCO_4]^{\ominus}$

(c) $[Fe(CO)_4]^{2-}$ (d) $[Mn(CO)_6]^+$

23. Which of the following has lowest C—O bond order?

(a) $[Ni(CO)_4]$ (b) $[CoCO_4]^{\ominus}$

(c) $[Fe(CO)_4]^{2-}$ (d) $[Mn(CO)_6]^+$

24. Select the correct order of C—O bond length:

(a) $[M(CO)_3(PF_3)] < [M(CO)_3(PCl_3)] < [M(CO)_3(PMe_3)]$

(b) $[M(CO)_3(PF_3)] > [M(CO)_3(PCl_3)] > [M(CO)_3(PMe_3)]$

(c) $[M(CO)_3(PF_3)] = [M(CO)_3(PCl_3)] = [M(CO)_3(PMe_3)]$

(d) $[M(CO)_3(PF_3)] = [M(CO)_3(PCl_3)] > [M(CO)_3(PMe_3)]$

Comprehension-9: (Q. 25 to Q. 27)

The great scientist **LAXMI** isolated two complexes and in chemical abstract, she reported "A metal complex having composition $Cr(NH_3)_4Cl_2Br$ has been isolated in two forms, (*A*) and (*B*). The form (*A*) reacts with $AgNO_3$ to give a white precipitate readily soluble in dilute aqueous ammonia, whereas (*B*) gives a pale yellow precipitate soluble in concentrated ammonia.

25. Complexes *A* and *B* are respectively:

(a) $[Cr(NH_3)_4Cl_2]Br$, $[Cr(NH_3)_4Br]Cl_2$

(b) $[Cr(NH_3)_4Br]Cl_2$, $[Cr(NH_3)_4Cl_2]Br$

(c) $[Cr(NH_3)_4ClBr]Cl$, $[Cr(NH_3)_4Cl_2]Br$

(d) $[Cr(NH_3)_4Cl_2]Br$, $[Cr(NH_3)_4ClBr]Cl$

26. Cr atom is.....hybridized.

(a) sp^3d^2 in both complexes

(b) d^2sp^3 in both complexes

(c) sp^3d^2 in *A* and d^2sp^3 in *B*

(d) d^2sp^3 in *A* and sp^3d^2 in *B*

27. EAN and magnetic moment of Cr in *A* and *B* are:

(a) 33, $\sqrt{15}$ B.M. (b) 36, $\sqrt{15}$ B.M.

(c) 33, $\sqrt{24}$ (d) 36, $\sqrt{24}$ B.M.

Comprehension-10: (Q. 28 to Q. 30)

$Ni^{II}(NH_3)_4(NO_3)_2 \cdot 2H_2O$ molecule may have two unpaired electrons or zero unpaired electron and measurement of magnetic moment helps us to predict the geometry.

28. If magnetic moment value is zero, then the formula of the complex will be:

(a) $[Ni(NH_3)_4](NO_3)_2 \cdot 2H_2O$

(b) $[Ni(NH_3)_2(H_2O)_2](NO_3)_2 \cdot 2NH_3$

(c) $[Ni(NH_3)_4(H_2O)_2](NO_3)_2$

(d) $[Ni(NO_3)_2(H_2O)_2] \cdot 4NH_3$

29. If the magnetic moment value is $2\sqrt{2}$ and conducts electricity, then the formula of the complex is:

(a) $[Ni(NH_3)_4](NO_3)_2 \cdot 2H_2O$

(b) $[Ni(NH_3)_2(H_2O)_2](NO_3)_2 \cdot 2NH_3$

(c) $[Ni(NH_3)_4(H_2O)_2](NO_3)_2$

(d) $[Ni(NH_3)_4(NO_3)_2] \cdot 2H_2O$

30. The higher and lower values of magnetic moment of the given complex corresponds to the following geometries, respectively:

(a) Octahedron and Tetrahedron

(b) Octahedron and square planar

(c) Square planar and Octahedron

(d) Octahedron and Octahedron

Comprehension-11: (Q. 31 to Q. 34)

A, *B*, and *C* are three complexes of chromium(III) with the empirical formula $H_{12}O_6Cl_3Cr$. All the three complexes have water and chloride ions as ligands. Complex *A* does not react with concentrated H_2SO_4, whereas complex *B* and *C* lose 6.75% and 13.5% of their original weights respectively on treatment with concentrated H_2SO_4.

31. Complex *A* is:

(a) $[Cr(H_2O)_6]Cl_3$

(b) $[Cr(H_2O)_5Cl]Cl_2 . H_2O$

(c) $[Cr(H_2O)_4Cl_2]Cl . 2H_2O$

(d) None of these

32. Loss in weight on treatment with concentrated H_2SO_4 is due to:

(a) Cl^- is lost as HCl

(b) Cr^{3+} is lost as $Cr_2(SO_4)_3$

(c) H_2O is lost due to absorption

(d) Cl^- is lost as Cl_2

33. How many coordinated water molecule(s) is/are present in complex C?

(a) 4 (b) 5

(c) 6 (d) 3

34. Select the correct statement:

(a) Conductance in these complexes is in order $C < B < A$

(b) EAN of chromium is identical in each complex

(c) Non-reactivity of *A* with conc. H_2SO_4 is due to absence of water molecules outside coordinated sphere

(d) All of the above are correct

Comprehension-12: (Q. 35 to Q. 37)

If in the mixed carbonyl, the other ligand is also pi acceptor, it would compete with the ligand CO for gaining the metal d_π electron charge. The higher is the extent of back donation in CO, the lesser will be the stretching vibration frequency for C—O bond. If PF_3 is better π-acceptor than CO, then answer the following.

35. Select the correct order of M—C bond order in the following molecule and ions:

(a) $[Ni(CO)_4] > [Co(CO)_4]^{\ominus} > [Fe(CO)_4]^{2-}$

(b) $[Ni(CO)_4] = [Co(CO)_4]^{\ominus} = [Fe(CO)_4]^{2-}$

(c) $[Co(CO)_4]^{\ominus} > [Fe(CO)_4]^{2-} > [Ni(CO)_4]$

(d) $[Ni(CO)_4] < [Co(CO)_4]^{\ominus} < [Fe(CO)_4]^{2-}$

36. Select the correct order of stretching vibration frequency C—O bond in following molecules:

(a) $[Ni(CO)_4] > [Ni(PF_3)(CO)_3]$

(b) $[Ni(CO)_4] < [Ni(CO)_3(PF_3)]$

(c) $[Ni(CO)_4] = [Ni(PF_3)(CO)_3]$

(d) Cannot be predicted

37. Select the correct order of C—O bond length in the following molecules:

(a) $[Mo(CO)_3\ (PF_3)_3] > [Mo(CO)_3\ (PCl_3)_3] > [Mo(CO)_3\ (P(Me)_3)_3]$

(b) $[Mo(CO)_3\ (P(Me)_3)_3] > [Mo(CO)_3\ (PF_3)_3] > [Mo(CO)_3\ (PCl_3)_3]$

(c) $[Mo(CO)_3\ (PCl_3)_3] > [Mo(CO)_3\ (P(Me)_3)_3] > [Mo(CO)_3\ (PF_3)_3]$

(d) $[Mo(CO)_3\ (PF_3)_3] < [Mo(CO)_3\ (PCl_3)_3] < [Mo(CO)_3\ (P(Me)_3)_3]$

Comprehension-13: (Q. 38 and Q. 39)

In the manufacture of iron, a gas (*A*) is formed in the zone of combustion of the blast furnace. The gas (*A*) reacted with coke in the zone of fusion to form another gas (*B*). *X* moles of (*B*) reacts with iron at 200°C and 100 atm pressure to form a compound (*C*).

38. The magnetic moment and effective atomic number of the (*C*) respectively are:

(a) 4.93 and 36 (b) 0 and 36

(c) 0 and 34 (d) None

39. The *d* orbital(s) involved in the formation of the complex (*C*) will be:

(a) d_{z^2} (b) $d_{x^2-y^2}$ and d_{z^2}

(c) *dxy* and $d_{x^2-y^2}$ (d) $d_{x^2-y^2}$

Comprehension-14: (Q. 40 and Q. 41)

Valence bond theory describes the bonding in complexes in terms of coordinate–covalent bonds resulting from overlap of filled ligand orbitals with vacant metal hybrid orbitals. This theory explains magnetic behavior and geometrical shape of coordination compounds. Magnetic moment of a complex compound can be determined experimentally and theoretically by using spin only formula.

Magnetic moment = $\sqrt{n(n+2)}$ B.M. (where n = No. of unpaired electrons).

40. The value of spin only magnetic moment for octahedral complex of the following configuration is 2.84 B.M. The correct statement is:

(a) d^4 (in weak field ligand)

(b) d^2 (in weak field and in strong field ligand)

(c) d^3 (in weak field and in strong field ligand)

(d) d^6 (in strong field ligand)

41. Ni^{2+} cation combines with a uninegative monodentate ligand X^- to form a paramagnetic complex $[NiCl_4]^2$. The number of unpaired electron(s) in central metal cation and geometry of this complex respectively are:

(a) One, tetrahedral (b) Two, tetrahedral

(c) One, square planar (d) Two, square planar

Assertion-Reasoning Type

1. **Statement-1:** Complexes containing three bidentate ligands do not show optical activity.

Statement-2: Octahedral complex $[Co(NH_3)_4Cl_2]Cl$ shows geometrical isomerism.

(a) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true; statement-2 is NOT a correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

2. **Statement-1:** $Ni(CO)_4$ complex has no unpaired electrons.

Statement-2: 4*s*-electrons of Ni atom enter into the inner *d*-orbitals to facilitate the dsp^2-hybridization in Ni atom.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

3. **Statement-1:** A solution of $[Ni(H_2O)_6]^{2+}$ is green but a solution of $[Ni(CN)_4]^{2-}$ is colorless.

Statement-2: $[Ni(CN)_4]^{2-}$ is square planar complex.

(a) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true; statement-2 is NOT a correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

4. **Statement-1:** Cu^+ ion is unstable in aqueous solution, whereas Fe^{2+} ion is stable.

Statement-2: Cu^+ disproportionate in aqueous solution.

(a) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true; statement-2 is NOT a correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

5. **Statement-1:** Δ_o increases in the order of $[CrCl_6]^{3-} < [Cr(CN)_6]^{3-} < [Cr(C_2O_4)_3]^{3-}$.

Statement-2: The stronger the ligand field, the higher will be Δ_o value.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

6. **Statement-1:** NO^+ has lower π accepting tendency than the CO.

Statement-2: NO donate 3 electrons into the vacant orbital of metal cation or atom.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

7. **Statement-1:** Hybridization of $[AuCl_4]^{\ominus}$ is sp^3.

Statement-2: Hybridization of Au in above complex compound does not depend upon nature of ligand.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

8. **Statement-1:** The d_{C-O} in bridging carbonyl group is longer than that of terminal carbonyl group.

Statement-2: With increase in extent of synergic bonding, the C — O bond length increases.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

9. **Statement-1:** $[M(AA)_3]^{n\pm}$ is optically inactive.

Statement-2: Plane of symmetry is not present and center of symmetry is not present.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

Matching Column Type

1. Match the column:

Column-I	Column-II
(a) $[Ag(NH_3)_2]^+$	(p) Octahedral
(b) $[Cu(NH_3)_4]^{2+}$	(q) Tetrahedral
(c) $[Cr(H_2O)_6]^{2+}$	(r) Trigonal bipyramidal
(d) $[Fe(CO)_5]$	(s) Square planar
	(t) Linear

2. Match the column:

List-I	List-II
(a) $[Ni(CN)_4]^{2-}$	(p) Tetrahedral
(b) $[ZnCl_4]^{2-}$	(q) Square planar
(c) $[Co(en)_3]^{3+}$	(r) Octahedral
(d) $[Zn(NH_3)_4]^{2+}$	(s) Square pyramidal

3. Match the column:

Column-I (Complex)	Column-II (Conductance)
(a) $[Pt(NH_3)_5Cl]Cl_3$	(p) 229
(b) $[Pt(NH_3)_3Cl_3]Cl$	(q) 97
(c) $[Pt(NH_3)_4Cl_2]Cl_2$	(r) 404
(d) $[Pt(NH_3)_6]Cl_4$	(s) 523

4. Match the column ***(unitary match):***

Column-I (Complex ion)	Column-II (Value charge on complex ion)
(a) $[Hg(CN)_4]^x$	(p) 3–
(b) $[Co(NH_3)_2Cl_4]^x$	(q) 2–
(c) $[Fe(CN)_6]^x$	(r) 1–
	(s) 2+

5. Match the complex (in Column-I) with the hybridization of the central ion (in Column-II):

Column-I	Column-II
(a) $Ni(CO)_4$	(p) sp^3d^2
(b) $[Ni(CN)_4]^{2-}$	(q) sp^3
(c) $[Fe(CN)_6]^{4-}$	(r) d^2sp^3
(d) $[MnF_6]^{4-}$	(s) dsp^2

6. Match the complex (in Column-I) with the geometry (in Column-II):

Column-I	Column-II
(a) $[Ni(dmg)_2]$	(p) Tetrahedral
(b) $[ZnCl_4]^{2-}$	(q) Trigonal bipyramidal
(c) $[Fe(CO)_5]$	(r) Square planar
(d) $[Co(NO_2)_6]^{4-}$	(s) Square pyramidal
	(t) Octahedral

7. Match the complex (in Column-I) with the oxidation number of Co (in Column-II):

Column-I	Column-II
(a) $[Co(NCS)(NH_3)_5]SO_4$	(p) –1
(b) $Na[Co(CO)_4]$	(q) 0
(c) $Na_4[Co(S_2O_3)_3]$	(r) +1
(d) $Co_2(CO)_8$	(s) +2
	(t) +3

8. Match the complex (in Column-I) with the type of isomerism (in Column-II) ***(unitary match):***

Column-I	Column-II
(a) $[Co(NH_3)_4Cl_2]$	(p) Optical
(b) *cis*$[Co(en)_2Cl_2]$	(q) Ionization
(c) $[Co(en)_2(NO_2)Cl]SCN$	(r) Coordination
(d) $[Co(NH_3)_6][Cr(CN)_6]$	(s) Geometrical

9. Match the complex (in Column-I) with the unpaired electron of the central ion (in Column-II)

Column-I	Column-II
(a) $[Fe(H_2O)_6]^{2+}$	(p) 0
(b) $[Fe(H_2O)_6]^{3+}$	(q) 1
(c) $[Fe(CN)_6]^{4-}$	(r) 2
(d) $[Fe(CN)_6]^{3-}$	(s) 3
(e) $[Ni(H_2O)_4]^{2+}$	(t) 4
	(u) 5

10. Match the geometry (given in Column-I) with the complexes (given in Column-II) in:

Column-I	Column-II
(a) Octahedral	(p) $[Ni(CN)_4]^-$
(b) Square planar	(q) $Ni(CO)_4$
(c) Tetrahedral	(r) $[Fe(CN)_6]^{4-}$
	(s) $[Ni(CN)_4]^{4-}$

11. Match the column:

Column-I	Column-II
(a) Hexabromido-platinate (2–)	(p) Monodentate ligand is present in complex/ion
(b) Potassium diammine-tetrabromidoco-baltate (III)	(q) Negative ligand is present in complex ion or molecule
(c) Tris(ethylenediamine) copper(II)	(r) Neutral ligand is present in complex ion/molecule sulphate
(d) Hexacarbonyl-manganese (I) perchlorate	(s) Central atom of complex or ion is a member of 3*d* transition series
	(t) Octahedral structure of complex ion/molecule

12. Match the column:

Column-I	Column-II
(a) $[Pt(NH_3)_2Cl_2]$	(p) Square planar complex
(b) $[Pt\,Cl_2\,(en)]$	(q) Central atom is a member of 3*d* transition series
(c) $[Pt(NH_3)(NO_2)(py)\,NH_2OH)]$	(r) Complex which shows geometrical isomerism
(d) $[Zn(gly)_2]$	(s) Non-planar complex
	(t) Both neutral as well as negative ligand are present in complex

13. Match the column:

Column-I	Column-II
(a) [Mabcd]	(p) Complex which shows geometrical isomerism
(b) $[M(AB)_2]$	(q) Two geometrical isomers

(c) $[M(AA)b_2]$ (r) Chelating ligand is present in complex

(d) $[M(AB)(CD)]$ (s) Complex in which ligand has two same donor atom

14. Match the column:

Column-I	Column-II
(a) $[Pt(NH_3)_2Cl_4]$	(p) Complex molecule/ion in which neutral ligand is present
(b) $[Cr(en)_2Cl_2]^+$	(q) Complex which shows geometrical isomerism
(c) $[Cr(gly)_3]$	(r) d^2sp^3-hybridization is present in central atom of complex molecule/ion
(d) $[Cr(en)_3]^{3+}$	(s) Two geometrical isomers
	(t) Complex in which only nitrogen atom acts as donor atom

15. Match the following:

Column-I	Column-II
(a) $[Cr(en)_2Cl_2]^+$	(p) Optical isomerism
(b) $[Fe(CN)_6]^{3-}$	(q) $d^2\,sp^3$-hybridization
(c) $[Ni(NH_3)_6]^{2+}$	(r) Paramagnetic
(d) $[CoF_6]^{3-}$	(s) sp^3d^2-hybridization

16. Match the column:

Column-I	Column-II
(a) Two unpaired electron	(p) $[Ni(en)_3]^{2+}$
(b) No unpaired electron	(q) $[VF_6]^{3-}$
(c) Optical isomerism	(r) $[NiCl_2(SCN)_4]^{4-}$
(d) Inner orbital complex	(s) $[Fe(CN)_6]^{4-}$

17. Match the Column:

Column-I	Column-II
(a) $[Cu(NH_3)_4]SO_4$	(p) dsp^2
(b) $[Pt(NH_3)_2Cl_2]$	(q) Octahedral
(c) $K_4[Fe(CN)_6]$	(r) sp^3d^2
(d) $[Fe(H_2O)_6]Cl_3$	(s) Square planar

18. Match the following:

Column-I	Column-II
(a) $[Ni\,(NH_3)_6]^{2+}$	(p) d^2sp^3 and diamagnetic
(b) $[Cr\,(NH_3)_6]^{3+}$	(q) sp^3d^2 and diamagnetic
(c) $[Co\,(NH_3)_6]^{3+}$	(r) sp^3d^2 and two unpaired electrons
(d) $[Zn\,(NH_3)_6]^{2+}$	(s) d^2sp^3 and three unpaired electrons

19. Match the column:

Column-I (Type of complex)	Column-II (The change in number of stereoisomer by the associated process with the given complex)
(a) $[M(AB)_2ab]^{n\pm} \xrightarrow{-a/+b}$	(p) 2
(b) $[Ma_2b_2c_2]^{n\pm} \xrightarrow{-b/+d}$	(q) 6
(c) $[M(AA)_2a_2]^{n\pm} \xrightarrow{-a/+c}$	(r) 3
(d) $[M(AB)a_3b]^{n\pm} \xrightarrow{-a/+b}$	(s) 5
	(t) 0

20. Match the column:

Column-I	Column-II
(a) $K_4[Fe(CN)_6]$	(p) d^2sp^3-hybridization
(b) $K_3[Fe(CN)_6]$	(q) Octahedral geometry
(c) $Fe_4[Fe(CN)_6]_3$	(r) Blue color due to charge transfer
(d) $[Co(NH_3)_6]^{3+}$	(s) Six electrons are present in t_{2g} orbitals
	(t) E.A.N is 36

21. Match the column:

Column-I	Column-II
(a) $[Pt(en)Cl_2]$	(p) Bidentate ligand present in complex moelcule/ion
(b) $[Pt(ox)_2]^{2-}$	(q) dsp^2-hybridization
(c) $[Fe(OH)_4]^{\ominus}$	(r) Only monodentate ligand is present in complex molecule/ion
(d) $[Pt(NH_3)_4]^{2+}$	(s) Planar
	(t) sp^3-hybridization

22. Match the column:

Column-I	Column-II
(a) $[M(AA)b_2cd]^{n\pm}$	(p) Four optically active isomer
(b) $[Ma_3bcd]^{n\pm}$	(q) Four geometrical isomer
(c) $[M(AB)b_2c_2]^{n\pm}$	(r) All geometrical isomers are optically active
(d) $[M(AB)_3]^{n\pm}$	(s) Two pair of enantiomer
	(t) Two optically inactive isomer.

Note: $\widehat{AA}$, $\widehat{AB}$ a,b,c,d are not having chiral center.

23. Match the column:

Column-I	Column-II
(a) $[Cr(H_2O)_5Br]^{2+}$	(p) Paramagnetic in nature
(b) $[Cu(NH_2CH_2CH_2NH_2)Cl_4]^{2-}$	(q) Geometrical isomerism is exhibited
(c) $[Pt(ox)_2]^{2-}$	(r) Optical isomerism is exhibited
(d) $[Fe(OH)_4]^{\ominus}$	(s) Do not follow Sidgwick E.A.N. rule
	(t) Complex having symmetrical bidentate ligand

24. Match the column:

Column-I	Column-II
(a) $[Be(gly)_2]$	(p) Complex which shows geometrical isomerism
(b) $[Ni(gly)_2]$	(q) Complex which shows optical isomerism
(c) $[Zn(gly)_2]$	(r) Complex which has dsp^2-hybridized central atom
(d) $[Pt(gly)_2]$	(s) Complex which has sp^3-hybridized central atom
	(t) Complex which has *s*-block element

25. Match the column:

Column-I	Column-II
(a) $[M(AA)_3]$	(p) Complex molecule which shows optical isomerism
(b) $[M(AA)_2b_2]$	(q) Only one *cis* and one *trans* isomer
(c) $[M(AA)b_2c_2]$	(r) Only one *cis* and two *trans* isomer
(d) $[M(AA)b_2cd]$	(s) Four geometrical isomer
	(t) Complex in which any *cis* isomer is optical active

26. Match the column:

Column-I	Column-II
(a) $[Cr(CN)_3(NO_2)_3]^{4-}$	(p) Outer orbital complex
(b) $[Co(C_2O_4)_3]^{3-}$	(q) Inner orbital complex
(c) $[Fe(EDTA)]^-$	(r) $\mu = 2\sqrt{2}$ B.M.
(d) $[Ni(en)_3](NO_3)_2$	(s) Shows optical activity

27. Match the following:

Column-I	Column-II
(a) $[Cr(en)_3]^{3+}$	(p) Paramagnetic
(b) $[Mn(CN)_6]^{3-}$	(q) $\mu_{spin} = \sqrt{15}$ B.M.
(c) $[Co(H_2O)_6]^{2+}$	(r) Two unpaired electrons
(d) $[Fe(CN)_6]^{3-}$	(s) Inner orbital complex

28. Match the column:

Column-I (Complex)	Column-II
(a) $[Ni(CO)_4]$	(p) sp^3-hybridization
(b) $[Co(CO)_4]^{\ominus}$	(q) Tetrahedral
(c) $[Fe(CO)_4]^{2-}$	(r) E.A.N is 36
(d) $[Fe(CO)_5]$	(s) Neutral complex compound
	(t) Central atom is a member of 3*d*-transition series

29. Match the column:

Column–I	Column–II
(a) MnO_4^-	(p) d^3s-hybridization
(b) CrO_4^{2-}	(q) Tetrahedral structure
(c) $Cr_2O_7^{2-}$	(r) Diamagnetic but colorful species
(d) CrO_2Cl_2	(s) +6 oxidation state on central atom
	(t) All X—O bonds are identical (where X is central atom)

30. Match the column:

Column-I	Column-II
(a) $[Fe(CO)_4]^{2-}$	(p) Complex having lowest bond length of CO ligand
(b) $[V(CO)_6]^{\ominus}$	(q) Follow Sidgwick's rule of E.A.N.
(c) $K[PtCl_3(C_2H_4)]$	(r) Synergic bonding is involved in complex/ion
(d) $[Fe(H_2O)_5NO]SO_4$	(s) Complex having highest bond length of CO ligand
	(t) Oragnometallic compound

31. Match the column:

Column-I	Column-II (Number of unpaired electron)	μ (B.M.)
(a) $[Fe(NH_3)_6]^{2+}$	(p) 0	0
(b) $[MnO_4]^-$	(q) 5	5.9
(c) $[Mn(NH_3)_6]^{2+}$	(r) 1	1.73
	(s) 4	4.90

32. Match the column:

Column-I	Column-II (Property which is different in given pair)
(a) $K_4[Ni(CN)_4]$ and $[Ni(en)_3]S_2O_3$	(p) Number of unpaired electrons
(b) $K_4[NiF_6]$ and $K_2[NiF_6]$	(q) Magnetic behavior (i.e., para/dia)
(c) $K_4[Co(NO_2)_6]$ and $[Fe(H_2O)_6]Cl_3$	(r) Hybridization
	(s) Geometry

33. Match the column:

Column-I	Column-II
(a) $[Ma_2\, b_2\, c_2]$	(p) Six geometrical *cis* isomers
(b) $[Ma_4\, bc]$	(q) Four *trans* geometrical isomers
(c) $[Ma_2\, b_2\, cd]$	(r) Octahedral complex compound
(d) $[Ma_2\, bcde]$	(s) Five geometrical isomers
	(t) Only two geometrical isomer

34. Match the column:

Column-I	Column-II
(a) $[Ma_3bcd]$	(p) The number of stereoisomers are two
(b) $[Ma_3b_3]$	(q) The number of pair of enantiomer is zero
(c) $[Mabcdef]$	(r) The number of stereoisomers are five
(d) $[Ma_2\, b_2\, c_2]$	(s) The pair of enantiomer is one
	(t) The pairs of enantiomers are fifteen

35. Match the column:

Column-I	Column-II
(a) $[M(AB)_3]$	(p) Zero pair of enantiomers
(b) $[M(AB)\,(CD)ef]$	(q) Ten pairs of enantiomers
(c) $[Ma_3\, b_2\, c]$	(r) Four number of stereoisomers
(d) $[Ma_4\, bc]$	(s) Two geometrical isomers

36. Match the following:

Column-I	Column-II
(a) $[Ni(CO)_4]$	(p) sp^3-hybridization
(b) $[AgF_4]^-$	(q) Diamagnetic
(c) $[Zn(CN)_4]^{2-}$	(r) dsp^2
(d) $[RhCl(PPh_3)_3]$	(s) Only unidentate ligand
	(t) Paramagnetic

Integer Answer Type

1. Find the number of ligands which are negative as well as flexidentate.

CO_3^{2-}, CH_3COO^-, $X^\ominus$, $H^\ominus$

2. Find the number of ligands which are monodentate as well as ambidentate.

$\overset{\ominus}{C}N$, $C_2O_2S_2^{2-}$, NO_2^-, $\overset{\ominus}{O}CN$

3. Find the number of ligand(s) in which donor atom is only N.

$NH_2CH_2COO^\ominus$, en, dien, Py, EDTA

4. Find the number of non-classical ligand which are negative ligand.

$\overset{\ominus}{C}N$, $S_2O_3^{2-}$ $C_3H_5^\ominus$, $C_5H_5^\ominus$

5. Find the number of *cis* isomer in $[Ma_2b_2]$.

6. Find the number of facial isomers in Ma_3b_3 complex.

7. Find the number of optical isomers are in Ma_3b_2c complex.

8. Find the ratio of stereoisomers and geometrical isomers in Ma_3b_2c.

9. Find the ratio of *cis* isomer and *trans* isomer in $[M(AB)\,b_2c_2]$.

10. How many ions are produced by $K_4[Fe(CN)_6]$ in an aqueous solution?

11. How many precipitated ions are produced by $CrCl_3 \cdot 5NH_3$ in an aqueous solution?

12. How many unpaired $e^\ominus$ are present in $[Ni(CN)_4]^{2-}$?

13. How many atomic orbitals are involved in hybridization of $[Co(NH_3)_6]^{2+}$?

14. How many maximum possible coordinated water molecules are present in $CrCl_3 \cdot 4H_2O$ complex compound?

15. Find the number of strong field ligand(s) from the following:

NH_3, en, $\overset{\ominus}{Cl}$, CH_3COO^-, $\overset{\ominus}{C}N$

16. Find the number of weak field ligand(s) from the following:

$\overset{\ominus}{Cl}$, H_2O, Py, $NO_2^{\ominus}$

17. How many unpaired $e^{\ominus}$ are present in t_{2g} orbital of $[Cr(NH_3)_6]^{3+}$?

18. How many minimum coordinated $Cl^{\ominus}$ ions are present in $CoCl_2 \cdot Br \cdot 4NH_3$ complex?

19. Find the ratio of *trans*-isomers in $[M(AA)\ b_2c_2]$ and $[Ma_4b_2]$, respectively.

20. Find the number of total possible ionization isomers in $[Pt(NH_3)_4Cl_2]Br_2$.

21. Find the number of total possible coordination isomers in $[Pt(NH_3)_4][Cu(Cl)_4]$.

22. How many donor atoms are present in EDTA?

23. What is the oxidation state of central atom in $[PtCl_3C_2H_4]^{\ominus}$ ion?

24. What is the coordination number of Cu in $[Cu(en)_2]^{2+}$?

25. What is the oxidation number of central atom in $[Co(NH_3)_2(NO_2)_4]^{\ominus}$?

26. How many geometrical isomer(s) is/are possible in $[Pt(NH_3)(NH_2OH)\ Py(NO_2)]^+$?

27. How many EDTA (ethylenediamine tetraacetate) molecule(s) is/are required to make an octahedral complex with Ca^{2+}?

28. In hexacyanidomanganate(II) ion the Mn atom assumes d^2sp^3-hybrid states. Then the number of unpaired electrons in the complex is:

29. Find the total number of possible structural isomers of the compound $[\overset{II}{Cu}\ (NH_3)_4][\overset{II}{Pt}\ Cl_4]$.

30. In the complex $Ni(CO)_x$, find the value of x.

31. In tris(ethylenediamine) cobalt(III) chloride, find the coordination number of cobalt.

32. Find the number of geometrical isomers of $[Co(NH_3)_3(NO_2)_3]$.

33. Find the number of unpaired electron(s) in the complex ion $[CoF_6]^{3-}$.

34. The sum of primary and secondary valencies of chromium in the complex $CrCl_3 \cdot 6NH_3$ is:

35. The complex $[Co(NH_3)_3Cl_3]$ when dissolved in water gives how many ions?

36. Find the number of isomeric forms in which $[Co(NH_3)_4Cl_2]^+$ ion can occur.

37. Find the number of ions formed when copper ammonium sulphate is dissolved in water.

38. Find the number of ions furnished per molecule of the complex $[Ni(NH_3)_4]Cl_2$.

39. Predict the number of unpaired electrons in a tetrahedral d^6 ion and in a square planar d^7 ion.

Note: [If answer is 1 and 2, then represent as 12.]

40. Find the number of unpaired electron present in the d-orbitals (whose lobes are present along the axis) for the complex $[Co(SCN)_4]^{2-}$.

41. Find the total number of possible isomers (*cis-trans* and optical) of $CrCl_2en_2^+$.

42. Find the total number of possible isomers of $[CrCl_3(NH_3)_3]$.

43. Find the total number of possible isomers of $[CrCl_2(CN)(NH_3)en]$.

44. Find the number of unpaired electrons calculated in $[Co(NH_3)_6]^{3+}$ and $[CoF_6]^{3-}$.

45. Find out the number of $3d$ electrons occupied in t_{2g} orbitals of hydrated Cr^{3+} ion (octahedral).

46. Find the number of ligand(s) which is/are chelating.

en, $C_2O_4^{2-}$, acac, DMG, gly

47. Find the number of ligand(s) which is/are polydentate ligand.

en, dmg, dien, EDTA

48. Find the number of geometrical isomer in $[Pt(gly)_2]$.

49. Find the number of geometrical isomer in $[M(AB)_3]$.

50. How many unpaired $e^{\ominus}$ are present in e_g orbital of MnO_4^-?

51. How many $e^{\ominus}$ are present in d_{z^2} orbital of $[Ni(gly)_2]$?

52. How many coordinated water molecule(s) is/are present in brown ring complex?

53. Find the ratio of geometrical isomers in $[M(AA)_2b_2]$ and optical isomers of $[M(AA)_3]$.

54. What is the value of x in $H_x[Cr(CO)_5]$?

55. Write the sum of geometrical isomer in $[Ma_2b_2c_2]$ complex and stereoisomers in $[M(AB)_3]$ complex.

56. If $AgNO_3$ solution is added in excess to 1 M solution of $CoCl_3 \cdot XNH_3$, one mole of AgCl is formed. What is the value of x?

57. Predict the number of unpaired electrons for each of the following:

(i) A tetrahedral d^6 ion (ii) $[Co(H_2O)_6]^{2+}$

(iii) $[Cr(H_2O)_6]^{3+}$ (iv) A square planar d^7 ion

(v) A coordination compound with magnetic moment of 5.92 B.M.

58. Find the values of highest oxidation state of chromium:

59. Find the number of t_{2g} and e_g electrons in $[NiF_6]^{2-}$.
Note: [If answer is 4 and 2 then represent as 42.]

60. Find total possible stereoisomer for the molecule $[Ma_2bcde]^{n\pm}$ (where a,b,c,d,e are simple monodentate ligand having no chiral center).

61. Write the sum of geometrical isomers in $[Pt(H_2N-CH(CH_3)-COO^-)_2]$ complex and stereoisomers of $[Pt(gly)_3]^+$ complex.

62. Find the coordination number and oxidation number of X in the given compound $[X(NH_3)_5(SO_4)]Cl$.

63. Find the magnetic moment of a salt containing Zn^{2+} ion.

64. Find the number of ligand(s) which is/are ambidentate and bidentate.

$$\overset{\ominus}{S}CN, \overset{\ominus}{O}CN, S_2O_3^{2-}, C_2O_2S_2^{2-}$$

65. Find the number of ligand(s) which is/are non-classical ligand.

$$CO,\ NO,\ C_2H_4, C_3H_5^{\ominus}, H^{\ominus}$$

66. Find the number of ligand(s) which are monodentate, neutral as well as non-classical ligand.

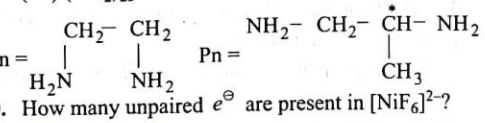
$$CO,\ \overset{\ominus}{C}N,\ S_2O_3^{2-},\ PF_3$$

67. Find the number of ligands which are non-classical ligand and π donor as well as π acceptor ligand.

$$CO,\ PH_3,\ PF_3,\ C_3H_5^{\ominus}, C_5H_5^{\ominus}$$

68. Find the number of stereoisomer in $[Pt(NH_2-CH(CH_3)COO^-)_2]$.

69. Find the number of geometrical isomers in $[Co(en)(Pn)(NO_2)_2]$.



70. How many unpaired $e^{\ominus}$ are present in $[NiF_6]^{2-}$?

71. How many $e^{\ominus}$ are present in d-orbitals which are present along the axis in $[Ti(H_2O)_6]^{3+}$?

72. If Hund's rule violated, then how many unpaired $e^{\ominus}$ are present in $[Cr(NH_3)_6]^{3+}$ complex ion?

73. How many d-orbital(s) is/are involved in hybridization of $[AuCl_4]^{\ominus}$?

74. Find the oxidation state of Co in its oxo-complex species $[Co_2O_4(C_2H_4)_2(H_2O)_2]^{2-}$.

75. Find the oxidation state of NO in the brown ring complex $[Fe(H_2O)_5NO]SO_4$.

76. Find the number of ions formed on dissolving one molecule of $FeSO_4(NH_4)_2SO_4 \cdot 6H_2O$ in water.

77. How many pairs of enantiomers are possible for $[M(AA)(BC)de]$?

78. Find the total number of isomer of $[Be(gly)_2]$.

79. Number of pair of enantiomer of $[Ma_2b_2cd]$ is _____.

80. Find the number of unpaired electrons in t_{2g}-set of d-orbitals in $[Co(H_2O)_3F_3]$ complex.

81. The number of total possible stereoisomers for $[Pd(NH_2-CH(CH_3)-CO_2^-)_2]^0$ is:

82. What are the values of m and n in the anionic species $[V(CO)_m]^{n-}$, if it is following Sidgwick E.A.N. rule and having octahedral shape?

83. Find the total number of possible isomers of $[ZnCl_2F_2]^{2-}$.

84. How many maximum atom(s) is/are present in same plane of $Cr(CO)_6$?

85. An alcoholic solution of dimethylglyoxime is added to an aqueous solution of nickel(II) chloride. Slow addition of ammonium hydroxide lead to the precipitation of a Rosy-red colored metal complex. Then find out the number of hydrogen bonds present in the structure of the complex.

NCERT Exemplar Exercises

Single Correct Answer Type

1. Which of the following complexes formed by Cu^{2+} ions is most stable?

(a) $Cu^{2+} + 4NH_3$ $[Cu(NH_3)_4]^{2+}$, $\log K = 11.6$
(b) $Cu^{2+} + 4CN^-$ $[Cu(CN)_4]^{2-}$, $\log K = 27.3$
(c) $Cu^{2+} + 2en$ $[Cu(en)_2]^{2+}$, $\log K = 15.4$
(d) $Cu^{2+} + 4H_2O$ $[Cu(H_2O)_4]^{2+}$, $\log K = 8.9$

2. The color of the coordination compounds depends on the crystal field splitting. What will be the correct order of absorption of wavelength of light in the visible region, for the complexes, $[Co(NH_3)_6]^{3+}$, $[Co(CN)_6]^{3-}$, $[Co(H_2O)_6]^{3+}$:

(a) $[Co(CN)_6]^{3-} > [Co(NH_3)_6]^{3+} > [[Co(H_2O)_6]^{3+}$
(b) $[Co(NH_3)_6]^{3+} > [Co(H_2O)_6]^{3+} > [Co(CN)_6]^{3-}$
(c) $[Co(H_2O)_6]^{3+} > [Co(NH_3)_6]^{3+} > [Co(CN)_6]^{3-}$
(d) $[Co(CN)_6]^{3-} > [Co(NH_3)_6]^{3+} > [Co(H_2O)_6]^{3+}$

3. When 0.1 mol $CoCl_3(NH_3)_5$ is treated with excess of $AgNO_3$, 0.2 mol of AgCl are obtained. The conductivity of solution will correspond to

(a) 1:3 electrolyte (b) 1:2 electrolyte
(c) 1:1 electrolyte (d) 3:1 electrolyte

4. When 1 mol $CrCl_3 \cdot 6H_2O$ is treated with excess of $AgNO_3$, 3 mol of AgCl are obtained. The formula of the complex is:
   (a) $[CrCl_3(H_2O)_3] \cdot 3H_2O$
   (b) $[CrCl_2(H_2O)_4]Cl \cdot 2H_2O$
   (c) $[CrCl(H_2O)_5]Cl_2 \cdot H_2O$
   (d) $[Cr(H_2O)_6]Cl_3$
5. The correct IUPAC name of $[Pt(NH_3)_2Cl_2]$ is:
   (a) Diamminedichloridoplatinum(II)
   (b) Diamminedichloridoplatinum(IV)
   (c) Diamminedichloridoplatinum(0)
   (d) Dichloridodiammineplatinum(IV)
6. The stabilization of coordination compounds due to chelation is called the chelate effect. Which of the following is the most stable complex species?
   (a) $[CoCl_6]^{-4}$ (b) $[Fe(SCN)_6]^{3-}$
   (c) $[Fe(C_2O_4)_3]^{3-}$ (d) $[Fe(H_2O)_6]^{3+}$
7. Indicate the complex ion which shows geometrical isomerism:
   (a) $[Cr(H_2O)_4Cl_2]^+$ (b) $[Pt(NH_3)_3Cl]^+$
   (c) $[Co(NH_3)_6]^{3+}$ (d) $[Co(CN)_5(NC)]^{3-}$
8. The CFSE for octahedral $[CoCl_6]^{4-}$ is 18,000 cm^{-1}. The CFSE for tetrahedral $[CoCl_4]^{2-}$ will be:
   (a) 18,000 cm^{-1} (b) 16000 cm^{-1}
   (c) 8000 cm^{-1} (d) 20000 cm^{-1}
9. Due to the presence of ambidentate ligands coordination compounds show isomerism. Palladium complexes of the type $[Pd(C_6H_5)_2(SCN)_2]$ and $[Pd(C_6H_5)_2(NCS)_2]$ are:
   (a) Linkage isomers
   (b) Coordination isomers
   (c) Ionization isomers
   (d) Geometrical isomers
10. The compounds $[Co(SO_4)(NH_3)_5]Br$ and $[Co(SO_4)(NH_3)_5]Cl$ represent:
   (a) Linkage isomerism
   (b) Ionization isomerism
   (c) Coordination isomerism
   (d) No isomerism
11. A chelating agent has two or more than two donor atoms to bind to a single metal ion. Which of the following is not a chelating agent?
   (a) Thiosulphato (b) Oxalato
   (c) Glycinato (d) Ethane-1,2-diamine
12. Which of the following species is not expected to be a ligand?
   (a) NO (B) NH_4^+
   (c) $NH_2CH_2CH_2NH_2$ (d) CO
13. What kind of isomerism exists between $[Cr(H_2O)_6]Cl_3$ (violet) and $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$ (greyish-green)?
   (a) Linkage isomerism
   (b) Solvate isomerism
   (c) Ionization isomerism
   (d) Coordination isomerism
14. IUPAC name of $[Pt(NH_3)_2Cl(NO_2)]$ is:
   (a) Platinum diaminechloronitrite
   (b) Chloronitrito-N-ammineplatinum(II)
   (c) Diamminechloridonitrito-N-platinum(II)
   (d) Diamminechloronitrito-N-platinate(II)

Multiple Correct Answers Type

Note: In the following questions two or more options may be correct.

1. Atomic number of Mn, Fe, and Co are 25, 26, and 27 respectively. Which of the following inner orbital octahedral complex ions are diamagnetic?
   (a) $[Co(NH_3)_6]^{3+}$ (b) $[Mn(CN)_6]^{3-}$
   (c) $[Fe(CN)_6]^{4-}$ (d) $[Fe(CN)_6]^{3-}$
2. Atomic number of Mn, Fe, Co, and Ni are 25, 26, 27, and 28 respectively. Which of the following outer orbital octahedral complexes have same number of unpaired electrons?
   (a) $[MnCl_6]^{3-}$ (b) $[FeF_6]^{3-}$
   (c) $[CoF_6]^{3-}$ (d) $[Ni(NH_3)_6]^{2+}$
3. Which of the following options are correct for $[Fe(CN)_6]^{3-}$ complex?
   (a) d^2sp^3 hybridization (b) sp^3d^2 hybridization
   (c) Paramagnetic (d) Diamagnetic
4. An aqueous pink solution of cobalt(II) chloride changes to deep blue on addition of excess of HCl. This is because _____.
   (a) $[Co(H_2O)_6]^{2+}$ is transformed into $[CoCl_6]^{4-}$
   (b) $[Co(H_2O)_6]^{2+}$ is transformed into $[CoCl_4]^{2-}$
   (c) Tetrahedral complexes have smaller crystal field splitting than octahedral complexes
   (d) Tetrahedral complexes have larger crystal field splitting than octahedral complex
5. Which of the following complexes are homoleptic?
   (a) $[Co(NH_3)_6]^{3+}$ (b) $[Co(NH_3)_4Cl_2]^+$
   (c) $[Ni(CN)_4]^{2-}$ (d) $[Ni(NH_3)_4Cl_2]$

6. Which of the following complexes are heteroleptic?
   (a) $[Cr(NH_3)_6]^{3+}$ (b) $[Fe(NH_3)_4 Cl_2]^+$
   (c) $[Mn(CN)_6]^{4-}$ (d) $[Co(NH_3)_4Cl_2]$
7. Identify the optically active compounds from the following:
   (a) $[Co(en)_3]^{3+}$ (b) *trans*- $[Co(en)_2Cl_2]^+$
   (c) *cis*- $[Co(en)_2 Cl_2]^+$ (d) $[Cr (NH_3)_5Cl]$
8. Identify the correct statements for the behavior of ethane-1, 2-diamine as a ligand.
   (a) It is a neutral ligand
   (b) It is a didentate ligand
   (c) It is a chelating ligand
   (d) It is a unidentate ligand
9. Which of the following complexes show linkage isomerism?
   (a) $[Co(NH_3)_5 (NO_2)]^{2+}$ (b) $[Co(H_2O)_5CO]^{3+}$
   (c) $[Cr(NH_3)_5 SCN]^{2+}$ (d) $[Fe(en)_2Cl_2]^+$

Short Answer Type

1. Arrange the following complexes in the increasing order of conductivity of their solution: $[Co(NH_3)_3Cl_3]$, $[Co(NH_3)_4Cl_2]Cl$, $[Co(NH_3)_6]Cl_3$, $[Cr(NH_3)_5Cl]Cl_2$
2. A coordination compound $CrCl_3 \cdot 4H_2O$ precipitates silver chloride when treated with silver nitrate. The molar conductance of its solution corresponds to a total of two ions. Write structural formula of the compound and name it.
3. A complex of the type $[M(AA)_2X_2]^{+n}$ is known to be optically active. What does this indicate about the structure of the complex? Give one example of such complex.
4. Magnetic moment of $[MnCl_4]^{2-}$ is 5.92 BM. Explain giving reason.
5. On the basis of crystal field theory explain why Co(III) forms paramagnetic octahedral complex with weak field ligands whereas it forms diamagnetic octahedral complex with strong field ligands.
6. Why are low spin tetrahedral complexes not formed?
7. Give the electronic configuration of the following complexes on the basis of crystal field splitting theory. $[CoF_6]^{3-}$, $[Fe(CN)_6]^{4-}$ and $[Cu(NH_3)_6]^{2+}$.
8. Explain why $[Fe(H_2O)_6]^{3+}$ has magnetic moment value of 5.92 BM whereas $[Fe(CN)_6]^{3-}$ has a value of only 1.74 BM.
9. Arrange the following complex ions in increasing order of crystal field splitting energy (O): $[Cr(Cl)_6]^{3-}$, $[Cr(CN)_6]^{3-}$, $[Cr(NH_3)_6]^{3+}$.
10. Why do compounds having similar geometry have different magnetic moment?
11. $CuSO_4 \cdot 5H_2O$ is blue in color while $CuSO_4$ is colorless. Why?
12. Name the type of isomerism when ambidentate ligands are attached to central metal ion. Give two examples of ambidentate ligands.

Matching Column Type

Note: In the following questions match the items given in Columns I and II.

1. Match the complex ions given in Column-I with the colors given in Column-II and assign the correct code:

Column-I (Complex ion)	Column-II (Color)
(a) $[Co(NH_3)_6]^{3+}$	(p) Violet
(b) $[Ti(H_2O)_6]^{3+}$	(q) Green
(c) $[Ni(H_2O)_6]^{2+}$	(r) Pale blue
(d) $[Ni(H_2O)_4 (en)]^{2+}$ (aq)	(s) Yellowish orange
	(t) Blue

Code:
   (a) a (p) b (q) c (s) d (t)
   (b) a (s) b (r) c (q) d (p)
   (c) a (r) b (q) c (s) d (p)
   (d) a (s) b (p) c (q) d (r)

2. Match the coordination compounds given in Column-I with the central metal atoms given in Column-II and assign the correct code:

Column-I (Coordination compound)	Column-II (Central metal atom)
(a) Chlorophyll	(p) Rhodium
(b) Blood pigment	(q) Cobalt
(c) Wilkinson catalyst	(r) Calcium
(d) Vitamin B12	(s) Iron
	(t) Magnesium

Code:
   (a) a (t) b (s) c (p) d (q)
   (b) a (r) b (s) c (t) d (p)
   (c) a (s) b (r) c (q) d (p)
   (d) a (r) b (s) c (p) d (q)

3. Match the complex ions given in Column-I with the hybridization and number of unpaired electrons given in Column-II and assign the correct code:

Column-I (Complex ion)	Column-II (Hybridization, number of unpaired electrons)
(a) $[Cr(H_2O)_6]^{3+}$	(p) dsp^2, 1
(b) $[Co(CN)_4]^{2-}$	(q) sp^3d^2, 5
(c) $[Ni(NH_3)_6]^{2+}$	(r) d^2sp^3, 3
(d) $[MnF_6]^{4-}$	(s) sp^3, 4
	(t) sp^3d^2, 2

Code:

(a) a (r) b (p) c (t) d (q)
(b) a (s) b (r) c (q) d (p)
(c) a (r) b (q) c (s) d (p)
(d) a (s) b (p) c (q) d (r)

4. Match the complex species given in Column-I with the possible isomerism given in Column-II and assign the correct code:

Column-I (Complex species)	Column-II (Isomerism)
(a) $[Co(NH_3)_4 Cl_2]^+$	(p) Optical
(b) cis-$[Co(en)_2 Cl_2]^+$	(q) Ionization
(c) $[Co(NH_3)_5 (NO_2)]Cl_2$	(r) Coordination
(d) $[Co(NH_3)_6] [Cr(CN)_6]$	(s) Geometrical
	(t) Linkage

Code:

(a) a (p) b (q) c (s) d (t)
(b) a (s) b (r) c (q) d (p)
(c) a (s) b (p) c (t) d (r)
(d) a (s) b (p) c (q) d (r)

5. Match the compounds given in Column-I with the oxidation state of cobalt present in it (given in Column-II) and assign the correct code.

Column-I (Compound)	Column-II (Oxidation state of Co)
(a) $[Co(NCS)(NH_3)_5](SO_3)$	(p) + 4
(b) $[Co(NH_3)_4Cl_2]SO_4$	(q) 0
(c) $Na_4[Co(S_2O_3)_3]$	(r) + 1
(d) $[Co_2(CO)_8]$	(s) + 2
	(t) + 3

Code:

(a) a (p) b (q) c (s) d (t)
(b) a (s) b (r) c (q) d (p)
(c) a (t) b (p) c (s) d (q)
(d) a (s) b (p) c (q) d (r)

Assertion-Reasoning Type

Note: In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are true, reason is correct explanation of assertion.

(b) Assertion and reason both are true but reason is not correct.

(c) Assertion is true, reason is false.

(d) Assertion is false, reason is true.

1. **Assertion:** Toxic metal ions are removed by the chelating ligands.

   Reason: Chelate complexes tend to be more stable.

2. **Assertion:** $[Cr(H_2O)_6]Cl_2$ and $[Fe(H_2O)_6]Cl_2$ are reducing in nature.

   Reason: Unpaired electrons are present in their *d*-orbitals.

3. **Assertion:** Linkage isomerism arises in coordination compounds containing ambidentate ligand.

   Reason: Ambidentate ligand has two different donor atoms.

4. **Assertion:** Complexes of MX_6 and MX_5L type (X and L are unidentate) do not show geometrical isomerism.

   Reason: Geometrical isomerism is not shown by complexes of coordination number 6.

5. **Assertion:** $[Fe(CN)_6]^{3-}$ ion shows magnetic moment corresponding to two unpaired electrons.

   Reason: Because it has d^2sp^3 type hybridization.

Long Answer Type

1. Using crystal field theory, draw energy level diagram, write electronic configuration of the central metal atom/ion and determine the magnetic moment value in the following:
   (i) $[CoF_6]^{3-}$, $[Co(H_2O)_6]^{2+}$, $[Co(CN)_6]^{3-}$
   (ii) $[FeF_6]^{3-}$, $[Fe(H_2O)_6]^{2+}$, $[Fe(CN)_6]^{4-}$

2. Using valence bond theory, explain the following in relation to the complexes given below: $[Mn(CN)_6]^{3-}$, $[Co(NH_3)_6]^{3+}$, $[Cr(H_2O)_6]^{3+}$, $[FeCl_6]^{4-}$

(i) Type of hybridization
(ii) Inner or outer orbital complex
(iii) Magnetic behavior.
(iv) Spin only magnetic moment value

3. $CoSO_4Cl_5NH_3$ exists in two isomeric forms 'A' and 'B'. Isomer 'A' reacts with $AgNO_3$ to give white precipitate, but does not react with $BaCl_2$. Isomer 'B' gives white precipitate with $BaCl_2$ but does not react with $AgNO_3$. Answer the following questions.
   (i) Identify 'A' and 'B' and write their structural formulas.
   (ii) Name the type of isomerism involved.
   (iii) Give the IUPAC name of 'A' and 'B'.
4. What is the relationship between observed color of the complex and the wavelength of light absorbed by the complex?
5. Why are different colors observed in octahedral and tetrahedral complexes for the same metal and same ligands?

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. A square planar complex is formed by hybridization of which atomic orbitals?
   (a) s, p_x, p_y, d_{yz} (b) $s, p_x, p_y, d_{x^2-y^2}$
   (c) s, p_x, p_y, d_{y^2} (d) s, p_y, p_z, d_{xy}
   (AIEEE, 2002)
2. The type of isomerism present in nitropentamine chromium(III) chloride is:
   (a) Optical (b) Linkage
   (c) Ionization (d) Polymerization
   (AIEEE, 2002)
3. CH_3–Mg–Br is an organometallic compound due to:
   (a) Mg–Br bond (b) C–Mg bond
   (c) C–Br bond (d) C–H bond
   (AIEEE, 2002)
4. The most stable ion is:
   (a) $[Fe(OH)_3]^{3-}$ (b) $[Fe(Cl)_6]^{3-}$
   (c) $[Fe(CN)_6]^{3-}$ (d) $[Fe(H_2O)_6]^{3-}$
   (AIEEE, 2002)
5. Ammonia forms the complex ion $[Cu(NH_3)_4]^{2+}$ with copper ions in alkaline solutions but not in acidic solutions. What is the reason for it?
   (a) In acidic solutions, protons coordinate with ammonia molecules forming. NH_4^+ ions and NH_3 molecules are not available
   (b) In alkaline solutions, insoluble $Cu(OH)_2$ is precipitated which is soluble in excess of any alkali
   (c) Copper hydroxide is an amphoteric substance
   (d) In acidic solutions, hydration protects copper ions
   (AIEEE, 2003)
6. One mole of the complex compound $Co(NH_3)_5Cl_3$ gives 3 moles of ions on dissolution in water. One mole of the same complex reacts with two moles of $AgNO_3$ solution to yield two moles of AgCl(s). The structure of the complex is:
   (a) $[Co(NH_3)_3\ Cl_3] \cdot 2NH_3$
   (b) $[Co(NH_3)_4\ Cl_2] \cdot 2NH_3$
   (c) $[Co(NH_3)_4\ Cl]Cl_2 \cdot NH_3$
   (d) $[Co(NH_3)_5\ Cl] \cdot Cl_2$
   (AIEEE, 2003)
7. In the coordination compound, $K_4[Ni(CN)_4]$, the oxidation state of nickel is:
   (a) 0 (b) +1
   (c) +2 (d) –1
   (AIEEE, 2003)
8. Among the properties (i) reducing, (ii) oxidizing, and (iii) complexing, the set of properties shown by CN^- ion towards metal species is:
   (a) (iii) and (i) (b) (ii) and (iii)
   (c) (i) and (ii) (d) (i), (ii), and (iii)
   (AIEEE, 2004)
9. The coordination number of a central metal atom in a complex is determined by:
   (a) The number of ligands around a metal ion bonded by both sigma and pi-bonds
   (b) The number of ligands around a metal ion bonded by pi-bonds
   (c) Number of ligands around a metal ion bonded by sigma bonds
   (d) The number of only anionic ligands bonded to the metal ion
   (AIEEE, 2004)
10. Which one of the following complexes is an outer orbital complex?
   (a) $[Co(NH_3)_6]^{3+}$ (b) $[Mn(CN)_6]^{4-}$
   (c) $[Fe(CN)_6]^{4-}$ (d) $[Ni(NH_3)_6]^{2+}$
   (AIEEE, 2004)

11. Coordination compounds have great importance in biological systems. In this context, which of the following statements is incorrect?
    (a) Cyanocobalamin is B_{12} and contains cobalt
    (b) Hemoglobin is the red pigment of blood and contains irons
    (c) Chlorophylls are green pigments in plants and contain calcium
    (d) Carboxypeptidase-A is an enzyme and contains zinc

(AIEEE, 2004)

12. Which one of the following has the largest number of isomers?
    (a) $[Ir(PR_3)_2H(CO)]^{2+}$
    (b) $[Co(NH_3)_5Cl]^{2+}$
    (c) $[Ru(NH_3)_4Cl_2]^+$
    (d) $[Co(en)_2Cl_2]^+$ (R = alkyl group, en = ethylenediamine)

(AIEEE, 2004)

13. The correct order of magnetic moments [spin only values in Bohr Magneton (B.M.)] among is:
    (a) $[Fe(CN)_6]^{4-} > [MnCl_4]^{2-} > [CoCl_4]^{2-}$
    (b) $[MnCl_4]^{2-} > [Fe(CN)_6]^{4-} > [CoCl_4]^{2-}$
    (c) $[MnCl_4]^{2-} > [CoCl_4]^{2-} > [Fe(CN)_6]^{4-}$
    (d) $[Fe(CN)_6]^{4-} > [CoCl_4]^{2-} > [MnCl_4]^{2-}$

(AIEEE, 2004)

14. The oxidation state of Cr in $[Cr(NH_3)_4Cl_2]^+$ is:
    (a) 0 (b) +1
    (c) +2 (d) +3

(AIEEE, 2005)

15. The IUPAC name of the coordination compound $K_3[Fe(CN)_6]$ is:
    (a) Tripotassium hexacyanoiron(II)
    (b) Potassium hexacyanoiron(II)
    (c) Potassium hexacyanoferrate(III)
    (d) Potassium hexacyanoferrate(II)

(AIEEE, 2005)

16. Which of the following compounds shows optical isomerism?
    (a) $[Co(CN)_6]^{3-}$ (b) $[Co(C_2O_4)_3]^{3-}$
    (c) $[ZnCl_4]^{2-}$ (d) $[Cu(NH_3)_4]^{2+}$

(AIEEE, 2005)

17. Which one of the following cyano complexes would exhibit the lowest value of paramagnetic behavior?
    (a) $[Co(CN)_6]^{3}$ (b) $[Fe(CN)_6]^{3-}$
    (c) $[Mn(CN)_6]^{3}$ (d) $[Cr(CN)_6]^{3-}$

(AIEEE, 2005)

18. The value of the 'spin only' magnetic moment for one of the following configurations is 2.84 BM. The correct one is:
    (a) d^6 (in strong ligand field)
    (b) d^3 (in weak as well as in strong fields)
    (c) d^4 (in weak ligand fields)
    (d) d^4 (in strong ligand fields)

(AIEEE, 2005)

19. The IUPAC name for the complex $[Co(NO_2)(NH_3)_5Cl_2]$ is:
    (a) Pentaammine nitrito-N-cobalt(II) chloride
    (b) Pentaammine nitrito-N-cobalt(III) chloride
    (c) Nitrito-N-pentaamminecobalt(III) chloride
    (d) Nitrito-N-pentaamminecobalt(II) chloride

(AIEEE, 2006)

20. A metal, M, forms chlorides in its +2 and +4 oxidation states. Which of the following statements about these chlorides is correct?
    (a) MCl_2 is more ionic than MCl_4
    (b) MCl_2 is more easily hydrolysed than MCl_4
    (c) MCl_2 is more volatile than MCl_4
    (d) MCl_2 is more soluble in anhydrous ethanol than MCl_4

(AIEEE, 2006)

21. Nickel (Z = 28) combines with a uninegative monodentate ligand X^- to form a paramagnetic complex $[NiX_4]^{2-}$. The number of unpaired electron(s) in nickel and geometry of this complex ion are, respectively:
    (a) One, square planar
    (b) Two, square planar
    (c) One, tetrahedral
    (d) Two, tetrahedral

(AIEEE, 2006)

22. In $Fe(CO)_5$, the Fe–C bond possesses:
    (a) Ionic character
    (b) σ-character only
    (c) π-character
    (d) Both σ- and π-characters

(AIEEE, 2006)

23. How many EDTA (ethylenediaminetetraacetic acid) molecules are required to make an octahedral complex with a Ca^{2+} ion?
    (a) One (b) Two
    (c) Six (d) Three

(AIEEE, 2006)

24. The 'spin-only' magnetic moment [in units of Bohr magneton, (m_B)] of Ni^{2+} in aqueous solution would be (atomic number of Ni = 28):

(a) 6 (b) 1.73
(c) 2.84 (d) 4.90

(AIEEE, 2006)

25. Which of the following has a square planar geometry?

(a) $[PtCl_4]^{2-}$ (b) $[(CoCl_4]^{2-}$
(c) $[FeCl_4]^{2-}$ (d) $[NiCl_4]^{2-}$

(AIEEE, 2007)

26. The coordination number and the oxidation state of the element 'E' in the complex $[E(en)_2(C_2O_4)]NO_2$, where (en) is ethylene diamine, are, respectively:

(a) 6 and 2 (b) 4 and 2
(c) 4 and 3 (d) 6 and 3

(AIEEE, 2008)

27. In which of the following complexes of the Co (atomic no. = 27), will the magnitude of Δ_o be the highest?

(a) $[Co(CN)_6]^{3-}$ (b) $[Co(C_2O_4)_3]^{3-}$
(c) $[Co(H_2O)_6]^{3+}$ (d) $[Co(NH_3)_6]^{3+}$

(AIEEE, 2008)

28. Which of the following has an optical isomer?

(a) $[Co(en)(NH_3)_2]^{2+}$
(b) $[Co(H_2O)_4(en)]^{3+}$
(c) $[Co(en)_2(NH_3)_2]^{3+}$
(d) $[Co(NH_3)_3Cl]^+$

29. Which of the following pairs represent linkage isomers?

(a) $[Pd(PPh_3)_2(NCS)_2]$ and $[Pd(PPh_3)_2(SCN)_2]$
(b) $[Co(NH_3)_5NO_3]SO_4$ and $[Co(NH_3)_5SO_4]NO_3$
(c) $[PtCl_2(NH_3)_4Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$
(d) $[Cu(NH_3)_4][PtCl_4]$ and $[Pt(NH_3)_4][CuCl_4]$

(AIEEE, 2009)

30. A solution containing 2.675 g of $CoCl_3 \cdot 6NH_3$ (molar mass = 267.5 g mol^{-1}) is passed through a cation exchanger. The chloride ions obtained in solution were treated with excess of $AgNO_3$ to give 4.78 g of AgCl (molar mass = 143.5 g mol^{-1}). The formula of the complex is:

(a) $[Co(NH_3)_6]Cl_3$ (b) $[CoCl_2(NH_3)_4]Cl$
(c) $[CoCl_3(NH_3)_3]$ (d) $[CoCl(NH_3)_5]Cl_2$

(AIEEE, 2010)

31. Which one of the following has an optical isomer?

(a) $[Zn(en)(NH_3)_2]^{2+}$ (b) $[Co(en)_3]^{3+}$
(c) $[Co(H_2O)_3(en)]^{3+}$ (d) $[Zn(en)_2]^{2+}$

(AIEEE, 2010)

32. Which of the following facts about the complex $[Cr(NH_3)_6Cl_3$ is wrong?

(a) The complex involves d^2sp^3 hybridization and is octahedral in shape
(b) The complex is paramagnetic
(c) The complex is an outer orbital complex
(d) The complex gives white precipitate with silver nitrate solution

(AIEEE, 2011)

33. The magnetic moment (spin only) of $[NiCl_4]^{2-}$ is:

(a) 1.82 BM (b) 5.46 BM
(c) 2.82 BM (d) 1.41 BM

(AIEEE, 2011)

34. Among the ligands NH_3, en, CN^-, and CO, the correct order of their increasing field strength is:

(a) $NH_3 < en < CN^- < CO$
(b) $CN^- < NH_3 < CO < en$
(c) $en < CN^- < NH_3 < CO$
(d) $CO < NH_3 < en < CN^-$

(AIEEE, 2011)

35. Which one of the following complex ions has geometrical isomers?

(a) $[Ni(NH_3)_5Br]^+$
(b) $[Co(NH_3)_2(en)_2]^{3+}$
(c) $[Cr(NH_3)_4(en)_2]^{3+}$
(d) $[Co(en)_3]^{3+}$ (en = ethylenediamine)

(AIEEE, 2011)

36. Which among the following will be named as dibromidobis (ethylene diamine) chromium(III) bromide?

(a) $[Cr(en)_3]Br_3$ (b) $[Cr(en)_2Br_2]Br$
(c) $[Cr(en)Br_4]^-$ (d) $[Cr(en)Br_2]Br$

(AIEEE, 2012)

37. Which of the following complex species is not expected to exhibit optical isomerism?

(a) $[Co(en)_3]^{3+}$ (b) $[Co(en)_2Cl_2]^+$
(c) $[Co(NH_3)_3Cl_3]$ (d) $[Co(en)(NH_3)_2Cl_2]^+$

(JEE Main, 2013)

38. The octahedral complex of a metal ion M^{3+} with four monodentate ligands L_1, L_2, L_3, and L_4 absorb wavelength in the region of red, green, yellow, and blue, respectively. The increasing order of ligand strength of the four ligands is:

(a) $L_3 < L_2 < L_4 < L_1$ (2) $L_1 < L_2 < L_4 < L_3$
(c) $L_4 < L_3 < L_2 < L_1$ (4) $L_1 < L_3 < L_2 < L_4$

(JEE Main, 2014)

39. The equation which is balanced and represents the correct product(s) is:

(a) $[Mg(H_2O)_6]^{2+} + (EDTA)^{4-} \xrightarrow{\text{excess NaOH}} [Mg(EDTA)]^{2+} + 6H_2O$
(b) $CuSO_4 + 4KCN \rightarrow K_2[Cu(CN)_4] + K_2SO_4$
(c) $Li_2O + 2KCl \rightarrow 2LiCl + K_2O$
(d) $[CoCl(NH_3)_5]^+ + 5H^+ \rightarrow Co^{2+} + 5NH_4^+ + Cl^-$

(JEE Main, 2014)

40. The correct statement about the magnetic properties of $[Fe(CN)_6]^{3-}$ and $[FeF_6]^{3-}$ is: (Z = 26).

(a) $[Fe(CN)_6]^{3-}$ is paramagnetic, $[FeF_6]^{3-}$ is diamagnetic
(b) Both are diamagnetic
(c) $[Fe(CN)_6]^{3-}$ is diamagnetic, $[FeF_6]^{3-}$ is paramagnetic
(d) Both are paramagnetic

(JEE Main, 2014)

41. An octahedral complex of Co^{3+} is diamagnetic. The hybridization involved in the formation of the complex is:

(a) d^2sp^3 (b) dsp^3d
(c) dsp^2 (d) sp^3d^2

(JEE Main, 2014)

JEE (Advanced) Exercises

Fill in the Blanks Type

1. AgCl dissolves in excess of KCN solution to give the _____ complex compound.

(IIT-JEE, 1980)

2. The type of magnetism exhibited by $[Mn(H_2O)_6]^{2+}$ ion is _____.

(IIT-JEE, 1994)

3. The IUPAC name of $[Co(NH_3)_6]Cl_3$ is _____.

(IIT-JEE, 1994)

True/False Type

1. Both potassium ferrocyanide and potassium ferricyanide are diamagnetic.

(IIT-JEE, 1989)

Single Correct Answer Type

1. Among $Ni(CO)_4$, $[Ni(CN)_4]^{2-}$, and $NiCl_4^{2-}$

(a) $Ni(CO)_4$ and $NiCl_4^{2-}$ are diamagnetic and $[Ni(CN)_4]^{2-}$ is paramagnetic
(b) $NiCl_4^{2-}$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $Ni(CO)_4$ is paramagnetic
(c) $Ni(CO)_4$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $NiCl_4^{2-}$ is paramagnetic
(d) $Ni(CO)_4$ is diamagnetic, and $NiCl_4^{2-}$ and $[Ni(CN)_4]^{2-}$ are paramagnetic

(IIT-JEE, 1991)

2. Among the following ions which has the highest paramagnetism?

(a) $[Cr(H_2O)_6]^{3+}$ (b) $[Fe(H_2O)_6]^{2+}$
(c) $[Cu(H_2O)_6]^{2+}$ (d) $[Zn(H_2O)_6]^{2+}$

(IIT-JEE, 1993)

3. Which of the following is formed when excess of KCN is added to an aqueous solution of copper sulphate?

(a) $Cu(CN)_2$ (b) $K_2[Cu(CN)_4]$
(c) $K[Cu(CN)_2]$ (d) $K_3[Cu(CN)_4]$

(IIT-JEE, 1996)

4. The geometries of $Ni(CO)_4$ and $Ni(PPh_3)_2Cl_2$ are:

(a) Both square planar
(b) Tetrahedral and square planar, respectively
(c) Both tetrahedral
(d) Square planar and tetrahedral, respectively

(IIT-JEE, 1999)

5. Among the following, identify the species with an atom in +6 oxidation state:

(a) MnO_4^- (b) $Cr(CN)_6^{3-}$
(c) NiF_6^{2-} (d) CrO_2Cl_2

(IIT-JEE, 2000)

6. The complex ion which has no *d*-electrons in the central metal atom is:

(a) $[MnO_4]^-$ (b) $[Co(NH_3)_6]^{3+}$
(c) $[Fe(CN)_6]^{3-}$ (d) $[Cr(H_2O)_6]^{3+}$

(IIT-JEE, 2001)

7. The pair of compounds having metals in their highest oxidation state is:

(a) MnO_2, $FeCl_3$
(b) $[MnO_4]^-$, CrO_2Cl_2
(c) $[Fe(CN)_6]^{3-}$, $[Co(CN)_6]^{3-}$
(d) $[NiCl_4]^{2-}$, $[CoCl_4]^-$

(IIT-JEE, 2004)

8. The compound having a tetrahedral geometry is:

(a) $[Ni(CN_4)]^{2-}$ (b) $[Pd(CN)_4]^{2-}$
(c) $[PdCl_4]^{2-}$ (d) $[NiCl_4]^{2-}$

(IIT-JEE, 2004)

9. Spin only magnetic moment of the compound $Hg[Co(SCN)_4]$ is:

(a) $\sqrt{3}$ (b) $\sqrt{15}$
(c) $\sqrt{24}$ (d) $\sqrt{8}$

(IIT-JEE, 2004)

10. Which kind of isomerism is exhibited by octahedral $Co(NH_3)_4Br_2Cl$?

(a) Geometrical and ionization
(b) Geometrical and optical
(c) Optical and ionization
(d) Geometrical only

(IIT-JEE, 2005)

11. If the bond length of the C—O bond in CO is 1.128 Å, what is the value of the bond length in $[Fe(CO)_5]$?

(a) 1.15 Å (b) 1.128 Å
(c) 1.72 Å (d) 1.118 Å

(IIT-JEE, 2006)

12. Among the following metal carbonyls, the C—O bond order is lowest in:

(a) $[Mn(CO)_6]^+$ (b) $[Fe(CO)_5]$
(c) $[Cr(CO)_6]$ (d) $[V(CO_6)]^-$

(IIT-JEE, 2007)

13. Both $[Ni(CO)_4]$ and $[Ni(CN)_4]^{2-}$ are diamagnetic. The hybridizations of nickel in these complexes, respectively, are:

(a) sp^3, sp^3 (b) sp^3, dsp^2
(c) dsp^2, sp^3 (d) dsp^2, dsp^2

(IIT-JEE, 2008)

14. The IUPAC name of $[Ni(NH_3)_4][NiCl_4]$ is:

(a) Tetrachloronickel(II)-tetraaminenickel(II)
(b) Tetramminenickel(II)-tetrachloronickel(II)
(c) Tetraamminenickel(II)-tetrachloronickelate(II)
(d) Tetrachloronickel(II)-tetraaminenickelate(0)

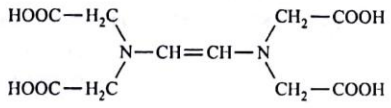
(IIT-JEE, 2008)

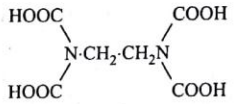
15. Among the following, the colored compound is:

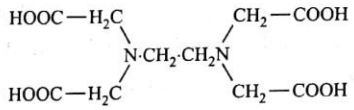
(a) CuCl (b) $K_3[Cu(CN)_4]$
(c) CuF_2 (d) $[Cu(CH_3CN)_4]BF_4$

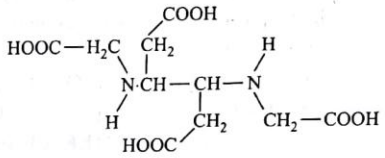
(IIT-JEE, 2008)

16. The correct structure of ethylenediamineteraacetic acid (EDTA) is:

(a)


(b)


(c)


(d)


(IIT-JEE, 2010)

17. The ionization isomer of $[Cr(H_2O)_4Cl(NO_2)]Cl$ is:

(a) $[Cr(H_2O)_4(O_2N)]Cl_2$
(b) $[Cr(H_2O)_4Cl_2](NO_2)$
(c) $[Cr(H_2O)_4Cl(ONO)]Cl$
(d) $[Cr(H_2O)_4Cl_2(NO_2)]H_2O$ **(IIT-JEE, 2010)**

18. The complex showing a spin-magnetic moment of 2.82 B.M. is:

(a) $Ni(CO)_4$ (b) $[NiCl_4]^{2-}$
(c) $Ni(PPh_3)_4$ (d) $[Ni(CN)_4]^{2-}$

(IIT-JEE, 2010)

19. Geometrical shapes of the complexes formed by the rection of Ni_2^+ with Cl^-, CN^- and H_2O, respectively, are:

(a) Octahedral, tetrahedral and square planar
(b) Tetrahedral, square planar and octahedral
(c) Square planar, tetrahedral and octahedral
(d) Octahedral, square planar and octahedral

(IIT-JEE, 2011)

20. Among the following complexes (**K–P**)

$K_3[Fe(CN)_6]$ (**K**), $[Co(NH_3)_6]Cl_3$ (**L**),

$Na_3[Co(oxalate)_3]$ (**M**), $[Ni(H_2O)_6]Cl_2$ (**N**),

$K_2[Pt(CN)_4]$ (**O**) and $[Zn(H_2O)_6](NO_3)_2$ (**P**)

(a) K, L, M, N (b) K, M, O, P
(c) L, M, O, P (d) L, M, N, O

(IIT-JEE, 2011)

21. As per IUPAC nomenclature, the name of the complex $[Co(H_2O)_4(NH_3)_2]Cl_3$ is:

(a) Tetaaquadiaminecobalt(III) chloride
(b) Tetraaquadiamminecobalt(III) chloride
(c) Diaminetetraaquacoblat(III) chloride
(d) Diamminetetraaquacobalt(III) chloride

(IIT-JEE, 2012)

22. The color of light absorbed by an aqueous solution of $CuSO_4$ is:
(a) Organge-red (b) Blue-green
(c) Yellow (d) Violet
(IIT-JEE, 2012)

23. Consider the following complex ions P, Q, and R,
$\mathbf{P} = [FeF_6]^{3-}$, $\mathbf{Q} = [V(H_2O)_6]^{2+}$, and $\mathbf{R} = [Fe(H_2O)_6]^{2+}$
The correct order of the complex ions, according to their spin-only magnetic moment values (in B.M.) is:
(a) R < Q < P (b) Q < R < P
(c) R < P < Q (d) Q < P < R
(JEE Advanced, 2013)

Multiple Correct Answers Type

1. The pair(s) of coordination complex/ion exhibiting the same kind of isomerism is(are):
(a) $[Cr(NH_3)_5Cl]Cl_2$ and $[Cr(NH_3)_4Cl_2]Cl$
(b) $[Co(NH_3)_4Cl_2]^+$ and $[Pt(NH_3)_2(H_2O)Cl]^+$
(c) $[CoBr_2Cl_2]^{2-}$ and $[PtBr_2Cl_2]^{2-}$
(d) $[Pt(NH_3)_3(NO_3)]$ Cl and $[Pt(NH_3)_3Cl]$ Br
(JEE Advanced, 2013)

Comprehension Type

For Problems 1–3

The coordination number of Ni^{2+} is 4.
$NiCl_2 + KCN(excess) \rightarrow A$ (Cyano complex)
$NiCl_2 + conc\ HCl(excess) \rightarrow B$ (Chloro complex)

1. The IUPAC name of *A* and *B* are:
(a) Potassium tetracyanonickelate(II), potassium tetrachloronickelate(II)
(b) Tetracyanopotassiumnickelate(II), tetrorachloropotassiumnickelate(II)
(c) Tetracyanonickel(II), tetrachloronickel(II).
(d) Potassium tetracyanonickel(II), potassium tetrachloronickel(II).

2. Predict the magnetic nature of *A* and *B*:
(a) Both are diamagnetic.
(b) *A* is diamagnetic and *B* is paramagnetic with one unpaired electron.
(c) *A* is diamagnetic and *B* is paramagnetic with two unpaired electrons.
(d) Both are paramagnetic.

3. The hybridization of *A* and *B* are:
(a) dsp^2, sp^3 (b) sp^3, sp^3
(c) dsp^2, dsp^2 (d) sp^3d^2, d^2sp^3
(IIT-JEE, 2006)

Assertion-Reasoning Type

Read the following questions and answer as per the directions given below:

(a) Statement-I is true; Statement-II is also true; Statement-II is a correct explanation for Statement-I.
(b) Statement-I is true; Statement-II is true; Statement-II is not the correct explanation for Statement-I.
(c) Statement-I is true; Statement-II is false.
(d) Statement-I is false; Statement-II is true.

1. **Statement-I:** $[Fe(H_2O)_5NO]SO_4$ is paramagnetic.
Statement-II: The Fe in $[Fe(H_2O)_5NO]SO_4$ has three unpaired electrons.
(IIT-JEE, 2008)

2. **Statement-I:** The geometrical isomer of the complex $[M(NH_3)_4Cl_2]$ are optically inactive.
Statement-II: Both geometrical isomers of the complex $[M(NH_3)_4Cl_2]$ possess axis of symmetry.
(IIT-JEE, 2008)

Matching Column Type

1. Match the complexes in Column-I with their properties listed in Column-II.

Column-I	Column-II
(a) $[Co(NH_3)_4(H_2O)_2]Cl_2$	(p) Geometrical isomers
(b) $[Pt(NH_3)_2Cl_2]$	(q) Paramagnetic
(c) $[Co(H_2O)_5Cl]Cl$	(r) Diamagnetic
(d) $[Ni(H_2O)_6]Cl_2$	(s) Metal ion with +2 oxidation state

(IIT-JEE, 2007)

This section contains four questions, each having two matching lists. Choices for the correct combination of elements form List-I and List-II are given as options (a), (b), (c), and (d), out of which one is correct.

2. Match each coordination compound in List-I with an appropriate pair of characteristics from List-II and select the correct answer using the code given below the lists.
{en = $H_2NCH_2CH_2NH_2$ 'atomic numbers; Ti = 22; Cr = 24; Co = 27; Pt = 78}

List-I	List-II
(P) $[Cr(NH_3)_4Cl_2]Cl$	(1) Paramagnetic and exhibits ionization isomerism

(Q) $[Ti(H_2O)_5Cl](NO_3)_2$ (2) Dimagnetic and exhibits *cis-trans* isomerism

(R) $[Pt(en)(NH_3)Cl]NO_3$ (3) Paramagnetic and exhibits *cis-trans* isomerism

(S) $[Co(NH_3)_4(NO_3)_2]NO_3$ (4) Dimagnetic and exhibits ionization isomerism

Code:

	P	Q	R	S
(a)	4	2	3	1
(b)	3	1	4	2
(c)	2	1	3	4
(d)	1	3	4	2

Integer Answer Type

1. $EDTA^{4-}$ is ethylenediaminetetraacetate ion. The total number of N–Co–O bond angles in $[Co(EDTA)]^{-1}$ complex ion is _____.

(JEE Advanced, 2013)

Subjective Type

1. Write the balanced chemical equations for the following:
"Potassium ferricyanide reacts with hydrogen peroxide in basic solution".

(IIT-JEE, 1989)

2. Give reasons in two or three sentences only for the following.
"The species $[CuCl_4]^{2-}$ exists, while $[CuI_4]^{2-}$ does not".

(IIT-JEE, 1992)

3. The acidic aqueous solution of ferrous ion forms a brown complex in the presence of NO_3^-, by the following two steps:

$$[Fe(H_2O)_6]^{2+} + NO_3^- + H^+ \rightarrow \cdots + [Fe(H_2O)_6]^{3+} + H_2O$$

$$[Fe(H_2O)_6]^{2+} + \cdots \rightarrow \cdots + H_2O$$

Complete and balance the equations.

(IIT-JEE, 1993)

4. Identify the complexes which are expected to be colored. Explain.

(i) $[Ti(NO_3)_4]$ **(ii)** $[Cu(NCCH_3)]^+BF_4$

(iii) $[Cr(NH_3)_6]^{3+}3Cl^-$ **(iv)** $K_3[VF_6]$

(IIT-JEE, 1994)

5. Write the IUPAC names for the following compounds:

(i) $[Co(NH_3)_5ONO]Cl_2$

(ii) $K_3[Cr(CN)_6]$

(IIT-JEE, 1995)

6. Write the IUPAC name for $[Cr(NH_3)_5CO_3]Cl$.

(IIT-JEE, 1996)

7. Write a balanced equation for the reaction of argentite with KCN and name the products in the solution.

(IIT-JEE, 1996)

8. Write the formulae of the following complexes:

(i) Pentamminechlorocobalt(III) ion

(ii) Lithiumtetrahydridoaluminate(III)

(IIT-JEE, 1997)

9. *A*, *B*, and *C* are three complexes of chromium(III) with the empirical formula $H_{12}O_6C_{13}Cr$. All the three complexes have water and chloride ion as ligands. Complex *A* does not react with concentrated H_2SO_4, whereas complexes *B* and *C* lose 6.75% and 13.5% of their original mass, respectively, on treatment with concentrated H_2SO_4. Identify *A*, *B*, and *C*.

(IIT-JEE, 1999)

10. An aqueous solution containing 1 mol of HgI_2 and 2 mol of NaI, is orange in color. On addition of excess NaI the solution becomes colorless. The orange color reappears on subsequent addition of NaOCl. Explain with equations.

(IIT-JEE, 1999)

11. Draw the structures of $[Co(NH_3)_6]^{3+}$, $[Ni(CN)_4]^{2-}$, and $[Ni(CO)_4]$. Write the hybridization of atomic orbitals of the transition metal in each case.

(IIT-JEE, 2000)

12. A metal complex having composition $Cr(NH_3)_4Cl_2Br$ has been isolated in two forms *A* and *B*. The form *A* reacts with $AgNO_3$ to give a white precipitate readily soluble in dilute aqueous ammonia, whereas *B* gives a pale-yellow precipitate soluble in concentrated ammonia. Write the formula of *A* and *B* and state the hybridization of chromium in each. Calculate their magnetic moments (spin-only value).

(IIT-JEE, 2001)

13. Deduce the structures of $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ considering the hybridization of the metal ion. Calculate the magnetic moment (spin only) of the species.

(IIT-JEE, 2002)

14. Write the IUPAC nomenclature of the given complex along with its hybridization and structure $K_2[Cr(NO)(NH_3)(CN)_4]$, $\mu = 1.73$.

(IIT-JEE, 2003)

15. $NiCl_2$ in the presence of dimethyl glyoxime (DMG) gives a complex which precipitates in the presence of NH_4OH, giving a bright red color.

(a) Draw its structure and show H bonding.

(b) Give the oxidation state of Ni and its hybridization.

(d) Predict whether it is paramagnetic or diamagnetic.

(IIT-JEE, 2004)

16. AlF_3 is insoluble in anhydrous HF but when little KF is added to the compound it becomes soluble. On addition of BF_3, AlF_3 is precipitated. Write the balanced chemical equations.

(IIT-JEE, 2004)

17. Write the balanced chemical equations for developing a black and white photographic film. Also, give the reason as to why the solution of sodium thiosulphate on acidification turns milky white and give the balanced chemical equation of this reaction.

(IIT-JEE, 2005)

18. $Fe^{3+} \xrightarrow{SNC^- \text{(Excess)}} \underset{\text{Blood red}}{A} \xrightarrow{F^- \text{(Excess)}} \underset{\text{Colorless}}{B}$

Identify A and B.

(a) Write the IUPAC names of A and B.

(b) Find out the spin only magnetic moment of B.

(IIT-JEE, 2005)

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

20. (c) Zeise's salt is a metal–alkene complex $K[PtCl_3(C_2H_4)] \cdot H_2O$.

21. (a) $[Ni(NH_3)_6]^{2+}$, $[CoF_6]^{3-}$, and $[FeF_6]^{3-}$ involve sp^3d^2-hybridization, while $[Co(NH_3)_6]^{3+}$ involves d^2sp^3-hybridization.

22. (a) $[Ni(CN)_4]^{2-}$ involves dsp^2-hybridization, whereas $[Ni(CO)_4]$, $[NiCl_4]^{2-}$, and $[Ni(PF_3)_4]$ involve sp^3-hybridization.

23. (b) The electronic configurations of Cr, Fe, Co, and Ti in the complexes are $(3d)^3$, $(3d)^5$, $(3d)^6$, and $(3d)^1$, respectively. These involve d^2sp^3, sp^3d^2, d^2sp^3, and d^2sp^3-hybridization, respectively.

24. (d) The electronic configurations of Ni, Fe, Co and Cr in the given complexes are $(3d)^8$, $(3d)^6$, $(3d)^6$ and $(3d)^4$, respectively. These involve dsp^2, d^2sp^3, d^2sp^3 and sp^3d^2-hybridization, respectively. The complex $[Cr(H_2O)_6]SO_4$ will be paramagnetic as Cr contains four unpaired electrons.

25. (c) The color of the complex compound is due to d–d electronic transition.

26. (a) t_{2g} orbitals have higher energy by $(2/5)\Delta_t$.

29. (b) Salt is represented as $[Cu(H_2O)_4]SO_4 \cdot H_2$. Four H_2O molecules are coordinated to Cu^{2+} while remaining one H_2O molecule is H-bonded to SO_4^{2-}.

37. (b) dsp^2-hybridization gives square planar complex with $d_{x^2-y^2}$ orbitals involved in hybridization forming angles of 90°.

38. (b) The $-NO_2$ group can show $-NO_2$(nitro) or $-ONO$ (nitrito) linkage with metal.

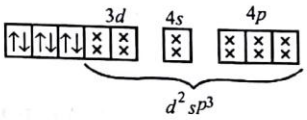
39. (a) $[Co(en)_2Cl_2]^+$ shows geometrical as well as optical isomerism.

40. (d) Mn^{2+}, Fe^{2+}, and Co^{2+} has $3d^5$, $3d^6$, and $3d^7$ configuration having 5, 0, and 3 unpaired electrons, respectively.

41. (c) B in BF_4^- has sp^3-hybridization leading to tetrahedral geometry.

43. (d) $[Co(CN)_6]^{3-}$ has d^2sp^3 hybridization and six d electrons are paired due to strong field ligand. Thus no unpaired electrons

Co^{3+}, Electronic configuration = [Ar] $3d^6$



[No unpaired electron paramagnetism = 0]

44. (d) The magnetic moment of $[NiCl_4]^{2-}$ reveals that the species is paramagnetic having two unpaired electrons i.e., Ni^{2+} is $3d^8$. The four electron pairs by Cl^- ligand leads to sp^3-hybridization in Ni^{2+} and do not disturb Ni^{2+} configuration to give tetrahedral geometry.

45. (a) Magnetic moment indicates that there are three unpaired electrons present in chromium. These must be

present in lower energy orbitals which are $3d_{xy}$, $3d_{yz}$, and $3d_{xz}$.

50. (b) The larger the number of unpaired electrons, the more it has paramagnetism. The outer configurations are $Cr^{3+}: 3d^3$; $Fe^{2+}: 3d^6$; $Cu^{2+}: 3d^9$; $Zn: 3d^{10}$

56. (a) $[Co(NH_3)(H_2O)Cl]Cl_2$ [according to I.U.P.A.C. 2005]

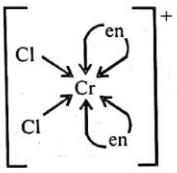
72. (b) $[\overset{+IV}{Pt}Cl_2(NH_3)_4][\overset{2+II}{Pt}Cl_4^{2-}]$; $[\overset{+IV}{Pt}Cl_3(NH_3)_3^{+}][\overset{+II}{Pt}Cl_3(NH_3)^{-}]$ $[\overset{+II}{Pt}Cl(NH_3)_3^{+}][\overset{+IV}{Pt}Cl_5(NH_3)^{-}]$; $[\overset{II}{Pt}(NH_3)_4^{2+}][\overset{IV}{Pt}Cl_6^{2-}]$

73. (c) $K[PtCl_3(\eta^2\text{-}C_2H_4)]$ E.A.N. of Pt $= 78 - 2 + 3 \times 2 + 2 = 84$

JEE (Advanced) Exercises

Single Correct Answer Type

7. (b) *cis*-$[CrCl_2en_2]^+$ exists as a pair of enantiomers.



10. (a) 2.83 Bohr magneton implies two unpaired electrons according to the expression $\sqrt{n(n+2)}$ B.M. The species Cu, Ni, Ti, and Co in the given complexes have $(3d)^8$, $(3d)^8$, $(3d)^0$, and $(3d)^6$ electronic configurations, respectively. These involve sp^3, d^2, dsp^2, sp^3 and d^2sp^3-hybridization, respectively. Thus, the complex $[Ni(NH_3)_6]^{2+}$ has two unpaired electron.

11. (b) We have $4\Delta_0 = 9\Delta t$

12. (b) t_{2g} orbitals (d_{xy}, d_{xz}, d_{yz}) have lower energy by $(2/5)\Delta_0$.

13. (a) The order is $SCN^- < F^- < CN^-$.

15. (b) Sum of charges = net charges

16. (c) EAN = Z − oxidation number + 2 × coordination number $= 26 - 3 + 2 \times 6 = 35$.

18. (c) EDTA is hexadentate

21. (b) Ni shows sp^3, sp^3, and dsp^2-hybridization in $Ni(CO)_4$ · $[NiCl_4]^{2-}$, and $[Ni(CN)_4]^{2-}$, respectively. CN^- being strong field ligand pairs up unpaired electron in Ni^{2+}.

22. (a) A more basic ligand and bidentate ligand form stable bond with metal ion due to chelation.

23. (c) $[Co(NH_3)_5Cl]Cl_2 \xrightarrow{H_2O} [Co(NH_3)_5Cl]^{2+} + 2Cl^-$

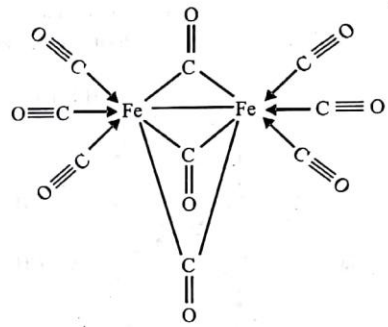
$2AgNO_3 + 2Cl^- \longrightarrow 2AgCl + 2\,NO_3^-$

24. (c) Optical isomerism is very common in octahedral complexes having general formula $[MA_2B_2C_2]^{n-}$, $[M(AA)_3]^{n-}$, $M(AA)_2b_2]^{n-}$, $[M(AA)_2AB]^{n-}$, and $[M(AB)_3]^{n-}$ where *AA* is symmetrical bidentate ligand such as $\overset{COO^-}{\overset{|}{COO^-}}$ and *AB* is unsymmetrical bidentate ligand.

25. (d) The metal Fe makes the back bonding to CO. The metal to ligand bond creates a synergic effect which strengthens bond between CO and Fe which results in shortening of bond length.

30. (a) Each species has 14 electrons and bond order for each is three.

37. (c)



E.A.N. of Fe $= 26 + 1 + 1 + 1 + 1 + 3 \times 2 = 36$

38. (c)

Co in $[Co(CO)_4]^-$: 3*d* [↑↓][↑↓][↑↓][↑↓][↑↓] 4*s* [↑↓] 4*p* [↑↓][↑↓][↑↓]

Hybridization : sp^3, $\mu_{eff} = 0$

Ni in $[Ni(CN)_4]^{4-}$: 3*d* [↑↓][↑↓][↑↓][↑↓][↑↓] 4*s* [↑↓] 4*p* [↑↓][↑↓][↑↓]

Hybridization : sp^3, $\mu_{eff} = 0$

39. (d) $H_x[Pt\,y_6]$

If coordination number of Pt = 6, then O.S. of Pt = +4

$\therefore \quad x + 4 + 6 \times (-1) = 0$

$\therefore \quad x = 2$

41. (a) $[MnCl_4]^{2-}$: $P > \Delta_t$; d^5-system $\mu_{eff} = 5.9$ B.M.

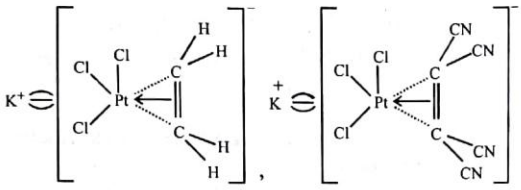
$[CoCl_4]^{2-}$: $P > \Delta_t$; d^7-system $\mu_{eff} = 3.89$ B.M.

$[Fe(CN)_6]^{4-}$: $P < \Delta_0$; d^6-system $\mu_{eff} = 0$ B.M.

42. (c) X-ray studies have established that Prussian blue and Turnbull's blue are identical. Fe^{3+} partially oxidizes $[Fe^{II}(CN)_6]^{4-}$ forming some $[Fe^{III}(CN)_6]^{3-}$

Thus, $Fe[Fe(CN)_6]^-$ is formed.

43. (a) Due to synergic bonding

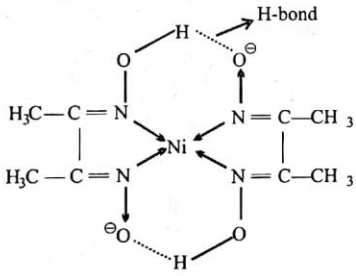


CN has $-I$ effect and hence it produces $+\delta$ charge on carbon atom. So carbon atom accept more electrons from metal cation.

With increase in synergic bonding, C—C bond length increases.

49. (d) NO in +1 state is proved by magnetic moment. Name of NO^+ = N nitrosonium or nitrosylium.

53. (b) Dimethylglyoxime is coordinated to Ni^{2+} through two nitrogen atoms.



54. (b) Ferrocene is $Fe(\eta^5\text{-}C_5H_5)_2$ complex.

55. (c) e_g orbitals $(d_{z^2}, d_{x^2-y^2})$ have higher energies by $(3/5)\Delta_o$.

56. (d) e_g orbitals have lower energies by $(3/5)\Delta_t$.

58. (c) $\overset{\ominus}{C}N$ acts as ligand and reducing agent.

59. (b) Magnetic moment = $\sqrt{n(n+2)}$ = 2.84.

60. (a) Co^{3+}, Fe^{3+}, and Cr^{3+} have 6, 5, and 3 d electrons, respectively.

61. (c) In $Hg[Co(SCN)_4]$, Co exists as Co^{2+}

$_{27}Co$: $3d^7, 4s^2$ or [↑↓ | ↑↓ | ↑ | ↑ | ↑] [↑↓]

$_{27}Co^{2+}$: $3d^7$ or [↑↓ | ↑↓ | ↑ | ↑ | ↑]

SCN^- ligand provides four electron pair to show sp^3-hybridization in $[Co(SCN)_4]^{2-}$ and thus three unpaired electron exists on Co^{2+}.

∴ Magnetic moment = $\sqrt{n(n+2)} = \sqrt{3(3+2)} = \sqrt{15}$

62. (b) Same magnetic moment = Same number of unpaired electrons

$\mu = \sqrt{n(n+2)}$

where n = number of unpaired electrons

$Co^{2+} = 3d^7$, 3 unpaired electrons;

$Cr^{2+} = 3d^4$, 4 unpaired electrons;

$Mn^{2+} = 3d^5$, 5 unpaired electrons;

$Fe^{2+} = 3d^6$, 4 unpaired electrons

68. (b) In sodium nitroprusside, NO acts as positive ligand [nitrosonium]

70. (b) $[Co(H_2O)_6]^{3+} = d^2sp^3$, low spin, diamagnetic, zero B.M.

71. (b) Fe (in ground state)

3d: [↑↓ | ↑ | ↑ | ↑ | ↑] 4s: [↑↓] 4p: [| |] CO : strong ligand

Fe in $[Fe(\overset{-II}{C}O)]_4^{2-}$ 3d: [↑↓ | ↑↓ | ↑↓ | ↑↓ | ↑↓] 4s: [↑↓] 4p: [↑↓ | ↑↓ | ↑↓]

sp^3 Hybridization

Shape : tetrahedral

72. (d)

Fe^{2+} 3d: [↑↓ | ↑ | ↑ | ↑ | ↑] 4s: [ ] 4p: [| |]

Fe^{2+} in $K_4[\overset{II}{F}e(CN)_5(O_2)]$ 3d: [↑↓ | ↑↓ | ↑↓ | ↑↓ | ↑↓] 4s: [↑↓] 4p: [↑↓ | ↑↓ | ↑↓]

Hybridization : d^2sp^3

Complex is paramagnetic due to presence of unpaired electron at O_2^- i.e., superoxide acting as ligand.

73. (b) $[Fe(H_2O)_5(\overset{+}{N}O)]^{2+}$ → Hybridization: sp^3d^2

→ μ_{eff}: 3.89 B.M.

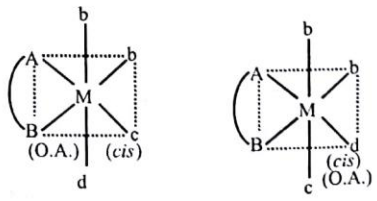
→ In spite of electronic transition from NO to Fe^{2+}, total number of electrons remain conserved. Hence E.A.N. does not change.

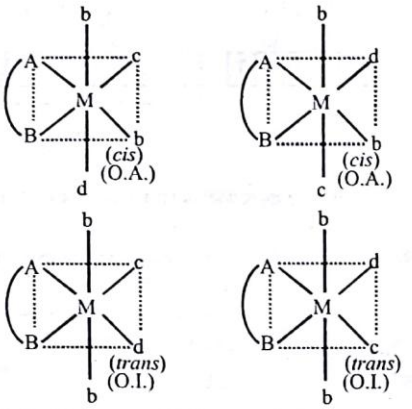
74. (d) (a) $Ti(CO)_6$; E.A.N. of Ti = 22 − 0 + 6 × 2 = 34
Hence can only act as oxidizing agent.

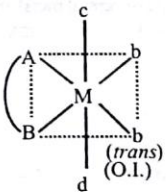
(b) $Mn(CO)_5$; E.A.N. of Mn = 25 − 0 + 5 × 2 = 35
Hence can only act as oxidizing agent.

(c) $Mn(CO)_6$; E.A.N. of Mn = 25 − 0 + 6 × 2 = 37
Hence can only act as reducing agent.

75. (c)







→ Number of G.I. = 7
→ All *cis*: O.A. Optically active
→ One *trans*: O.A.
→ Two *trans*: O.I. (Optically inactive)

76. (b) $[\overset{III}{Cr}(H_2O)_6]^{3+}$; Hybridization: d^2sp^3, Inner orbital complex.

$[\overset{+III}{Fe}(CN)_6]^{3-}$; $P < \Delta_0$: Hybridization: d^2sp^3, Inner orbital / low spin / spin paired complex

$[\overset{+I}{Cu}(CN)_4]^{3-}$; Hybridization: sp^3

$[Mn(H_2O)_6]^{2+}$; $P < \Delta_0$: Hybridization: sp^3d^2: outer orbital / high spin / spin free complex

85. (c) Wilkinson's catalyst = $[RhCl(PPh_3)_3]$

Multiple Correct Answers Type

2. (a), (d)

The stock system puts the calculated oxidation number of the metal ion as a Roman numeral in parentheses after the name of the metal. This is the more common convention, although there are cases in which it is difficult to assign oxidation numbers.

The Ewing–Bassett system puts the charge on the coordination sphere in parentheses after the name of the metal. This convention is used by chemical abstracts and offers an unambiguous identification of the species.

13. (a), (b), (c)

Correct name for $Na_2[Ni(EDTA)]$ – Sodium ethylenediaminetetraacetatonickelate (II).

14. (a), (b), (c), (d)

$sp^3d \Rightarrow sp_xp_yp_z\, d_{x^2-y^2}$

$dsp^3 \Rightarrow d_{x^2-y^2}\, sp_xp_yp_z$

$sp^3d^2 \Rightarrow sp_xp_yp_z\, d_{x^2-y^2}\, d_{z^2}$

$sp^3d^3 \Rightarrow sp_xp_yp_z\, d_{x^2-y^2}\, d_{z^2}\, d_{xy}$

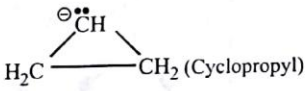
18. (b), (c), (d)

$Ni(CO)_4$ involves sp^3-hybridization with $(3d)^{10}$ electronic configuration of Ni. It is diamagnetic.

29. (a), (c)

σ–C_3H_5 can exist in two structures.

(i) $CH_2 = CH - \overset{\bullet\bullet}{C}H_2^{\ominus}$ (Allyl)

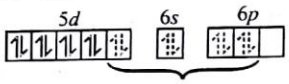
(ii) 

32. (a), (b), (c)

The species which show secondary valencies in a complex are Lewis base.

33. (a), (b), (d)

(a) $[AuCl_4]^-$, Au^{3+} : $5d^8$

Au^{3+} in $[AuCl_4]^-$ 

Hybridization : dsp^3, $\mu_{eff} = 0$

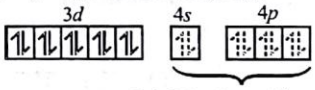
(b) $[\overset{III}{Co}(H_2O)_6]^{3+}$, $P < \Delta_0$.

Hence hybridization: d^2sp^3, $\mu_{eff} = 0$

(c) $[\overset{III}{Co}F_6]^{3-}$, $P < \Delta_0$.

Hence hybridization: sp^3d^2, $\mu_{eff} = 4.9$ B.M.

(d) $[\overset{-I}{Co}(CO)_4]^-$: Co in $[Co(CO)_4]^-$



Hybridization : sp^3, $\mu_{eff} = 0$

34. (b), (c), (d)

The number of unpaired electrons of the ions in the given choices are:

Mn^{2+} ($n = 5$); Ni^{2+} ($n = 2$), Co^{2+} ($n = 3$), and Fe^{2+} ($n = 4$)

The correct sequence of magnetic moment would be $Mn^{2+} > Fe^{2+} > Co^{2+} > Ni^{2+}$.

35. (a), (b), (c)

The species which show secondary valencies in a complex are Lewis base.

37. (a, b, c)

(a) Fe^{2+} changes to brown-colored ring complex

(b) $NO \longrightarrow NO^+ + e^-$ $\quad Fe^{2+} + e^- \longrightarrow Fe^+$

Fe^{2+} [Ar] $3d^6$ [↑↓|↑|↑|↑|↑]

(c) Fe^{+} [Ar] $3d^7$ [↑↓|↑↓|↑|↑|↑]

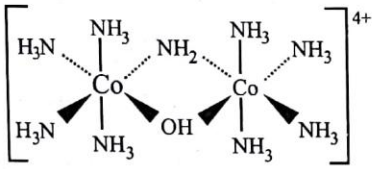
Three unpaired electrons

Magnetic moment $\sqrt{n(n+2)} = \sqrt{15} = 3.87$ BM

Thus, (a), (b), and (c) are true

(d) = sp^3d^2 hybridization.

42. (a), (b)



47. (a), (b)

NO in +1 state it is proved by magnetic moment. Name of NO^+ = nitrosonium or nitrosylium.

51. (a), (b), (c)

$[\overset{II}{Fe}(CN)_6]^{4-}$ Low spin complex, $\mu_{eff} = 0$.

54. (a), (b), (d)

The σ and π bondings are through C of CO.

Comprehension Type

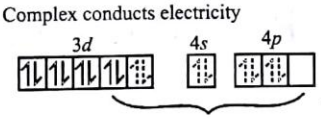
3. (a) $[Cu(NH_3)_4]SO_4$

E.A.N = 29 – 2 + 2 × 4

= 27 + 8 = 35

29. (c) (a) Ni^{2+} ($3d^8$) in $[Ni(NH_3)_4](NO_3)_2 \cdot 2H_2O$

Complex conducts electricity



Hybridization : dsp^2,

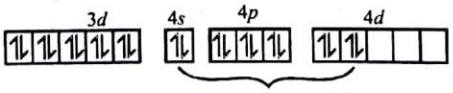
$\mu_{eff} = 0$

(b) $[Ni(NH_3)_2(H_2O)_2](NO_3)_2 \cdot 2NH_3$

The complex will not exist due to the presence of ammoniates, i.e., NH_3 as solvent of crystallization because NH_3 cannot lie in voids of crystal lattice in the presence of H_2O.

(c) Ni^{2+} ($3d^8$) in $[Ni(NH_3)_4(H_2O)_2](NO_3)_2$

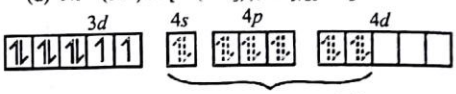
Complex conducts electricity due to ionic complex.



Hybridization : sp^3d^2,

$\mu_{eff} = 2.8$ B.M.

(d) Ni^{2+} ($3d^8$) in $[Ni(NH_3)_4(NO_3)_2] \cdot 2H_2O$



Hybridization : sp^3d^2

$\mu_{eff} = 2.8$ B.M.

But complex does not conduct electricity due to neutral complex.

30. (d) Ni^{2+} ($3d^8$): For coordination number = 6, $\mu_{eff} = 2.8$ B.M.

For coordination number = 4 (square planar), $\mu_{eff} = 0$

35. (d) $M \underset{\sigma}{\overset{\pi}{\rightleftarrows}} C \equiv O$

Higher the negative oxidation state of central metal, the higher will be back donation from $M \xrightarrow{\pi} C \equiv O$, hence $M - C$ bond order will increase.

36. (b) If PF_3 is a better π-acceptor ligand than CO, then extent of back donation from $M \xrightarrow{\pi} C \equiv O$ decreases, and hence bond order of CO will less decrease. Stretching frequency of C – O bond ∝ bond order of $C \equiv O$

Therefore, stretching frequency of $[Ni(PF_3)(CO)_3] > [Ni(CO)_4]$.

37. (d) C – O bond length $\propto \dfrac{1}{\text{CO bond order}}$

In the presence of PF_3 bond order of CO will be maximum due to better π-acceptor tendency of PF_3 in compansion to PCl_3 or PMe_3.

38. (a) $Fe + 5CO \xrightarrow[100\text{ atm}]{200°C} Fe(CO)_5$

Hybridization = dsp^3

d-orbital = d_{z^2}; Geometry = Trigonal bipyramidal

40. (b)

(a) e_g [1|]

t_{2g} [1|1|1]

$p > \Delta_0$

d^4

μ_{eff} = 4·9 B.M.

(b) e_g [|]

t_{2g} [1|1|]

$p > \Delta_0$

or

$p < \Delta_0$

d^2

μ_{eff} = 2·89 B.M.

(c) e_g [|]

t_{2g} [1|1|1]

$p > \Delta_0$

or

$p < \Delta_0$

d^3

μ_{eff} = 3.89 M.B

(d) e_g [ ][ ]

t_{2g} [↿⇂][↿⇂][↿] $\mu_{eff} = 1.73$B.M.

$p > \Delta_0$

d^5

41. (b) Ni^{2+} in $[NiCl_4]^{2-}$

3d [↿⇂][↿⇂][↿⇂][↿][↿] 4s [ ] 4p [ ][ ][ ]

Hybridization : sp^3; Shape : Tetrahedral

$\mu_{eff} = 2.89$ B.M.

Assertion-Reasoning Type

2. (c) $Ni(CO)_4$ is tetrahedral complex and has no unpaired electron.

$Ni(CO)_4$ $\quad Ni \longrightarrow [Ar]\ 3d^8\ 4s^2\ 4p^0$

3d [↿⇂][↿⇂][↿⇂][↿][↿] 4s [↿⇂] 4p [ ][ ][ ]

CO is a strong field ligand and it will pair up unpaired electrons and undergoes sp^3 hybridization.

CO CO CO CO

[↿⇂][↿⇂][↿⇂][↿⇂][↿⇂] [××] [××][××][××]

sp^3 Hybridization

5. (d) According to spectrochemical series, CN^- is a strong field ligand, so it has more Δ_0 value.

So correct order of Δ_0 for these complex ions is: $[CrCl_6]^{3-} < [Cr(C_2O_4)_3]^{3-} < [Cr(CN)_6]^{3-}$

6. (d) Due to having positive charge the tendency of π-accepting property of NO^+ will be higher than that of CO.

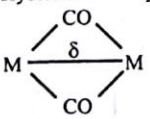
7. (d) Au^{3+}(ground state) 5d [↿⇂][↿⇂][↿⇂][↿][↿] 6s [ ] 6p [ ][ ][ ]

Although Cl^- is a weak ligand but due to high z_{eff} values of Au^{3+}, unpaired electrons will pair up.

Au^{3+} in $[AuCl_4^-]$ 5d [↿⇂][↿⇂][↿⇂][↿⇂] 6s [ ] 6p [ ][ ][ ]

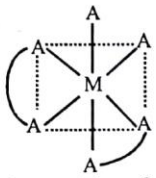
Hybridization: dsp^2; shape : square planar; $\mu_{eff} = 0$

8. (a)



In bridging carbonyl group, extent of $M \xrightarrow{\pi} CO$ bonding increases due to involvement of two metals for one CO group.

9. (d)



Asymmetric configuration due to the absence of plane of symmetry and center of symmetry; hence, it is optically active.

Matching Column Type

16. (a) p, q, r; (b) s; (c) p; (d) q, s

$[Ni(en)_3]^{2+}$: Type of hybridization – sp^3d^2 (outer orbital complex)
No. of unpaired electrons = 2 (paramagnetic)
Complex ion is optically active

$[VF_6]^{3-}$: Type of hybridization – d^2sp^3 (inner orbital complex)
No. of unpaired electrons = 2 (paramagnetic)

$[NiCl_2(SCN)_4]^{4-}$: Type of hybridization – sp^3d^2 (outer orbital complex)
No. of unpaired electrons = 2 (paramagnetic)

$[Fe(CN)_6]^{4-}$: Type of hybridization – d^2sp^3 (inner orbital complex)
No. of unpaired electrons = 0 (diamagnetic)

23. (a) p, s; (b) p, s, t; (c) s, t; (d) p, s

(a) $[\overset{III}{Cr}(H_2O)_5Br]^{2+}$ Hybridization d^2sp^3

$\mu_{eff} = 3.89$ B.M.

No geometrical, optical isomerism

E.A.N. = 24 – 3 + 12 = 33, does not follow E.A.N. rule

(b) $[\overset{II}{Cu}(NH_2CH_2CH_2NH_2)Cl_4]^{2-}$

Hybridization sp^3d^2

$\mu_{eff} = 1.732$ B.M.

No geometrical, Optical isomerism

E.A.N. = 29 – 2 + 12 = 39, does not follow E.A.N. rule

(c) $[\overset{II}{Pt}(OX)_2]^{2-}$ Hybridization dsp^2

$\mu_{eff} = 0$

No geometrical, optical isomerism

E.A.N. = 78 – 2 + 2 × 4 = 84, does not follow E.A.N. rule

(d) $[\overset{III}{Fe}(OH)_4]^-$ Hybridization sp^3

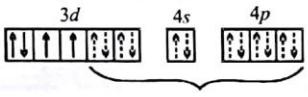
$\mu_{eff} = 5.9$ B.M.

No geometrical, optical isomerism

E.A.N. = 26 − 3 + 4 × 2 = 31 does not follow E.A.N. rule

26. (a) q, r; (b) q, s; (c) q, s; (d) p, r, s

(a) $[Cr(CN)_3(NO_2)_3]^{4-}$



Hybridization : d^2sp^3; octahedral

31. (a) s; (b) p; (c) q

(a) $[Fe(NH_3)_6]^{2+}$, $P > \Delta_0$, hybridization: sp^3d^2, μ_{eff} = 4.9 B.M., number of unpaired electrons = 4

(b) $[MnO_4]^-$, hybridization: d^3s, $\mu_{eff} = 0$, number of unpaired electrons = 0

(c) $[Mn(NH_3)_6]^{2+}$, $P > \Delta_o$, hybridization sp^3d^2, number of unpaired electrons = 5, $\mu_{eff} = 5.9$ B.M.

32. (a) p, q, r, s; (b) p, q, r; (c) p, r

(a) $K_4[Ni(CN)_4]$: Ni^0: Hybridization: sp^3, Shape: Tetrahedron, $\mu_{eff} = 0$

$K_2[NiCl_4]$: Ni^{2+}: Hybridization: sp^3, Shape: Tetrahedron, $\mu_{eff} = 2.8$ B.M.

(b) $K_4[\overset{+II}{NiF_6}]:\overset{2+}{Ni}$: Hybridization: sp^3d^2, Shape: Octahedron, $\mu_{eff} = 2.8$ B.M.

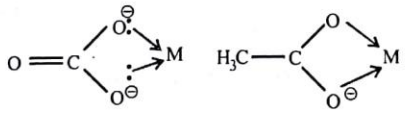
$K_2[\overset{+IV}{NiF_6}]:\overset{+IV}{Ni}$ ($P < \Delta_0$), Hybridization d^2sp^3, Shape: Octahedron, $\mu_{eff} = 0$

(c) $K_4[Co(NO_2)_6]$: Co^{2+} : d^7, Hybridization: d^2sp^3, Shape: Octahedron, $\mu_{eff} = 1.73$ B.M.

$[Fe(H_2O)_6]Cl_3$: Fe^{3+} : d^5 : Hybridization: sp^3d^2, Shape: Octahedron, $\mu_{eff} = 5.9$ B.M.

Integer Answer Type

1. (2)

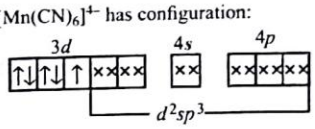


CH_3COO^-, CO_3^{2-} are negative ligand as well as flex-identate ligand.

19. (2) $\frac{2}{1} = 2$

27. (1) As EDTA is hexadentate ligand.

28. (1) $[Mn(CN)_6]^{4-}$ has configuration:



× × Electron pair donated by CN^-.

29. (4) The four isomers are $[Cu(NH_3)_4][PtCl_4]$, $[Cu(NH_3)_3Cl][PtCl_3(NH_3)]$, $[Pt(NH_3)_3Cl][CuCl_3(NH_3)]$, and $[Pt(NH_3)_4][CuCl_4]$.

30. (4) Monomeric form of nickel carbonyl is $Ni(CO)_4$.

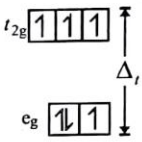
31. (6) *Tris*(ethylenediamine)cobalt(III) chloride is $[Co(NH_2CH_2CH_2NH_2)_3]Cl_3$; $NH_2CH_2CH_2NH_2$ is bidentate ligand and thus coordination no. = 3 × 2 = 6.

32. (2) Two *fac* and *mer* forms.

35. (0) $[Co(NH_3)_3Cl_3]$ is not ionized on dissolution.

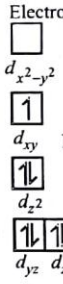
37. (2) $[Cu(NH_3)_4]SO_4 \rightleftharpoons [Cu(NH_3)_4]^{2+} + SO_4^{2-}$

39. (41) Electronic distribution in a tetrahedral d^6 ion



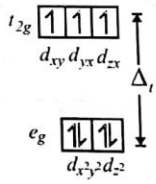
Number of unpaired electrons = 4

Electronic distribution in square planar d^7 ion



Number of unpaired electrons = 1

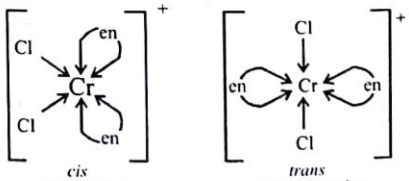
40. (0) $[\overset{II}{Co}(SCN)_4]^{2-}$



No. of unpaired electron present in *d*-orbitals whose lobes are present along axis = 0

$Co^{2+}(d^7)$ in $[\overset{II}{Co}(SCN)_4]^{2-}$

41. (3)



cis optical active *trans* optical inactive

42. (2) $[CrCl_3(NH_3)_3]$ has plane of symmetry. Hence it is optically inactive.

43. (8) There are four geometrical isomers: two isomers of *cis*-dichloro and two isomers of *trans*-dichloro. All the two *cis* isomers are optically active. Hence, there are six isomers.

53. (1) $\frac{2}{2} = 1$

54. (1) Effective atomic number = 36

$\therefore$ 36 = 24 — (—x) +10

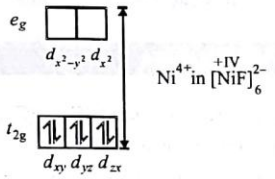
$\therefore$ $X = 2$ $\therefore$ Formula is $H_2[Cr(CO)_5]$

55. (9) Total number of geometrical isomer in $Ma_2b_2c_2 = 5$

Total number of stereo isomers in $M(AB)_3 = 4$

Sum of geometrical isomer and stereo isomer of given complex = 9

59. (60)



60. (15) $[Ma_2bcde]$ Total geometrical isomers = 9 (6 *cis*, 3 *trans*)

Optical = 15 (12 optical active, 3 optical inactive)

Steroisomers = 15

61. (8) Total number of geometrical isomers in $[Pt(H_2N{-}CH(CH_3){-}COO^-)_2] = 4$

Total number of stereo isomers in $[Pt(gly)_3]^+ = 4$

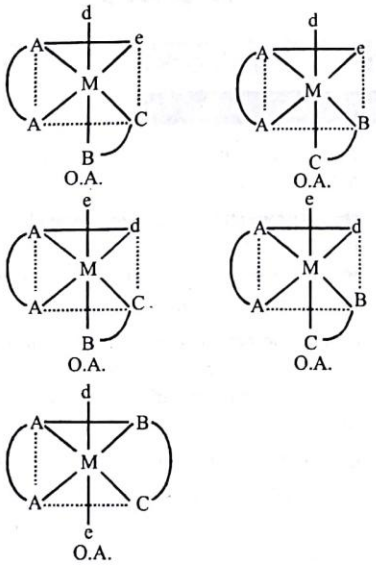
Sum of geometrical isomers and stereo isomers of given complexes = 8

74. (3) $2 \times x + 4 \times (-2) + 2 \times 0 + 2 \times 0 = -2 \therefore x = +3.$

76. (5) It is a double salt:

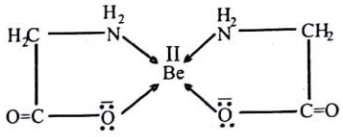
$$FeSO_4.(NH_4)_2SO_4.6H_2O \longrightarrow Fe^{2+} + 2SO_4^{2-} + 2NH_4^+ + 6H_2O$$

77. (5)



Five pairs of enantiomers are possible.

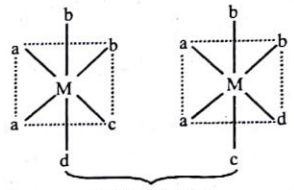
78. (2) As. Be^{2+} $\underbrace{\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}}_{\text{Hybridization : } sp^3}$ (Tetrahedral)



(optically active)

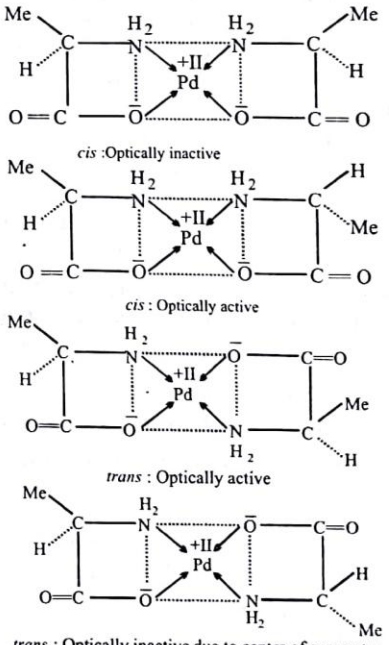
Asymmetric configuration due to absence of plane of symmetry, hence optically active. Therefore, number of space/stereoisomers = 2

79. (2) Only *cis*- isomers are optically active. Their number = 2



80. (2) $[Co(H_2O)_3F_3]$: Overall ligand field will be weak.

81. (6)



trans : Optically inactive due to center of symmetry.

Total number of space isomers = 6

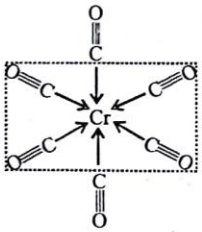
82. (61) $\Rightarrow [V(CO)_m]^{n-}$

$\Rightarrow$ For octahedral shape of complex; $m = 6$

$\Rightarrow$ E.A.N. of V = 36 = 22 + n + 6 × 2n = 1

83. (2) There are only two isomers *d* and *l*.

85. (9)



9 atoms are present in same plane.

NCERT Exemplar Exercises

Short Answer Type

1. $[Co(NH_3)_3Cl_3] < [Cr(NH_3)_4Cl_2]Cl < [Co(NH_3)_5Cl]Cl_2 < [Co(NH_3)_6]Cl_3$
2. $[Co(H_2O)_4Cl_2]Cl$ (tetraaquadichloridocobalt(III) chloride)
3. An optically active complex of the type $[M(AA)_2X_2]^{+n}$ indicates *cis*-octahedral structure, e.g. *cis*-$[Pt(en)_2Cl_2]^{2+}$ or *cis*- $[Cr(en)_2Cl_2]^+$
4. The magnetic moment of 5.92 BM corresponds to the presence of five unpaired electrons in the *d*-orbitals of Mn^{2+} ion. As a result the hybridization involved is sp^3 rather than dsp^2. Thus tetrahedral structure of $[MnCl_4]^{2-}$ complex will show 5.92 BM magnetic moment value.
5. With weak field ligands; $\Delta_0 < p$, the electronic configuration of Co(III) will be $t_{2g}^4 e_g^2$ and it has 4 unpaired electrons and is paramagnetic. With strong field ligands, $\Delta_0 < p$, the electronic configuration will be $t_{2g}^6 e_g^0$. It has no unpaired electrons and is diamagnetic.
6. Because for tetrahedral complexes, the crystal field stabilization energy is lower than pairing energy.
7. $[CoF_6]^{3-}$, $Co^{3+}(d^6)$ $t_{2g}^4 e_g^2$,
   $[Fe(CN)_6]^{4-}$, $Fe^{2+}(d^6) t_{2g}^6 e_g^0$,
   $[Cu(NH_3)_6]^{2+}$, Cu^{2+} $(d^9) t_{2g}^6 e_g^3$,
8. $[Fe(CN)_6]^{3-}$ involves d^2sp^3 hybridization with one unpaired electron and $[Fe(H_2O)_6]^{3+}$ involves sp^3d^2 hybridization with five unpaired electrons. This difference is due to the presence of strong ligand CN^- and weak ligand H_2O in these complexes.
9. Crystal field splitting energy increases in the order $[Cr(Cl)_6]^{3-} < [Cr(NH_3)_6]^{3+} < [Cr(CN)_6]^{3-}$
10. It is due to the presence of weak and strong ligands in complexes, if CFSE is high, the complex will show low value of magnetic moment and vice versa, e.g. $[CoF_6]^{3-}$ and $[Co(NH_3)_6]^{3+}$, the former is paramagnetic and the latter is diamagnetic.
11. In $CuSO_4 \cdot 5H_2O$, water acts as ligand as a result it causes crystal field splitting. Hence *d*—*d* transition is possible in $CuSO_4 \cdot 5H_2O$ and shows color. In the anhydrous $CuSO_4$ due to the absence of water (ligand), crystal field splitting is not possible and hence no color.
12. Linkage isomerism

    (i) $M \leftarrow N(=O)_2$

    (ii) $M \leftarrow SCN$ thiocyanato-S $M \leftarrow NCS$ thiocyanato-N

Long Answer Type

3. (i) A-$[Co(NH_3)_5SO_4]Cl$ B-$[Co(NH_3)_5Cl]SO_4$
   (ii) Ionization isomerism
   (iii) (A), Pentaamminesulphatocobalt(III) chloride
   (iv) (B), Pentaamminechlorocobalt(III) sulphate.
4. When white light falls on the complex, some part of it is absorbed. Higher the crystal field splitting, lower will be the wavelength absorbed by the complex. The observed color of complex is the color generated from the wavelength left over.
5. $\Delta_t = \left(\frac{4}{9}\right)\Delta_0$, So lower wavelength is absorbed in octahedral complex than tetrahedral complex for 9 same metal and ligands.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (b) Square planar complex is formed by hybridization of $d_{x^2-y^2}, s, p_x, p_y$.
2. (b) Nitropentammine chromium(III) chloride is $[Cr(NH_3)_5(NO)_2]Cl_2$. It will show linkage isomerism because it contains NO_2 ligand, which is an ambidentate ligand.
3. (b) Organometallic compounds are those in which positively charged metals are directly bonded to negatively charged carbon. The answer is C–Mg bond.
4. (c) Stability of $[Fe(CN)_6]$ is more due to presence of strong field ligand CN^-.
5. (a) NH_3 can act as ligand but NH_4^+ cannot act as ligand.

6. (d) Total 3 moles of ions are generated on dissolution in water, that is, one complex ion and two simple ions.

$$[Co(NH_3)_5Cl] \cdot Cl_2 \xrightarrow{H_2O} [Co(NH_3)_5^{\oplus}Cl] + 2Cl^{\ominus}$$

$$\xrightarrow[AgNO_3]{} [Co(NH_3)_5Cl]\,NO_3 + 2AgCl\downarrow$$

One mole of complex reacts with two moles of $AgNO_3$; thus, it must have 2 Cl atoms bonded by ionic linkage. Coordination number of Co is 6.

7. (a) Let the oxidation state of Ni be x.

then

$$4(+1) + x + 4(-1) = 0$$

$$\Rightarrow \quad x = 0$$

8. (a) $CN^{\ominus}$ forms complexes with several metal ions, for example, metal species.

$$Fe^{2+} + 4\,CN^- \rightarrow [Fe(CN)_6]^{4-}$$

CN^- can also act as a reducing agent for metal species, for example,

$$Cu^{2+} + CN^- \rightarrow \underset{\text{White ppt.}}{Cu(CN)\downarrow} + \underset{\text{Cyanogen gas}}{(CN)_2\uparrow}$$

However, there is no example of CN^- acting as oxidizing agent on metal ions or species.

9. (c) The coordination number of the central atom or ion is determined by the number of sigma bonds between the ligands and the central atom or ion. Pi-bonds, if any, between the ligating atom and the central atom or ion are not considered for the determination of coordination number.

10. (d) Ni^{+2} coordination number is 6 and always forms outer orbital complex.

11. (c) The correct statement should be chlorophylls are green pigments in plants and contain magnesium.

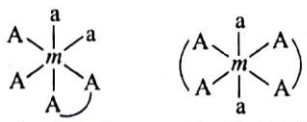
12. (d)

(a) $[Ir(PR_3)_2H(CO)]^{2+}$ will show two geometrical isomers.

(b) $[Co(NH_3)_5Cl]^{2+}$ will not show any geometrical and optical isomerism.

(c) $[Ru(NH_3)_4\,Cl_2]^+$ will show two geometrical isomerism.

(d) $[Co(en)_2\,Cl_2]^+ \equiv [M(\overline{AA})_2\,a_2]$



optically active optically inactive

13. (c) $[Fe(CN)_6]^{4-}$

Fe^{2+} $3d^64s^0$

↑↓	↑↓	↑↓

M.M = 0 B.M.

$[MnCl_4]^{2-}$

Mn^{2+} $3d^54s^0$

1	1	1

1	1

M.M = $\sqrt{35}$ B.M.

$[CoCl_4]^{2-}$

Co^{+2} $3d^74s^0$

1	1	1

↑↓	↑↓

M.M = $\sqrt{15}$ B.M.

14. (d) Let the oxidation state of Cr is x.

Oxidation state of NH_3 is zero and of Cl is -1.

Thus, $x + 4(0) + 2(-1) = +1$

$\Rightarrow \quad x = +3$

16. (b)

(a) $[Co(CN)_6]^{3-} \equiv [Ma_6]^{3-}$

It will not show geometrical and optical isomerism.

(b) $[Co(C_2O_4)_3]^{3-} \equiv [M(\overline{AA})_3]^{3-}$

It will not show geometrical isomerism but it is optically active.

(c) $[ZnCl_4]^{2-}$

It will not show geometrical and optical isomerism.

(d) $[Cu(NA_3)_4]^{2+}$

It will not show geometrical and optical isomerism.

17. (a)

$[CoCN_6]^{3-}$ Co^{+3} $3d^64s^0$

M.M. = 0 B.M.

↑↓	↑↓	↑↓

$2Hg_2Cl_2 + 2NH_4OH \rightarrow 2Hg(NH_2)Cl + 2Hg + 2H_2O + 2HCl$

$[Fe(CN)_6]^{3-}$ Fe^{+3} $3d^54s^0$

M.M. = $\sqrt{3}$ B.M.

↑↓	↑↓	1

$[Mn(CN)_6]^{3-}$ Mn^{+3} $3d^44s^0$

M.M. = $\sqrt{8}$ B.M.

⇅	↑	↑

$[Cr(CN)_6]^{3-}$ Cr^{+3} $3d^3 4s^0$

M.M. = $\sqrt{15}$ B.M.

↑	↑	↑

18. (d) M.M. = 2.84 B.M. → No. of unpaired electron is 2

d^6(in strong ligand field)

⇅	⇅	↑

d^3(in weak as well as in stron field ligand fields)

↑	↑	↑

d^4(in weak ligand fields)

↑	

↑	↑	↑

d^4(in strong ligand fields)

⇅	↑	↑

20. (a) As per Fajan's rule, with increase in charge density on the cation, the covalent character in the compound increases.

21. (d) Ni: in $[NiX_4]^2$ is Ni^{2+}.

Ni electronic configuration: $3d^8\ 4s^2$

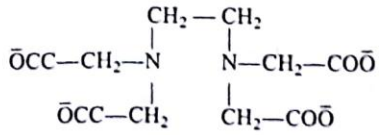
Ni^{2+} electronic configuration: $3d^8\ 4s^0$

⇅	⇅	⇅	⇅	⇅

As the complex is paramagnetic, thus, the two unpaired electrons will remain unpaired. Hence, the hybridization should be sp^3 and geometry, thus is tetrahedral.

22. (b) $Fe(CO)_5$, has synergic bonding.

23. (a) $EDTA^{4-}$ is a hexadentate ligand in which donor atoms are N (two) and oxygen (four).



(decimal to get the impaired electrons)

24. (c) $m = \sqrt{n(n+2)}$

In Ni^{2+}, unpaired electron is 2.

$\therefore \quad m = \sqrt{2(2+2)} = \sqrt{8}$

$= 2.828$

$= 2.84$

25. (a)

$[PtCl_4]^{2-}$ Pt^{+2} $5d^8 6s^0$

⇅	⇅	⇅	⇅				

dsp^2

Others are tetrahedral complex.

26. (d) $[E(en)_2(C_2O_4)]NO_2$

$E + 2(0) + (-2) + (-1) = 0$

$E = +3$

27. (a) Other factors are same. The complex having strong field ligand has the highest magnitude of Δ_0.

28. (c) $[Co(en)_2(NH_3)_2]^{3+} \equiv [M(\overline{AA})_2 a_2]^{3+}$

It has to geometrical isomers. Its *cis* isomer is optically active.

29. (a) Linkage isomers contain ambidentate ligand NCS and $S\bar{C}N$.

30. (a) AgCl obtained is 4.78 g, that is, $\frac{4.78}{143.5}$ moles.

Thus, in $\frac{2.675}{267.5}$ moles of complex, $\frac{4.78}{143.5}$ moles of Cl^- ions were isonizable.

That is, li 10^{-2} moles of complex, $\frac{1}{30}$ moles Cl^- are produced.

$\therefore$ 1 mole of complex $\rightarrow \frac{1}{30} \times 10^{-2}$ moles of Cl^-

$= \frac{100}{30} = 3.3$ moles

Thus, the formula of complex should be $[Co(NH_3)_6]Cl_3$.

31. (b)

(a) $[Zn(en)(NH_3)_2]^{2+}$

It has no geometrical and optical isomers.

(b) $[Co(en)_3]^{3+}$

It has no geometrical isomers, but it is optically active.

(c) $[Co(H_2O)_3(en)]^{3+}$

It has no geometrical and optical isomers.

(d) $[Zn(en)_2]^{2+}$

It has no geometrical and optical isomers.

32. (c)

$[Cr(NH_3)_6]Cl_3$ Cr^{+3} $3d^3 45^0$

d^2sp^3 and paramagnetic

1	1	1

33. (d)

$[NiCl_4]^{2-}$

↑↓	1	1

Ni^{+2} $3d^8 45^0$

M.M. = $\sqrt{8}$ = 2.82 B.M.

34. (a) Increasing order of field strength is NH_3 < en < CN^- < CO.

In general, field strength order is Halogen Family < Oxygen Family < Nitrogen Family < Carbon Family.

35. (b)

(a) $[Ni(NH_3)_5Br]^+$
It has no geometrical and optical isomers.

(b) $[Co(NH_3)_2(en)_2]^{3+}$
It has two geometrical isomers.

(c) $[Cr(NH_3)_4(en)_2]^{3+}$
It has no geometrical isomers.

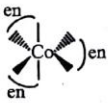
(d) $[Co(en)_3]^{3+}$
It has no geometrical isomers, but it is optically active.

36. (b)

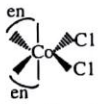
(a) We first name cation and then anion.

(b) If cation is complex, then we first name ligand in alphabetical order and then central atom with oxidation state remain numeral in common brackets.

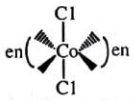
37. (c)

(a) 

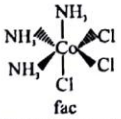
(Optically active)

(b) 

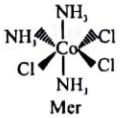
cis (Optically active)



trans (Optically inactive)

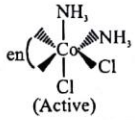
(c) 

fac (Optically inactive)

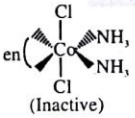


Mer (Optically inactive)

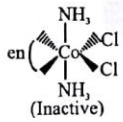
(d) Exist in three G.I.



(Active)



(Inactive)



(Inactive)

38. (d) The frequency order of given absorbed light is:

Blue > Green > Yellow > Red.

Respective ligands L_4 L_2 L_3 L_1

Hence the ligand strength order is $L_4 > L_2 > L_3 > L_1$.

Because strong field ligand causes higher splitting gap for octahedral-complex and absorbs high frequency light for *d-d* transition.

Hence the answer is (d).

39. (d)

(a) $[Mg(H_2O)_6]^{+2} + (EDTA)^{-4} \xrightarrow[\text{of NaOH}]{\text{excess}} [Mg(EDTA)]^{-2} + 6H_2O$

(b) $CuSO_4 + 5KCN \rightarrow K_3[Cu(CN_4) + K_2SO_4 + \frac{1}{2}(CN)_2$

(c) $2LiCl + K_2O \rightarrow Li_2O + 2KCl$
backward reaction of given equation is correct

(d) $[CoCl(NH_3)_5]^+ + 5H^+ \rightarrow Co^{+2} + 5NH_4^+ + Cl^-$
Hence NH_3 gets protonated and makes Co^{+2} ion free in solution.

40. (d) In $[FeF_6]^{3-}$, 5 unpaird electron present is In $[Fe(CN)_6]^{3-}$ 1 unpaired electron present.

41. (a) Co^{+3} is diamagnetic and having d^6 by configuration under SFL.

JEE (Advanced) Exercises

Fill in the Blanks Type

1. AgCl dissolves in excess of KCN solution to give the **$K[Ag(CN)_2]$** complex compound.
$AgCl + 2KCN \rightarrow K[Ag(CN)_2] + KCl$

2. The type of magnetism exhibited by $[Mn(H_2O)_6]^{2+}$ ion is **paramagnetism**.

3. The IUPAC name of $[Co(NH_3)_6]Cl_3$ is **hexamminecobalt(III) chloride**.

True/False Type

1. **False.**
   Potassium ferrocyanide is diamagnetic but potassium ferricyanide is paramagnetic.

Single Correct Answer Type

1. (c)

$[NiCl_4]^{2-}$

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8 4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

Chlorido is a weak field ligand, no pairing.

sp^3-Hybridization (tetrahedral)

There are two unpaired electrons, so the complex is paramagnetic.

Spin magnetic moment

$\mu = \sqrt{n(n+2)}$ BM

$= \sqrt{2(2+2)}$ BM $= \sqrt{8}$ BM

$[Ni(CN)_4]^{2-}$

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8 4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

Cyano is a strong field ligand, it causes pairing.

3d					4s	4p		
↑↓	↑↓	↑↓	↑↓					

dsp^2-Hybridization (square planar)

There are no unpaired electrons so, the complex is diamagnetic.

Spin magnetic moment = zero

$[NiCl_4]^{2-}$

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8 4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

Chlorido is a weak field ligand, no pairing

sp^3-Hybridization (tetrahedral)

There are two unpaired electrons, so the complex is paramagnetic.

Spin magnetic moment

$\mu = \sqrt{n(n+2)}$ BM

$= \sqrt{2(2+2)}$ BM $= \sqrt{8}$ BM

2. (b) $[Cr(H_2O)_6]^{3+}$

The oxidation number of Cr is +3

Atomic number = 24

$Cr = [Ar]3d^5 4s^1$

$Cr^{3+} = [Ar]3d^3 4s^0$

3d					4s	4p		
↑	↑	↑						

There are three unpaired electrons.

$[Fe(H_2O)_6]^{2+}$

The oxidation number of Fe is +2.

Atomic number = 26

$Fe = [Ar]3d^6 4s^2$

$Fe^{2+} = [Ar]3d^6 4s^0$

3d					4s	4p		
↑↓	↑	↑	↑	↑				

There are four unpaired electrons.

$[Cu(H_2O)_6]^{2+}$

The oxidation number of Cu is +2.

Atomic number = 29

$Cu = [Ar]3d^{10} 4s^1$

$Cu^{2+} = [Ar]3d^9 4s^0$

3d					4s	4p		
↑↓	↑↓	↑↓	↑↓	↑				

There is one unpaired electron.

$[Zn(H_2O)_6]^{2+}$

The oxidation number of Zn is + 2.

Atomic number = 30

$Zn = [Ar]3d^{10}\,4s^2$

$Zn^{2+} = [Ar]3d^{10}\,4s^0$

3d					4s	4p		
↑↓	↑↓	↑↓	↑↓	↑↓				

There are no unpaired electrons.

$[Fe(H_2O)_6]^{2+}$ has the maximum number of unpaired electrons; therefore, the highest degree of paramagnetism.

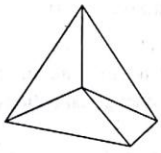
3. (d) When excess of KCN is added to an aqueous solution of copper sulphate, $K_3[Cu(CN)_4]$ is formed.

$CuSO_4 + 2KCN \rightarrow Cu(CN)_2 + K_2SO_4$

$2Cu(CN)_2 \rightarrow Cu_2(CN)_2 + (CN)_2$

$Cu_2(CN)_2 + 6KCN \rightarrow 2K_3[Cu(CN)_4]$

4. (c)



$Ni(CO)_4$

Oxidation number = 0

$Ni = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^8, 4s^2$

$Ni^{2+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}$

3d					4s	4p		
↓↑	↓↑	↓↑	↓↑	↓↑				

sp^3-Hybridization

Geometry of $Ni(CO)_4$ is tetrahedral.

$Ni(PPh_3)_2Cl_2$

Oxidation number = +2

$Ni^{2+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^8$

3d⁸					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

sp^3-Hybridization

Geometry of $Ni(PPh_3)_2Cl_2$ is tetrahedral.

5. (d) MnO_4^- : Mn (+7)

$Cr(CN)_6^{3-}$: Cr (+3)

NiF_6^{2-} : Ni(+4)

CrO_2Cl_2 : Cr(+6)

6. (a) MnO_4^- : Mn(+7)

Mn ($z = 25$)

$[Ar]3d^5\,4s^2$

Mn^{+7} : [Ar]

No d electrons left.

7. (b) MnO_2(+4) and $FeCl_3$(+3)

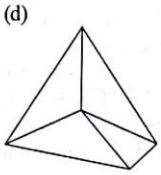
MnO_4^- (+7) and CrO_2Cl_2(+6)

$[Fe(CN)_6]^{3-}$ (+3) and $[Co(CN)_6]^{3-}$ (+3)

$[NiCl_4]^{2-}$ and $[CoCl_4]$(+3)

For manganese, +7 is the maximum oxidation state and for chromium, +6 is the maximum oxidation state.

8. (d)



$[Ni(Cl)_4]^{2-}$

The oxidation state of Ni is +2.

The atomic number of Nickel is 28.

$Ni = [Ar]3d^8 4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

sp^3-Hybridization , tetrahedral shape.

9. (b) $Hg[Co(SCN)_4]$,

Co is present as Co^{2+}.

The atomic number of cobalt is 27.

$Co = [Ar]3d^7 4s^2$

$Co^{2+} = [Ar]3d^7$

↑↓	↑↓	↑	↑	↑				

Unpaired electrons, $n = 3$

Magnetic moment = $\sqrt{n(n+2)}$

$= \sqrt{3(3+2)} = \sqrt{15}$ BM

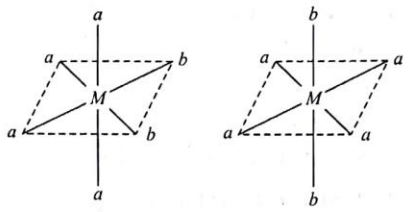
10. (a) $Co(NH_3)_4Br_2Cl$ is octahedral in shape.

It shows ionization and geometrical isomerism.

$[Co(NH_3)_4Br_2]Cl \rightleftharpoons [Co(NH_3)_4Br_2]^+ + Cl^-$

$[Co(NH_3)_4BrCl]Br \rightleftharpoons [Co(NH_3)_4BrCl]^+ + Br^-$

The above two structures are geometrical isomers because they furnish different ions on dissociation. $Co(NH_3)_4Br_2Cl$ is of Ma_4b_2 type, and it shows geometrical isomerism as shown here.



Ma_4b_2

11. (d) The overlap of a lone pair on the C atom with the empty hybrid metal orbital forms a metal-to-carbon σ-bond. The transition metal atom in a metal carbonyl fills the non-bonding *d*-orbitals which are of proper symmetry to overlap with the anti-bonding orbitals of CO. The electronic charge is transferred from the filled non-bonding orbitals of the metals to π^*-orbitals of the ligand CO. This reduces the bond order of CO. The π back-bonding strengthens the M—C bond order, it weakens the C—O bond order. So the bond length increases slightly.

12. (d) The overlap of a lone pair on the C atom with the empty hybrid metal orbital forms a metal-to-carbon σ-bond. The transition metal atom in a metal carbonyl fills the non-bonding *d*-orbitals which are of proper symmetry to overlap with the anti-bonding orbitals of CO. The electronic charge is transferred from the filled non-bonding orbitals of the metals to π^*-orbitals of the ligand CO. This reduces the bond order of CO. The π back-bonding strengthens the M—C bond order and weakens the C—O bond order.

CO is a strong ligand, it causes pairing of electrons.

Mn^+: $(z = 25)$

$[Ar]3d^5 4s^1 \Rightarrow [Ar]3d^6 4s^0$

Three lone pairs are available for back-bonding with vacant orbital of C in CO.

Fe^0: $(z = 26)$

$[Ar]3d^6 4s^2 \Rightarrow [Ar]3d^8$

Four lone pairs are available for back-bonding with vacant orbital of C in CO.

Cr^0: $(z = 24)$

$[Ar]3d^5 4s^1 \Rightarrow [Ar]3d^6 4s^0$

Three lone pairs are available for back-bonding with vacant orbital of C in CO.

V^-: $(z = 23)$

$[Ar]3d^4 4s^2 \Rightarrow [Ar]3d^6 4s^0$

Three lone pairs are available for back-bonding with vacant orbital of C in CO.

Minimum back-bonding is possible in $[V(CO)_6]^{-1}$, so the M—C bond order is the lowest.

13. (b)

	$[Ni(CN)_4]^{2-}$	$[NiCl_4]^{2-}$
Oxidation number	+2	+2
Coordination number	4	4
Hybridization	dsp^2	sp^3
Shape	Square planar	Tetrahedral
Unpaired electrons	0	2
Magnetic moment	0	$\sqrt{8}$ BM

CN^- is a strong field ligand, hence it causes the pairing of 3*d*-electrons, whereas Cl^- is a weak field ligand and it does not cause pairing.

14. (c) $[Ni(NH_3)_4][NiCl_4]$

In both cation and anion, oxidation state of nickel is +2.

The IUPAC name is tetraaminenickel(II) tetra-chloridonickelate(II).

15. (c) CuF_2 is blue colored.

In CuF_2, Cu^{2+} ions are present.

In all the other given options, the oxidation number of copper is +1.

$Cu = [Ar]3d^{10}4s^1$

$Cu^{2+} = [Ar]3d^9$

Unpaired electron present

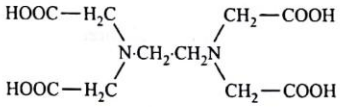
Colored

$Cu^+ = [Ar]3d^{10}$

No unpaired electron

Colorless

16. (c)



is the correct structure of ethylenediaminetetraacetatic acid. It is a hexa-dentate ligand.

17. (b) The ionization isomer of $[Cr(H_2O)_4Cl(NO_2)]Cl$ is $[Cr(H_2O)_4Cl_2](NO_2)$.

$[Cr(H_2O)_4Cl(NO_2)]Cl$

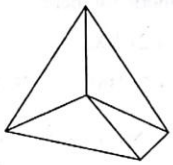
$\rightarrow [Cr(H_2O)_4Cl(NO_2)]^+ + Cl^-$

$[Cr(H_2O)_4Cl_2](NO_2)$

$\rightarrow [Cr(H_2O)_4Cl_2]^+ + NO_2^-$

Both of them give different ions on dissociation.

18. (d)



$[Ni(Cl)_4]^{2-}$

The oxidation state of Ni is +2.

The atomic number of nickel is 28.

$Ni = [Ar]3d^8 4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

sp^3-Hybridization, tetrahedral shape.

There are two unpaired electrons.

Spin magnetic moment $= \sqrt{n(n+2)}$

$= \sqrt{2(2+2)} = \sqrt{8}$ BM

≈ 2.82 BM

19. (b) $Ni^{2+} + Cl^- \rightarrow NiCl_4$; tetrahedral

$Ni^{2+} + CN^- \rightarrow Ni(CN)_4$; square planar

$Ni^{2+} + H_2O \rightarrow [Ni(H_2O)_6]^{+2}$; octahedral

20. (c) K: $K_3[Fe(CN_6)] \rightarrow Fe^{3+} \equiv 3D^5$ (odd electrons)

It is paramagnetic.

L: $[Co(NH_3)_6]Cl_3 \rightarrow CO^{3+} \equiv 3d^6$

NH_3 a strong field ligand and hence back pairing

⇅	⇅	⇅		

d^6

It is diamagnetic.

M: $Na_3[Co(OX)_3] \rightarrow Co^{3+} \equiv 3d^6$

21. (d) $[Co(H_2O)_4(NH_3)_2]Cl_3$

= Diaminetet raaqua cobalt(III) chloride

22. (a) $CuSO_4$ will be absorbing orange-red color and hence will be of blue color.

23. (b) spin only magnetic moment $= \sqrt{n(n+2)}$ B.M.

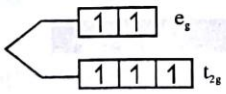
$n \rightarrow$ number of unpaired electrons

P: $[FeF_6]^{3-}$

$F^- \rightarrow$ (weak field ligand)

$\Delta_0 < P$

Fe^{3+} [Ar] $3d^5$



number of unpaired electron = 5

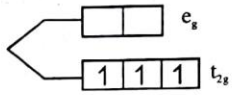
$\mu = \sqrt{5(5+2)} = \sqrt{35}$

Q: $[V(H_2O)_6]^{2+}$

$H_2O \rightarrow$ (weak field ligand)

$\Delta_0 < P$

$V^{2+} \rightarrow$ [Ar] $3d^3$



number of unpaired electron = 3

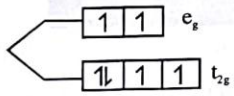
$\mu = \sqrt{3(3+2)} = \sqrt{15}$

R: $[Fe(H_2O)_6]^{2+}$

$H_2O \rightarrow$ (weak field ligand)

$\Delta_0 < P$

Fe^{2+}; [Ar] $3d^6$



number of unpaired electron = 4

$\mu = \sqrt{4(4+2)} = \sqrt{24}$

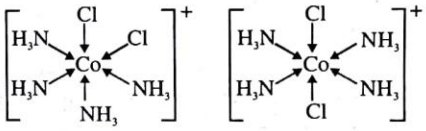
Hence, Q < R < P

Multiple Correct Answers Type

1. (b), (d)

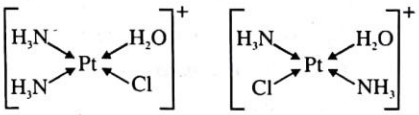
(a) $[Cr(NH_3)_5Cl]Cl_2$ does not show any isomerism while $[Cr(NH_3)_4Cl_2]Cl$ shows geometrical isomerism

(b) $[Co(NH_3)_4Cl_2]^+$ and $[Pt(NH_3)_2(H_2O)(Cl)]^+$



cis *trans*

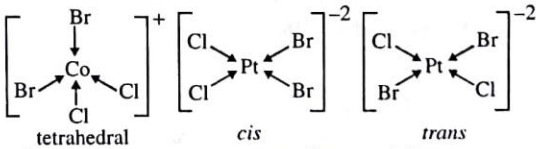
hence, $[Co(NH_3)_4Cl_2]^+$ ion shows geometrical isomerism. $[Pt(NH_3)_2(H_2O)(Cl)]^+$



cis *trans*

hence, $[Pt(NH_3)_2(H_2O)(Cl)]^+$ ion shows geometrical isomerism

(c) $[CoBr_2Cl_2]^{2-}$ and $[PtBr_2Cl_2]^{2-}$



tetrahedral does not show any isomerism

cis square planar and shows geometrical isomerism

trans

does not show any isomerism square planar and shows geometrical isomerism

(d) $[Pt(NH_3)_3(NO_3)]Cl$ and $[Pt(NH_3)_3Cl]Br$

$$\left\{\begin{matrix}[Pt(NH_3)_3(No_3)]Cl \\ [Pt(NH_3)_3Cl]NO_3\end{matrix}\right\}$$

show ionization isomerism

$$\left\{\begin{matrix}[Pt(NH_3)_3Cl]Br \\ [Pt(NH_3)_3Br]Cl\end{matrix}\right\}$$

show ionization isomerism

Hence, answer is (b), (d)

Comprehension Type

1. (a) $NiCl_2 + 4KCN \rightarrow K_2[Ni(CN)_4] + 2KCl$

A is $K_2[Ni(CN)_4]$

Potassium tetracyanonickelate(II)

$K_2[Ni(CN)_4] + 4HCl(conc) \rightarrow K_2[Ni(CN)_4] + 4HCN$

B is $K_2[NiCl_4]$

Potassium tetrachloridonickelate(II)

2. (c) $[Ni(CN)_4]^{2-}$

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8\,4s^2$

$Ni^{2+} = [Ar]3d^8$

	3d				4s	4p		
↑↓	↑↓	↑↓	↑	↑				

Cyano is a strong field ligand, it causes pairing

	3d				4s	4p		
↑↓	↑↓	↑↓	↑↓					

dsp^2-Hybridization (square planar)

There are no unpaired electrons, so the complex is diamagnetic.

Spin magnetic moment = zero

$[NiCl_4]^{2-}$

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8\,4s^2$

$Ni^{2+} = [Ar]3d^8$

	3d				4s	4p		
↑↓	↑↓	↑↓	↑	↑				

Chlorido is a weak field ligand, no pairing.

sp^3-Hybridization (tetrahedral)

There are two unpaired electrons, so the complex is paramagnetic.

Spin magnetic moment

$\mu = \sqrt{n(n+2)}$ BM

$= \sqrt{2(2+2)}$ BM $= \sqrt{8}$ BM

3. (a)

$K_2[Ni(CN)_4]$: dsp^2-hybridization

$K_2[NiCl_4]$: sp^3-hybridization

Assertion-Reasoning Type

1. (a) $[Fe(H_2O)_5NO]SO_4$

NO has charge equal to +1 in this complex. Therefore, the oxidation number of Fe in the complex becomes +1.

$Fe^{+} = [Ar]3d^6\,4s^2$

$Fe^{+} = [Ar]3d^6\,4s^1$

	3d				4s	4p		
↑↓	↑	↑	↑	↑	↑			

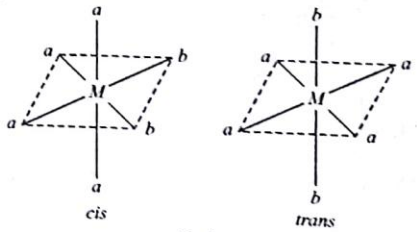
After pairing

	3d				4s	4p		
↑↓	↑↓	↑	↑	↑				

NO^{+} causes pairing of 4s electron inside.

Thus, the configuration is $3d^7$ and the number of unpaired electrons is 3.

2. (a)



Ma_4b_2

The *cis* and *trans* forms of the complex $[M(NH_3)_4Cl_2]$ are optically inactive. Both geometrical isomers of the complex $[M(NH_3)_4Cl_2]$ possess axis of symmetry.

Matching Column Type

1. (a) → (p, q, s); (b) → (p, r, s); (c) → (q, s); (d) → (q, s)

In all the given complexes, the metal is in +2 oxidation state.

$[Co(NH_3)_4(H_2O)_2]Cl_2$ can show geometrical isomerism, it is an octahedral complex of Ma_4b_2 type.

$[Pt(NH_3)_2Cl_2]$ can show geometrical isomerism, it is a tetrahedral complex of Ma_2b_2 type.

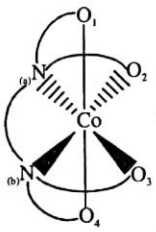
$[Co(NH_3)_4(H_2O)_2]Cl_2$ is paramagnetic, it has three unpaired electrons.
$[Pt(NH_3)_2Cl_2]$ is diamagnetic. It does not have any unpaired electrons.
$[Co(H_2O)_5Cl]Cl$ is paramagnetic. It has three unpaired electrons.
$[Ni(H_2O)_6]Cl_2$ is paramagnetic. It has two unpaired electrons.

2. (b)

(P) $[Cr^{III}(NH_3)_4Cl_2]Cl$ (3 upaired electrons)	(1) Complex given in (P) is paramagnetic and shows two geometrical isomerism (*cis* and *trans*) (does not show ionization isomer)
(Q) $[Ti^{III}(H_2O)_5Cl](NO_3)_2$ (1 unpaired electrons)	(2) Complex given in (Q) is paramagnetic and shows ionization isomerism
(R) $[Pt^{II}(en)(NH_3)Cl]NO_3$ (1 unpaired electrons)	(3) Complex given in (R) is diamagnetic and shows ionization isomerism
(S) $[Co^{III}(NH_3)_4(NO_3)_2]NO_3$ (0 unpaired electrons)	(4) Complex given in (S) is diamagnetic and does not show ionization isomerism (show geometrical isomerism)

Integer Answer Type

1. (8)



$= [Co^{III}(EDTA)]^-$

Total 8 N–Co–O bond angles

(a)N–Co–O_1	(b)N–Co–O_1
(a)N–Co–O_2	(b)N–Co–O_2
(a)N–Co–O_3	(b)N–Co–O_3
(a)N–Co–O_4	(b)N–Co–O_4

Subjective Type

1. Potassium ferricyanide is reduced to potassium ferrocyanide as follows:

$$2K_3Fe(CN)_6 + H_2O_2 + 2KOH \rightarrow 2K_4Fe(CN)_6 + 2H_2O + O_2$$

2. "The species $[CuCl_4]^{2-}$ exists, while $[CuI_4]^{2-}$ does not."

$$2CuI_2 \rightarrow Cu_2I_2 + I_2$$

Iodide ion reduces Cu^{2+} to cuprous iodide and I_2. So $[CuI_4]^{2-}$ does not exist.

3. $3[Fe(H_2O)_6]^{2+} + NO_3^- + 4H^+ \rightarrow NO + 3[Fe(H_2O)_6]^{3+} + 2H_2O$

$[Fe(H_2O)_6]^{2+} + NO \rightarrow [Fe(H_2O)_5NO]^{2+} + H_2O$

4. $[Ti(NO_3)_4]$
The oxidation state of Ti is +4.
The atomic number of titanium is 22.
$Ti = [Ar]3d^2 4s^2$
$Ti^{4+} = [Ar]$
Incomplete *d*-orbital is not there, so it is colorless.
$[Cu(NCCH_3)]^+ BF_4^-$
The oxidation state of Cu is +1.
The atomic number of copper is 28.
$Cu = [Ar]3d^{10} 4s^1$
$Cu^+ = [Ar]3d^9$
Incomplete *d*-orbital is not there, so it is colorless.
$[Cr(NH_3)_6]^{3+} 3Cl^-$
The oxidation state of Cr is +23.
The atomic number of chromium is 24.
$Cr = [Ar]3d^{10} 4s^1$
$Cr^{3+} = [Ar]3d^8$
Incomplete *d*-orbitals are there, so it is colored.
$K_3[VF_6]$
The oxidation state of V is +3.
The atomic number of vanadium is +3.
$V = [Ar]3d^3 4s^2$
$V^{3+} = [Ar]3d^3$
Incomplete *d*-orbitals are there, so it is colored.

5. **(i)** $[Co(NH_3)_5ONO]Cl_2$

Pentamminenitritocobalt(II) chloride
(ii) $K_3[Cr(CN)_6]$

Potassiumhexacyanochromate(III)

6. $[Cr(NH_3)_5CO_3]Cl$

Pentaamminecarbonatochromium(III) chloride

7. Argentite is the sulphide ore of silver.

$$Ag_2S + 4KCN \rightarrow 2K[Ag(CN)_2] + K_2S$$

8. **(i)** Pentaamminechlorocobalt(III) ion

$[Co(NH_3)_5Cl]^{2+}$

(ii) Lithiumtetrahydrogenaluminate(III)
$Li[AlH_4]$

9. *A*, *B*, and *C* are three complexes of chromium(III) with the empirical formula $H_{12}O_6C_{13}Cr$. All the three complexes have water and chloride ion as ligands.

Complex *A* does not react with concentrated H_2SO_4.

A is $[Cr(H_2O)_6]Cl_3$.

$[Cr(H_2O)_6]Cl_3 + H_2SO_4 \rightarrow$ No reaction

Water molecules inside the coordination sphere are not removed by sulphuric acid.

Complex *B* loses 6.75% of its original mass on treatment with concentrated H_2SO_4.

B is $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$

One mole of H_2O which is outside the coordination sphere is removed with sulphuric acid.

Molecular weight of the complex = 266.5

$$\text{Percentage loss in mass} = \frac{18}{266.5} \times 100 = 6.75\%$$

Complex *C* loses 13.5% of its original mass on treatment with concentrated H_2SO_4.

C is $[Cr(H_2O)_4Cl_2] \cdot Cl \cdot 2H_2O$

Two moles of H_2O are removed which are outside the coordination sphere.

$$\text{Percentage loss in mass} = 2 \times \frac{18}{266.5} \times 100 = 13.50\%$$

10. HgI_2 has orange/scarlet color.

It dissolves in sodium iodide due to the formation of a complex.

$$HgI_2 + 2NaI \rightarrow Na_2HgI_4$$

With NaOCl, again a precipitate of HgI_2 is formed.

$$3Na_2HgI_4 + 2NaOCl + 2H_2O \rightarrow 3HgI_2 + 2NaI_3 + 4NaOH + 2NaCl$$

11. $[Ni(CN)_4]^{2-}$

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8\,4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

Cyano is a strong field ligand, it causes pairing

3d					4s	4p		
↑↓	↑↓	↑↓	↑↓					

dsp^2-Hybridization (square planar)

There are no unpaired electrons, so the complex is diamagnetic.

Spin magnetic moment = zero

$[Ni(CO)_4]$

The oxidation number of Ni is 0.

Atomic number = 28

$Ni = [Ar]3d^8\,4s^2$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑	↑↓			

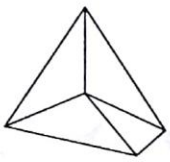
CO is a strong field ligand, it causes pairing.

3d					4s	4p		
↑↓	↑↓	↑↓	↑↓	↑↓				

sp^3-Hybridization (tetrahedral)

There are no unpaired electrons, so the complex is diamagnetic.

Spin magnetic moment = zero



$[Co(NH_3)_6]^{3+}$

The oxidation number of Co is +3.

Atomic number = 27

$Co = [Ar]3d^7\,4s^2$

$Co^{3+} = [Ar]3d^6\,4s^0$

3d					4s	4p		
↑↓	↑	↑	↑	↑				

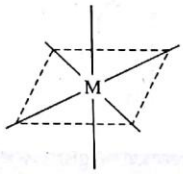
In this case, NH_3 causes pairing

3d					4s	4p		
↑↓	↑↓	↑↓						

d^2sp^3-Hybridization (octahedral)

There are no unpaired electrons, so the complex is diamagnetic.

Spin magnetic moment = zero



12. A metal complex having composition $Cr(NH_3)_4Cl_2Br$ has been isolated in two forms *A* and *B*. The form *A* reacts with $AgNO_3$ to give a white precipitate readily soluble in dilute aqueous ammonia. This is a test for chloride ion. *B* gives a pale-yellow precipitate soluble in concentrated ammonia. This is a test for bromide ion.

A is $[Cr(NH_3)_4ClBr]Cl$.

$$[Cr(NH_3)_4ClBr]Cl + AgNO_3$$

$$\rightarrow \underset{\text{White}}{AgCl\downarrow} + [Cr(NH_3)_4ClBr]^+ NO_3^-$$

$$AgCl + 2NH_4OH \rightarrow [Ag(NH_3)_2Cl] + 2H_2O$$

B is $[Cr(NH_3)_4Cl_2]Br$.

$$[Cr(NH_3)_4Cl_2]Br + AgNO_3$$

$$\rightarrow \underset{\text{Yellow}}{AgBr\downarrow} + [Cr(NH_3)_4Cl_2]^+ NO_3^-$$

$$AgBr + 2NH_4OH \rightarrow [Ag(NH_3)_2Br] + 2H_2O$$

In both *A* and *B*:

The oxidation number of Cr is +3.

Atomic number = 24

$Cr = [Ar]3d^5\,4s^1$

$Cr^{3+} = [Ar]3d^3\,4s^0$

3d					4s	4p		
↑	↑	↑						

d^2sp^3-Hybridization (octahedral)

Thereare three unpaired electrons, so the complex is paramagnetic.

Spin magnetic moment

$$\mu = \sqrt{n(n+2)}\ \text{BM} = \sqrt{3(3+2)}\ \text{BM} = \sqrt{15}\ \text{BM}$$

13. $[NiCl_4]^{2-}$

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8\,4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

Chlorido is a weak field ligand, no pairing.

sp^3-Hybridization (tetrahedral)

There are two unpaired electrons, so the complex is paramagnetic.

Spin magnetic moment

$$\mu = \sqrt{n(n+2)}\ \text{BM} = \sqrt{2(2+2)}\ \text{BM} = \sqrt{8}\ \text{BM}$$

$[Ni(CN)_4]^{2-}$

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8\,4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

Cyano is a strong field ligand, it causes pairing.

3d					4s	4p		
↑↓	↑↓	↑↓	↑↓					

dsp^2-Hybridization (square planar)

There are no unpaired electrons, so the complex is diamagnetic.

Spin magnetic moment = zero

14. $K_2[Cr(NO)(NH_3)(CN)_4]$

Its IUPAC name is

Potassium amminetetracyanonitrosochromate(I)

The oxidation number of Cr is +1.

Atomic number = 24

$Cr = [Ar]3d^5\,4s^1$

$Cr^{+} = [Ar]3d^5$

3d					4s	4p		
↑	↑	↑	↑	↑				

Given $\mu = 1.73$ BM

$\therefore \sqrt{n(n+2)} = 1.73$

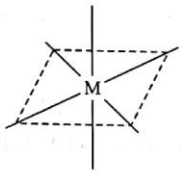
or $n = 1$ (only one unpaired electron)

After pairing

3d					4s	4p		
↑↓	↑↓	↑						

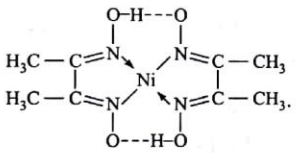
d^2sp^3-Hybridization occurs.

Shape is octahedral.



15. $NiCl_2$ in the presence of dimethyl glyoxime (DMG) gives a complex which precipitates in the presence of NH_4OH, giving a bright-red color.

The structure of the complex is



The oxidation state of Ni in this compound is +2. The ligand is strong, so it causes pairing. Therefore, it shows dsp^2-hybridization.

The oxidation number of Ni is +2.

Atomic number = 28

$Ni = [Ar]3d^8\,4s^2$

$Ni^{2+} = [Ar]3d^8$

3d					4s	4p		
↑↓	↑↓	↑↓	↑	↑				

After pairing:

3d					4s	4p		
↑↓	↑↓	↑↓	↑↓					

dsp^2-Hybridization occurs.

There are no unpaired electrons, so the complex is diamagnetic.

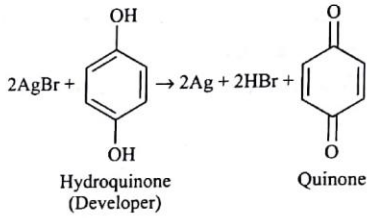
16. Anhydrous HF is stabilized due to intermolecular H bonding and is less dissociated. AlF_3 is soluble in HF in the presence of KF due to the formation of $[AlF_6]^{3-}$.

$$3KF + AlF_3 \rightarrow K_3[AlF_6]$$

BF_3 displaces out F^- from $[AlF_6]^{3-}$ because it is more acidic than AlF_3.

$$K_3[AlF_6] + BF_3 \rightarrow AlF_3\downarrow + 3KBF_4$$

17. A mild reducing agent is used for sensitized silver bromide.



The unreacted AgBr is treated with sodium thiosulphate (hypo) to give a soluble complex.

$$AgBr + 2Na_2S_2O_3 \rightarrow Na_3[Ag(S_2O_3)_2] + NaBr$$

An aqueous solution of sodium thiosulphate on acidification turns milky white because colloidal sulphur is formed.

$$Na_2S_2O_3 + 2HCl \rightarrow 2NaCl + H_2O + SO_2 + S$$

18. A is $[Fe(SCN)(H_2O)_5]^{2+}$.

The IUPAC name is pentaaquathiocyanatoferrate (III) ion.

B is $[FeF_6]^{3-}$.

The IUPAC name is Hexafluridoferrate(III).

$$Fe^{3+} + SCN^- \rightarrow [Fe(SCN)(H_2O)_5]^{2+}$$

(Blood-red color)

$$Fe[SCN(H_2O)_5]^{2+} + 6F^- \rightarrow [FeF_6]^{3-} + SCN^- + 5H_2O$$

$B[FeF_6]^{3-}$

The oxidation number of iron is +3.

Atomic number = 26

$Fe = [Ar]3d^6\,4s^2$

$Fe^{3+} = [Ar]3d^5$

↑	↑	↑	↑	↑

Which means five unpaired electrons

Spin magnetic moment $= \sqrt{n(n+2)} = \sqrt{5(5+2)}$

$= \sqrt{35}$ BM

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (b)	2. (b)	3. (c)	4. (d)	5. (c)	6. (c)	7. (c)	8. (b)	9. (a)	10. (b)
11. (b)	12. (a)	13. (c)	14. (d)	15. (d)	16. (d)	17. (b)	18. (a)	19. (c)	20. (c)
21. (a)	22. (a)	23. (b)	24. (d)	25. (c)	26. (a)	27. (a)	28. (b)	29. (b)	30. (a)
31. (a)	32. (c)	33. (a)	34. (b)	35. (a)	36. (a)	37. (b)	38. (b)	39. (a)	40. (d)
41. (c)	42. (b)	43. (d)	44. (d)	45. (a)	46. (a)	47. (b)	48. (c)	49. (a)	50. (b)
51. (b)	52. (a)	53. (b)	54. (a)	55. (b)	56. (a)	57. (b)	58. (c)	59. (c)	60. (b)
61. (a)	62. (a)	63. (b)	64. (d)	65. (b)	66. (b)	67. (c)	68. (a)	69. (b)	70. (d)
71. (d)	72. (b)	73. (c)	74. (d)	75. (b)	76. (a)	77. (c)	78. (b)	79. (c)	80. (a)
81. (d)	82. (c)	83. (d)	84. (d)	85. (d)					

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a)	2. (a)	3. (b)	4. (b)	5. (d)	6. (b)	7. (b)	8. (a)	9. (c)	10. (a)
11. (b)	12. (b)	13. (a)	14. (d)	15. (b)	16. (c)	17. (c)	18. (c)	19. (b)	20. (a)
21. (b)	22. (a)	23. (c)	24. (c)	25. (d)	26. (b)	27. (b)	28. (d)	29. (a)	30. (a)
31. (b)	32. (b)	33. (a)	34. (b)	35. (c)	36. (c)	37. (c)	38. (c)	39. (d)	40. (c)
41. (a)	42. (c)	43. (a)	44. (a)	45. (a)	46. (b)	47. (d)	48. (d)	49. (d)	50. (d)
51. (c)	52. (a)	53. (b)	54. (b)	55. (c)	56. (d)	57. (c)	58. (c)	59. (b)	60. (a)
61. (c)	62. (b)	63. (b)	64. (c)	65. (b)	66. (d)	67. (a)	68. (b)	69. (b)	70. (c)
71. (b)	72. (d)	73. (b)	74. (d)	75. (c)	76. (b)	77. (a)	78. (a)	79. (c)	80. (a)
81. (b)	82. (b)	83. (a)	84. (a)	85. (c)					

Multiple Correct Answers Type

1. (a), (b), (c), (d)	2. (a), (b)	3. (c), (d)	4. (a), (c)	5. (a), (b)
6. (a), (c), (d)	7. (a), (b), (c)	8. (a), (b)	9. (a), (b), (d)	10. (b), (c)
11. (b), (c)	12. (a), (b), (c), (d)	13. (a), (b), (c)	14. (a), (b), (c), (d)	15. (a), (b), (c), (d)
16. (a), (b), (c)	17. (a), (b), (d)	18. (b), (c), (d)	19. (a), (b)	20. (a), (b), (c)
21. (a), (b), (c)	22. (a), (c), (d)	23. (b), (c), (d)	24. (a), (b), (c)	25. (b), (c), (d)
26. (b), (c), (d)	27. (a), (b), (c), (d)	28. (a), (b), (c)	29. (a), (c)	30. (a), (b), (c), (d)
31. (c), (d)	32. (a), (c), (d)	33. (a), (b), (d)	34. (b), (c), (d)	35. (a), (b), (c)
36. (b), (c), (d)	37. (a), (b), (c)	38. (a), (c), (d)	39. (a), (b), (c)	40. (a), (c), (d)
41. (b), (c), (d)	42. (a), (b)	43. (c), (d)	44. (a), (b), (c), (d)	45. (a), (b), (c)
46. (a), (b), (c)	47. (a), (b)	48. (a), (b)	49. (a), (b), (c)	50. (b), (c), (d)
51. (a), (b), (c)	52. (a), (b), (c)	53. (a), (b)	54. (a), (b), (d)	55. (a), (b), (c)
56. (a), (b), (c)	57. (c), (d)	58. (a), (b), (d)	59. (b), (c)	

Comprehension Type

Comprehension-1	1. (b)	2. (b)	3. (b)
Comprehension-2	4. (c)	5. (a)	6. (b)
Comprehension-3	7. (d)	8. (d)	

Comprehension-4	**9.** (b)	**10.** (c)	**11.** (c)	
Comprehension-5	**12.** (c)	**13.** (a)	**14.** (d)	
Comprehension-6	**15.** (a)	**16.** (a)	**17.** (a)	**18.** (a)
Comprehension-7	**19.** (d)	**20.** (c)	**21.** (d)	
Comprehension-8	**22.** (c)	**23.** (c)	**24.** (a)	
Comprehension-9	**25.** (c)	**26.** (b)	**27.** (a)	
Comprehension-10	**28.** (a)	**29.** (c)	**30.** (b)	
Comprehension-11	**31.** (a)	**32.** (c)	**33.** (a)	**34.** (d)
Comprehension-12	**35.** (d)	**36.** (b)	**37.** (d)	
Comprehension-13	**38.** (b)	**39.** (a)		
Comprehension-14	**40.** (b)	**41.** (b)		

Assertion-Reasoning Type

1. (d) **2.** (c) **3.** (b) **4.** (a) **5.** (d) **6.** (d) **7.** (d) **8.** (a) **9.** (d)

Matching Column Type

1. (a) t; (b) s; (c) p; (d) r
2. (a) q; (b) p; (c) r; (d) p
3. (a) r; (b) q; (c) p; (d) s
4. (a) q; (b) r; (c) p
5. (a) q; (b) s; (c) r; (d) p
6. (a) r; (b) p; (c) q; (d) t
7. (a) t; (b) p; (c) s; (d) q
8. (a) s; (b) p; (c) q; (d) r
9. (a) t; (b) u; (c) p; (d) q; (e) r
10. (a) r; (b) p; (c) q, s
11. (a) p, q, t; (b) p, q, r, s,t; (c) r, s, t; (d) p, r, s, t
12. (a) p, r, t; (b) p, t; (c) p, r, t; (d) q, s
13. (a) p; (b) p, q, r; (c) r, s; (d) p, q, r
14. (a) p, q, r, s; (b) p, q, r, s; (c) q, r, s; (d) p, r, t
15. (a) p, q, r; (b) q, r; (c) r, s; (d) r, s
16. (a) p, q, r; (b) s; (c) p; (d) q, s
17. (a) p, s; (b) p, s; (c) q; (d) q, r
18. (a) r; (b) s; (c) p; (d) q
19. (a) r; (b) p; (c) t; (d) p
20. (a) p, q, s, t; (b) p, q; (c) p, q, r, s, t; (d) p, q, s, t
21. (a) p, q, s; (b) p, q, s; (c) r, t; (d) q, r, s
22. (a) p, q, s, t; (b) q; (c) p, q, s, t; (d) p, r, s
23. (a) p, s; (b) p, s, t; (c) s, t; (d) p, s
24. (a) q, s, t; (b) p, r; (c) q, s; (d) p, r
25. (a) p; (b) p, q, t; (c) p, r, t; (d) p, s, t
26. (a) q, r; (b) q, s; (c) q, s; (d) p, r, s
27. (a) p, q, s; (b) p, r, s; (c) p, q; (d) p, s
28. (a) p, q, r, s, t; (b) p, q, r, t; (c) p, q, r, t; (d) r,s, t
29. (a) p, q, r, t; (b) p, q, r, s, t; (c) p, q, r, s; (d) p, q, r, s, t
30. (a) q, r, s, t; (b) p, q, r, t; (c) r, t; (d) r
31. (a) s; (b) p; (c) q
32. (a) p, q, r, s; (b) p, q, r; (c) p, r
33. (a) q, r, s; (b) r, t; (c) q, r; (d) p, r
34. (a) r, s; (b) p, q; (c) t; (d) s
35. (a) r, s; (b) q; (c) p; (d) p, s
36. (a) p, q, s; (b) r, q, s; (c) p, q, s; (d) r, q, s

Integer Answer Type

1. (2)	**2.** (3)	**3.** (3)	**4.** (3)	**5.** (1)	**6.** (1)	**7.** (0)	**8.** (1)	**9.** (1)	**10.** (5)
11. (2)	**12.** (0)	**13.** (6)	**14.** (4)	**15.** (3)	**16.** (2)	**17.** (3)	**18.** (1)	**19.** (2)	**20.** (3)
21. (4)	**22.** (6)	**23.** (2)	**24.** (4)	**25.** (3)	**26.** (3)	**27.** (1)	**28.** (1)	**29.** (4)	**30.** (4)
31. (6)	**32.** (2)	**33.** (4)	**34.** (9)	**35.** (0)	**36.** (2)	**37.** (2)	**38.** (3)	**39.** (41)	**40.** (0)
41. (3)	**42.** (2)	**43.** (6)	**44.** (0, 4)	**45.** (3)	**46.** (5)	**47.** (2)	**48.** (2)	**49.** (2)	**50.** (0)
51. (2)	**52.** (5)	**53.** (1)	**54.** (2)	**55.** (9)	**56.** (4)	**57.** (4, 3, 3, 1, 5)		**58.** (6)	**59.** (60)
60. (15)	**61.** (8)	**62.** (6, 3)	**63.** (0)	**64.** (1)	**65.** (4)	**66.** (2)	**67.** (2)	**68.** (6)	**69.** (5)
70. (0)	**71.** (0)	**72.** (1)	**73.** (1)	**74.** (3)	**75.** (1)	**76.** (5)	**77.** (5)	**78.** (2)	**79.** (2)
80. (2)	**81.** (6)	**82.** (61)	**83.** (2)	**84.** (9)	**85.** (2)				

NCERT Exemplar Exercises

Single Correct Answer Type

1. (b) 2. (c) 3. (b) 4. (d) 5. (a) 6. (c) 7. (a) 8. (c) 9. (a) 10. (d)
11. (a) 12. (b) 13. (b) 14. (c)

Multiple Correct Answers Type

1. (a), (c) 2. (a), (c) 3. (a), (c) 4. (b), (c) 5. (a), (c) 6. (b), (d) 7. (a), (c) 8. (a), (b), (c)
9. (a), (c)

Matching Column Type

1. (b) 2. (a) 3. (a) 4. (d) 5. (c)

Assertion-Reasoning Type

1. (a) 2. (b) 3. (a) 4. (c) 5. (d)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (b) 2. (b) 3. (b) 4. (c) 5. (a) 6. (d) 7. (a) 8. (a) 9. (c) 10. (d)
11. (c) 12. (d) 13. (c) 14. (d) 15. (c) 16. (b) 17. (a) 18. (d) 19. (b) 20. (a)
21. (d) 22. (b) 23. (a) 24. (c) 25. (a) 26. (d) 27. (a) 28. (c) 29. (a) 30. (a)
31. (b) 32. (c) 33. (d) 34. (a) 35. (b) 36. (b)
37. (c) 38. (d) 39. (d) 40. (d) 41. (a)

JEE (Advanced) Exercises

Single Correct Answer Type

1. (c) 2. (b) 3. (d) 4. (c) 5. (d) 6. (a) 7. (b) 8. (d) 9. (b) 10. (a)
11. (d) 12. (d) 13. (b) 14. (c) 15. (c) 16. (c) 17. (b) 18. (d) 19. (b) 20. (c)
21. (d) 22. (a) 23. (b)

Muliple Correct Answers Type

1. (b), (d)

Comprehension Type

1. (a) 2. (c) 3. (a)

Assertion-Reasoning Type

1. (a) 2. (a)

Matching Column Type

1. (a) → (p, q, s); (b) → (p, r, s); (c) → (q, s); (d) → (q, s) 2. (b)

Integer Answer Type

1. (8)

3

General Principles of Extraction of Metals

JEE (Main) Exercises

Single Correct Answer Type

1. Froth floatation process is used for the:
   (a) Oxide ores (b) Sulphide ores
   (c) Chloride ores (d) All of these
2. In the froth floatation process, for the benefication of ores, the ore particles float because:
   (a) They are light
   (b) Their surface is not easily wetted by water
   (c) They bear electrostatic charge
   (d) They are insoluble
3. Zone refining is a method to obtain:
   (a) Very high temperature (b) Ultrapure Al
   (c) Ultrapure metals (d) Ultrapure oxides
4. Cassiterite is an ore of:
   (a) Mn (b) Ni
   (c) Sb (d) Sn
5. Cryolite is:
   (a) Na_3AlF_6 and is used in the electrolysis of alumina for decreasing electrical conductivity
   (b) Na_3AlF_6 and is used in the electrolysis of alumina for lowering the melting point of alumina
   (c) Na_3AlF_6 and is used in the electrolytic purification of alumina
   (d) Na_3AlF_6 and is used in the electrolysis of alumina
6. The process of converting hydrated alumina into anhydrous alumina is called:
   (a) Roasting (b) Smelting
   (c) Dressing (d) Calcination
7. Pyrolusite is a/an:
   (a) Oxide ore (b) Sulphide ore
   (c) Carbide ore (d) Not an ore
8. Composition of azurite mineral is:
   (a) $CuCO_3 \cdot CuO$ (b) $Cu(HCO_3)_2 \cdot Cu(OH)_2$
   (c) $2CuCO_3 \cdot Cu(OH)_2$ (d) $CuCO_3 \cdot 2Cu(OH)_2$
9. Which of the following metal is not manufactured by electrolysis?
   (a) Na (b) Mg
   (c) Al (d) Fe
10. Poling process is used:
    (a) For the removal of Cu_2O from Cu
    (b) For the removal of Al_2O_3 from Al
    (c) For the removal of Fe_2O_3 from Fe
    (d) All of these
11. The pyrometallurgical operations involve the use of:
    (a) High temperature (b) Sulphide ores
    (c) Electrolysis (d) Complexation
12. Aluminium is extracted by the electrolysis of:
    (a) Bauxite
    (b) Alumina
    (c) Alumina mixed with molten cryolite
    (d) Molten cryolite

13. Which of the following ores is best concentrated by froth floatation process?
(a) Malachite (b) Cassiterite
(c) Galena (d) Magnetite

14. The function of flux during the smelting of the ore is:
(a) To make the ore porous
(b) To remove gangue
(c) To facilitate reduction (d) To facilitate oxidation

15. Complex formation method is used for the extraction of:
(a) Zn (b) Ag
(c) Hg (d) Cu

16. Heating of pyrites in presence of air to remove sulphur is called:
(a) Roasting (b) Calcination
(c) Smelting (d) Fluxing

17. The acidic refractory material is:
(a) CaO (b) P_2O_5
(c) SiO_2 (d) MgO

18. The incorrect statement is:
(a) Calamine and siderite are carbonates
(b) Argentite and cuprite are oxides
(c) Zinc blende and iron pyrites are sulphides
(d) Malachite and azurite are ores of copper

19. Composition of malachite mineral is:
(a) $CuCO_3 \cdot CuO$ (b) $Cu(HCO_3)_2 \cdot Cu(OH)_2$
(c) $2CuCO_3 \cdot Cu(OH)_2$ (d) $CuCO_3 \cdot Cu(OH)_2$

20. Select the correct statement:
(a) Calcination and roasting take place in reverberatory furnace and small roasting takes place in small blast furnace
(b) Calcination and roasting take place only in small blast furnace
(c) Calcination and roasting take place only in reverberatory furnace
(d) All are correct

21. Bauxite is extracted by:
(a) Hall's process (b) Baeyer's process
(c) Serpek's process (d) All of these

22. Tin is extracted from its ore, cassiterite, by:
(a) Electrolytic reduction
(b) Carbon-monoxide reduction
(c) Carbon reduction
(d) The aluminothermic process

23. Tin is not refined by:
(a) Liquation (b) Zone refining
(c) Poling (d) Any of these

24. Matte contains:
(a) Cu_2S, FeS, and silica
(b) Cu_2S, FeO, and silica
(c) Cu_2S, CuO, and silica
(d) Cu_2S, Cu_2O, and silica

25. The ore that is concentrated by froth floatation process is:
(a) Cinnabar (b) Bauxite
(c) Malachite (d) Zincite

26. Hydro-metallurgical process of extraction of metals is based on:
(a) Complex formation (b) Hydrolysis
(c) Dehydration (d) Dehydrogenation

27. In alumino-thermic process, aluminium is used as:
(a) Oxidizing agent (b) Reducing agent
(c) Dehydrating agent
(d) Complex formation agent

28. Which of the following metals are found in native state?
Ag, Pt, C, Si, N, O, Mg, Na, Pb.
(a) Ag, Pt, C, N, O (b) Ag, Pt, Mg
(c) Ag, Pt, Pb, Mg (d) Ag, Pt

29. Most abundant metal in earth crust is:
(a) Al (b) O
(c) Fe (d) Si

30. $CaS_2 + \frac{3}{2}O_2 \longrightarrow CaS_2O_3$

What is the difference in average oxidation number of sulphur in product and in reactant in the above given reaction?
(a) 1 (b) 2
(c) 3 (d) 4

31. Ellingham diagram represents:
(a) Change of ΔG with temperature
(b) Change of ΔH with temperature
(c) Change of ΔG with pressure
(d) Change of $(\Delta G - T\Delta S)$ with temperature

32. To carry out a reduction process, select a temperature so as to make:
(a) ΔG negative (b) ΔG positive
(c) ΔH negative (d) ΔH positive

33. Self-reduction of the sulphide ore takes place during:
(a) Roasting (b) Smelting
(c) Calcination (d) Cupellation

34. Corundum is ..... mineral of Al:
(a) Silicate (b) Oxide
(c) Double salt (d) Sulphate

35. Purest form of iron is:
(a) Cast iron (b) Wrought iron
(c) Pig iron (d) None of these

36. Cementite is:
(a) Predominant content of cement
(b) A mineral of calcium
(c) A carbide of iron in steel
(d) None of these

37. Iron obtained from blast furnace is:
(a) Wrought iron (b) Cast iron
(c) Pig iron (d) Steel

38. In the extraction of nickel by Mond's process, the metal is obtained by:
(a) Electrochemical reduction
(b) Thermal decomposition
(c) Chemical reduction by aluminium
(d) Reduction by carbon

39. Iron obtained from reduction zone of the blast furnace is:
(a) Wrought iron (b) Cast iron
(c) Spongy iron (d) Steel

40. Refining of silver is done by:
(a) Liquation (b) Poling
(c) Cupellation (d) Van Arkel method

41. Bessemerization is carried out for
I: Fe, II: Cu, III: Al, IV: silver
(a) I, II (b) II, III
(c) III, IV (d) I, III

42. Calcination is the process of heating the ore:
(a) In inert gas
(b) In the presence of air
(c) In the absence of air or limited supply of air
(d) In the presence of CaO and MgO

43. $Ag_2S + NaCN + Zn \longrightarrow Ag$
This method of extraction of Ag by complex formation and then its displacement is called:
(a) Parke's method
(b) Mac Arthur–Forest method
(c) Serpek method
(d) Hall's method

44. The slag obtained during the extraction of copper from copper pyrites is composed of:
(a) Cu_2S (b) $CuSiO_3$
(c) $FeSiO_3$ (d) SiO_2

45. In zone-refining method, the molten zone:
(a) Consists of impurities only
(b) Contains more impurity than the original metal
(c) Contains the purified metal only
(d) Moves to either side

46. Out of Cu_2S, HgS, and ZnS, roasting is used to convert the minerals into metal in case of:
(a) Cu_2S, ZnS (b) HgS, ZnS
(c) Cu_2S (d) HgS

47. During smelting, an additional substance is added which combines with impurities to form a fusible mass. The additional substance is called:
(a) Flux (b) Slag
(c) Gangue (d) Ore

48. The process of isolation of metals by dissolving the ore in a suitable chemical reagent followed by precipitation of the metal by a more electropositive metal is called:
(a) Electrometallurgy (b) Hydrometallurgy
(c) Electro-refining (d) Zone-refining

49. Smelting involves reduction of metal oxide with:
(a) Carbon (b) Self-reduction
(c) Magnesium (d) Aluminium

50. Zone-refining has been employed for preparing ultra-pure samples of:
(a) Cu (b) Zn
(c) Ge (d) Ag

51. In the aluminothermite process, aluminium acts as:
(a) An oxidizing agent (b) A flux
(c) A reducing agent (d) A solder

52. In which of the following minerals, is aluminium not present?
(a) Cryolite (b) Mica
(c) Feldspar (d) Fluorspar

53. Which of the following metals is obtained by leaching the ore with dilute cyanide solution?
(a) Silver (b) Titanium
(c) Vanadium (d) Zinc

54. Which method of purification is represented by the equations:

$$\underset{\text{(Impure)}}{Ti} + 2I_2 \xrightarrow{500\,K} TiI_4 \xrightarrow{1675\,K} \underset{\text{(Pure)}}{Ti} + 2I_2$$

(a) Cupellation (b) Poling
(c) Van Arkel (d) Zone refining

55. Which of the following benefication processes is used for the mineral, $Al_2O_3 \cdot 2H_2O$?
(a) Froth floatation (b) Leaching
(c) Liquation (d) Magnetic separation

56. Malachite is an ore of:
(a) Iron (b) Zinc
(c) Copper (d) Mercury

57. Heating of pyrites to remove sulphur is called:
(a) Smelting (b) Calcination
(c) Liquation (d) Roasting

58. In the metallurgy of which of the following, is cupellation process used?
(a) Copper (b) Silver
(c) Iron (d) Aluminium

59. The methods chiefly used for the extraction of lead and tin from their ores are, respectively:
(a) Self-reduction and carbon reduction
(b) Self-reduction and electrolytic reduction
(c) Carbon reduction and self-reduction
(d) Cyanide process and carbon reduction

60. Vapor phase refining of nickel is carried out using:
(a) I_2 (b) Cl_2
(c) HCl (d) CO

61. Complexes formed in the following methods are:
(I) Mond's process for purification of nickel
(II) Removal of lead poisoning from the body
(III) Cyanide process for extraction of silver
(IV) Froth floatation process for separation of ZnS from galena ore by using depressant

	I	II	III	IV
(a)	$Ni(CO)_4$	$[Pb(EDTA)]^{2-}$	$[Ag(CN)_2]^-$	$[Zn(CN)_2]$
(b)	$Ni(CO)_4$	$[Pb(EDTA)]^{2-}$	$[Ag(CN)_2]^-$	$[Zn(CN)_4]^{2-}$
(c)	$Ni(CO)_6$	$[Pb(EDTA)]^{4-}$	$[Ag(CN)_2]^-$	$[Zn(CN)_6]^{4-}$
(d)	$Ni(CO)_4$	$[Pb(EDTA)]^{2-}$	$[Ag(CN)_4]^{3-}$	$[Zn(CN)_4]^{2-}$

62. Silver is obtained from $Na[Ag(CN)_2]$ by reaction with:
(a) Fe (b) Na
(c) Zn (d) Au

63. Which of the following reactions taking place in the blast furnace during extraction of iron is endothermic?
(a) $CaCO_3 \longrightarrow CaO + CO_2$
(b) $2C + O_2 \longrightarrow 2CO$
(c) $C + O_2 \longrightarrow CO_2$
(d) $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

64. Casseterite ore consists of magnetic impurity named as:
(a) Chromite (b) Wolframite
(c) Magnetite (d) Limonite

65. $A + 3O_2 \longrightarrow 2ZnO + 2SO_2$
Find the formula of A
(a) $ZnCO_3$ (b) ZnS
(c) $ZnSO_4$ (d) $ZnCO_3 \cdot 3Zn(OH)_2$

66. Which of the following term is not related to Al-extraction?
(a) Serpek's process (b) Hall–Heroult process
(c) Thermite process (d) Hoop's process

67. Which of the following is not the ore of Fe?
(a) Siderite (b) Limonite
(c) Magnetite (d) Anthracite

68. Gold is extracted by hydrometallurgical process based on its property:
(a) Of being electropositive
(b) To form complexes which are water soluble
(c) Of being less reactive
(d) To form salts which are water soluble

JEE (Advanced) Exercises

Single Correct Answer Type

1. Van Arkel method of purification of metals involves converting the metal to a:
(a) Volatile enough stable compund
(b) Volatile unstable compound
(c) Non-volatile stable compound
(d) None of these

2. When an aqueous solution of sodium chloride is electrolyzed using platinum electrodes, the ions discharged at the electrodes are:
(a) Sodium and hydrogen (b) Sodium and chloride
(c) Hydrogen and chloride
(d) Hydroxyl and chloride

3. Native silver metal forms a water soluble complex with a dilute aqueous solution of NaCN in the presence of:
(a) Nitrogen (b) Oxygen
(c) Carbon dioxide (d) Argon

4. Extraction of zinc from zinc blende is achieved by:
(a) Electrolytic reduction
(b) Roasting followed by reduction with carbon
(c) Roasting followed by reduction with another metal
(d) Roasting followed by self-reduction

5. The metal oxide which cannot be reduced to metal by carbon is:
(a) ZnO (b) Fe_2O_3
(c) PbO (d) Al_2O_3

6. The actual reducing agent of haematite in blast furnace is:
(a) C (b) CO
(c) Al (d) CO_2

7. In the cyanide process for extraction of gold and silver from ores, the cyanide solution acts as a:
(a) Reducing agent to reduce the gold and silver compounds present in the ores into the metallic states
(b) Leaching agent to bring the gold and silver into solution as cyanide complexes and thus separate these metals from the ores
(c) Leaching agent to dissolve all the other constituents of the ores leaving the gold and silver as metals
(d) Leaching agent to bring the ores into solution

8. During the process of electrorefining of Cu, some metals present as impurity settle as anode mud. These are:
(a) Sn and Ag (b) Pb and Zn
(c) Ag and Au (d) Fe and Ni

9. Electrolytic reduction process is used for the extraction of:
(a) Alkali metals (b) Alkaline earth metals
(c) Aluminium (d) All of these

10. Choose the correct code regarding roasting process:
(I) It is the process of heating ore in air to obtain the oxide
(II) It is an exothermic process
(III) It is used for hydrated oxide and oxysalt ore
(IV) It is used after the concentration of ore
(a) I, II, and III (b) I, II, and IV
(c) I, III, and IV (d) I, II, III, and IV

11. The ignition mixture in "alumino thermite" process consists of a mixture of:
(a) Magnesium powder and BaO_2 or $KClO_3$
(b) Magnesium powder, aluminium, and $BaO_2/KClO_3$
(c) Magnesium and aluminium powder
(d) Magnesium and aluminium oxides

12. Metal sulphides occur mainly in rocks and metal halides in lakes and seas because:
(a) Metal sulphides are soluble in water while metal chlorides are insoluble in water
(b) Metal sulphides are insoluble in water while metal chlorides are soluble in water
(c) Metal sulphide and metal chlorides both are soluble
(d) Metal sulphides and metal chlorides both are insoluble

13. From which of the following reaction is blister copper obtained?
(a) $Cu_2S + FeO \longrightarrow 2Cu + FeO$
(b) $Cu_2S + FeS \longrightarrow 2Cu + FeS_2$
(c) $Cu_2S + 2Cu_2O \longrightarrow 6Cu + SO_2$
(d) $Cu^{2+} + Fe \longrightarrow Fe^{2+} + Cu$

14. During the extraction of copper from chalcopyrites, iron is removed as:
(a) $Fe_3(PO_4)_2$ (b) Fe_2O_3
(c) $Fe_2(SiO_3)_3$ (d) $FeSiO_3$

15. Blister copper is:
(a) Electrolytically refined copper
(b) A mixture of impure copper and silver
(c) Copper containing 2% impurity
(d) Present in the anode mud in an electrolytic process

16. In the electrolytic refining of silver, the anode mud obtained contains:
(a) Zn, Ag, and Au (b) Zu, Cu, Ag, and Au
(c) Au (d) Cu, Ag, and Au

17. ΔG^o vs T plot in Ellingham diagram slopes downward for the reaction:
(a) $Mg + 1/2\ O_2 \longrightarrow MgO$
(b) $2Ag + 1/2O_2 \longrightarrow Ag_2O$
(c) $C + 1/2\ O_2 \longrightarrow CO$
(d) $CO + 1/2\ O_2 \longrightarrow CO_2$

18. Self-reduction of CuS to Cu can be carried out in:
(a) Bessemer converter (b) Blast furnace
(c) Both (a) and (b) (d) None of these

19. When alloy of silver and lead is rich in silver:
(a) Cupellation process is used
(b) Parke's method is used
(c) Bett's method is used
(d) Any of these methods can be used

20. Phosphorus separates, in the extraction of iron, as:
(a) Slag, $Ca_3(PO_4)_2$ (b) Volatile P_2O_5
(c) Slag, $Mg_3(PO_4)_2$ (d) Ca_3P_2

21. In the metallurgy of iron, when $CaCO_3$ is added to the blast furnace, calcium ion appears as:
(a) CaO (b) Metallic Ca
(c) Gangue (d) Slag

22. The method not used for the extraction of Al is:
(a) Van Arkel (b) Serpek's
(c) Baeyer (d) Hall–Heroult

23. Four metals and their methods of refinement are given
(i) Ni, Cu, Zr, Ga
(ii) Electrolysis, Van Arkel process, zone refining, Mond's process
Choose the right method for each:
(a) Ni: Electrolysis, Cu: Van Arkel process, Zr: Zone refining, Ga: Mond's process
(b) Ni: Mond's process, Cu: Electrolysis, Zr: Van Arkel process, Ga: Zone refining
(c) Ni: Mond's process, Cu: Van Arkel process, Zr: Zone refining, Ga: Electrolysis
(d) Ni: Electrolysis, Cu: Zone refining, Zr: Van Arkel process, Ga: Mond's process

24. Extraction of aluminium from aluminium oxide (Al_2O_3) is best done by:
(a) Electrolytic reduction of Al_2O_3
(b) Reduction of Al_2O_3 with carbon
(c) Reduction of Al_2O_3 with sodium
(d) Reduction of Al_2O_3 with CO

25. Chemical leaching is useful in the concentration of:
(a) Copper pyrites (b) Bauxite
(c) Galena (d) Cassiterite

26. Which one of the following is not a method of concentration of metals?
(a) Gravity separation
(b) Froth floatation process
(c) Electromagnetic separation
(d) Smelting

27. $Ag_2S + NaCN \longrightarrow (A)$, $(A) + Zn \longrightarrow (B)$
(B) is a metal. Hence, (A) and (B) are:
(a) $Na_2[Zn(CN)_4]$, Zn (b) $Na[Ag(CN)_2]$, Ag
(c) $Na_2[Ag(CN)_4]$, Ag (d) $Na_3[Ag(CN)_4]$, Ag

28. Which of the following does not contain Mg?
(a) Magnetite (b) Magnesite
(c) Epsom (d) Carnallite

29. Annealing of steel is the process of heating steel:
(a) To a bright red hot and then cooling it slowly
(b) To a bright red hot and then cooling it suddenly
(c) To a temperature much below redness and cooling it slowly
(d) None of the above

30. Which of the following process is not a physical process of separation?
(a) Levigation (b) Magnetic separation
(c) Leaching (d) Froth floatation

31. The process of concentrating Au and Ag ores is based upon their solubility in:
(a) NH_3 (b) HNO_3
(c) HCl (d) KCN

32. Which of the following metal is sometimes found native in nature?
(a) Aluminium (b) Copper
(c) Iron (d) Magnesium

33. In the Parke's process of Ag-extraction, Zn is removed from (Zn–Ag) alloy by using
(a) Cupellation (b) Electrolytic refining
(c) Distillation (d) Fractional crystallization

34. In the extraction of copper from its sulphide ore, the metal is formed by reduction of Cu_2O with:
(a) FeS (b) CO
(c) Cu_2S (d) SO_2

35. In the process of extraction of gold,

$$\text{Roasted gold ore} + CN^- + H_2O \xrightarrow{O_2} [X] + OH^-$$

$$[X] + Zn \longrightarrow [Y] + Au$$

(a) $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_4]^{2-}$
(b) $X = [Au(CN)_4]^{2-}$, $Y = [Zn(CN)_4]^{2-}$
(c) $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_6]^{4-}$
(d) $X = [Au(CN)_4]^-$, $Y = [Zn(CN)_4]^{2-}$

36. Carbon cannot be used to produce magnesium by chemical reduction of MgO because:
(a) Carbon is not a powerful reducing agent
(b) Magnesium reacts with carbon to form carbides
(c) Carbon does not react with magnesium
(d) Carbon is a non-metal

37. The ore haivng two different metal atoms is:
(a) Hematite (b) Galena
(c) Magnetite (d) Copper pyrites

38. Which of the following statement is correct regarding Cu-extraction?
(a) In the smelting step, carbon reduction takes places
(b) During roasting, Cu_2S remains almost unaffected
(c) In Bessemer converter, only self-reduction occurs, not slag formation
(d) Blister formed in the blister Cu is due to dissolved CO_2

39. Which of the following process is not involved in the extraction of Fe?

(a) Gravity separation (b) Leaching
(c) Roasting (d) Carbon reduction

40. Carbon reduction process is not commerically applicable for which of the following set of oxides to extract the respective metal?

(I) ZnO (II) Fe_2O_3
(III) Al_2O_3 (IV) SnO_2
(V) MgO

(a) ZnO, Fe_2O_3, SnO_2 (b) ZnO, SnO_2, MgO
(c) MgO, Al_2O_3 (d) MgO, SnO_2, Al_2O_3

41. Which of the following metal can be reduced by carbon reduction as well as self-reduction?

(a) Fe (b) Al
(c) Pb (d) None of these

42. Which of the following metal is leached by cyanide process?

(a) Ag (b) Na
(c) Al (d) Cu

43. Which one of the following ore is not concentrated by froth floatation process?

(a) Copper pyrites (b) Cinnabar
(c) Pyrolusite (d) Zinc blende

44. Sulphide ores of metals are usually concentrated by froth floatation process. Which one of the following sulphide ores offers an exception and is concentrated by chemical leaching?

(a) Galena (b) Copper pyrite
(c) Sphalerite (d) Argentite

45. Among the metals Cr, Fe, Mn, Ti, Ba, and Mg, the one that cannot be obtained by reduction of its metal oxide by aluminium is:

(a) Cr (b) Fe
(c) Mn (d) Ba

46. Which of the following factors is of no significance for roasting sulphide ores to the oxides and not subjecting the sulphide ores to carbon reduction directly?

(a) CO_2 is more volatile than CS_2
(b) Metal sulphides are thermodynamically more stable than CS_2
(c) CO_2 is thermodynamically more stable than CS_2
(d) Metal sulphides are less stable than the corresponding oxides

47. The method not used in metallurgy to refine the impure metal is:

(a) Mond's process (b) Van-Arkel process
(c) Liquation (d) All are used

48. Chalcogens are:

(a) Hydrocarbons (b) Ore forming elements
(c) Oxide forming elements
(d) Those having ability to catenate

49. The oxidation state of Cu and Fe in Chalcopyrite is, respectively:

(a) +2, +2 (b) +1, +2
(c) +1, +3 (d) +2, +1

50. Extraction of zinc from zinc blende is achieved by:

(a) Electrolytic reduction
(b) Roasting followed by reduction with carbon
(c) Roasting followed by reduction with another metal
(d) Roasting followed by self-reduction

51. Copper can be extracted by hydrometallurgy but not zinc because:

(a) Copper is comparatively less active metal as its reduction potential is high. It can be displaced from solutions of Cu^{2+} ion by more active metals
(b) Zn displaced from solution of Zn^{2+} ion, a more reactive metal than it, but then readily react with water forming their corresponding ions and evolve hydrogen gas
(c) Both (a) and (b) are correct
(d) Copper can never be extracted by hydrometallurgy

52. Consider the following reactions at 1000°C:

(i) $Zn_{(s)} + 1/2\ O_{2(g)} \longrightarrow ZnO_{(s)}$
$\Delta G^o = -360\ kJ\ mol^{-1}$

(ii) $C_{(s)} + 1/2\ O_{2(g)} \longrightarrow CO_{(g)}$
$\Delta G^o = -460\ kJ\ mol^{-1}$

Choose the correct statement at 1000°C:

(a) Zinc can be oxidized by CO
(b) Zinc oxide can be reduced by C
(c) Both statements (i) and (ii) are true
(d) Both statements (i) and (ii) are false

53. Formation of $Ni(CO)_4$ and subsequently its decomposition into Ni and CO (recycled) make the basis of Mond's process:

$$Ni + 4CO \xrightarrow{T_1} Ni(CO)_4 \xrightarrow{T_2} Ni + 4CO$$

T_1 and T_2 are:

(a) 100°C, 50°C (b) 50°C, 100°C
(c) 50°C, 230°C (d) 230°C, 50°C

54. Oxides of the various metals are converted into metal by heating but not in:

(a) Ag_2O (b) CuO

(c) HgO (d) All of these

55. When $FeCr_2O_4$ (chromite) is reduced with Al:

(a) Cr and Fe_2O_3 are formed

(b) Fe and Cr_2O_3 are formed

(c) Fe and Cr (ferrochrome) are formed

(d) $FeCrO_4$ is formed

56. Boron can be obtained by various methods but not by:

(a) Pyrolysis of BI_3 (Van Arkel)

(b) Reducing BCl_3 with H_2

(c) Electrolysis of fused BCl_3

(d) Oxidation of B_2O_3

57. Which of the following statement is correct?

(a) Roasting is unnecessarily done for Fe-extraction because there is no sulphide ore

(b) In the smelting step of Cu-extraction, reduction of the ore takes place

(c) Ores may not be mineral

(d) Sphalerite is the ore of zinc

58. Consider the following metallurgical processes:

1. Heating impure metal with CO and distilling the resulting volatile carbonyl (b.pt. 43°C) and finally decomposing at 150°C to 230°C to get the pure metal
2. Heating the sulphide ore in air until a part is converted to oxide and then further heating in the absence of air to let the oxide react with unchanged sulphide
3. Electrolyzing the molten electrolyte containing $CaCl_2$ to obtain the metal

The processes used for obtaining sodium, nickel, and copper are, respectively,

(a) 1, 2, and 3 (b) 2, 3, and 1

(c) 3, 1, and 2 (d) 2, 1, and 3

59. Consider the following statements:

Roasting is carried out to

1. Convert sulphide to oxide and sulphate
2. Remove water of hydration
3. Melt the ore
4. Remove arsenic and sulphur impurities

Of these statements:

(a) 1, 2, and 3 are correct

(b) 1 and 4 are correct

(c) 1, 2, and 4 are correct

(d) 2, 3, and 4 are correct

60. The element which could be extracted by electrolytic reduction of its oxide dissolved in a high temperature melt is:

(a) Sodium (b) Magnesium

(c) Fluorine (d) Aluminium

61. In which of the following isolations is no reducing agent required?

(a) Iron from haematite

(b) Tin from tin oxide

(c) Mercury from cinnabar

(d) Zinc from zinc blende

62. The following are the extraction process of silver but not:

(a) As a side product in electrolytic refining of copper

(b) Parke's process in which Zn is used to extract silver by solvent extraction from molten lead

(c) By reaction of silver sulphide with KCN and then reaction of soluble complex with Zn

(d) By heating $Na[Ag(CN)_2]$

63. Reduction of a metal oxide by excess carbon at high temperature is a method for the commercial preparation of some metals. This method can be successfully applied in the case of:

(a) BeO and Al_2O_3 (b) ZnO and Fe_2O_3

(c) CaO and Cr_2O_3 (d) BaO and U_3O_8

64. The salt which is least likely to be found in minerals is:

(a) Chloride (b) Sulphate

(c) Sulphide (d) Nitrate

65. Which of the following statement is correct?

(a) Froth floatation method can only be used for sulphide ore

(b) Tin stone consists of wolframite as non-magnetic impurity

(c) In cyanide process for the extraction of silver, Zn is used as leaching agent

(d) Bessemerization process is used in the extraction of copper from copper pyrite

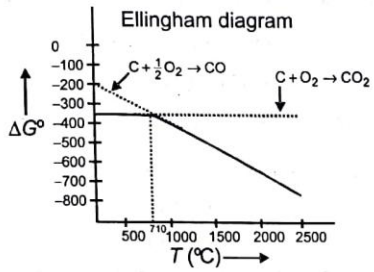
66. A solution containing 1 mol L^{-1} each of $Cu(NO_3)_2$, $AgNO_3$, $Hg_2(NO_3)_2$, and $Mg(NO_3)_2$ is electrolyzed using inert electrodes; with increasing potential difference applied across the electrodes, the sequence of deposition of metals on the cathode will be:

$$\left(E^{\circ}_{Ag^+|Ag} = 0.80\,V,\ E^{\circ}_{Hg^{+2}|Hg} = 0.79\,V,\ E^{\circ}_{Cu^{+2}/Cu} = 0.34\,V,\ E^{\circ}_{Mg^{+2}|Mg} = -2.37\,V\right)$$

(a) Ag, Hg, Cu, Mg (b) Mg, Ag, Cu, Hg
(c) Ag, Hg, Cu (d) Cu, Hg, Ag

67. Thermite reduction is not used for commercial extraction of the respective metal from which of the following oxides?
(a) Mn_3O_4 (b) TiO_2
(c) Fe_2O_3 (d) Cr_2O_3

68.



Which of the following is incorrect on the basis of the above Ellingham diagram for carbon?
(a) Up to 710°C, the reaction of formation of CO_2 is energetically more favorable, but above 710°C, the formation of CO is preferred
(b) In principle, carbon can be used to reduce any metal oxide at a sufficiently high temperature
(c) $\Delta S\,(C_{(s)} + 1/2\,O_{2(g)} \longrightarrow CO_{(g)}) < \Delta S\,(C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)})$
(d) Carbon reduces many oxides at elevated temperature because ΔG^o vs temperature line has a negative slope

Multiple Correct Answers Type

1. $Ca_3(PO_4)_2$ is:
(a) Thomas slag
(b) Formed in manufacturing of steel iron
(c) Used in manufacture of phosphorus fertilizer
(d) Used as a refractory material

2. Which of the following ores is/are oxide ore(s)?
(a) Cassiterite (b) Bauxite
(c) Cryolite (d) Haematite

3. Select the correct statement(s):
(a) Gravity separation method is used in concentration of oxide ore and carbonate ore
(b) Magnetic separation method is used for separation of non-magnetic rutile and magnetic impurity of chlorapatite
(c) Fe_3O_4 is magnetic and impurities non-magnetic
(d) MnO_2 is non-magnetic and impurities magnetic

4. Auto-reduction process is used for the extraction of:
(a) Cu (b) Hg
(c) Pb (d) Al

5. Which of following reaction is not an example of thermite reaction?
(a) $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$
(b) $3Mn_3O_4 + 8Al \longrightarrow 4Al_2O_3 + 9\,Mn$
(c) $2HgO + HgS \longrightarrow 3Hg + SO_2$
(d) $2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$

6. Which represent incorrect matching of metals with their ores?

	Mg	Na	Cu	Al
(a)	Chloride	chloride	sulphide	silicate
(b)	Carbonate	chloride	sulphide	oxide
(c)	Carbonate	carbonate	oxide	phosphate
(d)	Oxide	chloride	sulphide	oxide

7. Which of the following reactions represent correct method?
(a) $NaCl_{(molten)} \longrightarrow Na^+ + Cl^{\ominus}$: Down cell
(b) $Ni(CO)_4 \longrightarrow Ni + 4CO$: Mond process
(c) $Ag_2CO_3 \longrightarrow 2Ag + CO_2 + 1/2\,O_2$: Van Arkel method
(d) $ZrI_4 \longrightarrow Zr + 2I_2$: Van Arkel method

8. For the pyrometallurgical method used for the extraction of copper from sulphide ore, which statement(s) is/are correct?
(a) Pyrometallurgy is a dry method
(b) It involves concentration by leaching the sulphide ore with dil. H_2SO_4
(c) It involves concentration of the sulphide ore by froth floatation process
(d) It involves concentration by leaching for every ore

9. Blister copper is:
(a) Impure copper
(b) Obtained in self-reduction process during bassemerization
(c) Obtained in carbon reduction process during bassemerization
(d) None is correct

10. Froth floatation process used for the concentration of sulphide ore:

(a) Is based on the difference in wettability of different minerals

(b) Uses sodium ethyl xanthate, $C_2H_5OCS_2Na$, as collector

(c) Uses NaCN as depressant in the mixture of ZnS and PbS when ZnS forms soluble complex and PbS forms froth

(d) Uses pine oil as frothing agent

11. Mg can be obtained:

(a) By heating $MgCl_2$ (anhydrous) with Na in the atmosphere of coal gas

(b) By electrolysis of fused carnallite

(c) By electrolysis of aqueous solution of carnallite

(d) None of the above

12. NaCl and $CaCl_2$ are also added to fused $MgCl_2$ in the electrolysis of $MgCl_2$. Select the incorrect statement(s) for this solution:

(a) Melting point is decreased and conductivity is increased

(b) Melting point is increased and conductivity is decreased

(c) Melting point and conductivity both are decreased

(d) Melting point and conductivity both are increased

13. SnO_2 is reduced to metallic Sn on smelting oxide with anthracite and lime. In this, the function of lime is:

(a) It acts as a flux

(b) It removes acidic impurities as slag

(c) It removes basic impurities as slag

(d) It acts as a slag

14. Poling process:

(a) Reduces SnO_2 to Sn

(b) Oxidizes impurities like iron; removes as scum

(c) Uses green poles

(d) Uses brown poles

15. Refining of tin can be done by:

(a) Cupellation (b) Liquation

(c) Poling (d) Electrorefining

16. Which is the correct process–mineral matching in metallurgical extraction?

(a) Leaching : Ag

(b) Zone-refining : Sn

(c) Liquation : Sn

(d) Van Arkel : Zr

17. Tempering of steel:

(a) Is heating the steel to appropriate temperature and then cooling it slowly

(b) Increases mechanical strength

(c) Changes ratio of iron in steel

(d) Decreases mechanical strength

18. Of the following reduction processes:

(i) $Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$

(ii) $ZnO + C \longrightarrow Zn + CO$

(iii) $Cu_2O + C \longrightarrow 2Cu + CO$

(iv) $PbO + C \longrightarrow Pb + CO$

correct process is/are:

(a) (i) (b) (ii)

(c) (iii) (d) (iv)

19. Reaction(s) involved in thermite process is/are:

(a) $3Mn_3O_4 + 8Al \longrightarrow 9Mn + 4Al_2O_3$

(b) $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$

(c) $2Fe + Al_2O_3 \longrightarrow 2Al + Fe_2O_3$

(d) $B_2O_3 + 2Al \longrightarrow 2B + Al_2O_3$

20. Which of the following compounds are not called Thomas slag?

(a) Calcium silicate (b) Calcium phosphate

(c) Barium phosphate (d) Strontium silicate

21. Out of the following metals, that can be obtained by electrolysis of the aqueous solution of their salts is/are:

(a) Ag (b) Au

(c) Cu (d) Mg

22. Mond's process is not used for:

(a) Ni (b) Al

(c) Fe (d) Cu

23. The metal(s) which cannot be obtained by electrolysis of aqueous solution of their salts is/are:

(a) Ag (b) Mg

(c) Cu (d) Al

24. The anodic mud obtained during electrorefining of Cu contains:

(a) Ag (b) Fe

(c) Au (d) Zn

25. In Fe-extraction, the roasting is carried out because:

(a) All FeO are to be converted to Fe_2O_3

(b) The formation of $FeSiO_3$ slag is prevented

(c) Fe_2O_3 does not react with SiO_2 to form slag
(d) The formation of slag ($CaSiO_3$) is enhanced

26. Brine solution on electrolysis will give:
(a) NaOH (b) O_2
(c) Cl_2 (d) H_2

27. The extraction of metals from oxide ores involve(s):
(a) Reduction with carbon
(b) Reduction with aluminium
(c) Electrolytic reduction
(d) Reduction with CO

28. Select the correct statement(s):
(a) When temperature is raised, a point will be reached where the graph crosses the $\Delta G = 0$ line. Below this temperature, the free energy of formatin of the oxide is negative, so the oxide is stable
(b) When temperature is raised, a point will be reached where the graph crosses the $\Delta G = 0$ line. Above this temperature, the free energy of formation of the oxide is positive, and the oxide becomes unstable, and should decompose into the metal and dioxygen
(c) Theoretically, all oxides can be decomposed to give the metal and dioxygen if a sufficiently high temperature can be attained
(d) Theoretically, all oxides cannot be decomposed to give the metal and dioxygen if a sufficiently high temperature can be attained

29. Metals which can be extracted by smelting process is/are:
(a) Sn (b) Cu
(c) Zn (d) Al

30. Which of the following steps is/are involved in roasting?
(a) Remove water of hydration
(b) Remove arsenic and sulphur impurities
(c) Convert sulphide to oxide and sulphate
(d) None of these

31. Which of the following ores is/are sulphide ore(s)?
(a) Galena (b) Cinnabar
(c) Tinstone (d) Copper pyrites

32. In the commerical extraction of iron, roasting is adopted becuase:
(a) It removes impurities of S, As, and Sb in the form of their elemental vapor.
(b) It prevents slag formation by Fe_2O_3.
(c) It prevents slag formation by FeO.
(d) Limonite is converted into its anhydrous form.

33. Select the correct statement(s):
(a) In hydrometallurgy, Zn is used as oxidizing agent in the purification of Ag from $[Ag(CN)_2]^{\ominus}$
(b) When pine oil or eucalyptus oil is added into the water, it lowers down the surface tension by which froth is formed
(c) Sodium ethyl xanthate is used as collector
(d) Basic copper carbonate or $PbSO_4$ is concentrated by froth floatation method by using an activator

34. Select the correct statement(s) for calcination:
(a) Carbonate ore is converted in oxide ore
(b) Hydrated oxide ore is converted into its oxide ore
(c) Oxidizable volatile impurties are removed by calcination process
(d) Only calcination occurs for carbonate or oxide ore.

35. H_2 is not widely used as the reducing agent in metallurgic process because:
(a) Many metals react with H_2 at elevated temperature forming hydrides
(b) There is a risk of explosion from H_2 and O_2 present in the air
(c) $\Delta\overset{\circ}{G}/T$ line for $2H_2 + O_2 \rightarrow 2H_2O$ has positive slop, and runs parallel to many metal oxide lines so, reducing power of H_2 does not increase with temperature
(d) $\Delta\overset{\circ}{G}/T$ line for $2H_2 + O_2 \rightarrow 2H_2O$ has positive slop, and runs parallel to many metal oxide lines, so reducing power of H_2 increase with temperature

36. Which is/are correct statement(s)?
(a) Casseterite, chromite, and pitchblende are concentrated by hydraulic washing (tabling)
(b) Pure Al_2O_3 is obtained from the bauxite ore by leaching in the Baeyer's process
(c) Sulphide ore is concentrated by calcination method
(d) Roasting can convert sulphide into oxide or sulphate and part of sulphide may also act as a reducing agent

37. Which is/are the correct method–metal matching for refining of crude metals?
(a) Distillation: zinc and mercury
(b) Liquation: tin
(c) Van Arkel: zirconium
(d) Mond process: lead

38. Select the correct reduction process:
(a) $2[Ag(CN)_2]^- + Zn \longrightarrow [Zn(CN)_4]^{2-} + 2Ag$
(b) $CuO + H_2 \longrightarrow Cu + H_2O$
(c) $Al_2O_3 + 3Zn \longrightarrow 2Al + 3ZnO$
(d) $MgO + C \xrightarrow[\text{temp.}]{\text{high}} Mg + CO$

39. Select the incorrect meaning of softening of lead:

(a) Melting pure lead at high temperature

(b) Removal of impurities, except silver, present in commerical lead

(c) Formation of lead alloy

(d) Formation of 100% pure lead

40. Softened lead is not desilverized by:

(a) Parke's method (b) Roasting method

(c) Calcination (d) Electrolysis

41. Select the correct statement(s):

(a) When the lead–silver alloy is rich in silver, lead is removed by the cupellation process

(b) When the lead–silver alloy is rich in lead, silver is removed by Parke's or Pattinson's process

(c) Zinc forms an alloy with lead, from which lead is separated

(d) Zinc forms an alloy with silver, from which zinc is separated by distillation

42. In the leaching of Ag_2S with NaCN, a stream of air is also passed. It is because of:

(a) Reversible nature of reaction between Ag_2S and NaCN

(b) Oxidized Na_2S formed into Na_2SO_4.

(c) Irreversible nature of reaction between Ag_2S and NaCN

(d) None of the above

43. $(Ag + Pb)\text{ alloy} \xrightarrow[\text{is added}]{\text{melt and zinc}} (Ag + Pb + Zn)\text{ melt} \xrightarrow{\text{cool}} \begin{matrix}\text{Layer } X \\ \text{Layer } Y\end{matrix}$

Select the correct statement(s) based on above scheme:

(a) Layer X contains zinc and silver

(b) Layer Y contains lead and silver but amount of silver in this layer is smaller than in the layer X.

(c) X and Y are immiscible layers

(d) X and Y are miscible layers

44. Which mineral has/have been named correctly?

(a) Bauxite : $Al_2O_3 \cdot 2H_2O$

(b) Corundum : Al_2O_3

(c) Cryolite : $3NaF \cdot AlF_3$

(d) Galena : HgS

45. Chemical leaching is not useful in the concentration of:

(a) Copper pyrites (b) Bauxite

(c) Galena (d) Cassiterite

46. In the equation,

$$4M + 8\,CN^- + 2\,H_2O + O_2 \longrightarrow 4\,[M(CN)_2]^- + 4\,OH^-,$$

the metal M is:

(a) Copper (b) Silver

(c) Gold (d) Zinc

47. Which of the following statements are correct regarding metallurgy of iron?

(a) Coke reduces FeO to Fe above 710°C

(b) CO reduces Fe_2O_3 to FeO below 710°C

(c) Coke reduces Fe_2O_3 to FeO below 710°C

(d) CO reduces Fe_2O_3 to FeO above 710°C

48. The major role of fluorspar which is added in small amount in the electrolytic reduction of Al_2O_3 dissolved in fused cryolite is:

(a) As a catalyst

(b) To make the fused mixture very conducting

(c) To lower the fusion temperature of the melt

(d) To decreases the rate of oxidation of carbon at the anode

49. Select the correct statements for Ellingham diagram:

(a) Any metal will reduce the oxide of other metals which lie above it in the Ellingham diagram

(b) According to Ellingham diagram, Al will not reduce MgO at temperature below 1350°C

(c) According to Ellingham diagram, Al will reduce MgO at temperature below 1350°C

(d) Any metal will not reduce the oxide of other metals which lie above it in the Ellingham diagram

50. The extraction of metals from sulphide ore involves:

(a) Reduction with carbon (b) Froth floatation

(c) Reduction with Al (d) Electrolytic reduction

51. Find the correct match:

Column-I	Column-II
(a) Azurite	$CuCO_3 \cdot 2Cu(OH)_2$
(b) Malachite	$Cu(OH)_2 \cdot CuCO_3$
(c) Anglesite	$PbSO_4$
(d) Chalcocite	Cu_2S

52. Which of the following statements are correct?

(a) The process of producing a hard coating of iron nitride on the surface of steel is called nitriding

(b) The process of producing a thin coating of iron carbide on the surface of mild steel is called case-hardening

(c) Quenched steel is produced by heating steel to redness and allowing it to cool slowly

(d) Stainless steel is produced by heating wrought iron in molten chromium

53. Carbon can be used to reduce a number of oxides and other compounds, and because of the low cost and availability of coke, this method is widely used, but the disadvantages are that:

(a) High temperature is needed, which is expensive

(b) Many metals combine with carbon to form carbides

(c) Low temperature is needed, which is expensive

(d) Many metal combine with carbon and do not form carbides

54. Select the correct statement(s):

(a) Based on reactivity series, occurrence of certain elements takes place in native state

(b) Due to the basic nature of oxides of alkaline earth elements, they combine with atmospheric acidic oxides giving salts

(c) Based on reactivity series, occurence of certain elements takes place in atomic state

(d) None is correct

55. The reduction of an oxide by aluminium is not called:

(a) Ellingham process

(b) Goldschmidt's aluminothermite process

(c) Kroll's process (d) Van Arkel process

56. Which of the following steps are involved in hydrometallurgical process?

(a) $Cu_2S + 2Cu_2O \longrightarrow 6Cu + SO_2$

(b) $CuFeS_2 + 2H_2SO_4 \longrightarrow CuSO_4 + FeSO_4 + 2H_2S$

(c) $Ag_2S + 2NaCN \longrightarrow [Ag(CN)_2]^- + Na_2S$

(d) $CuCO_3 + H_2SO_4 \longrightarrow CuSO_4 + H_2O + CO_2$

57. Which are not sulphate ore of Mg?

(a) Dolomite (b) Carnallite

(c) Magnesite (d) Kieserite

58. In the Baeyer's process, which of the following statements are incorrect?

(a) Al_2O_3 goes into solution as soluble $Al(OH)_4^-$ while other basic oxides as TiO_2 and Fe_2O_3 remain insoluble.

(b) Al_2O_3 changes to AlN which in turn is decomposed by H_2O

(c) Al_2O_3 changes to $Al_2(CO_3)_3$ which changes to $AlCl_3$

(d) Al_2O_3 changes to $Al_2(SO_4)_3$ which changes to Al_2S_3

59. $$\boxed{\text{Bauxite}} \xrightarrow[\uparrow N_2]{+C} \boxed{\overset{\overset{CO}{\uparrow}}{AlN}} \xrightarrow{H_2O} Al(OH)_3 \xrightarrow{\Delta} Al_2O_3$$

This flow-sheet is not for:

(a) Baeyer's process (b) Serpek's process

(c) Hall's process (d) Kroll's process

60. Silver containing lead as an impurity is not purified by:

(a) Poling (b) Cupellation

(c) Levigation (d) Distillation

61. Which of the following oxides cannot be reduced to metal by carbon?

(a) ZnO (b) Al_2O_3

(c) CuO (d) CaO

62. Select the correct statements for Ellingham diagram:

(a) The slope of the curves of the formation of metal oxide is +ve because ΔG° becomes less negative or increases with the rise in temperature

(b) Each curve is a straight line except when some change takes place in phase ($s \rightarrow l$ or $l \rightarrow g$)

(c) Each curve is not a straight line except when some change takes place in phase ($s \rightarrow l$ or $l \rightarrow g$)

(d) The slope of the curves of the formation of metal oxide is –ve because ΔG° becomes less negative or increases with the rise in temperature

63. Which of the following metal oxides are reduced by self-reduction method?

(a) Cu_2O (b) PbO

(c) HgO (d) CaO

64. Which of the following pair consists of ore of the same metal?

(a) Magnesite, cerussite

(b) Chalcocite, copper pyrites

(c) Bauxite, corundum

(d) Anglesite, cerussite

65. Which of the following statement(s) is/are correct?

(a) The chemical processes in the production of steel from haematite ore involve reduction followed by oxidation

(b) In Hall–Heroult process, the electrolyte used is a molten mixture of alumina and cryolite or fluorspar

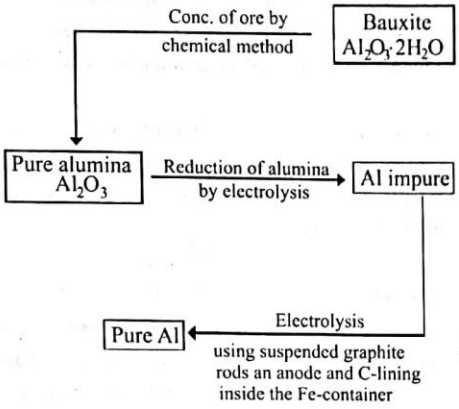
(c) Lead is extracted from its chief ore galena by both carbon reduction as well as self-reduction

(d) Haematitie, cassiterite, and argentite are oxide ores

Comprehension Type

Comprehension-1: (Q. 1 to Q. 4)

Extraction of aluminium can be understood by:



Electrolytic reduction of Al_2O_3:

Electrolyte : (Al_2O_3 + Cryolite + CaF_2)

Cathode : Carbon inside the Fe-container

Anode : Graphite rods

1. The purpose of adding cryolite is:
   (a) To decrease the electrical conductivity of pure aluminium
   (b) To lower the melting point of Al_2O_3
   (c) To remove the impurities as slag
   (d) To increase the Al percentage in the yield
2. Coke powder is spread over the molten electrolyte to:
   (a) Prevent the heat radiation from the surface
   (b) Prevent the corrosion of graphite anode
   (c) Prevent the oxidation of molten aluminium by air
   (d) Both (a) and (b)
3. The function of fluorspar (CaF_2) is:
   (a) To increase the melting point of electrolyte
   (b) To increase electrolytic conductivity power
   (c) To remove the impurities as slag
   (d) All of these
4. The molten electrolytes contain Na^+, Al^{3+}, and Ca^{2+} but only Al gets deposited at cathode because:
   (a) Standard reduction potential of Al is more than that of Na and Ca
   (b) Standard oxidation potential of Al is more than that of Na and Ca
   (c) Discharge potential of Al^{3+} is higher than Na^+ and Ca^{2+}
   (d) Graphite reacts only with Al^{3+} and not with Na^+ and Ca^{2+}

Comprehension-2: (Q. 5 to Q. 7)

Roasting is a process in which the ore (mostly sulphide) is heated strongly in the presence of excess of air. The heating should be done at a temperature below the melting point of the ore.

5. Select the correct statement:
   (a) Roasting also removes easily oxidizable volatile impurties like arsenic as As_2O_3, antimony as Sb_2O_3, and sulphur as SO_2
   (b) The release of SO_2 (in roasting process) has been a serious air pollution problem
   (c) In roasting process, if temperature is fairly low (about 500°C) and the concentration of SO_2 in the gaseous environment is more, sulphate may be produced, that is stable, and high temperature is needed to decompose it
   (d) All are correct
6. $2PbS + 3O_2 \longrightarrow A + 2SO_2$
   The name of A is:
   (a) Litharge (b) Galena
   (c) Sesquioxide (d) None of these
7. Sometimes roasting may not bring about complete oxidation:
   $$2CuFeS_2 + 4O_2 \longrightarrow A + 2FeO + 3SO_2$$
   Find out A:
   (a) Cu_2O (b) CuO
   (c) Cu_2S (d) CuS

Comprehension-3: (Q. 8 to Q. 11)

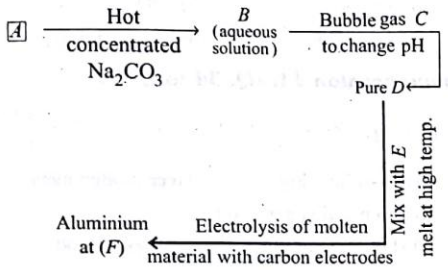
Lead obtained from galena ore (PbS) by air reduction or carbon reduction process contains base metal (Cu, Bi, Sn, As) as impurities; it is due to the presence of these impurites that lead becomes hard and brittle.

8. Parke's process is also called:
   (a) Softening process (b) Desilverisation method
   (c) Cupellation (d) None of these
9. Zn–Ag alloy formed in the upper layer of molten lead is skimmed off from the surface of the molten lead by perforated ladles. This alloy contains lead as impurity. This impurity of Pb is removed by:
   (a) Distillation process (b) Cupellation
   (c) Liquation (d) Bett's electrolysis

10. Ag can be obtained from purified Zn–Ag alloy by:
(a) Distillation (b) Poling
(c) Liquation (d) Reduction

11. Cupellation is used for purification of:
(a) Pb (b) Ag
(c) Zn (d) Fe

Comprehension-4: (Q. 12 to Q. 16)



12. Find out *A*:
(a) $CuFeS_2$ (b) $MgCl_2 \cdot 6H_2O$
(c) $Al_2O_3 \cdot 2H_2O$ (d) Fe_2O_3

13. Find out *B*:
(a) $Na[Al(OH)_4]$ (b) NaOH
(c) H_2SO_4 (d) Al_2O_3

14. Find out *C*:
(a) CO_2 (b) SO_2
(c) SO_3 (d) NO_2

15. Find out *E*:
(a) Na_3GeF_6 (b) Na_3AlF_6
(c) Al_2O_3 (d) None of these

16. Find out *F*:
(a) Cathode (b) Anode
(c) Electrolyte (d) None of these

Comprehension-5: (Q. 17 and Q. 18)

All minerals are not the ore but all ores are minerals. The extraction of a particular metal depends upon several factors and overall it has to be convenient and economical.

17. $\underset{\text{(Sulphide ore)}}{A} + NaCN \underset{}{\overset{air}{\rightleftharpoons}} \underset{\text{(complex)}}{B} + Na_2S$
$\xrightarrow{O_2} Na_2SO_4$

Then *B* is:
(a) Ferromagnetic
(b) Paramagnetic
(c) Linear complex
(d) Coordination number of central atom is 4

18. Which of the following statement is true?
(a) Na-ethyl xanthate is used as frother exclusively
(b) Levigation cannot be applied for sulphide in any condition
(c) Froth floatation can be applied for non-sulphide ore also using suitable activator
(d) Impurities like S and As are removed as elemental vapor in roasting

Comprehension-6: (Q. 19 to Q. 21)

Lead obtained from galena ore (PbS) by air reduction or carbon reduction process contains base metal (Cu, Bi, As, Sn, Zn) as impurities.

19. The removal of the impurity of Ag from the commercial lead is called:
(a) Desilverization of lead
(b) Softening process
(c) Bett's electrolysis
(d) Cupellation

20. Which of the following electrolyte is used for electrolysis of Pb?
(a) $PbSO_4 + H_2SO_4$ (b) $PbCl_2 + HCl$
(c) $PbSiF_6 + H_2SiF_6$ (d) None of these

21. Gelatin acts as addition agent in electrolysis of Pb; in the presence of gelatin, Pb becomes:
(a) Hard and brittle (b) Soft and useless
(c) Smooth and uniform (d) Only brittle

Comprehension-7: (Q. 22 to Q. 24)

Calcination is a process in which the ore is heated strongly in the absence of air to remove volatile impurities. It thermally decomposes the carbonate.

22. $A \xrightarrow{\text{Calcination}} CaO + MgO + 2CO_2$

Find out *A*:
(a) $CaCO_3$ (b) $MgCO_3$
(c) $CaCO_3 \cdot MgCO_3$ (d) $CaSO_4 \cdot MgCO_3$

23. $2Fe_2O_3 \cdot 3H_2O \xrightarrow{\text{Calcination}} A + 3H_2O$

Find out *A*:
(a) 2FeO (b) $2Fe_3O_4$
(c) $2Fe_2O_3$ (d) $FeO \cdot FeCO_3$

24. $Al_2O_3 \cdot 2H_2O \xrightarrow{\text{Calcination}} B + 2H_2O$

The name of product *B* is:
(a) Corundum (b) Bauxite
(c) Aluminum hydroxide (d) None of these

Comprehension-8: (Q. 25 to Q. 27)

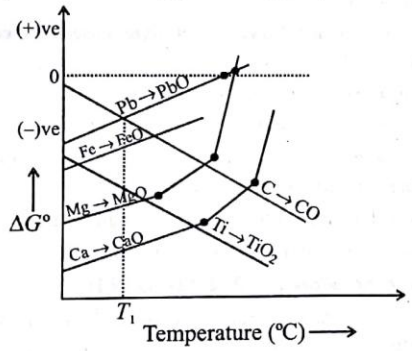
Pb is a very important element of carbon family. It forms a number of compounds which are very useful in industries.

25. Which of the following electrolysis process is used for purification of Pb?
(a) Hall process (b) Parke's process
(c) Bett's electrolysis process
(d) None of these

26. The removal of impurity of Ag from the commercial lead is called:
(a) Softening process (b) Liquation
(c) Parke's process (d) Cupellation

27. The process of removal of base metals (Cu, Sn, Bi, As) from lead is called:
(a) Softening process (b) Liquation
(c) Parke's process (d) Cupellation

Comprehension-9: (Q. 28 to Q. 30)

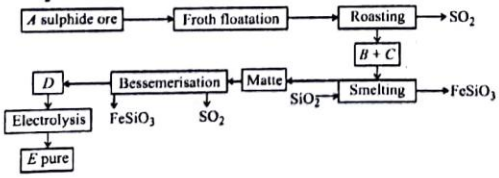


28. Which in the above curve is wrongly presented?
(a) $C \rightarrow CO_2$ (b) $Ti \rightarrow TiO_2$
(c) $Pb \rightarrow PbO$ (d) $Mg \rightarrow MgO$

29. Which of the given metal oxides is having minimum thermal decomposition temperature?
(a) CaO (b) FeO
(c) PbO (d) MgO

30. Which of the following metal's oxide can be reduced by Fe as reducing agent at temperature T_1?
(a) Pb (b) Ca
(c) Mg (d) None of these

Comprehension-10: (Q. 31 to Q. 33)



31. Find out A:
(a) Cu_2S (b) $CuFeS_2$
(c) FeS_2 (d) Fe_3O_4

32. Find out B and C:
(a) FeS + FeO (b) $Cu_2O + Cu_2S$
(c) Cu_2O + FeS (d) Cu_2S + FeO

33. Find out D:
(a) Pig iron (b) FeO
(c) Blister Cu (d) Wrought iron

Comprehension-11: (Q. 34 to Q. 36)

$$(A + Ag) + Zn \longrightarrow (A + Ag + Zn) \xrightarrow{\text{Cooling}} \frac{x \text{ layer}}{y \text{ layer}}$$

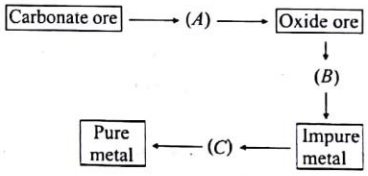
x layer-solid alloy y layer-molten metal

34. Molten metal is purified by:
(a) Hall-Heroult process (b) Hoop method
(c) Baeyer's process
(d) Bett's electrolysis process

35. Metal A is:
(a) Cu (b) Sn
(c) Fe (d) Pb

36. Layer x contains:
(a) Zn + Pb alloy (b) Zn + Ag alloy
(c) Only Ag (d) Only Pb

Comprehension-12: (Q. 37 to Q. 39)



37. A metal is in combined state as carbonate; find out process A:
(a) Roasting (b) Calcination
(c) Smelting (d) Reduction

38. Find out process B:
(a) Roasting (b) Reduction
(c) Van Arkel (d) Smelting

39. Find out process C:
(a) Electrolysis (b) Reduction
(c) Smelting (d) Roasting

Comprehension-13: (Q. 40 to Q. 44)

Copper is extracted from copper pyrites. After roasting, the ore is mixed with silica and coke and then smelted

in a blast furnace. The matte obtained from the blast furance is charged into a silica lined converter. Some silica is also added and a hot air blast is thrown into the mixture to obtain blister copper which is purified by electrorefining.

40. The chemical formula for copper pyrites is:

(a) $CuFeS_2$ (b) Cu_2S

(c) Cu_2O (d) $CuCO_3 \cdot Cu(OH)_2$

41. During roasting, copper pyrites are ultimately converted into a mixture of:

(a) $FeS + Cu_2S$ (b) $FeS + Cu_2O$

(c) $FeO + Cu_2S$

(d) $FeS + Cu_2S + FeO + Cu_2O$

42. Coke is added during smelting:

(a) To reduce FeO to Fe

(b) To reduce Cu_2O to Cu

(c) To check the oxidation of FeO to Fe_2O_3

(d) To check the oxidation of Cu_2O to CuO

43. The chemical composition of the slag formed during smelting process is:

(a) $CuSiO_3$ (b) $FeSiO_3$

(c) $CaSiO_3$ (d) $Cu_2O \cdot SiO_2$

44. Matte is a mixture of:

(a) Cu_2S + FeS (small amount)

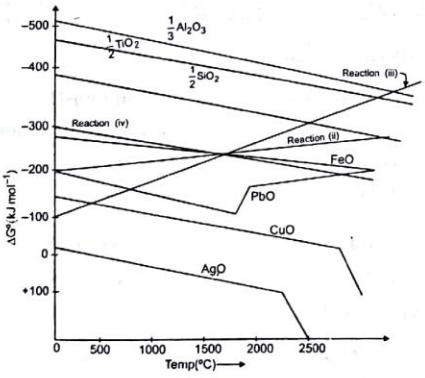
(b) FeS + Cu_2S (small amount)

(c) Cu_2O + FeO (small amount)

(d) FeO + Cu_2O (small amount)

Comprehension-14: (Q. 45 to Q. 47)

These equilibria can be discussed in terms of thermodynamic functions.



For the reactions:

(i) $M_{(s)} + \frac{1}{2}O_{2(g)} \longrightarrow MO_{(s)}$

(ii) $\frac{1}{2}C_{(s)} + \frac{1}{2}O_{2(g)} \longrightarrow \frac{1}{2}CO_{2(g)}$

(iii) $C_{(s)} + \frac{1}{2}O_{2(g)} \longrightarrow CO_{(g)}$

(iv) $CO_{(g)} + \frac{1}{2}O_{2(g)} \longrightarrow CO_{2(g)}$

The temperature dependence of ΔG° of reaction (i) to (iv) is shown in the given diagram. This is known as Ellingham diagram. With the help of Ellingham diagram, one can easily predict the most suitable reducing agent for the reduction of metal oxides.

45. A metal oxide $MO_{(s)}$ can be reduced by carbon or carbon monoxide successfully when the line in Ellingham diagram for reaction (i):

(a) Lies above the line for one of the reactions (ii) to (iv)

(b) Intersects the line for one of the reactions (ii) to (iv)

(c) Lies below the line for one of the reactions (ii) to (iv)

(d) May lie above or below the line for one of the reactions (ii) to (iv) depending upon the temperature

46. CuO can be reduced to Cu conveniently by using C or CO at any temperature:

(a) Approximately equal to room temperature

(b) Above room temperature

(c) Below room temperature

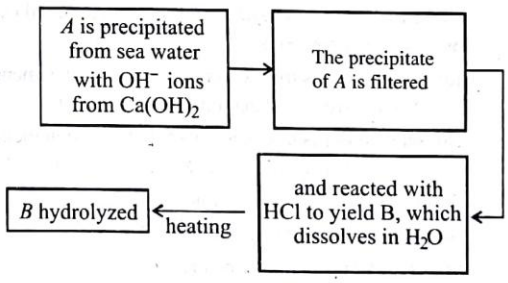
(d) At all temperature

47. Al_2O_3 can be reduced by carbon at a temperature of:

(a) 30°C (b) 500°C

(c) 2000°C (d) > 2500°C

Comprehension-15: (Q. 48 to Q. 50)



48. Find out *A*:

(a) Mg cation (b) $MgCl_2$

(c) $Mg(OH)_2$ (d) Ca cation

49. The compound *B* is:

(a) Anhy. $MgCl_2$ (b) $Mg(OH)_2$

(c) $Ca(OH)_2$ (d) $MgCl_2 \cdot 6H_2O$

50. When B is hydrolyzed, then which of the following compound is formed?

(a) Anhy. $MgCl_2$ (b) MgO

(c) $Mg(OH)_2$ (d) $MgCl_2 \cdot 6H_2O$

Comprehension-16: (Q. 51 to Q. 53)

In many extraction processes, an oxide is added deliberately to combine with other impurities and form a stable molten phase immiscible with molten metal called a slag. The process is termed smelting.

51. The principle of slag formation is essentially the following:

$$\text{Non-metal oxide} + \text{Metal oxide} \longrightarrow X$$

Find out X.

(a) Non-fusible (easily melted) slag

(b) Fusible (easily melted) slag

(c) Solid phase miscible with molten metal

(d) Solid phase immiscible with molten metal

52. In the extraction of iron, which of the following flux is used for the formation of slag:

(a) $MgCO_3$ (b) $ZnCO_3$

(c) SiO_2 (d) $CaCO_3$

53. FeO is the impurity in the extraction of Cu from copper pyrite. Which of the following flux is used for the removal of impurity?

(a) CaO (b) MgO

(c) SiO_2 (d) $FeSiO_3$

Assertion-Reasoning Type

1. **Statement-1:** Reduction of Fe_2O_3 with CO is done below 710°C.

Statement-2: ΔG is negative at this temperature; thus, process is spontaneous.

(a) Statement-1 is true, statement-2 is true; statement -2 is a correct explanation for statement -1.

(b) Statement-1 is true, statement-2 is true; statement -2 is NOT a correct explanation for statement -2.

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true.

2. **Statement-1:** Silver may be prepared by using silver coins; in this process, coins are treated with HNO_3 and then treated with HCl to get AgCl, but directly coins are not treated with HCl.

Statement-2: HCl is not a good oxidizing agent.

(a) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true; statement-2 is NOT a correct explanation for statement-1.

(c) Statement-1 is true, statement-2 is false

(d) Statement-1 is false, statement-2 is true

3. **Statement-1:** Graphite is used as anode but diamond is not.

Statement-2: There exist free electrons between two parallel sheets of graphite; hence, it helps in electron conduction.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true but statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

4. **Statement-1:** Copper and zinc are obtained by electrolysis of aqueous solution of their sulphates.

Statement-2: Elements that react with water are often extracted from fused melts of their ionic salts.

(a) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true but statement-2 is NOT the correct explanation for statement-1

(c) Statement-1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

Matching Column Type

1. Match the column:

Column-I (Metal)	Column-II (Purification method)
(a) Hg	(p) Zone refining method
(b) Ag	(q) Liquation
(c) Ga	(r) $\overset{\ominus}{C}N$ process
(d) Pb	(s) Distillation

2. Match the column:

Column-I	Column-II
(a) Roasting	(p) Process in which volatile impurities are removed

(b) Calcination	(q) Process in which hydrated water is removed
(c) Concentration	(r) Magnetic impurities removed
	(s) Sulphide ore converted into its oxide ore

3. Match the column:

Column-I	Column-II
(a) Flux	(p) SiO_2
(b) Slag	(q) CaO
(c) Acidic flux	(r) $CaSiO_3$
(d) Basic flux	(s) MgO
	(t) $FeSiO_3$

4. Match the column (for electrolytic refining of Cu):

Column-I	Column-II
(a) Anode	(p) Thin sheets of pure Cu
(b) Cathode	(q) An aqueous solution of copper sulphate containing H_2SO_4
(c) Electrolyte	(r) Ag, Au
(d) Anode mud	(s) Impure metal of Cu

5. Match Column-I with Column-II.

Column-I	Column-II
(a) Cyanide process	(p) Ultrapure Ge
(b) Floatation process	(q) Pine oil
(c) Electrolytic reduction	(r) Extraction of Al
(d) Zone refining	(s) Extraction of Au

6. Match the column:

Column-I	Column-II
(a) Van Arkel method	(p) Manufacture of caustic soda
(b) Cupellation	(q) Purification of titanium
(c) Poling	(r) Purification of copper
	(s) Refining of silver

7. Match the column:

Column - I	Column - II
(a) Vapor phase refining process	(p) Cu
(b) Thermite process	(q) Fe
(c) Self-reduction	(r) B
(d) Bessemerization	(s) Al
	(t) Ni

8. Match the column:

Column-I	Column-II
(a) Van Arkel method	(p) Manufacture of Mg
(b) Dow's sea-water process	(q) Purification of titanium
(c) Cupellation	(r) Manufacture of Na
(d) Poling	(s) Purification of Cu
	(t) Refining of silver

9. Match the column:

Column-I	Column-II
(a) Bauxite ore	(p) Roasting
(b) SnO_2 ore	(q) Calcination
(c) Native silver ore	(r) Leaching
(d) $CuFeS_2$ ore	(s) Electrolysis

10. Match the following:

Column-I	Column-II
(a) Slag formation	(p) Extraction of copper from copper pyrites
(b) Froth-floatation	(q) Extraction of iron from haematite
(c) Leaching	(r) Extraction of tin from cassiterite
(d) Roasting	(s) Extraction of lead from galena
	(t) Extraction of gold from its native ore

11. Match the column:

Column-I	Column-II
(a) Anglesite	(p) Sulphate ore
(b) Galena	(q) Sulphide ore
(c) Cerussite	(r) Ore of Pb
(d) Cinnabar	(s) Carbonate ore
	(t) Ore of Hg

12. Match the commercial extraction process listed in Column-I with metals listed in Column-II:

Column-I	Column-II
(a) Self-reduction	(p) Lead
(b) Carbon reduction	(q) Silver
(c) Complex formation and displacement by metal	(r) Copper
(d) Decomposition of iodide	(s) Boron

13. Match the column:

Column-I	Column-II
(a) Ni	(p) Van Arkel de boer process
(b) Zr	(q) Zone refining process
(c) Si	(r) Mond's process
(d) Fe	(s) Bessemerization
	(t) Reduction in blast furnace

14. Match the column:

Column-I	Column-II
(a) Froth floatation	(p) Pb ore
(b) Self-reduction	(q) Cu ore
(c) Roasting	(r) Fe ore
(d) Pyrometallurgy	(s) Sn ore
	(t) Zn ore

15. Match the column:

Column-I	Column-II
(a) $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$	(p) Roasting
(b) $Ni(CO)_4 \xrightarrow{230°C} Ni + 4CO$	(q) Calcination
(c) $Fe_2O_3 . 3H_2O \xrightarrow{\Delta} 2Fe_2O_3 + 3H_2O$	(r) Vapor phase refining process
(d) $PbS + 2O_2 \longrightarrow PbO + SO_2$	(s) Thermite reaction

16. Match the column:

Column-I	Column-II
(a) Poling	(p) Sn
(b) Cupellation	(q) Ag
(c) Zone refining	(r) Cu
(d) Parke's process	(s) Ge
	(t) Si

17. Match the column:

Column-I	Column-II
(a) Ni	(p) A solution of lead silico fluoride $PbSiF_6$ containing 8–10% of H_2SiF_6 is used as electrolyte for
(b) Pb	(q) Complex formation reaction is involved in extraction of
(c) Cu	(r) Self-reduction
(d) Hg	(s) Carbon monoxide is used for extraction of
	(t) *d*-block element

18. Match the column:

Column-I (Processes involved)	Column-II (Related to)
(a) Serpeck's process	(p) Purification of aluminium
(b) Dow's sea-water process	(q) Purification of alumina
(c) Hall–Heroult process	(r) Preparation of hydrated $MgCl_2$
(d) Hoop's process	(s) Purification of tin
	(t) Reduction of alumina

19. Match the column:

Column-I	Column-II
(a) Magnetic separation	(p) $CuFeS_2$
(b) Froth floation	(q) Fe_3O_4
(c) Gravity separation	(r) $ZnCO_3$
(d) *p*-block metal is present in the ore	(s) PbS
	(t) Ag_2S

20. Match the column:

Column-I (Conversion processes)	Column-II (Involves which of the following operation/s)
(a) Auriferrous rock $\longrightarrow$ Au	(p) Roasting
(b) Haemetite containing siderite and magnetite $\longrightarrow$ Fe	(q) Smelting
(c) Bauxite $\longrightarrow$ Al	(r) Leaching
(d) Galena $\longrightarrow$ Pb	(s) Electrolytic reduction
	(t) Froth floatation

Integer Answer Type

1. How many ores are sulphide ores from the given ores?

Azurite, Chalcocite, Iron pyrites, Limonite

2. How many metals are commercially purified by Van Arkel method from the given metals?

Ti, B, Zr, Pb, Hg

3. How many metals are commercially purified by electrolysis method from the given metals?

Na, Al, Pb, Ni

4. Find the number of following reactions which are involved in roasting process:

(i) $S_8 + 8O_2 \xrightarrow{\Delta} 8SO_2\uparrow$

(ii) $4Sb + 3O_2 \xrightarrow{\Delta} 2Sb_2O_3\uparrow$

(iii) $4As + 3O_2 \xrightarrow{\Delta} 2As_2O_3\uparrow$

(iv) $2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2\uparrow$

(v) $ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2\uparrow$

5. Find the number of reaction from the given reactions which can show calcination process:

(i) $CaCO_3 \cdot MgCO_3 \xrightarrow{\Delta} CaO + MgO + CO_2$

(ii) $CuCO_3 \cdot Cu(OH)_2 \xrightarrow{\Delta} 2CuO + H_2O + CO_2$

(iii) $Al_2O_3 \cdot 2H_2O \xrightarrow{\Delta} Al_2O_3 + 2H_2O$

(iv) $2Cu_2S + 3O_2 \xrightarrow{\Delta} 2Cu_2O + 2SO_2$

6. Find the number of basic flux from the given compounds:

SiO_2, MgO, CaO, FeO, B_2O_3, $CaCO_3 \cdot MgCO_3$

7. Find the number of metal oxides which are decomposed on normal heating from the given oxides:

Na_2O, Al_2O_3, PbO, Ag_2O, HgO

8. How many metallic ores are concentrated by magnetic separation method from the given ores?

Cassiterite, Pyrolusite, Rutile, Magnetite, Galena, Cinnabar

9. Find the number of metals from the given metals which can be commercially purified by zone refining methods:

Si, Ge, Ga, Al, Ti, Zr

10. How many metals are commercially extracted by pyrometallurgy from the given metals?

Cu, Fe, Sn, Au, K, Na

11. Find the number of acidic flux from the given compounds:

$CaCO_3$, $Na_2B_4O_7$, $MgSiO_3$, $FeSiO_3$, SiO_2

12. How many metals are commercially reduced by Goldschmidt alumino-thermic process from the given metals?

Na, Pb, Al, Mn, Cr, Sn

13. Find the number of metals which are commercially reduced by self-reduction from the given metals:

Fe, Al, Zn, Sn, Pb, Hg, Cu

14. Find the number of metals which are commercially reduced by carbon reduction method from the given metals:

Ag, Cr, Mn, Sn, Zn, Fe

15. How many metals are commercially extracted by hydrometallurgy from the given metals?

Ag, Mn, In, Cr, Pb, Au

16. How many metals are commercially extracted by electrometallurgy from the given metals?

Al, Mg, Na, K, Ag, Hg, Ti, Th, Zr, B

17. How many reactions can show slag formation process from the given reactions?

(i) $SiO_2 + CaO \longrightarrow CaSiO_3$

(ii) $FeO + SiO_2 \longrightarrow FeSiO_3$

(iii) $CaO + P_2O_5 \longrightarrow Ca_3(PO_4)_2$

(iv) $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$

(v) $MgCO_3 + SiO_2 \longrightarrow MgSiO_3 + CO_2$

NCERT Exemplar Exercises

Single Correct Answer Type

1. In the extraction of chlorine by electrolysis of brine _____.
   (a) Oxidation of Cl^- ion to chlorine gas occurs
   (b) Reduction of Cl^- ion to chlorine gas occurs
   (c) For overall reaction ΔG has negative value
   (d) A displacement reaction takes place

2. When copper ore is mixed with silica in a reverberatory furnace, copper matte is produced. The copper matte contains _____.
   (a) Sulphides of copper (II) and iron (II)
   (b) Sulphides of copper (II) and iron (III)
   (c) Sulphides of copper (I) and iron (II)
   (d) Sulphides of copper (I) and iron (III)

3. Which of the following reactions is an example of autoreduction?
   (a) $Fe_3O_4 + 4CO \rightarrow 3Fe + 4CO_2$
   (b) $Cu_2O + C \rightarrow 2Cu + CO$
   (c) $Cu^{2+}(aq) + Fe(s) \rightarrow Cu(s) + Fe^{2+}(aq)$
   (d) $Cu_2O + \frac{1}{2}Cu_2S \rightarrow 3Cu + \frac{1}{2}SO_2$

4. A number of elements are available in earth's crust but most abundant elements are _____.
   (a) Al and Fe (b) Al and Cu
   (c) Fe and Cu (d) Cu and Ag

5. Zone refining is based on the principle that _____.
   (a) Impurities of low boiling metals can be separated by distillation
   (b) Impurities are more soluble in molten metal than in solid metal
   (c) Different components of a mixture are differently adsorbed on an adosrbent
   (d) Vapors of volatile compound can be decomposed in pure metal

6. In the extraction of copper from its sulphide ore, the metal is formed by the reduction of Cu_2O with:
   (a) FeS (b) CO
   (c) Cu_2S (d) SO_2

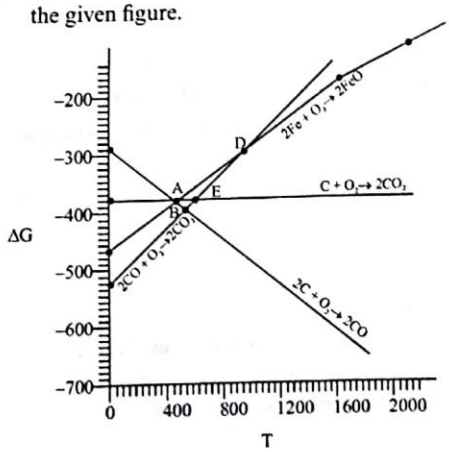
7. Brine is electrolyzed by using inert electrodes. The reaction at anode is _____.
   (a) $Cl^-(aq.) \rightarrow \frac{1}{2}Cl_2(g) + e^-$; $E^\circ_{cell} = 1.36$ V
   (b) $2H_2O(l) \rightarrow O_2(g) + 4H^+ + 4e^-$; $E^\circ_{cell} = 1.23$ V
   (c) $Na^+(aq.) + e^- \rightarrow Na(s)$; $E^\circ_{cell} = 2.71$ V
   (d) $H^+(aq.) + e^- \rightarrow \frac{1}{2}H_2(g)$; $E^\circ_{cell} = 0.00$ V

8. In the metallurgy of aluminium _____.
   (a) Al^{3+} is oxidized to Al(s)
   (b) Graphite anode is oxidized to carbon monoxide and carbon dioxide
   (c) Oxidation state of oxygen changes in the reaction at anode
   (d) Oxidation state of oxygen changes in the overall reaction involved in the process

9. Electrolytic refining is used to purify which of the following metals?
   (a) Cu and Zn (b) Ge and Si
   (c) Zr and Ti (d) Zn and Hg

10. Extraction of gold and silver involves leaching the metal with CN^- ion. The metal is recovered by _____.
   (a) Displacement of metal by some other metal from the complex ion
   (b) Roasting of metal complex
   (c) Calcination followed by roasting
   (d) Thermal decomposition of metal complex

Note: Answer the questions 11–13 on the basis of the given figure.



11. Choose the correct option of temperature at which carbon reduces FeO to iron and produces CO.
   (a) Below temperature at point A
   (b) Approximately at the temperature corresponding to point A
   (c) Above temperature at point A but below temperature at point D
   (d) Above temperature at point A

12. Below point 'A' FeO can _____.
   (a) Be reduced by carbon monoxide only
   (b) Be reduced by both carbon monoxide and carbon
   (c) Be reduced by carbon only
   (d) Not be reduced by both carbon and carbon monoxide

13. For the reduction of FeO at the temperature corresponding to point D, which of the following statements is correct?
   (a) ΔG value for the overall reduction reaction with carbon monoxide is zero
   (b) ΔG value for the overall reduction reaction with a mixture of 1 mol carbon and 1 mol oxygen is positive
   (c) ΔG value for the overall reduction reaction with a mixture of 2 mol carbon and 1 mol oxygen will be positive
   (d) ΔG value for the overall reduction reaction with carbon monoxide is negative

Multiple Correct Answers Type

Note: In the following questions two or more options may be correct.

1. At the temperature corresponding to which of the points in the figure given in Q. 10, FeO will be reduced to Fe by coupling the reaction $2FeO \rightarrow 2Fe + O_2$ with all of the following reactions?
   (i) $C + O_2 \rightarrow CO_2$ (ii) $2C + O_2 \rightarrow 2CO$ and (iii) $2CO + O_2 \rightarrow 2CO_2$
   (a) Point A (b) Point B
   (c) Point D (d) Point E

2. Which of the following options are correct?
   (a) Cast iron is obtained by remelting pig iron with scrap iron and coke using hot air blast
   (b) In extraction of silver, silver is extracted as cationic complex
   (c) Nickel is purified by zone refining
   (d) Zr and Ti are purified by Van Arkel method

3. In the extraction of aluminium by Hall-Heroult process, purified Al_2O_3 is mixed with CaF_2 to:
   (a) Lower the melting point of Al_2O_3
   (b) Increase the conductivity of molten mixture
   (c) Reduce Al^{3+} into Al(s)
   (d) Acts as catalyst
4. Which of the following statements is correct about the role of substances added in the froth floatation process?
   (a) Collectors enhance the non-wettability of the mineral particles
   (b) Collectors enhance the wettability of gangue particles
   (c) By using depressants in the process two sulphide ores can be separated
   (d) Froth stabilizers decrease wettability of gangue
5. In the froth floatation process, zinc sulphide and lead sulphide can be separated by _____.
   (a) Using collectors
   (b) Adjusting the proportion of oil to water
   (c) Using depressant
   (d) Using froth stabilizers
6. Common impurities present in bauxite are _____.
   (a) CuO (b) ZnO
   (c) Fe_2O_3 (d) SiO_2
7. Which of the following ores are concentrated by froth floatation?
   (a) Haematite (b) Galena
   (c) Copper pyrites (d) Magnetite
8. Which of the following reactions occur during calcination?
   (a) $CaCO_3 \rightarrow CaO + CO_2$
   (b) $2FeS_2 + \frac{11}{2}O_2 \rightarrow Fe_2O_3 + 4SO_2$
   (c) $Al_2O_3 \cdot x\,H_2O \rightarrow Al_2O_3 + x\,H_2O$
   (d) $ZnS + \frac{3}{2}O_2 \rightarrow ZnO + SO_2$
9. For the metallurgical process of which of the ores calcined ore can be reduced by carbon?
   (a) Haematite (b) Calamine
   (c) Iron pyrites (d) Sphalerite
10. The main reactions occurring in blast furnace during extraction of iron from haematite are _____.
   (a) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
   (b) $FeO + SiO_2 \rightarrow FeSiO_3$
   (c) $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$
   (d) $CaO + SiO_2 \rightarrow CaSiO_3$
11. In which of the following method of purification, metal is converted to its volatile compound which is decomposed to give pure metal?
   (a) Heating with stream of carbon monoxide
   (b) Heating with iodine
   (c) Liquation
   (d) Distillation
12. Which of the following statements are correct?
   (a) A depressant prevents certain type of particle to come to the froth
   (b) Copper matte contains Cu_2S and ZnS
   (c) The solidified copper obtained from reverberatory furnace has blistered appearance due to evolution of SO_2 during the extraction
   (d) Zinc can be extracted by self-reduction
13. In the extraction of chlorine from brine _____.
   (a) ΔGV for the overall reaction is negative
   (b) ΔGV for the overall reaction is positive
   (c) EV for overall reaction has negative value
   (d) EV for overall reaction has positive value

Short Answer Type

1. Why is an external emf of more than 2.2 V required for the extraction of Cl_2 from brine?
2. At temperatures above 1073 K coke can be used to reduce FeO to Fe. How can you justify this reduction with Ellingham diagram?
3. Wrought iron is the purest form of iron. Write a reaction used for the preparation of wrought iron from cast iron. How can the impurities of sulphur, silicon and phosphorus be removed from cast iron?
4. How is copper extracted from low grade copper ores?
5. Write two basic requirements for refining of a metal by Mond process and by Van Arkel Method.
6. Although carbon and hydrogen are better reducing agents but they are not used to reduce metallic oxides at high temperatures. Why?
7. How do we separate two sulphide ores by froth floatation method? Explain with an example.
8. The purest form of iron is prepared by oxidising impurities from cast iron in a reverberatory furnace.

   Which iron ore is used to line the furnace? Explain by giving reaction.

9. The mixture of compounds A and B is passed through a column of Al_2O_3 by using alcohol as eluant. Compound A is eluted in preference to compound B.

   Which of the compounds A or B, is more readily adsorbed on the column?

10. Why is sulphide ore of copper heated in a furnace after mixing with silica?

11. Why are sulphide ores converted to oxide before reduction?

12. Which method is used for refining Zr and Ti? Explain with equation.

13. What should be the considerations during the extraction of metals by electrochemical method?

14. What is the role of flux in metallurgical processes?

15. How are metals used as semiconductors refined? What is the principle of the method used?

16. Write down the reactions taking place in Blast furnace related to the metallurgy of iron in the temperature range 500–800 K.

17. Give two requirements for vapour phase refining.

18. Write the chemical reactions involved in the extraction of gold by cyanide process. Also give the role of zinc in the extraction.

Matching Column Type

Note: Match the items given in Column-I and Column-II in the following questions.

1. Match the items of Column-I with items of Column-II and assign the correct code:

Column-I	Column-II
(a) Pendulum	(p) Chrome steel
(b) Malachite	(q) Nickel steel
(c) Calamine	(r) Na_3AlF_6
(d) Cryolite	(s) $CuCO_3 \cdot Cu(OH)_2$
	(t) $ZnCO_3$

Code:
(a) a (p) b (q) c (r) d (s)
(b) a (q) b (s) c (t) d (r)
(c) a (q) b (r) c (s) d (t)
(d) a (s) b (t) c (r) d (q)

2. Match the items of Column-I with the items of Column-II and assign the correct code:

Column-I	Column-II
(a) Colored bands	(p) Zone refining
(b) Impure metal to volatile complex	(q) Fractional distillation
(c) Purification of Ge and Si	(r) Mond Process
(d) Purification of mercury	(s) Chromatography
	(t) Liquation

Code:
(a) a (p) b (q) c (s) d (t)
(b) a (s) b (r) c (p) d (q)
(c) a (r) b (s) c (q) d (p)
(d) a (t) b (s) c (r) d (q)

3. Match items of Column-I with the items of Column-II and assign the correct code:

Column-I	Column-II
(a) Cyanide process	(p) Ultrapure Ge
(b) Froth floatation Process	(q) Dressing of ZnS
(c) Electrolytic reduction	(r) Extraction of Al
(d) Zone refining	(s) Extraction of Au
	(t) Purification of Ni

Code:
(a) a (s) b (q) c (r) d (p)
(b) a (q) b (r) c (p) d (t)
(c) a (p) b (q) c (r) d (s)
(d) a (r) b (s) c (t) d (p)

4. Match the items of Column-I with the items of Column-II and assign the correct code:

Column-I	Column-II
(a) Sapphire	(p) Al_2O_3
(b) Sphalerite	(q) NaCN
(c) Depressant	(r) Co
(d) Corundum	(s) ZnS
	(t) Fe_2O_3

Code:
(a) a (r) b (s) c (q) d (p)
(b) a (t) b (s) c (r) d (q)
(c) a (q) b (r) c (s) d (t)
(d) a (p) b (q) c (r) d (s)

5. Match the items of Column-I with items of Column-II and assign the correct code:

Column-I	Column-II
(a) Blisterred Cu	(p) Aluminium
(b) Blast furnace	(q) $2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$

(c) Reverberatory furnace (r) Iron

(d) Hall-Heroult process (s) $FeO + SiO_2 \rightarrow FeSiO_3$

(t) $2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$

Code:

(a) a (q) b (r) c (s) d (p)
(b) a (p) b (q) c (r) d (t)
(c) a (t) b (s) c (r) d (q)
(d) a (s) b (t) c (r) d (q)

Assertion-Reasoning Type

Note: In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Assertion is true but reason is false.
(d) Assertion is false but reason is true.
(e) Assertion and reason both are wrong.

1. **Assertion:** Nickel can be purified by Mond process.

   Reason: $Ni(CO)_4$ is a volatile compound which decomposes at 460 K to give pure Ni.

2. **Assertion:** Zirconium can be purificed by Van Arkel method.

   Reason: ZrI_4 is volatile and decomposes at 1800 K.

3. **Assertion:** Sulphide ores are concentrated by Froth Flotation method.

   Reason: Cresols stabilize the froth in froth flotation method.

4. **Assertion:** Zone refining method is very useful for producing semiconductors.

   Reason: Semiconductors are of high purity.

5. **Assertion:** Hydrometallurgy involves dissolving the ore in a suitable reagent followed by precipitation by a more electropositive metal.

   Reason: Copper is extracted by hydrometallurgy.

Long Answer Type

1. Explain the following:
   (a) CO_2 is a better reducing agent below 710 K whereas CO is a better reducing agent above 710 K.
   (b) Generally sulphide ores are converted into oxides before reduction.
   (c) Silica is added to the sulphide ore of copper in the reverberatory furnace.
   (d) Carbon and hydrogen are not used as reducing agents at high temperatures.
   (e) Vapour phase refining method is used for the purification of Ti.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. Aluminium is extracted by the electrolysis of:
   (a) Bauxite
   (b) Alumina
   (c) Alumina mixed with molten cryolite
   (d) Molten cryolite **(AIEEE, 2002)**

2. The metal extracted by leaching with a cyanide is:
   (a) Mg (b) Ag
   (c) Cu (d) Na **(AIEEE, 2002)**

3. Which one of the following ores is best concentrated by froth-flotation method?
   (a) Galena (b) Cassiterite
   (c) Magnetite (d) Malachite
   (AIEEE, 2004)

4. During the process of electrolytic refining of copper, some metals present as impurity settle as 'anode mud'. These are:
   (a) Fe and Ni (b) Ag and Au
   (c) Pb and Zn (d) Sn and Ag
   (AIEEE, 2005)

5. Which of the following factors is of no significance for roasting sulphide ores to the oxides and not subjecting the sulphide ores to carbon reduction directly?
   (a) Metal sulphides are thermodynamically more stable than CS_2
   (b) CO_2 is thermodynamically more stable than CS_2
   (c) Metal sulphides are less stable than the corresponding oxides
   (d) CO_2 is more volatile than CS_2
   (AIEEE, 2008)

6. Which method of purification is represented by the following equation?

$$Ti(s) + 2I_2(g) \xrightarrow{523\,K} TiI_4(g) \xrightarrow{1700\,K} Ti(s) + 2I_2(g)$$

(a) Zone refining (b) Cupellation
(c) Polling (d) Van Arkel

(AIEEE, 2012)

7. The form of iron obtained from blast furnace is:
(a) Steel (b) Wrought iron
(c) Cast iron (d) Pig iron

(JEE Main, 2014)

JEE (Advanced) Exercises

Fill in the Blanks Type

1. In the basic Bessemer process for the manufacture of steel, the lining of the converter is made up of _____. The slag formed consists of _____.

(IIT-JEE, 1980)

2. In the thermite process, _____ is used as a reducing agent. **(IIT-JEE, 1980)**
3. Cassiterite is an ore of _____. **(IIT-JEE, 1980)**
4. In extractive metallurgy of zinc, partial fusion of ZnO with coke is called _____ and reduction of the ore to molten metal is called _____ (smelting, calcining, roasting, sintering).

(IIT-JEE, 1988)

Single Correct Answer Type

1. In the aluminothermite process, aluminium is:
(a) An oxidizing agent
(b) A flux
(c) A reducing agent
(d) A solder

(IIT-JEE, 1983)

2. The major role of fluorspar (CaF_2) which is added in small quantities in the electrolytic reduction of alumina dissolved in fused cryolite (Na_3AlF_6) is:
(a) As a catalyst
(b) To make the fused mixture very conducting
(c) To increase the temperature of the melt
(d) To decrease the rate of oxidation of carbon at the anode

(IIT-JEE, 1993)

3. In the commercial electrochemical process for aluminium extraction, the electrolyte used is:
(a) $Al(OH)_3$ in NaOH solution
(b) An aqueous solution of $Al_2(SO_4)_3$
(c) A molten mixture of Al_2O_3 and Na_3AlF_6
(d) A molten mixture of AlO(OH) and $Al(OH)_3$

(IIT-JEE, 1999)

4. The chemical process in the production of steel from haematite ore involves:
(a) Reduction
(b) Oxidation
(c) Reduction followed by oxidation
(d) Oxidation followed by reduction

(IIT-JEE, 2000)

5. Electrolytic reduction of alumina to aluminium by Hall–Heroult process is carried out:
(a) In the presence of NaCl
(b) In the presence of fluorite
(c) In the presence of cryolite which forms a melt with lower melting temperature
(d) In the pressure of cryolite which forms a melt with higher melting temperature

(IIT-JEE, 2000)

6. The chemical composition of slag formed during the smelting process in the extraction of copper is:
(a) $Cu_2O + FeS$ (b) $FeSiO_3$
(c) $CuFeS_2$ (d) $Cu_2S + FeO$

(IIT-JEE, 2001)

7. Which of the following processes is used in extractive metallurgy of magnesium?
(a) Fused salt electrolysis
(b) Self-reduction
(c) Aqueous solution electrolysis
(d) Thermite reduction **(IIT-JEE, 2002)**

8. In the process of extraction of gold,

$$\text{Roasted gold ore} + CN^- + H_2O \xrightarrow{O_2} [X] + OH^-$$
$$[X] + Zn \rightarrow [Y] + Au$$

Identify the complexes $[X]$ and $[Y]$:
(a) $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_4]^{2-}$
(b) $X = [Au(CN)_4]^{3-}$, $Y = [Zn(CN)_4]^{2-}$
(c) $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_6]^{4-}$
(d) $X = [Au(CN)_4]^-$, $Y = [Zn(CN)_4]^{2-}$

(IIT-JEE, 2003)

9. The methods chiefly used for the extraction of lead and tin from their ores, respectively, are:
(a) Self-reduction and carbon reduction

(b) Self-reduction and electrolytic reduction
(c) Carbon reduction and self-reduction
(d) Cyanide process and carbon reduction

(IIT-JEE, 2004)

10. Which ore contains both iron and copper?
(a) Cuprite (b) Chalcocite
(c) Chalcopyrite (d) Malachite

(IIT-JEE, 2005)

11. Extraction of zinc from zinc blende is achieved by:
(a) Electrolytic reduction
(b) Roasting followed by reduction with carbon
(c) Roasting followed by reduction with another metal
(d) Roasting followed by self-reduction

(IIT-JEE, 2007)

12. Native silver metal forms a water soluble complex with a dilute aqueous solution of NaCN in the presence of:
(a) Nitrogen (b) Oxygen
(c) Carbon dioxide (d) Argon

(IIT-JEE, 2008)

13. In the cyanide extraction process of silver from argentite ore, the oxidizing and reducing agents used are:
(a) O_2 and CO, respectively
(b) O_2 and Zn dust, respectively
(c) HNO_3 and Zn dust, respectively
(d) HNO_3 and CO, respectively

(IIT-JEE, 2012)

14. Sulfide ores are common for the metals:
(a) Ag, Cu and Pb (b) Ag, Cu and Sn
(c) Ag, Mg and Pb (d) Al, Cu and Pb

(JEE Advanced, 2013)

Multiple Correct Answers Type

1. In the electrolysis of alumina, cryolite is added to:
(a) Lower the melting point of alumina
(b) Increase the electrical conductivity
(c) Minimize the anode effect
(d) Remove the impurities from alumina

(IIT-JEE, 1988)

2. Of the following, the metals that cannot be obtained by electrolysis of the aqueous solution of their salts are:
(a) Ag (b) Mg
(c) Cu (d) Al
(e) Cr

(IIT-JEE, 1990)

3. Extraction of metal from the ore cassiterite involves:
(a) Carbon reduction of an oxide ore
(b) Self-reduction of a sulphide ore
(c) Removal of copper impurity
(d) Removal of iron impurity

(IIT-JEE, 2011)

4. Oxidation states of the metal in the minerals hematite and magnetite, respectively, are:
(a) II, III in hematite and III in Magnetite
(b) II, III in hematite and II in Magnetite
(c) II in hematite and II, III in Magnetite
(d) III in hematite and II, III in Magnetite

(IIT-JEE, 2011)

5. The carbon-based reduction method is **NOT** used for the extraction of:
(a) Tin from SnO_2
(b) Iron from Fe_2O_3
(c) Aluminium from Al_2O_3
(d) Magnesium from $MgCO_3.CaCO_3$

(JEE Advanced, 2013)

6. Upon heating with Cu_2S, the reagent(s) that give copper metal is/are:
(a) $CuFeS_2$ (b) CuO
(c) Cu_2O (d) $CuSO_4$

(JEE Advanced, 2014)

Comprehension Type

For Problems 1–3

Copper is the most noble of the first row transition elements. It occurs in small deposits in several countries. Ores of copper include chalcanthite ($CuSO_4 \cdot 5H_2O$), atacamite [$Cu_2Cl(OH)_3$], cuprite (Cu_2O), copper glance (Cu_2S), and malachite [$Cu_2(OH)_2CO_3$]. However, 80% of the world copper production comes from the ore chalcopyrite ($CuFeS_2$). Extraction of copper from chalcopyrite includes roasting, iron removal, and self-reduction.

1. Partial roasting of chalcopyrite produces:
(a) Cu_2S and FeO (b) Cu_2O and FeO
(c) CuS and Fe_2O_3 (d) Cu_2O and Fe_2O_3

2. Iron is removed from chalcopyrite as:
(a) FeO (b) FeS
(c) Fe_2O_3 (d) $FeSiO_3$

3. In self-reduction, the reducing species is:
(a) S (b) O^{2-}
(c) S^{2-} (d) SO_2

(IIT-JEE, 2010)

Matching Column Type

1. Match the following metals listed in Column-I with extraction processes listed in Column-II.

Column-I	Column-II
(a) Silver	(p) Fused salt electrolysis
(b) Calcium	(q) Carbon reduction
(c) Zinc	(r) Carbon monoxide reduction
(d) Iron	(s) Amalgamation
(e) Copper	(t) Self-reduction

(IIT-JEE, 1979)

2. Match the following choosing one item from Column-I and the appropriate item from Column-II.

Column-I	Column-II
(a) Al	(p) Calamine
(b) Cu	(q) Cryolite
(c) Mg	(r) Malachite
(d) Zn	(s) Carnallite

(IIT-JEE, 1983)

3. Match the extraction processes listed in Column-I with the metals listed in Column-II.

Column-I	Column-II
(a) Self-reduction	(p) Lead
(b) Carbon reduction	(q) Silver
(c) Complex formation and displacement by metal	(r) Copper
(d) Decomposition of iodide	(s) Boron

(IIT-JEE, 2006)

4. Match the conversions in Column-I with the type(s) of reaction(s) given in Column-II.

Column-I	Column-II
(a) $PbS \rightarrow PbO$	(p) Roasting
(b) $CaCO_3 \rightarrow CaO$	(q) Calcination
(c) $ZnS \rightarrow Zn$	(r) Carbon reduction
(d) $Cu_2S \rightarrow Cu$	(s) Self-reduction

(IIT-JEE, 2008)

Subjective Type

1. Write the chemical equations involved in the extraction of lead from galena by self-reduction process. **(IIT-JEE, 1979)**

2. State the conditions under which the preparation of alumina from aluminium is carried out. Give the necessary equations which need not be balanced. **(IIT-JEE, 1983)**

3. Each of the following statements is true only under some specific conditions. Write the condition for each sub-question in not more than two sentences.
   (i) Metals can be recovered from their ores by chemical methods.
   (ii) High purity metals can be obtained by zone refining method. **(IIT-JEE, 1984)**

4. Write balanced chemical equations for the following: "Gold is dissolved in aquaregia."**(IIT-JEE, 1987)**

5. Answer the following questions briefly.
   (i) What is the actual reducing agent of haematite in blast furnace?
   (ii) Give the equations for the recovery of lead from galena by air reduction.
   (iii) Why is sodium chloride added during electrolysis of fused anhydrous magnesium chloride?
   (iv) Zinc, not copper, is used for the recovery of metallic silver from the complex $[Ag(CN)_2]^-$, explain.
   (v) Why is chalcocite roasted and not calcinated during recovery of copper? **(IIT-JEE, 1987)**

6. Give balanced equations for the following: "Extraction of silver from silver glance by cyanide process" **(IIT-JEE, 1988)**

7. Write balanced equations for "the extraction of copper from copper pyrites by self-reduction." **(IIT-JEE, 1990)**

8. Give briefly the isolation of magnesium from sea water. Give equations for the steps involved. **(IIT-JEE, 1993)**

9. Given reasons for the following: "Although aluminium is above hydrogen in the electrochemical series, it is stable in air and water." **(IIT-JEE, 1994)**

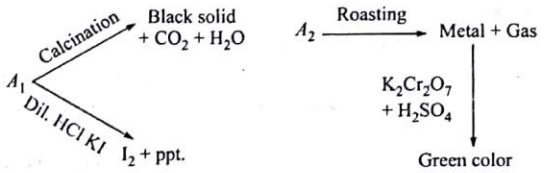
10. When the ore haematite is burnt in air with coke around 2000 K along with lime, the process not only produces steel but also produces a silicate slag that is useful in making building materials such as cement. Discuss the same and show through balanced chemical equations. **(IIT-JEE, 1998)**

11. Write the chemical reactions involved in the extraction of metallic silver from argentite. **(IIT-JEE, 2000)**

12. How is boron obtained from borax? Give chemical equations with reaction conditions. Write the structure of B_2H_6 and its reaction with HCl. **(IIT-JEE, 2002)**

13. Write down the reactions involved in the extraction of Pb. What is the oxidation number of lead in litharge? **(IIT-JEE, 2003)**

14. A_1 and A_2 are two ores of metal M. A_1 on calcination gives a black precipitate, CO_2, and water. Identify A_1 and A_2. **(IIT-JEE, 2004)**



Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

61. (b)

I Mond's porcess:

$$\underset{\text{Impure}}{Ni + 4CO\uparrow} \xrightarrow{50°C} \underset{\text{Volatile complex}}{[Ni(CO)_4]} \xrightarrow{230°C} \underset{\text{Pure}}{Ni + 4CO\uparrow}$$

II Removal of unreacted AgBr from photographic plate:

$$AgBr + 2Na_2S_2O_3 \rightleftharpoons Na_3[Ag(S_2O_3)_2] + NaBr$$

III Removal of lead poisoning:

$$Pb^{2+} + EDTA^{4-} \rightleftharpoons [Pb(EDTA)]^{2-}$$

IV Cyanide process:

$$2Ag + 4NaCN + H_2O + \frac{1}{2}O_2 \rightleftharpoons 2Na[Ag(CN)_2] + 2NaOH \text{ Native Ore}$$

V Separation of ZnS from PbS:

$$ZnS + CN^- \rightleftharpoons [Zn(CN)_4]^{2-}$$

64. (b) Cassiterite (SnO_2) is diamagnetic, while wolframite ($MnWO_4 + FeWO_4$) is paramagnetic.

66. (c) Thermite process is related to Goldschmidt thermite reduction or welding where aluminium is used in powdered form (thermite) as reducing agent.

67. (d) Anthracite is the purest form of coal.

JEE (Advanced) Exercises

Single Correct Answer Type

3. (b) $4Ag + 8NaCN + 2H_2O + O_2 \longrightarrow 4Na[Ag(CN)_2] + 4NaOH$

4. (b) $2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$;

$$ZnO + C \xrightarrow{>1270\,K} Zn + CO$$

10. (b)

(I) $M_2S + O_2 \longrightarrow M_2O$; $\Delta H = -$ ve

(II) Roasting is always exothermic

11. (a) BaO_2 or $KClO_3$ provides oxygen to burn Mg.

33. (c) As zinc is volatile at 920°C while Ag is not, hence on heating (Zn + Ag) alloy, zinc goes into vapor phase and Ag remains at the bottom of the vessel.

36. (b) $2Mg + 3C \xrightarrow{2000°C} Mg_2C_3$

38. (b) In Bessemer converter, slag of $FeSiO_3$ is also formed. Blister appearance is due to escape of SO_2 gas from molten copper.

39. (b) Leaching is required for hydrometallurgy or to purify or concentrate ore for electrolytic reduction.

40. (c) $MgO + C \xrightarrow[2000°C]{\text{at high temp.}} Mg + CO$

It is possible at high temperature; so it is not used for commerical purpose.

41. (c) A → Fe: by carbon reduction.

B → Al: by electrolytic reduction.

46. (a) The reduction process is on the thermodynamic stability of the products and not on their volatility.

49. (b) $2CuFeS_2$ ($Cu_2S + FeS + FeS_2$)

55. (c) Cr–Fe alloy: Ferrochrome is made similarily by the reduction of the ore chromite, $FeCr_2O_4$, with Al.

Multiple Correct Answers Type

23. (c), (d)

(a) During roasting S, As, and Sb will be oxidized into their volatile oxides SO_2, As_2O_3, and Sb_2O_3, respectively.

(c) During roasting, FeO is oxidized into Fe_2O_3 which does not form slag with silica.

(d) $Fe_2O_3 \cdot 3H_2O \xrightarrow{\Delta} Fe_2O_3 + 3H_2O\uparrow$

51. (b),(c),(d)

Azurite: $Cu(OH)_2 \cdot 2CuCO_3$

Comprehension Type

17. (c) If ore is Ag_2S, then

$$Ag_2S + 4NaCN \xrightleftharpoons{\text{air}} \underset{\text{(complex)}}{2Na[Ag(CN)_2]} + NaS_2 \xrightarrow{O_2} Na_2SO_4$$

Complex $[Ag(CN)_2]^-$ is linear and diamagnetic.

18. (c)

(a) Sodium ethylxanthate acts as collector.

(b) Levigation can be used for sulphide ore to remove majority of gangue when density difference in high.

(c) Froth floatation can also be used for non-sulphide ores having sulphide impurities, and the ore is recovered by using suitable activator.

(d) During roasting, impurities such as S and As are removed as their volatile oxides SO_2 and As_2O_3, respectively.

22. (c) $CaCO_3 \cdot MgCO_3 \xrightarrow{\text{Calcination}} CaO + MgO + 2CO_2$

28. (b) $Ti\,(s) + 1/2\,O_2(g) \xrightarrow{\Delta} TiO_2\,(s)$

By increasing temperature according to $\Delta G = \Delta H - T\Delta S$, ΔG for formation of TiO_2 will move toward +ve value.

29. (c) ΔG_f of PbO is touching the zero value of ΔG^o first.

30. (a) At T_1 temperature, ΔG_f of FeO is more negative than that of PbO.

Assertion-Reasoning Type

3. (a) Free electrons exist along layers of graphite.

Integer Answer Type

1. Azurite = $2\,CuCO_3 \cdot Cu(OH)_2$
Chalcocite = Cu_2S
Iron pyrites = FeS_2
Limonite = $Fe_2O_3 \cdot 3H_2O$

NCERT Exemplar Exercises

Short Answer Type

1. For the reaction

$2Cl^-\,(aq) + 2H_2O\,(l) \rightarrow 2OH^-\,(aq) + H_2(g) + Cl_2\,(g)$

Value of $\Delta G^\ominus$ is + 422 kJ. Using the equation $\Delta G^\ominus = -\,nFE^\ominus$ the value of $E^\ominus$ comes out to be –2.2 V. Therefore extraction of Cl_2 from brine will require an external emf of greater than 2.2 V.

2. As per Ellingham diagram at temperatures greater than 1073 K

$\Delta G\,(C, CO) < \Delta G\,(Fe, FeO)$. Hence coke can reduce FeO to Fe.

3. $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$

Limestone is added as flux and sulphur, silicon and phosphorus change to their oxides and pass into the slag.

4. Copper is extracted by hydrometallurgy from low grade copper ores. It is leached out using acid or bacteria. The solution containing Cu^{2+} is treated with scrap iron, Zn or H_2.

$2\,Cu^{2+}\,(aq) + H_2(g) \rightarrow 2Cu(s) + 2H^+(aq)$

$Cu^{2+} + Fe(s) \rightarrow Fe^{2+}\,(aq) + Cu(s)$

5. Basic requirements for both processes are:

(i) The metal should form a volatile compound with an available reagent.

(ii) The volatile compound should be easily decomposable, so that recovery of metal is easy.

6. It is because at high temperature carbon and hydrogen react with metals to form carbides and hydrides respectively.

7. Two sulphide ores can be separated by adjusting proportion of oil to water or by using depressants. For example, in the case of an ore containing ZnS and PbS, the depressant NaCN is used. It forms complex with ZnS and prevents it from coming with froth but PbS remains with froth.

8. Haematite

$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$

9. Since compound 'A' comes out before compound 'B', the compound 'B' is more readily adsorbed on column.

10. Iron oxide present as impurity in sulphide ore of copper forms slag which is iron silicate and copper is produced in the form of copper matte.

$FeO + SiO_2 \rightarrow FeSiO_3$

11. Sulphides are not reduced easily but oxides are easily reduced.

12. Van Arkel method is used for refining Zr and Ti. In this method crude metal is heated with iodine.

$Zr + 2I_2 \longrightarrow ZrI_4$

$ZrI_4 \xrightarrow{1800K} Zr + 2I_2$

13. Generally two things are considered so that proper precautions can be taken:

(i) reactivity of metal produced

(ii) suitability of electrodes

14. Flux is used for making the molten mass more conducting.

15. Semiconducting metal is produced by zone refining method which is based on the principle that the impurities are more soluble in melt than in the solid state of metals.

16. $3Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$

$Fe_3O_4 + 4CO \rightarrow 3Fe + 4CO_2$

$Fe_2O_3 + CO \rightarrow 2FeO + CO_2$

17. (i) The metal should form a volatile compound with available reagent.

(ii) The volatile compound should be easily decomposable so that the recovery is easy.

18. $4Au\,(s) + 8CN^-(aq) + 2H_2O\,(aq) + O_2\,(g) \rightarrow 4\,[Au(CN)_2]^-\,(aq) + 4OH^-\,(aq)$

$2[Au(CN)_2]^-\,(aq) + Zn(s) \rightarrow 2Au(s) + [Zn\,(CN)_4]^{2-}\,(aq)$

In this reaction zinc acts as a reducing agent.

Long Answer Type

1. (a) **Hint:** Use Ellingham diagram.

(b) **Hint:** Oxides are easier to reduce. See Ellingham diagram.

(c) **Hint:** Sulphide ore of copper contains iron as impurity which is removed as iron silicate (slag)

$$FeO + SiO_2 \rightarrow \underset{(Slag)}{FeSiO_3}$$

(d) **Hint:** Carbon and hydrogen react with metals at high temperature to form carbides and hydrides respectively.

(e) **Hint:** Ti reacts with iodine to form volatile TiI_4 which decomposes at high temperature to give extra pure titanium.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (c) Aluminium is extracted by the electrolysis of purified Al_2O_3, which is mixed with Na_3AlF_6 or CaF_2, which lowers the melting point of the mixture and brings conductivity. Steel cathode and graphite anode are used. The graphite anode is useful here for reduction to metal. The overall reaction may be taken as

$$Al_2O_3 + 3C \rightarrow 4Al + 3CO_2$$

The process of electrolysis is widely known as Hall–Heroult process.

2. (b) Leaching is often used if the ore is soluble in some suitable solvent. In the metallurgy of silver and that of gold, the respective metal is leached with a dilute solution of NaCN or KCN in the presence of air (for O_2) from which the metal is obtained later by replacement.

$4M(s) + 8CN^-\,(aq) + 2H_2O\,(aq) + O_2(g) \rightarrow 4[M(CN)_2]^-\,(aq) + 4OH^-\,(aq)$ (M = Ag or Au)

$2[M(CN)_2]^-\,(aq) + Zn(s) \rightarrow [Zn(CN)_4]^{2-}\,(aq) + 2M(s)$

3. (a) Froth-floatation method is used for removing gangue from sulphide ores.

Galena is PbS, Cassiterite is SnO_2, Magnetite is Fe_3O_4, and Malachite is $CuCO_3 \cdot Cu(OH)_2$.

4. (b) In electrolytic refining, the impure metal is made to act as anode. A strip of the same metal in pure form is used as cathode. They are put in a suitable electrolytic bath containing soluble salt of the same metal. The more basic metal remains in the solution and the less basic ones go to the anode mud.

5. (a)

(a) $PbS + C \rightarrow Pb + CS_2$

This reaction in non-spontaneous on the basis that PbS is more stable than CS_2.

(b) Carbon or CO is used as a reducing agent and they get converted to CO_2 rather than CS_2 because CO_2 is thermodynamically more stable than CS_2.

(c) $PbS + O_2 \rightarrow PbO + SO_2$

$PbS + PbO \rightarrow Pb + SO_2$

(d) Boiling point × Molecular mass

Both CO_2 and CS_2 are non-polar molecular.

6. (d) Van Arkel method is vapor phase refining method.

7. (d) Iron obtained in blast furnace is known as pig iron.

JEE (Advanced) Exercises

Fill in the Blanks Type

1. In the basic Bessemer process for the manufacture of steel, the lining of the converter is made up of **lime**. The slag formed consists of $\mathbf{Ca_3(PO_4)_2}$. Phosphorous is oxidized to P_4O_{10} which reacts with lime to form slag.

   $P_4 + 5O_2 \rightarrow P_4O_{10}$

   $6CaO + P_4O_{10} \rightarrow \underset{\text{(Thomas slag)}}{2Ca_3(PO_4)_2}$

2. In the thermite process **aluminium** is used as a reducing agent.

   A mixture of concentrated oxide ore and aluminium powder, commonly called as thermite, is taken in a steel crucible placed in a bed of sand.

   $Cr_2O_3 + 2Al \rightarrow 2Cr + Al_2O_3$

   $3Mn_3O_4 + 8Al \rightarrow 9Mn + 4Al_2O_3$

   A large amount of heat energy is released during reduction, which fuses both the alumina and the metal. Aluminium acts as a reducing agent and is itself oxidized.

3. Cassiterite is an ore of **tin.**

   Tin is extracted from oxide ore cassiterite by reduction with carbon in a reverberatory furnace.

   $SnO_2 + 2C \rightarrow Sn + 2CO$

4. In extractive metallurgy of zinc, partial fusion of ZnO with coke is called **sintering** and reduction of the ore to molten metal is called **smelting**.

Single Correct Answer Type

1. (c) A mixture of concentrated oxide ore and aluminium powder, commonly called as thermite, is taken in a steel crucible placed in a bed of sand.

   $Cr_2O_3 + 2Al \rightarrow 2Cr + Al_2O_3$

   $3Mn_3O_4 + 8Al \rightarrow 9Mn + 4Al_2O_3$

   A large amount of heat energy is released during reduction, which fuses both the alumina and the metal. Aluminium acts as a reducing agent and is itself oxidized.

2. (b) The electrolysis of pure alumina faces some difficulties. Pure alumina is a bad conductor of electricity. The fusion temperature of pure alumina is about 2000°C and at this temperature when electrolysis is carried out on the fused mass, the metal formed vaporizes, as the boiling point of aluminium is 1800°C. These difficulties are overcome by using a mixture containing alumina, cryolite (Na_3AlF_6), and fluorspar (CaF_2).

3. (c) The electrolysis of pure alumina faces some difficulties. Pure alumina is a bad conductor of electricity. The fusion temperature of pure alumina is about 2000°C and at this temperature when the electrolysis is carried out on the fused mass, the metal formed vaporizes as the boiling point of aluminium is 1800°C. These difficulties are overcome by using a mixture containing alumina, cryolite (Na_3AlF_6), and fluorspar (CaF_2).

4. (d) First, by calcination and roasting, the ferrous oxide is oxidized to ferric oxide. Then, in blast furnace, smelting is done, where it is reduced to get iron.

   $4FeO + O_2 \rightarrow 2Fe_2O_3$

   $Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$

   $Fe_2O_3 + CO \rightarrow FeO + CO_2$

   $FeO + CO \rightarrow Fe + CO_2$

5. (c) The electrolysis of pure alumina faces some difficulties. Pure alumina is a bad conductor of electricity. The fusion temperature of pure alumina is about 2000°C and at this temperature when the electrolysis is carried out on the fused mass, the metal formed vaporizes as the boiling point of aluminium is 1800°C. These difficulties are overcome by using a mixture containing alumina, cryolite (Na_3AlF_6), and fluorspar (CaF_2).

6. (b) When smelting is done in the blast furnace, most of the ferrous oxide is converted into ferric oxide. With silica, it forms ferrous silicate which is the slag.

   $FeO + SiO_2 \rightarrow FeSiO_3$

7. (a) Anhydrous magnesium chloride is fused with NaCl and anhydrous calcium chloride.

   The mixture is electrolyzed at 700°C in the presence of an inert gas in an electrolytic cell. Magnesium is discharged at cathode. The purpose of the addition of NaCl and $CaCl_2$ to anhydrous $MgCl_2$ is to lower the fusion temperature and make the fused mass a good conductor of electricity.

8. (a) $Au + 4CN^- + H_2O + \frac{1}{2}O_2 \rightarrow 2[Au(CN)_2]^- + 2OH^-$

   $2[Au(CN)_2]^- + Zn \rightarrow [Zn(Cn)_4]^{2-} + 2Au$

9. (a) The methods chiefly used for the extraction of lead and tin from their ores are self-reduction and carbon reduction, respectively.
Tin is extracted from oxide ore cassiterite by reduction with carbon in a reverberatory furnace.

$SnO_2 + 2C \rightarrow Sn + 2CO$

Lead is mainly extracted from sulphide ore called galena. Self-reduction finally takes place.

$2PbO + PbS \rightarrow 3Pb + SO_2$

$PbSO_4 + PbS \rightarrow 2Pb + 2SO_2$

10. (c) Chalcopyrite is $CuFeS_2$.

11. (b) When zinc blende is used, the powdered ore is concentrated by froth floatation process. The concentrated ore is heated in excess of oxygen at about 900°C. Zinc sulphide is oxidized to zinc oxide. If some of the ore is oxidized to zinc sulphate, it also decomposes at 900°C into ZnO. This is roasting. It is followed by reduction. The reaction that takes place during reduction is the conversion of the oxide into metal with the help of carbon.

$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2\uparrow$

$ZnSO_4 \xrightarrow{\Delta} ZnO + SO_2 + \frac{1}{2}O_2\uparrow$

$ZnO + C \xrightarrow{\Delta} Zn + CO\uparrow$

12. (b) Native silver metal forms a water-soluble complex with a dilute aqueous solution of NaCN in the presence of oxygen as follows:

$4Ag + 8NaCN + 2H_2O + O_2 \rightarrow 4Na[Ag(CN)_2] + 4NaOH$

13. (b) In the extraction of silver, Ag_2S is leached with KCN in the presence of air:

$Ag_2S + NaCN + O_2 \rightleftharpoons Na[Ag(CN)_2] + Na_2S_2O_3$

Thus, O_2 is oxidant.

$2Ag(CN)_2^- + Zn \longrightarrow [Zn(CN_4)]^{2-} + 2Ag\downarrow$

14. (a) Sulphide ores are common for Ag, Cu and Pb

i.e. Ag_2S (Silver glance)

Cu_2S (Copper glance or chalcocite)

$CuFeS_2$ (Chalcopyrite)

PbS (Galena)

While SnO_2 (Cassiterite)

$KCl.MgCl_2.6H_2O$ (Carnalite)

$Al_2O_3.2H_2O$ (Bauxite)

Multiple Correct Answers Type

1. (a), (b) The electrolysis of pure alumina faces some difficulties. Pure alumina is a bad conductor of electricity. The fusion temperature of pure alumina is about 2000°C and at this temperature when the electrolysis is carried out on the fused mass, the metal formed vaporizes as the boiling point of aluminium is 1800°C. These difficulties are overcome by using a mixture containing alumina, cryolite (Na_3AlF_6), and fluorspar (CaF_2).

2. (b), (d) Magnesium and aluminium lie above hydrogen in electrochemical series. Their standard reduction potentials are lower than that of hydrogen. When their salts are electrolyzed in aqueous solutions, hydrogen gas is liberated at the cathode.

3. (a), (c), (d) Cassiterite ore: SnO_2

$$\left.\begin{array}{l} SnO_2 + C \longrightarrow SnO + CO \\ SnO_2 + C \longrightarrow Sn + CO \end{array}\right\} \text{Carbon reduction}$$

Also iron is present as impurity in this ore.

4. (d) Hematite: Fe_2O_3: Iron (III)

Magnetite: $Fe_3O_4 \equiv FeO_4 : Fe_2O_3$: Iron (II, III)

5. (c), (d)

(a) $\boxed{SnO_2 \xrightarrow[\text{Reduction}]{\text{Carbon}} Sn}$

$SnO_2 + 2C \rightarrow Sn + 2CO\uparrow$

$SnO_2 + 2CO \rightarrow Sn + 2CO_2\uparrow$

(b) $\boxed{Fe_2O_3 \xrightarrow[\text{Reduction}]{\text{Carbon}} 2Fe}$

$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO\uparrow$

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2\uparrow$

(c)

$\boxed{Al_2O_3 \xrightarrow[\text{Reduction}]{\text{Electrolytic}} 2Al}$

$\underbrace{Al_2O_3 + Na_3AlF_6 + CaF_2}_{\text{Molten Electrolyte}} \xrightarrow{\text{Electrolysis}} Al_{(l)}$ (at cathode)

(d)

$MgCO_3.CaCO_3 \xrightarrow{\text{Calcination}} MgO.CaO$

(i) Fe–Si Alloy → Mg-metal

(ii) HCl → $[MgCl_2 + CaCl_2] \xrightarrow[\text{Reduction}]{\text{Electrolytic}}$ Mg-metal

In no process carbon is used as reducing agent.

6. (b), (c), (d) $Cu_2S + 2Cu_2O \xrightarrow{\Delta} 6Cu + SO_2$

Comprehension Type

1. (a) Partial roasting:

$$2CuFeS_2 + O_2 \xrightarrow{\Delta} Cu_2S + 2FeS + SO_2$$

$$2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2$$

2. (d) Removal of iron:

$$FeO + SiO_2 \rightarrow FeSiO_3(slag)$$

3. (c) Self-reduction:

$$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$$

The oxidation number of sulphur increases from –1 to +4. Therefore, S^{2-} is the reducing species.

Matching Column Type

1. (a) → (s); (b) → (p); (c) → (q, r); (d) → (t)

Silver metal is extracted by amalgamation process:

$$Ag + Hg \rightarrow (Hg) \xrightarrow{Distil} Ag\downarrow + Hg\uparrow$$

Calcium is extracted by the electrolysis of fused mixture of $CaCl_2$ and CaF_2.

When zinc blende is used, the powdered ore is concentrated by froth floatation process. The concentrated ore is heated in excess of oxygen at about 900°C. Zinc sulphide is oxidized to zinc oxide. If some of the ore is oxidized to zinc sulphate, it also decomposes at 900°C into ZnO. This is roasting. It is followed by reduction. The reaction that takes place during reduction is the conversion of the oxide into metal with the help of carbon.

$$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2\uparrow$$

$$ZnSO_4 \xrightarrow{\Delta} ZnO + SO_2 + \frac{1}{2}O_2\uparrow$$

$$ZnO + C \xrightarrow{\Delta} Zn + CO\uparrow$$

For iron, first by calcination and roasting, the ferrous oxide is oxidized to ferric oxide. Then, in blast furnace, smelting is done, where it is reduced to get iron.

$$4FeO + O_2 \rightarrow 2Fe_2O_3$$

$$Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$$

$$Fe_2O_3 + CO \rightarrow FeO + CO_2$$

$$FeO + CO \rightarrow Fe + CO_2$$

Copper is extracted by self-reduction.

$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$$

$$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$$

2. (a) → (q); (b) → (r); (c) → (s); (d) → (p)

Al	Cryolite	Na_3AlF_6
Cu	Malachite	$CuCO_3 \cdot Cu(OH)_2$
Mg	Carnallite	$KCl \cdot MgCl_2 \cdot 6H_2O$
Zn	Calamine	$ZnCO_3$

3. (a) → (p, r); (b) → (p); (c) → (q); (d) → (s)

Lead is mainly extracted from sulphide ore called galena. Roasting is done followed by reduction with carbon. Self-reduction finally takes place.

$$2PbO + PbS \rightarrow 3Pb + SO_2$$

$$PbSO_4 + PbS \rightarrow 2Pb + 2SO_2$$

Copper is extracted by self-reduction.

$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$$

$$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$$

In silver metal, the sulphide ore is treated with sodium cyanide. Sodium argentocyanide complex is formed which on treating with zinc metal gives silver.

$$Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2] + Na_2S$$

$$2Na[Ag(CN)_2] + Zn \rightarrow \underset{\text{Soluble}}{Na_2[Zn(CN)_4]} + \underset{\text{Ppt.}}{2Ag\downarrow}$$

By decomposition of iodide, boron metal is isolated.

4. (a) → (p); (b) → (q); (c) → (p, r); (d) → (p, s)

For PbS → PbO, roasting is done.

For $CaCO_3$ → CaO, calcination is done in the absence of air.

For ZnS → Zn, there is roasting followed by reduction.

$$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2\uparrow$$

$$ZnSO_4 \xrightarrow{\Delta} ZnO + SO_2 + \frac{1}{2}O_2\uparrow$$

$$ZnO + C \xrightarrow{\Delta} Zn + CO\uparrow$$

For Cu_2S → Cu, roasting is done followed by self-reduction.

$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$$

$$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$$

Subjective Type

1. Lead is mainly extracted from sulphide ore called galena. Roasting is done followed by reduction with carbon. Self-reduction finally takes place.

$$2PbS + 3O_2 \rightarrow 2PbO + SO_2$$

$$PbS + 2O_2 \rightarrow PbSO_4$$

$$PbSO_4 + PbO \rightarrow 2Pb + 2SO_2$$

$$PbS + 2PbO \rightarrow 3Pb + SO_2$$

2. $Al + NaOH \xrightarrow{\text{Aqueous}} NaAlO_2 + H_2O$

$NaAlO_2 \xrightarrow{CO_2} Al(OH)_3 + Na_2CO_3$

$Al(OH)_3 \xrightarrow{\Delta} \underset{\text{Alumina}}{Al_2O_3} + H_2O$

3. (i) Many metals occur in nature as oxides, carbonates, sulphides which can be calcined or roasted. Then, they can be further treated chemically to get the metal.

(ii) Elements such as Si, Ge, Ga, etc., which are used as semiconductors, are refined by zone refining method. Highly pure metals are obtained. The method is based on the difference in solubility of impurities in molten and solid state of the metal. A movable heater is fitted around a rod of the impure metal. The heater is slowly moved across the rod. The metal melts at the point of heating and as the heater moves on from one end of the rod to the other end, the pure metal crystallizes, while the impurities pass on to the adjacent molten zone.

4. Aquaregia is three parts conc. HCl and one part conc. HNO_3. Aquaregia forms nascent chlorine which attacks gold.

$HNO_3 + 3HCl \rightarrow NOCl + 2H_2O + 2Cl$

$Au + 3Cl \rightarrow AuCl_3$

$AuCl_3 + HCl \rightarrow HAuCl_4$

5. (i) For iron, first by calcination and roasting, the ferrous oxide is oxidized to ferric oxide. Then, in blast furnace, smelting is done, where it is reduced to get iron.

$4FeO + O_2 \rightarrow 2Fe_2O_3$

$Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$

$Fe_2O_3 + CO \rightarrow FeO + CO_2$

$FeO + CO \rightarrow Fe + CO_2$

Carbon monoxide is the actual reducing agent of hematite in the blast furnace.

(ii) Lead is mainly extracted from sulphide ore called galena. Roasting is done followed by reduction with carbon. Self-reduction finally takes place.

$2PbS + 3O_2 \rightarrow 2PbO + SO_2$

$PbS + 2O_2 \rightarrow PbSO_4$

$PbSO_4 + PbO \rightarrow 2Pb + 2SO_2$

$PbS + 2PbO \rightarrow 3Pb + SO_2$

(iii) The anhydrous magnesium chloride is fused with NaCl and anhydrous calcium chloride. The mixture is electrolyzed at 700°C in the presence of an inert gas in an electrolytic cell. Magnesium is discharged at the cathode. The purpose of the addition of NaCl and $CaCl_2$ to anhydrous $MgCl_2$ is to lower the fusion temperature and make the fused mass a good conductor of electricity. Sodium chloride prevents the hydrolysis of magnesium chloride.

(iv) Zinc is more reducing and cheaper than copper.

(v) Chalcocite is a sulphide ore of copper; therefore, it must be roasted in the presence of air to get oxide.

6. In case of silver metal, the sulphide ore is treated with sodium cyanide. Sodium argentocyanide complex is formed which on treating with zinc metal gives silver.

$Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2] + Na_2S$

$2Na[Ag(CN)_2] + Zn \rightarrow \underset{\text{Soluble}}{Na_2[Zn(CN)_4]} + \underset{\text{Ppt.}}{2Ag\downarrow}$

7. Roasting:

$2CuFeS_2 + O_2 \xrightarrow{\Delta} Cu_2S + 2FeS + SO_2$

$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 3SO_2$

$2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2$

Smelting:

$FeO + SiO_2 \rightarrow FeSiO_3$(Slag)

$Cu_2O + FeS \rightarrow Cu_2S + FeO$

Bessemerization:

Self-reduction

$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$

8. In sea water, $MgCl_2$ is present.

$MgCl_2 + Ca(OH)_2 \longrightarrow Mg(OH)_2\downarrow + CaCl_2$

$\underset{\text{Dry}}{Mg(OH)_2} \xrightarrow{\Delta} MgO + H_2O$

$MgO + C + Cl_2 \xrightarrow{\Delta} MgCl_2 + CO\uparrow$

The anhydrous magnesium chloride is fused with NaCl and anhydrous calcium chloride. The mixture is electrolyzed at 700°C in the presence of an inert gas in an electrolytic cell. Magnesium is discharged at the cathode. The purpose of the addition of NaCl and $CaCl_2$ to anhydrous $MgCl_2$ is to lower the fusion temperature and make the fused mass a good conductor of electricity. Sodium chloride prevents the hydrolysis of magnesium chloride.

At anode: $2Cl^- \rightarrow Cl_2 + 2e^-$

At cathode: $Mg^{2+} + 2e^- \rightarrow Mg$

9. When Al is exposed to air, it forms a thin invisible continuous resistant protective film of Al_2O_3.

10. First, by calcination and roasting, the ferrous oxide is oxidized to ferric oxide. Then, in blast furnace, smelting is done, where it is reduced to get iron.

$$4FeO + O_2 \rightarrow 2Fe_2O_3$$
$$Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$$
$$Fe_2O_3 + CO \rightarrow FeO + CO_2$$
$$FeO + CO \rightarrow Fe + CO_2$$

In the basic Bessemer process for the manufacture of steel, the lining of the converter is made up of lime. The slag formed consists of $Ca_3(PO_4)_2$. Phosphorous is oxidized to P_4O_{10} which reacts with lime to form slag.

$$P_4 + 5O_2 \rightarrow P_4O_{10}$$
$$6CaO + P_4O_{10} \rightarrow \underset{\text{(Thomas slag)}}{2Ca_3(PO_4)_2}$$

11. Silver is extracted from argentite ore by cyanide process. In case of silver metal, the sulphide ore is treated with sodium cyanide. Sodium argentocyanide complex is formed which on treating with zinc metal gives silver.

$$Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2] + Na_2S$$
$$2Na[Ag(CN)_2] + Zn \rightarrow \underset{\text{Soluble}}{Na_2[Zn(CN)_4]} + \underset{\text{Ppt.}}{2Ag\downarrow}$$

12. Finely ground borax is heated with concentrated hydrochloric acid or concentrated sulphuric acid when sparingly soluble orthoboric acid separates out.

$$Na_2B_4O_7 + 2HCl \rightarrow 2NaCl + H_2B_4O_7$$
$$Na_2B_4O_7 + H_2SO_4 \rightarrow Na_2SO_4 + H_2B_4O_7$$
$$H_2B_4O_7 + 5H_2O \rightarrow 4H_3BO_3$$

Orthoboric acid is strongly heated to get B_2O_3.

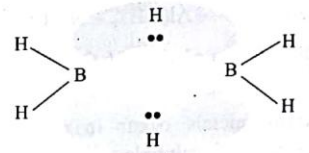
$$2H_3BO_3 \rightarrow B_2O_3 + 3H_2O$$

The reduction of boric anhydride (B_2O_3) can be done with sodium, potassium, or magnesium.

$$B_2O_3 + 6K \rightarrow 2B + 3K_2O$$
$$B_2O_3 + 3Mg \rightarrow 2B + 3MgO$$

Boron is obtained these days by the electrolysis of a fused mixture containing boric anhydride, magnesium oxide, and magnesium fluoride. The electrolysis is done in carbon crucible which acts as the anode and iron rod is used as the cathode. The magnesium discharged at the cathode reduces B_2O_3 to boron.

The structure of diborane is given below:



There are two types of hydrogen atoms. Four hydrogen atoms are terminal hydrogens. The other two hydrogen atoms are known as bridged hydrogens. The two boron atoms and the four terminal H atoms lie in the same plane, while the two bridging H atoms are in the plane perpendicular to the rest of the molecule. The four terminal hydrogens are bonded by normal covalent bonds. The bridged hydrogens are bonded by three-center electron pair bonds which involve two electrons but bind three atoms. There are two such types of bonds in diborane. The boron atom undergoes sp^3-hybridization. Two hybrid orbitals of each B atom overlaps with 1*s* orbitals of two H atoms. The hybrid orbital containing an unpaired electron of one B atom and the vacant hybrid orbital of the second B atom overlaps simultaneously with 1*s* orbital of an H atom to form B—H—B bridge bond. This B—H—B bond is called three-center electron pair bonds. It is also called banana bond.

$$B_2H_6 + HCl \rightarrow \underset{\text{Chlorodiborane}}{B_2H_5Cl} + H_2$$

13. Lead is mainly extracted from sulphide ore called galena. Roasting is done followed by reduction with carbon. Self-reduction finally takes place.

$$2PbS + 3O_2 \rightarrow 2PbO + SO_2$$
$$PbS + 2O_2 \rightarrow PbSO_4$$
$$PbSO_4 + PbO \rightarrow 2Pb + 2SO_2$$
$$PbS + 2PbO \rightarrow 3Pb + SO_2$$

Litharge is chemically PbO, and the oxidation state of lead is +2.

14. A_1 is malachite $CuCO_3 \cdot Cu(OH)_2$

$$CuCO_3 \cdot Cu(OH)_2 \xrightarrow{\Delta} 2CuO + CO_2\uparrow + H_2O$$

CuO is the black solid.

$$CuCO_3 \cdot Cu(OH)_2 \xrightarrow{\text{Dil. HCl}} CuCl_2 + CO_2 + H_2O$$

$$CuCl_2 \xrightarrow{KI} Cu_2I_2 + KCl + I_2$$

A_2 is copper glance Cu_2S, a sulphide ore.

$$Cu_2S \xrightarrow[\Delta]{O_2} Cu_2O + SO_2$$

$$Cu_2S + Cu_2O \rightarrow Cu + SO_2$$

The gas SO_2 gives green color with acidified $K_2Cr_2O_7$.

$$K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \rightarrow K_2SO_4 + \underset{\text{Green}}{Cr_2(SO_4)_3} + 4H_2O$$

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (b)	2. (b)	3. (c)	4. (d)	5. (b)	6. (d)	7. (a)	8. (c)	9. (d)	10. (a)
11. (a)	12. (c)	13. (c)	14. (b)	15. (b)	16. (a)	17. (c)	18. (b)	19. (d)	20. (a)
21. (d)	22. (c)	23. (b)	24. (a)	25. (a)	26. (a)	27. (b)	28. (d)	29. (a)	30. (c)
31. (a)	32. (a)	33. (a)	34. (b)	35. (b)	36. (c)	37. (c)	38. (b)	39. (c)	40. (c)
41. (a)	42. (c)	43. (b)	44. (c)	45. (b)	46. (d)	47. (a)	48. (b)	49. (a)	50. (c)
51. (c)	52. (d)	53. (a)	54. (c)	55. (b)	56. (c)	57. (d)	58. (b)	59. (a)	60. (d)
61. (b)	62. (c)	63. (a)	64. (b)	65. (b)	66. (c)	67. (d)	68. (b)		

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a)	2. (c)	3. (b)	4. (b)	5. (d)	6. (b)	7. (b)	8. (c)	9. (d)	10. (b)
11. (a)	12. (b)	13. (c)	14. (d)	15. (c)	16. (c)	17. (c)	18. (a)	19. (a)	20. (a)
21. (d)	22. (a)	23. (b)	24. (a)	25. (b)	26. (d)	27. (b)	28. (a)	29. (a)	30. (c)
31. (d)	32. (b)	33. (c)	34. (c)	35. (a)	36. (b)	37. (d)	38. (b)	39. (b)	40. (c)
41. (c)	42. (a)	43. (c)	44. (d)	45. (d)	46. (a)	47. (d)	48. (b)	49. (b)	50. (b)
51. (c)	52. (b)	53. (c)	54. (b)	55. (c)	56. (d)	57. (d)	58. (c)	59. (c)	60. (d)
61. (c)	62. (d)	63. (b)	64. (d)	65. (d)	66. (a)	67. (c)	68. (c)		

Multiple Correct Answers Type

1. (a), (b), (c)	2. (a), (b), (d)	3. (a), (c)	4. (a), (b), (c)	5. (c), (d)
6. (a), (c), (d)	7. (a), (b), (d)	8. (a), (c)	9. (a), (b)	10. (a), (b), (c), (d)
11. (a), (b)	12. (b), (c), (d)	13. (a), (b)	14. (a), (b), (c)	15. (b), (c), (d)
16. (a), (c), (d)	17. (a), (b)	18. (a), (b), (c), (d)	19. (a), (b), (d)	20. (a), (c), (d)
21. (a), (b), (c)	22. (b), (c), (d)	23. (c), (d)	24. (a), (c)	25. (a), (b), (c)
26. (a), (c), (d)	27. (a), (b), (c), (d)	28. (a), (b), (c)	29. (a), (b), (c)	30. (a), (b), (c)
31. (a), (b), (d)	32. (c), (d)	33. (b), (c), (d)	34. (a), (b)	35. (a), (b), (c)
36. (a), (b), (d)	37. (a), (c), (b)	38. (a), (b), (d)	39. (a), (c), (d)	40. (b), (c), (d)
41. (a), (b), (d)	42. (a), (b)	43. (a), (b), (c)	44. (a), (b), (c)	45. (a), (c), (d)
46. (b), (c)	47. (a), (b)	48. (b), (c)	49. (a), (b)	50. (a), (b)
51. (b), (c), (d)	52. (a), (b)	53. (a), (b)	54. (a), (b)	55. (a), (c), (d)
56. (b), (c), (d)	57. (a), (b), (c)	58. (b), (c), (d)	59. (a), (c), (d)	60. (a), (c), (d)
61. (b), (d)	62. (a), (b)	63. (a), (b), (c)	64. (b), (c), (d)	65. (a), (b), (c)

Comprehension Type

Comprehension-1	1. (b)	2. (d)	3. (b)	4. (a)	
Comprehension-2	5. (d)	6. (a)	7. (c)		
Comprehension-3	8. (b)	9. (c)	10. (a)	11. (b)	
Comprehension-4	12. (c)	13. (a)	14. (a)	15. (b)	16. (a)
Comprehension-5	17. (c)	18. (c)			
Comprehension-6	19. (a)	20. (c)	21. (c)		
Comprehension-7	22. (c)	23. (c)	24. (a)		
Comprehension-8	25. (c)	26. (c)	27. (a)		
Comprehension-9	28. (b)	29. (c)	30. (a)		
Comprehension-10	31. (b)	32. (d)	33. (c)		
Comprehension-11	34. (d)	35. (d)	36. (b)		
Comprehension-12	37. (b)	38. (b)	39. (a)		
Comprehension-13	40. (a)	41. (d)	42. (c)	43. (b)	44. (a)
Comprehension-14	45. (c)	46. (b)	47. (d)		
Comprehension-15	48. (a)	49. (d)	50. (b)		
Comprehension-16	51. (b)	52. (d)	53. (c)		

Assertion-Reasoning Type

1. (a) 2. (a)
3. (a) 4. (b)

Matching Column Type

1. (a) s; (b) r; (c) p; (d) q
2. (a) p, q, s; (b) p,q; (c) r
3. (a) p, q, s; (b) r, t; (c) p; (d) q, s
4. (a) s; (b) p; (c) q; (d) r
5. (a) s; (b) q; (c) r; (d) p
6. (a) q; (b) s; (c) r
7. (a) r, t; (b) s; (c) p; (d) p, q
8. (a) q; (b) p; (c) t; (d) s
9. (a) q, r, s; (b) p, r, s; (c) r, s; (d) p, s
10. (a) p, q, r, s ; (b) p, s; (c) r, t; (d) p, q, r, s
11. (a) p, r; (b) q, r; (c) r, s; (d) q, t
12. (a) p, r; (b) p; (c) q; (d) s
13. (a) r; (b) p; (c) q; (d) s, t
14. (a) p, q, t; (b) p, q; (c) p, q, r, s, t; (d) p, q, r, s, t
15. (a) s; (b) r; (c) q; (d) p
16. (a) p, r; (b) q; (c) s, t; (d) q
17. (a) q, s, t; (b) p, r; (c) r, t; (d) r, t
18. (a) q; (b) r; (c) t; (d) p
19. (a) q; (b) p, s, t; (c) r; (d) s
20. (a) r; (b) p, q; (c) r, s; (d) p, q, t

Integer Answer Type

1. (2) 2. (3) 3. (2) 4. (4) 5. (3) 6. (4) 7. (2) 8. (4) 9. (3) 10. (3)
11. (2) 12. (2) 13. (3) 14. (3) 15. (2) 16. (4) 17. (4)

NCERT Exemplar Exercises

Single Correct Answer Type

1. (a) 2. (c) 3. (d) 4. (a) 5. (b) 6. (c) 7. (a) 8. (b) 9. (a) 10. (a)
11. (d) 12. (a) 13. (a)

Multiple Correct Answers Type

1. (b), (d) 2. (a), (d) 3. (a), (b) 4. (a), (c) 5. (b), (c) 6. (c), (d)
7. (b), (c) 8. (a), (c) 9. (a), (b) 10. (a), (d) 11. (a), (b) 12. (a), (c)
13. (b), (c)

Matching Column Type

1. (b) 2. (b) 3. (a) 4. (a) 5. (a)

Assertion-Reasoning Type

1. (a) 2. (a) 3. (b) 4. (b) 5. (b)

Archives

JEE (Main) Exercises

1. (c) 2. (b) 3. (a) 4. (b) 5. (a) 6. (d) 7. (d)

JEE (Advanced) Exercises

Single Correct Answer Type

1. (c) 2. (b) 3. (c) 4. (d) 5. (c) 6. (b) 7. (a) 8. (a) 9. (a) 10. (c)
11. (b) 12. (b) 13. (b) 14. (a)

Multiple Correct Answers Type

1. (a), (b) 2. (b), (d) 3. (a), (c), (d) 4. (d) 5. (c), (d) 6. (b), (c), (d)

Comprehension Type

1. (a) 2. (d) 3. (c)

Matching Column Type

1. (a) → (s); (b) → (p); (c) → (q, r); (d) → (t)
2. (a) → (q); (b) → (r); (c) → (s); (d) → (p)
3. (a) → (p, r); (b) → (p); (c) → (q); (d) → (s)
4. (a) → (p); (b) → (q); (c) → (p, r); (d) → (p, s)

4

Qualitative Inorganic Analysis

JEE (Main) Exercises

Single Correct Answer Type

1. An aqueous solution of gas (X) turns red litmus blue; then gas will be:
   (a) SO_2 (b) SO_3
   (c) NH_3 (d) None of these

2. To aqueous solution of X on adding $CuSO_4$ a brown precipitate is obtained which turns white on adding of excess of $Na_2S_2O_3$ solution; on addition of Ag^+ ion solution, a yellow curdy precipitate is obtained which is insoluble in NH_4OH; then X will be:
   (a) $Cu_2I_2 + I_3^{\ominus}$ (b) CuI_2
   (c) Cu_2I_2 (d) KI

3. A imparts green color to the flame. Its solution does not give a precipitate on passing H_2S. When it is heated with solid $K_2Cr_2O_7$ and conc. H_2SO_4, reddish brown gas is evolved. The gas when passed in an aqueous solution of NaOH turns it yellow. Find out A:
   (a) $HgCl_2$ (b) $BaCl_2$
   (c) Both (a) and (b) (d) None of these

4. Which of the following anions will give same color of gas?
   (a) $NO_2^-, NO_3^-, I^{\ominus}$ (b) $NO_2^-, NO_3^-, CH_3COO^-$
   (c) $NO_2^-, Br^{\ominus}, I^{\ominus}$ (d) $NO_2^-, NO_3^-, Br^{\ominus}$

5. Which of the following anion exist in equilibrium condition with other anion depending upon the pH of the solution?
   (a) CrO_4^{2-} (b) SO_4^{2-}
   (c) CO_3^{2-} (d) SO_3^{2-}

6. $$\underset{\text{(Mixture of two anions)}}{A} \xrightarrow{\text{Conc. } H_2SO_4} B_{(g)} + C_{(g)} \longrightarrow \text{(Gas } B \text{ and gas } C \text{ both have same color.)}$$
   $$B_{(g)} \xrightarrow{H_2O} \text{Brown color to the solution}$$
   $$C_{(g)} \xrightarrow{H_2O} \text{No color}$$
   Find out (A):
   (a) $I^{\ominus}, Br^{\ominus}$ (b) Br , NO
   (c) $C_2O_4^{2-}, NO_3^-$ (d) NO_3^-, NO_2^-

7. Select the correct statement:
   (a) Cation and anion are also called acidic or basic radicals, respectively
   (b) Classification of anion is systematic as that of cation
   (c) All the anions are deducted by soda extract solution without any exception
   (d) None of these

8. Which of the following anions are identified by dil. H_2SO_4?
   (i) CO_3^{2-} (ii) SO_3^{2-} (iii) $S_2O_3^{2-}$ (iv) NO_3^-
   (v) $I^{\ominus}$ (vi) $C_2O_4^{2-}$
   (a) $CO_3^{2-}, SO_3^{2-}, NO_3^-, S_2O_3^{2-}$
   (b) $SO_3^{2-}, S_2O_3^{2-}, I^{\ominus}, NO_3^-$
   (c) $CO_3^{2-}, SO_3^{2-}, S_2O_3^{2-}$
   (d) $CO_3^{2-}, SO_3^{2-}, NO_3^-, C_2O_4^{2-}$

9. Which of the following pair of anions will give same gas on treatment with acid?

(a) CO_3^{2-}, HCO_3^- (b) SO_3^{2-}, $S_2O_3^{2-}$
(c) NO_2^-, NO_3^- (d) All are having same gas

10. When a mixture (A) of unknown gases is passed into the dichromate solution, then orange color turns to green; when the solution is boiled and gas passed into lime water, then lime water turns milky. Find out (A).

(a) CO_2, Cl_2 (b) H_2S, CO_2
(c) Both (a) and (b) (d) None of these

11.

$$A \xrightarrow{\Delta} B_{(s)} + C_{(g)}$$

(Used as a flux in metallurgy)

$$B_{(s)} \xrightarrow{H_2O} D \xrightarrow{C_{(g)}} \text{Milky solution}$$

Find out (A).

(a) $Ca(HCO_3)_2$ (b) $CaCO_3$
(c) Both (a) and (b) (d) Na_2CO_3

12. Which of the following metal will give redox reaction with steam water only?

(a) Zn (b) Mg
(c) Fe (d) Ag

13. Which of the following acid is non-oxidizing acid?

(a) Conc. H_2SO_4 (b) Conc. H_3PO_4
(c) Conc. HNO_3 (d) None of these

14. When Ag reacts with conc. HCl, then products will be:

(a) AgCl, Cl_2 (b) AgCl, H_2
(c) AgCl, H_2, Cl_2 (d) None of these

15. Which of the following metal will form NH_4NO_3 with dil. HNO_3 (20%)?

(a) Zn (b) Sn
(c) Ag (d) None of these

16.

$$\underset{\text{Mixture of two anions}}{A} \xrightarrow[\text{excess of BaCl2}]{\text{Cold}} \text{White ppt.} \xrightarrow{\text{Filtered}}$$

$$\text{Filtrate ppt.} \xrightarrow{\text{Boil}} \text{White ppt.}$$

Find out A:

(a) CO_3^-, HSO_3^- (b) CO_3^{2-}, HCO_3^-
(c) SO_3^{2-}, HSO_3^- (d) SO_3^{2-}, CO_3^{2-}

17.

$$\underset{\text{(White ppt.)}}{A} \xrightarrow{\text{Boil}} B \text{ (White ppt.)}$$

$$\underset{\text{(White ppt.)}}{C} \xrightarrow{\text{Boil}} D \text{ (Black ppt.)}$$

A and C both have sulphur containing anion; then identify A and C:

(a) $CaSO_3$, CaS_2O_3 (b) $PbSO_3$, PbS_2O_3
(c) $BaSO_3$, BaS_2O_3 (d) $PbSO_3$, BaS_2O_3

18. White ppt. of silver gives brown ppt. on boiling, but when it is heated (> 300°C), then a metallic black ppt. is obtained. Identify the compound of silver having white ppt:

(a) Ag_2SO_3 (b) $Ag_2S_2O_3$
(c) Ag_2CO_3 (d) AgCl

19. Which of the following complex of silver is not allowed on stand?

(a) $[Ag(NH_3)_4]^{\oplus}$ (b) $[Ag(CN)_2]^{\ominus}$
(c) $[Ag(NH_3)_2]^+$ (d) $Ag_2S_2O_3$

20. When $HgCl_2$ reacts with CO_3^{2-} anion, then:

(a) Reddish brown precipitate of $HgCO_3 \cdot 2HgO$ is formed
(b) Brownish red precipitate of $HgCO_3 \cdot 3HgO$ is formed
(c) Reddish brown precipitate of $HgCO_3 \cdot 3HgO$ is formed
(d) Blue ppt. of $Hg_4O_4CO_3$ is formed

21.

$$A \xrightarrow{\Delta} B + C_{(g)} + D_{\text{(Liquid at room temp.)}}$$

$$C_{(g)} \xrightarrow{\text{Dil. HCl}} B$$

(Sparingly soluble in water)

$$B \xrightarrow{\Delta} \text{Melt}$$

$$C_{(g)} \xrightarrow{\text{Baryta water}} \text{White turbidity}$$

Find out A, B, C, and D.

(a) Na_2CO_3, $NaHCO_3$, CO_2, H_2O
(b) $NaHCO_3$, Na_2O, CO_2, H_2O
(c) $NaHCO_3$, Na_2CO_3, CO_2, H_2O
(d) $KHCO_3$, K_2CO_3, CO_2, H_2O

22.

$$\underset{\text{(Mixture of two anions)}}{A} \xrightarrow[\text{excess of BaCl}_2]{\text{Cold}} \text{White ppt.} \xrightarrow{\text{filtered}}$$

$$\text{filtrate} \xrightarrow{\text{boil}} \text{White ppt.}$$

Find out (A).

(a) SO_3^{2-}, HSO_3^- (b) CO_3^{2-}, SO_3^{2-}
(c) SO_3^{2-}, $HCO_3^{\ominus}$ (d) None of these

23. A salt is made of bivalent ions X and Y, each of which is capable of decolorizing acidified $KMnO_4$ solution. The salt is likely to be:

(a) Stannic chloride (b) Ferric sulphate
(c) Ferrous sulphate (d) Ferrous oxalate

24. Which of the following salt will evolve sulphur dioxide gas along with formation of yellowish turbidity when treated with dilute H_2SO_4?

(a) Sodium sulphide (b) Sodium sulphite
(c) Sodium thiosulphate (d) Sodium sulphate

25. A colorless salt gives white precipitate with $CaCl_2$ solution. The salt also decolorizes acidified MnO_4^- with effervescence. On reaction with conc. H_2SO_4, the salt gives a colorless gaseous mixture containing:

(a) CO, CO_2 (b) CO_2, SO_2
(c) CO_2, H_2S (d) None of these

26. Aqueous solution of a salt + $MgSO_4$ solution $\longrightarrow$ no ppt. in cold $\xrightarrow{\text{Heating}}$ White ppt. appears

The salt contains the acidic radical:

(a) CO_3^{2-} (b) HCO_3^-
(c) SO_3^{2-} (d) $C_2O_4^{2-}$

27. Which of the following compound is formed when CO_2 gas is passed through an aqueous solution of sodium chromate?

(a) $Cr(OH)_3$ is precipitated
(b) Yellow solution of $Cr_2(CO_3)_2$ is formed
(c) Orange solution of $Na_2Cr_2O_7$ is formed
(d) No reaction

28. Which of the following ion gives a suffocating gas when treated with dilute HCl?

(a) Carbonate (b) Sulphite
(c) Sulphate (d) Borate

29. The acidic solution of a salt produces blue color with KI starch solution. The salt may be:

(a) Sulphite (b) Bromide
(c) Nitrite (d) Chloride

30. Sulphite on treatment with dil. H_2SO_4 liberates a gas which:

(a) Turns lead acetate paper black
(b) Burns with blue flame
(c) Smells like vinegar
(d) Turns acidified $K_2Cr_2O_7$ paper green

31. Violet vapors are given out when ..... is treated with conc. H_2SO_4.

(a) Bromide (b) Iodide
(c) Chloride (d) Nitrate

32. The color developed when sodium sulphide is added to sodium nitroprusside is:

(a) Purple (b) Yellow
(c) Red (d) Black

33. Which of the following compound does not gives ppt. with dil HCl?

(a) $AgNO_3$ (b) $Pb(NO_3)_2$
(c) $Hg_2(NO_3)_2$ (d) $Cu(NO_3)_2$

34. A gas is obtained by addition of dil. H_2SO_4 to a mixture which turns lead acetate paper black. It is:

(a) SO_2 (b) CO_2
(c) H_2S (d) NO_2

35. A mixture when rubbed with organic acid smells like vinegar. It contains:

(a) Sulphite (b) Nitrate
(c) Nitrite (d) Acetate

36. Soda extract is prepared by:

(a) Fusing soda and mixture and then extracting with water
(b) Dissolving $NaHCO_3$ and mixture in dil. HCl
(c) Boiling Na_2CO_3 and mixture, in dil. HCl
(d) Boiling Na_2CO_3 and mixture, in distilled water

37. For the tests of halides, the soda extract is acidified with:

(a) Conc. H_2SO_4 (b) Dil. HNO_3
(c) Dil. HCl (d) Any of the three

38. When an aqueous solution of gas (X) is added to $FeCl_3$ solution, a brown precipitate is obtained which is soluble in dil. HNO_3; gas (X) will give white fumes with HCl, then gas (X) is:

(a) SO_2 (b) Cl_2
(c) CO_2 (d) NH_3

39. A white solid is first heated with dilute H_2SO_4 and then with concentrated H_2SO_4. No action is observed in either case. The solid contains:

(a) Sulphide (b) Sulphite
(c) Sulphate (d) Thiosulphate

40. A precipitate of calcium oxalate will not dissolve in:

(a) Acetic acid (b) HCl
(c) HNO_3 (d) Aqua-regia

41. The brown ring test is performed for the qualitative detection of:

(a) Bromides (b) Iodides
(c) Nitrates (d) Phosphates

42. Which compound does not dissolve in hot dil. HNO_3?

(a) HgS (b) PbS
(c) CuS (d) CdS

43. Which one is not the interfering radical?

(a) PO_4^{3-} (b) BO_3^{3-}
(c) F^- (d) SO_4^{2-}

44. In the test for iodine, I_2 is treated with sodium thiosulphate ($Na_2S_2O_3$):

$$Na_2S_2O_3 + I_2 \longrightarrow NaI + ...$$

(a) $Na_2S_4O_6$ (b) Na_2SO_4
(c) Na_2S (d) Na_3ISO_4

45. Which of the following sulphides is yellow in color?
(a) CuS (b) CdS
(c) ZnS (d) CoS

46. Brown ring in the test of NO_3^- is formed due to the formation of:
(a) $FeSO_4 \cdot NO$ (b) $[Fe(SO_4)_2 \cdot HO] \cdot H_2O$
(c) $Fe_2(SO_4)_3 \cdot NO$ (d) None of these

47. The brown ring test for nitrates depends on:
(a) The reduction of nitrate to nitric oxide
(b) Oxidation of nitric oxide to nitrogen dioxide
(c) Reduction of ferrous sulphate to iron
(d) Oxidizing action of sulphuric acid

48. A sodium salt of unknown anion when treated with $MgCl_2$ gives white precipitate only on boiling. The anion is:
(a) SO_4^{2-} (b) HCO_3^-
(c) CO_3^{2-} (d) NO_3^-

49. In the brown ring test, the brown color of the ring is due to:
(a) A mixture to NO and NO_2
(b) Nitrosoferrous sulphate
(c) Ferrous nitrate (d) Ferric nitrate

50. S^{2-} and SO_3^{2-} can be distinguished by using:
(a) $(CH_3COO)_2Pb$ (b) $Na_2[Fe(CN)_5NO]$
(c) Both (a) and (b) (d) None of these

51. An aqueous solution containing Hg^{2+}, Hg_2^{2+}, Pb^{2+}, and Cd^{2+} ions will give precipitates of ..... with HCl.
(a) Hg_2Cl_2 only (b) $PbCl_2$ only
(c) Hg_2Cl_2 and $PbCl_2$ (d) $HgCl_2$ and $PbCl_2$

52. Which one of the following pairs of ions cannot be separated by H_2S in dilute HCl?
(a) Bi^{3+}, Sn^{4+} (b) Al^{3+}, Hg^{2+}
(c) Cu^{2+}, Zn^{2+} (d) Ni^{2+}, Cu^{2+}

53. In qualitative analysis, Cd is under:
(a) I group (b) II group
(c) III group (d) IV group

54. Which compound does not dissolve in hot dil. HNO_3?
(a) HgS (b) PbS
(c) CuS (d) CdS

55. Which of the following metal sulphides has maximum solubility in water?
(a) HgS, $K_{sp} = 10^{-54}$ (b) CdS, $K_{sp} = 10^{-30}$
(c) FeS, $K_{sp} = 10^{-20}$ (d) ZnS, $K_{sp} = 10^{-22}$

56. The compound formed in the borax-bead test of Cu^{2+} ion in oxidizing flame is:
(a) Cu (b) $CuBO_2$
(c) $Cu(BO_2)_2$ (d) None of these

57. Identify the correct order of solubility of Na_2S, CuS, and ZnS in aqueous medium:
(a) CuS > ZnS > Na_2S (b) ZnS > Na_2S > CuS
(c) Na_2S > CuS > ZnS (d) Na_2S > ZnS > CuS

58. Potassium chromate solution is added to an aqueous solution of a metal chloride. The precipitates thus obtained are insoluble in acetic acid. These are subjected to flame test; the color of the flame is:
(a) Lilac (b) Apple green
(c) Crimson red (d) Golden yellow

59. Consider the following observation:
M^{n+} + HCl $\longrightarrow$ White precipitate $\xrightarrow{\Delta}$ Water soluble
The metal ion M^{n+} will be:
(a) Hg^{2+} (b) Ag^+
(c) Pb^{2+} (d) Sn^{2+}

60. When H_2S is passed through Hg_2^{2+}, we get:
(a) HgS (b) HgS + Hg_2S
(c) HgS + Hg (d) Hg_2S

61. In Nessler's reagent for detection of ammonia, the active species is:
(a) Hg_2Cl_2 (b) Hg^{2+}
(c) Hg_2I_2 (d) HgI_4^{2-}

62. Precipitation of IV group cations takes place when H_2S passed is:
(a) Less ionized (b) Highly ionized
(c) Not ionized (d) None of these

63. Nessler's reagent is:
(a) $NaHgCl_4$ (b) K_2HgI_4/OH^-
(c) $Hg(NH_3)_2Cl$ (d) K_2HgI_4

64. To a metal nitrate, when KI solution is added, a black precipitate is produced at first; on adding excess of KI, orange solution is produced. Identify the metal ion:
(a) Hg^{2+} (b) Bi^{3+}
(c) Cu^{2+} (d) Pb^{2+}

65. The formula of the compound which gives violet color in Lassaigne's test for sulphur with sodium nitroprusside is:

(a) $Na_4[Fe(CN)_6S]$ (b) $Na_4[Fe(CN)_5NCS]$
(c) $Na_4[Fe(CN)_5NOS]$ (d) $Na_2[Fe(CN)_5NOS]$

66. When H_2S gas is passed through HCl containing aqueous solution of $CuCl_2$, $HgCl_2$, $BiCl_3$, and $CoCl_2$, it does not precipitate out:
(a) CuS (b) HgS
(c) Bi_2S_3 (d) CoS

67. Yellow color solution of $FeCl_3$ changes to light green when:
(a) $SnCl_2$ is added (b) Zn is added
(c) H_2S gas is passed (d) All are true

68. $Fe(OH)_3$ and $Cr(OH)_3$ ppt. are separated by:
(a) aq. NH_3 (b) HCl
(c) NaOH / H_2O_2 (d) H_2SO_4

69. Turnbull's blue and Prussian's blue, respectively, are:
$Fe^{II}[Fe^{II}(CN)_6]^{2-}$ (I) $Fe^{III}[Fe^{III}(CN)_6]$ (II)
$Fe^{II}[Fe^{III}(CN)_6]^{3-}$ (III) $Fe^{III}[Fe^{II}(CN)_6]^{4-}$ (IV)
(a) I, II (b) I, III
(c) III, IV (d) IV, III

70. Ferric alum gives red color with NH_4SCN due to formation of:
(a) $Al(SCN)_3$ (b) $FeSO_4$
(c) $Fe(SCN)_3$ (d) $Fe(SCN)_2$

71. H_2S would separate the following at pH < 7:
(a) Zn^{2+}, Co^{2+} (b) Cu^{2+}, Cd^{2+}
(c) Cu^{2+}, Cr^{3+} (d) Cu^{2+}, As^{3+}

72. Solution of (X) in dil. HCl + H_2O ⟶ White turbidity
(X) $\xrightarrow{H_2S/HCl}$ Brown ppt. (Y)
X is:
(a) Bi^{3+} (b) Pb^{2+}
(c) Cd^{2+} (d) Cu^{2+}

73. $AgNO_3$ gives white ppt. with hypo changing to black after some-time. Black ppt. is of:
(a) $Ag_2S_2O_3$ (b) Ag_2SO_4
(c) $Ag_2S_4O_6$ (d) Ag_2S

74. Ag_2S is soluble in NaCN due to formation of:
(a) $Na[Ag(CN)_2]$ (b) $Ag(CN)_2$
(c) $Na_2[Ag(CN)_3]$ (d) $Na_2[Ag(CN)_2]$

75. Cu^{2+} and Ag^+ are both present in the same solution. To precipitate one of the ions and leave the other in solution, add:
(a) $H_2S_{(aq)}$ (b) $HCl_{(aq)}$
(c) $HNO_{3(aq)}$ (d) $NH_4NO_{3(aq)}$

76. Of the following solutions, the one that is acidic is:
(a) $ZnSO_{4(aq)}$ (b) $NaAl(OH)_{4(aq)}$
(c) $NaHCO_{3(aq)}$ (d) $KNO_{3(aq)}$

77. With MnO, color of the bead in sodium carbonate-bead test is:
(a) Pink (b) Black
(c) Yellow (d) Green

78. With Cr_2O_3, color of the bead in sodium carbonate-bead test is:
(a) Red (b) Blue
(c) Yellow (d) Green

79. KI gives precipitate with all the cations given:
(a) Ag^+, Hg_2^{2+}, Pb^{2+} (b) Cu^{2+}, Zn^{2+}, Ni^{2+}
(c) Na^+, Ca^{2+}, Mg^{2+} (d) Ag^+, Ca^{2+}, Sr^{2+}

80. Aq. (A) + K_2CrO_4 ⟶ (B) (Red ppt.) $\xrightarrow{aq.\ NH_3}$ (C) (Black)
A is:
(a) $AgNO_3$ (b) $Pb(NO_3)_2$
(c) $Hg_2(NO_3)_2$ (d) $Ca(NO_3)_2$

81. The ion most difficult to remove as a precipitate is:
(a) Ag^+ (b) NH_4^+
(c) Fe^{3+} (d) Cu^{2+}

82. A colorless gas is dissolved in water and the resulting solution turns red litmus blue; the gas may have been which one of the following?
(a) HCl (b) H_2S
(c) SO_2 (d) NH_3

83. What would you observe if you add with shaking, excess dil. NaOH solution to $ZnCl_2$ solution?
(a) A white ppt.
(b) A white ppt. which later dissolves
(c) A green ppt.
(d) A green ppt. which later dissolves

84. A mixture is known to contain NO_3^- and NO_2^-. Before performing ring test for NO_3^-, the aqueous solution should be made free of NO_2^-. This is done by heating aqueous extract with:
(a) Conc. HNO_3 (b) Dil. HNO_3
(c) Urea (d) Zinc dust

85. A suspension containing insoluble substances HgS and FeS is treated with 2NHCl. On filtering, the filtrate contained appreciable amounts of which one of the following?
(a) Mercury, iron (b) Only iron
(c) Only mercury (d) None of these

86. In the separation of Cu^{2+} and Cd^{2+} in 2nd group of qualitative analysis of cations, tetrammine copper(II) sulphate and tetraammine cadmium(II) sulphate react with KCN to form the corresponding cyanide complexes; which one of the following pairs of the complexes and their relative stabilities enables the separation of Cu^{2+} and Cd^{2+}?

(a) $K_3[Cu(CN)_4]$: less stable and $K_2[Cd(CN)_4]$: more stable

(b) $K_3[Cu(CN)_4]$: more stable and $K_2[Cd(CN)_4]$: less stable

(c) $K_2[Cu(CN)_4]$: less stable and $K_2[Cd(CN)_4]$: more stable

(d) $K_2[Cu(CN)_4]$: more stable and $K_2[Cd(CN)_4]$: less stable

87. Which reagent is used to remove SO_4^{2-} or Cl^- from water?

(a) NaOH (b) $Pb(NO_3)_2$

(c) $BaSO_4$ (d) KOH

88. AgCl with NH_3 forms a complex:

(a) $Ag(NH_3)_2Cl$ (b) $AgNO_3$

(c) $AgNH_2Cl$ (d) Ag mirror

89. Acidic solution of a salt produced deep blue color with starch and KI. The salt is:

(a) Chloride (b) Nitrite

(c) Acetate (d) Bromide

90. $CuSO_4$ reacts with NH_4OH to give deep blue complex of:

(a) Copperammonium sulphate

(b) Copperammonium hydroxide

(c) Both (a) and (b)

(d) None of these

91. Prussian blue is formed when:

(a) Ferrous sulphate reacts with $FeCl_3$

(b) Ferric sulphate reacts with $K_4[Fe(CN)_6]$

(c) Ferrous ammonium sulphate reacts with $FeCl_3$

(d) Ammonium sulphate reacts with $FeCl_3$

92. Which compound will not give positive chromyl chloride test?

(a) Copper chloride, $CuCl_2$

(b) Mercuric chloride, $HgCl_2$

(c) Zinc chloride, $ZnCl_2$

(d) Anilinium chloride, $C_6H_5NH_3^+Cl^-$

93. A metal salt solution forms a yellow precipitate with potassium chromate in acetic acid, a white precipitate with dil. sulphuric acid, but gives no precipitate with sodium chloride or iodide. The white precipitate obtained when sodium carbonate is added to the metal salt solution consists of:

(a) Lead carbonate (b) Basic lead carbonate

(c) Barium carbonate (d) Strontium carbonate

94. An inorganic salt solution gives a yellow precipitate with silver nitrate. The precipitate dissolves in dil. nitric acid as well as in ammonium hydroxide. The solution contains:

(a) Bromide (b) Iodide

(c) Phosphate (d) Chromate

95. Which cation is detected by the flame test?

(a) NH_4^+ (b) K^+

(c) Mg^{2+} (d) Al^{3+}

96. Strongly acidified solution of barium nitrate gives a white precipitate with.....which did not dissolve even after large addition of water:

(a) Sodium phosphate (b) Sodium carbonate

(c) Sodium sulphate (d) Sodium chloride

97. A substance on treatment with dil. H_2SO_4 liberates a colorless gas which produces (i) turbidity with baryta water and (ii) turns acidified dichromate solution green. The reaction indicates the presence of:

(a) CO_3^{2-} (b) S^{2-}

(c) SO_3^{2-} (d) NO_2^-

98. Ca, Ba, and Sr ions are precipitated in fifth group as their:

(a) Oxides (b) Sulphates

(c) Carbonates (d) Sulphides

99. Conc. H_2SO_4 on addition to dry KNO_3 gives brown fumes of:

(a) SO_2 (b) SO_3

(c) NO (d) NO_2

100. Ferric ion forms a prussian blue colored ppt. due to the formation of:

(a) $K_4[Fe(CN)_6]$ (b) $Fe_4[Fe(CN)_6]_3$

(c) $KMnO_4$ (d) $Fe(OH)_3$

101. In the precipitation of the iron group in qualitative anlaysis, ammonium chloride is added before adding ammonium hydroxide to:

(a) Decrease concentration of OH^- ions

(b) Prevent interference by phosphate ions

(c) Increase concentration of Cl^- ions

(d) Increase concentration of NH_4^+ ions

102. H_2S gas, on passing through an alkaline solution, forms a white precipitate. The solution contains ions of:
(a) Pb (b) Zn
(c) Cu (d) Ni

103. Which gives violet color with borax?
(a) Fe (b) Pb
(c) Co (d) Mn

104. Yellow ammonium sulphide solution is a suitable reagent used for the separation of:
(a) HgS and PbS (b) PbS and Bi_2S_3
(c) Bi_2S_3 and CuS (d) CdS and As_2S_3

105. An orange red precipitate obtained by passing H_2S through an acidified solution of an inorganic salt indicates the presence of:
(a) Cadmium (b) Tin
(c) Antimony (d) Bismuth

106. The presence of NH_4^+ radical in solution can be detected by:
(a) Fehling's solution (b) Benedict's solution
(c) Schiff's reagent (d) Nessler's reagent

107. Excess of concentrated sodium hydroxide can separate a mixture of:
(a) Al^{3+} and Cr^{3+} (b) Cr^{3+} and Fe^{3+}
(c) Al^{3+} and Zn^{3+} (d) Zn^{2+} and Pb^{2+}

108. Potassium thiocyanate solution reacts with ferric chloride to give:
(a) Pink color (b) Deep blue color
(c) Green color (d) Blood-red color

109. A green mass is formed in the charcoal cavity test when a colorless salt (*X*) is fused with cobalt nitrate. (*X*) may contain:
(a) Aluminium (b) Copper
(c) Barium (d) Zinc

110. Which of the following sulphides has the maximum solubility product?
(a) HgS (b) PbS
(c) CuS (d) MnS

111. A white metal sulphide soluble in water is:
(a) CuS (b) Na_2S
(c) PbS (d) ZnS

112. Lead has been placed in qualitative group analysis 1st and 2nd because:
(a) It shows the valency one and two
(b) It forms insoluble $PbCl_2$
(c) It forms lead sulphide
(d) $PbCl_2$ is partially soluble in water

113. As_2S_3 is:
(a) Black (b) Yellow
(c) Orange (d) White

114. A black sulphide is formed by the action of H_2S on:
(a) $CuCl_2$ (b) $CdCl_2$
(c) $ZnCl_2$ (d) NaCl

115. $Pb(CH_3COO)_2$ gives.....color with H_2S:
(a) Black (b) White
(c) Red (d) Orange

116. Acidified $K_2Cr_2O_7$ turns green by:
(a) CO_2 (b) SO_3
(c) SO_2 (d) HNO_3

117. Chemical volcano is produced on heating:
(a) $K_2Cr_2O_7$ (b) $(NH_4)_2Cr_2O_7$
(c) $ZnCr_2O_7$ (d) K_2CrO_4

118. Which gives blood red color with ammonium thiocyanate?
(a) Fe^{3+} (b) Fe^{2+}
(c) Cu^{2+} (d) Cd^{2+}

119. A salt having BO_3^{3-} on burning with alcohol and conc. H_2SO_4 gives ..... edge flame:
(a) Green (b) Yellow
(c) Red (d) White

120. Carbonates of Ba, Sr, and Ca are:
(a) White (b) Blue
(c) Green (d) Yellow

121. The II group precipitates soluble in yellow ammonium sulphide may be:
(a) As, Sb, Sn (b) Cu, Hg, Bi, Cd
(c) Both (a) and (b) (d) None of these

122. CaC_2O_4 is .....in water:
(a) Insoluble (b) Soluble
(c) Complex (d) None of these

123. Nitric acid is generally not used for preparation of original solution in analysis of basic radicals, because it:
(a) Is oxidizing agent (b) Is reducing agent
(c) Forms insoluble nitrates
(d) Forms soluble nitrates

124. When dimethyl glyoxime solution is added to an aqueous solution of nickel chloride in presence of ammonium hydroxide:
(a) A black ppt. is formed
(b) A blue ppt. is formed
(c) A rose red ppt. is formed
(d) No ppt. is formed

125. A white salt soluble in NH_4OH but insoluble in water is:

(a) $BaSO_4$ (b) $CuSO_4$
(c) $PbSO_4$ (d) AgCl

126. The sulphide not soluble in hot dilute nitric acid is:

(a) CuS (b) ZnS
(c) CdS (d) HgS

127. KBr, on reaction with conc. H_2SO_4, gives reddish-brown gas:

(a) Bromine
(b) Mixture of bromine and HBr
(c) HBr (d) NO_2

128. Formation of a green-edged flame on igniting the vapors evolved by heating a given inorganic salt with a few mL of ethyl alcohol and conc. H_2SO_4 indicates the presence of a:

(a) Tartrate (b) Oxalate
(c) Acetate (d) Borate

129. The compound which turns black with NH_4OH is:

(a) Lead chloride (b) Mercurous chloride
(c) Mercuric chloride (d) Silver chloride

130. Formation of a rosy-red precipitate when a slightly alkaline solution of an inorganic salt is treated with dimethyl glyoxime confirms the presence of:

(a) Cobalt (b) Zinc
(c) Iron (d) Nickel

131. The metal that does not give the borax bead test is:

(a) Cr (b) Ni
(c) Pb (d) Mn

132. H_2S will precipitate the sulphides of all the metals from the solution of chlorides of Cu, Zn, and Cd if:

(a) The solution is aqueous
(b) The solution is acidic
(c) The solution is dilute acidic
(d) Any of the above solutions is present

133. To a solution of a substance, gradual addition of ammonium hydroxide results in a black precipitate which does not dissolve in excess of NH_4OH. However, when HCl is added to the original solution, a white precipitate is formed. The solution contained:

(a) Lead salt (b) Silver salt
(c) Mercurous salt (d) Copper salt

134. A compound is soluble in water. If ammonia is added to aqueous solution of the compound, a brown precipitate appears which is soluble in dil. HCl. The compound has:

(a) Aluminium (b) Zinc
(c) Iron (d) Cadmium

135. A light green colored salt soluble in water gives black precipitate on passing H_2S which dissolves readily in HCl. The metal ion present is:

(a) Co^{2+} (b) Fe^{2+}
(c) Ni^{2+} (d) Ag^{+}

136. An inorganic salt when heated evolves colored gas which bleaches moist litmus paper. The evolved gas is:

(a) NO_2 (b) SO_2
(c) N_2O (d) I_2

137. All ammonium salts liberate ammonia when:

(a) Heated with HCl (b) Heated with caustic soda
(c) Heated with H_2SO_4 (d) Heated with $NaNO_2$

138. Silver, mercury, and lead are grouped together in a scheme of qualitative analysis because they form:

(a) Nitrates
(b) Carbonates which dissolve in dil. HNO_3
(c) Insoluble chlorides (d) Colorless compounds

139. Manganese salt + PbO_2 + conc. $HNO_3 \longrightarrow$ The solution has purple color.
The color is due to:

(a) $HMnO_4$ (b) A lead salt
(c) $Mn(NO_3)_2$ (d) H_2MnO_4

140. An orange precipitate of II group is dissolved in conc. HCl; the solution when treated with excess of water turns milky due to formation of:

(a) Sn(OH)Cl (b) $Sb(OH)Cl_2$
(c) SbOCl (d) $Sb(OH)_2Cl$

JEE (Advanced) Exercises

Single Correct Answer Type

1. Which of the following sulphide is not soluble in dil. HNO_3?

(a) PbS (b) HgS
(c) ZnS (d) Bi_2S_3

2. Which of the following solutions gives precipitate with $Pb(NO_3)_2$ but not with $Ba(NO_3)_2$?

(a) Sodium chloride (b) Sodium sulphate
(c) Sodium nitrate
(d) Sodium hydrogen phosphate

3. The color developed when sodium sulphide is added to sodium nitroprusside is:
(a) Violet (b) Yellow
(c) Red (d) Black

4. A white powder when strongly heated gives off brown fumes. A solution of this powder gives a yellow precipitate with a solution of KI. When a solution of barium chloride is added to a solution of powder, a white precipitate results. This white powder may be:
(a) A soluble sulphate (b) KBr or NaBr
(c) $Ba(NO_3)_2$ (d) $AgNO_3$

5. In qualitative analysis, Cd^{2+} is under:
(a) I group (b) II group
(c) III group (d) IV group

6. The ion that cannot be precipitated by both HCl and H_2S is:
(a) Pb^{2+} (b) Ba^{2+}
(c) Ag^{+} (d) Sn^{2+}

7. Which sulphide is insoluble in dilute acids but soluble in alkalies:
(a) PbS (b) CdS
(c) FeS (d) As_2S_3

8. An aqueous solution of a substance gives a white precipitate on treatment with dilute hydrochloric acid, which dissolves on heating. When hydrogen sulphide is passed through the hot acidic solution, a black precipitate is obtained. The substance is a/an:
(a) Hg_2^{2+} salt (b) Cu^{2+} salt
(c) Ag^{+} salt (d) Pb^{2+} salt

9. When $S_2O_3^{2-}$ ion reacts with *X* cation, then first redox reaction takes place and after this ppt. reaction; then *X* may be:
(a) Cu^{2+} (b) Fe^{3+}
(c) Hg^{2+} (d) Bi^{3+}

10. Which is soluble in water?
(a) AgF (b) AgCl
(c) AgBr (d) AgI

11. Using dil. HCl, which of the following radical cannot be confirmed:
(a) S^{2-} (b) $S_2O_3^{2-}$
(c) CO_3^{2-} (d) NO_2^{-}

12. When $K_2Cr_2O_7$ is heated with conc. H_2SO_4 and soluble chloride such as KCl:
(a) Red vapors of CrO_2Cl_2 are evolved
(b) Cl^{-} ion is oxidized to Cl_2 gas
(c) $CrCl_3$ is formed
(d) $Cr_2O_7^{2-}$ ion is reduced to green Cr^{3+} ion

13. A salt on heating with dilute H_2SO_4 and subsequently treatment with a few drops of dilute $K_2Cr_2O_7$ turns into green solution. The salt may be a:
(a) Sulphate (b) Nitrate
(c) Sulphide (d) Chromate

14. The reagents NH_4Cl and aqueous NH_3 will precipitate:
(a) Ca^{2+} (b) Al^{3+}
(c) Mg^{2+} (d) Zn^{2+}

15. In a mixture of PbS, ZnS, and FeS_2, each component is separated from the other by using the reagents in which of the following sequence in froth floatation process?
(a) Potassium ethyl xanthate, KCN, NaOH, copper sulphate, acid
(b) KCN, $CuSO_4$, acid
(c) Potasssium ethyl xanthate, KCN
(d) None of these

16. A doctor by mistake administers a $Ba(NO_3)_2$ solution to a patient for radiography investigations. Which of the following should be given as the best to prevent the absorption of soluble barium?
(a) Na_2SO_4 (b) NaCl
(c) NH_4Cl (d) Na_2CO_3

17. Which of these is the correct group reagent for group cations?
(a) Mn^{2+} Co^{2+} Zn^{2+} Ni^{2+}; dil. HCl
(b) Mn^{2+} Co^{2+} Zn^{2+} Ni^{2+}; $NH_4Cl + NH_4OH + H_2S$
(c) Mn^{2+} Co^{2+} Zn^{2+} Ni^{2+}; $NH_4Cl + NH_4OH$
(d) Mn^{2+} Co^{2+} Zn^{2+} Ni^{2+}; $HCl + H_2S$

18. A white solid imparts a violet color to a Bunsen flame. On being heated with concentrated H_2SO_4, the solid gives violet vapors that turn starch paper blue. The salt may be:
(a) KI (b) NaI
(c) MgI_2 (d) $CaBr_2$

19. Thenard blue is:
(a) $Cu(NH_3)_4SO_4$ (b) $CoAl_2O_4$
(c) $K_2Fe[Fe(CN)_6]$ (d) $Fe_4[Fe(CN)_6]_3$

20. The chocolate colored precipitate is:
(a) $[Fe(H_2O)_5(NO)]SO_4$ (b) $Fe_2[Fe(CN)_6]$
(c) $Cu_2[Fe(CN)_6]$ (d) $HgSO_4$

21. Among the species A ($CrCl_3$), B (CuS), C ($AlCl_3$), D ($ZnCl_2$), which will be soluble in excess of NaOH?

(a) A, C, and D (b) C and D only
(c) B and C only (d) A and D only

22. $2Ag^+ \text{(excess)} + S_2O_3^{2-} \longrightarrow Ag_2S_2O_3 \xrightarrow[\Delta]{H_2O} X + H_2SO_4$

$2\,NO_2^- + 2I^- \xrightarrow{\text{acidic medium}} Y + I_2 + 2H_2O$

Suggest the formula of the products X and Y.

(a) $X = Ag_2O$, $Y = N_2$ (b) $X = Ag_2S$, $Y = N_2$
(c) $X = Ag_2O$, $Y = 2NO_2$ (d) $X = Ag_2S$, $Y = 2NO$

23.

$$A \text{ (Colorless salt)} \xrightarrow{\Delta} \underbrace{B + C}_{\text{Gas}} + D \xrightarrow{H_2O} E$$

Gas (C) turns solution (E) milky. (B) burns with blue flame. (A) also decolorizes MnO_4^-/H^+.

Thus (A), (B), (C), (D), and (E) are:

(a) $A = CaC_2O_4$, $B = CO_2$, $C = CO$, $D = CaO$, $E = Ca(OH)_2$
(b) $A = CaCO_3$, $B = CaO$, $C = CO$, $D = CO_2$, $E = Ca(OH)_2$
(c) $A = CaCl_2$, $B = Cl_2$, $C = O_2$, $D = CaO$, $E = Ca(OH)_2$
(d) $A = CaC_2O_4$, $B = CO$, $C = CO_2$, $D = CaO$, $E = Ca(OH)_2$

24. Which acid forms salts of any metal usually water soluble?

(a) $HClO_4$ (b) CH_3COOH
(c) HNO_3 (d) H_2CO_3

25. During the presence of SO_3^{2-} and S^{2-} in a mixture, with addition of dil. H_2SO_4, one can notice:

(a) SO_2 and H_2S are not formed
(b) SO_2 and H_2S formed undergo a redox change forming colloidal sulphur and thus no smell
(c) A smell of rotten egg
(d) A smell of burning sulphur

26. Which of the following is not a protonic acid?

(a) $PO(OH)_3$ (b) $B(OH)_3$
(c) $SO(OH)_2$ (d) $SO_2(OH)_2$

27. Which of the following will be precipitates when H_2S gas is passed through their solutions at pH = 10.0?

(a) Na^+ (b) Ba^{2+}
(c) Zn^{2+} (d) Ca^{2+}

28. $A \xrightarrow{\Delta} B + C_{(g)} + D_{(g)}$

(Solid) (Brown residue)

$\downarrow$ Aqueous NaOH

E (dirty green precipitate) $\xrightarrow[\text{to air}]{\text{on exposure}} F$

Find out A.

(a) $FeCl_3$ (b) $Fe_2(SO_4)_3$
(c) $FeSO_4$ (d) All are correct

29. $(D) \xleftarrow[\text{presence of HCl}]{BaCl_2 \text{ in}} (A) \xrightarrow[\text{with } K_2HgI_4]{\text{aq.solution}} (B)$

white ppt. (Light green) Brown ppt.

crystalline compound

$\downarrow$ Aqueous solution with $K_4[Fe(CN)_6]$

(C) Blue

Find out (A):

(a) $FeSO_4$ (b) $(NH_4)_2SO_4$
(c) $FeSO_4(NH_4)_2SO_4 \cdot 6H_2O$
(d) None of these

30. $Fe + \text{conc. } HNO_3 \longrightarrow X$
(> 80%)

Then X will be:

(a) Fe_2O_3 (b) FeO
(c) Fe_3O_4 (d) None of these

31. Select the incorrect statement:

(a) When SO_3^{2-} reacts with $Pb(NO_3)_2$, then a white ppt. is formed; on boiling, the precipitate is oxidized by atmospheric oxygen and lead sulphate is formed.
(b) White ppt. of $PbSO_3$ is soluble in dil. HNO_3, and excess of NaOH solution.
(c) When white ppt. of Ag_2SO_3 is boiled, then brown and metallic black ppt. is formed
(d) Ag_2SO_3 is insoluble in excess of Na_2SO_3 solution

32. When an aqueous solution of gas (X) is added in excess to a copper sulphate solution, a deep blue color is obtained; then gas is:

(a) CH_3COOH (b) NH_3
(c) SO_2 (d) None of these

33. When a mixture containing phosphate is heated with conc. HNO_3 and ammonium molybdate solution, a canary yellow precipitate is formed. The formula of the yellow precipitate is:

(a) $(NH_4)_3PO_4$ (b) $(NH_4)_3PO_4 \cdot 12MoO_4$
(c) $(NH_4)_3PO_4 \cdot 12MoO_3$
(d) $(NH_4)_3PO_4 \cdot (NH_4)_2 \cdot MoO_4$

34. A solution of a metal ion when treated with KI gives a red precipitate which dissolves in excess of KI to give a colorless solution. Moreover, the solution of metal

ion on treatment with a solution of cobalt(II)thiocyanate gives rise to deep blue crystalline precipitate. The metal ion is:

(a) Pb^{2+} (b) Hg^{2+}
(c) Cu^{2+} (d) Co^{2+}

35. $[X]$ + dil. $H_2SO_4 \longrightarrow [Y]$ colorless gas with suffocating smell

$[Y] + K_2Cr_2O_7 + H_2SO_4 \longrightarrow$ green solution

$[X]$ and $[Y]$ are:

(a) SO_3^{2-} and SO_2 (b) Cl^- and HCl
(c) S^{2-} and H_2S (d) CO_3^{2-} and CO_2

36. A colorless salt A $\xrightarrow{MnO_4^-/H^+}$ Decolorization of permanganate sol. occurs

$A \xrightarrow{Heat} \underbrace{X + Y + Z}_{\text{Gases}}$

$Z \xrightarrow{H_2O} B$

Gas $Y + B \longrightarrow$ milkiness

Gas X burns with blue flame. Mark the correct choice.

	A	X	Y	Z	B
(a)	$CaCO_3$	CO	CO_2	CaO	$Ca(OH)_2$
(b)	CaC_2O_4	CO	CO_2	CaO	$Ca(OH)_2$
(c)	CaC_2O_4	CO_2	CO	CaO	$Ca(OH)_2$
(d)	$CaOCl_2$	Cl_2	O_2	CaO	$Ca(OH)_2$

37. Colorless salt A

$\xrightarrow{\text{Conc. } H_2SO_4}$ Brown fumes

$\xrightarrow{Cu}$ Blue solution + metal C

$\xrightarrow{HCl}$ White ppt. soluble in NH_4OH

The salt A is:

(a) $Cu(NO_3)_2$ (b) $Pb(NO_3)_2$
(c) $AgNO_3$ (d) $Zn(NO_3)_2$

38. $NaCl + K_2Cr_2O_7 + \text{conc. } H_2SO_4 \xrightarrow{Heat}$ Red colored gas $\xrightarrow[\text{NaOH solution}]{\text{Dilute}}$ Yellow solution $\xrightarrow[Pb(CH_3COO)_2]{CH_3COOH} X$

The formula and color of X is:

(a) CrO_2Cl_2, red (b) $Cr_2(SO_4)_3$, green
(c) PbO, yellow (d) $PbCrO_4$, yellow

39. $[C] \xleftarrow{CaCl_2}$ $[A]$ (Colorless salt) $\xrightarrow[\Delta]{KOH}$ $[B]$ (Gas, giving white fumes with HCl)

White ppt. $[C]$ decolorizes pink color of acidified $KMnO_4$, then $[A]$ is:

(a) NH_4ClO_4 (b) NH_4NO_2
(c) $(NH_4)_2C_2O_4$ (d) $(NH_4)_2SO_4$

40. A colorless salt A decolorizes the brown color of $I_3^{\ominus}$. Solution of A on treatment with $AgNO_3$ gives white precipitate. The compound A turns $FeCl_3$ solution (yellow) to $FeCl_2$ solution (green). Identify A:

(a) Na_2S (b) $Na_2S_2O_3$
(c) Na_2CO_3 (d) Na_2SO_4

41. A gas X is passed through water to form saturated solution. The aqueous solution on treatment with $AgNO_3$ gives a white precipitate. The saturated aqueous solution also dissolves magnesium ribbon with evolution of a colorless gas Y. Identify X and Y:

(a) $X = CO_2$, $Y = Cl_2$ (b) $X = Cl_2$, $Y = CO_2$
(c) $X = Cl_2$, $Y = H_2$ (d) $X = H_2$, $Y = Cl_2$

42. $MgSO_4$ on reaction with NH_4OH and Na_2HPO_4 forms a white crystalline precipitate. What is its formula?

(a) $Mg(NH_4)PO_4$ (b) $Mg_3(PO_4)_2$
(c) $MgCl_2 \cdot MgSO4$ (d) $MgSO_4$

43. $KCl + \text{conc. } H_2SO_4 + K_2Cr_2O_7 \xrightarrow{\Delta} (X) \xrightarrow{NaOH} (Y)$

(X) is reddish brown colored gas soluble in NaOH forming (Y). (X) and (Y) are:

(a) Cr_2OCl_2, Na_2CrO_3 (b) $Cr_2O_2Cl_2$, Na_2CrO_3
(c) CrO_2Cl, Na_2CrO_4 (d) CrO_2Cl_2, Na_2CrO_4

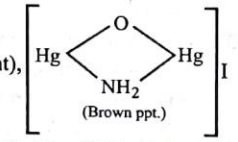
44. $K_2Cr_2O_7$ + conc. $H_2SO_4 + H_2O_2$ + ether $\longrightarrow$ blue perchromic anhydride (in ethereal layer)

Blue color is due to:

(a) CrO_3 (b) H_2CrO_4
(c) $H_2Cr_2O_3$ (d) CrO_5

45. $HgCl_2$ + excess of KI $\longrightarrow (A) \xrightarrow{NH_3/NaOH} (B)$.

(A) and (B), respectively, are:

(a) K_2HgI_4 (Nessler's reagent), 

(Iodide of Millon's base) (Y)

(b) (Y), (X)
(c) Both (X) (d) Both (Y)

46. To increase significantly the concentration of free Zn^{2+} ion in a solution of the complex ion $[Zn(NH_3)_4]^{2+}$,

$Zn^{2+}_{(aq)} + 4NH_3 \rightleftharpoons [Zn(NH_3)_4]^{2+}_{(aq)}$

add to the solution some:

(a) H_2O (b) $HCl_{(aq)}$

(c) $NH_{3(aq)}$ (d) $NH_4Cl_{(aq)}$

47. Three test tubes *A*, *B*, *C* contain Pb^{2+}, Hg_2^{2+}, and Ag^+ (but unknown). To each, aqueous solution NaOH is added in excess. Following changes occur.

A: Black ppt. *B*: Brown ppt

C: White ppt. but dissolves in excess of NaOH

A, *B*, and *C* contain, respectively:

(a) Pb^{2+}, Hg_2^{2+}, Ag^+ (b) Hg_2^{2+}, Ag^+, Pb^{2+}

(c) Ag^+, Pb^{2+}, Hg_2^{2+} (d) Ag^+, Hg_2^{2+}, Pb^{2+}

48. Consider the following equilibrium:

$$AgCl\downarrow + 2NH_3 \rightleftharpoons \underset{\text{Soluble}}{[Ag(NH_3)_2]^+} + Cl^-$$

White ppt. of AgCl appears on adding:

(a) NH_3 (b) Aq. NaBr

(c) Aq. HNO_3 (d) Aq. NH_4I

49. Borax on heating strongly above its melting point melts to a liquid, which then solidifies to a transparent mass commonly known as borax-bead. The transparent glassy mass consists of:

(a) Sodium pyroborate

(b) Boric anhydride

(c) Sodium meta-borate

(d) Boric anhydride and sodium metaborate

50. If CO_2 gas is passed into aq. Na_2CrO_4 yellow solution:

(a) Aq. $Na_2Cr_2O_7$ (orange) solution is formed

(b) Aq. $Cr_2(CO_3)_2$ is formed

(c) $Cr(OH)_3$ is precipitated

(d) No action

51. Four test tubes contain dil. HCl, $BaCl_2$, $CdCl_2$, and KNO_3 solution. Which of the following will identify $BaCl_2$?

(a) Dil. HCl (b) K_2CrO_4

(c) NaF (d) $AgNO_3$

52. A yellow solid known to be a single compound is completely insoluble in hot water but dissolves in hot dilute HCl to give an orange solution. When this solution is cooled, a white crystalline ppt. is formed. This white ppt. redissolves on heating the solution. The compound is:

(a) $Fe(OH)_3$ (b) $PbCrO_4$

(c) K_2CrO_4 (d) $Co(OH)_2$

53. A mixture upon adding conc. H_2SO_4 gives orange red fumes. It may contain the anion pair:

(a) $CrO_4^{2-} + Cl^-$ (b) $Br^- + Cl^-$

(c) $NO_3^- + Cl^-$ (d) $CrO_4^{2-} + NO_3^-$

54. $AgNO_{3(aq.)}$ gives yellow ppt. with:

(a) $KIO_{3(aq.)}$ (b) $KI_{(aq.)}$

(c) CHI_3 (d) CH_2I_2

55. The solution of a chemical compound *X* reacts with $AgNO_3$ solution to form a white precipitate of *Y* which dissolves in NH_4OH to give a complex *Z*. When *Z* is treated with dil. HNO_3, *Y* reappears. The chemical compound *X* can be:

(a) NaCl (b) CH_3Cl

(c) NaBr (d) NaI

56. The presence of magnesium is confirmed in the qualitative analysis by the formation of a white crystalline precipitate of:

(a) $Mg(HCO_3)_2$ (b) $MgNH_4PO_4$

(c) $MgNH_4(HCO_3)_3$ (d) $MgCO_3$

57. In qualitative inorganic analysis, phosphate, if present, is to be eliminated in the appropriate group in order to detect the radical:

(a) Pb^{2+} (b) As^{3+}

(c) Ca^{2+} (d) Cd^{2+}

58. Al^{3+}, Fe^{3+}, and Cr^{3+}, are grouped together for qualitative analysis because their:

(a) Carbonates are insoluble in NH_3

(b) Hydroxides are insoluble in NH_3

(c) Sulphides are soluble in acid

(d) None of these

59. SnS is:

(a) Black (b) Brown

(c) Orange (d) Yellow

60. Na_2CO_3 cannot be used in place of $(NH_4)_2CO_3$ for the precipitation of V group because:

(a) Na^+ interferes in the detection of V group

(b) Conc. of CO_3^{2-} is very low

(c) Na will react with acid radicals

(d) Mg will be precipitated

61. $CoCl_2$ is:

(a) Pink (b) Black

(c) Green (d) Colorless

62. Which on mixing gives deep brown color?

(a) $N_2O + O_2$ (b) $NO + O_2$

(c) $N_2O_3 + O_2$ (d) None of these

63. NaCl, NaBr, NaI mixture on adding conc. H_2SO_4 gives gases, respectively:

(a) HCl, Br_2, I_2 (b) HCl, HBr, HI

(c) Cl_2, Br_2, I_2 (d) None of these

64. Sodium nitroprusside when added to an alkaline solution of sulphide ions produces purple coloration due to the formation of:

(a) Na_4 [$Fe(SCN)_5NOS$] (b) Na_3 [$Fe(CN)_5NOS$]
(c) Na_2 [$Fe(CN)_5NOS$] (d) Na_4 [$Fe(CN)_5NOS$]

65. H_2S on passing through ammonical solution gives white ppt. The white ppt. is of:

(a) CoS (b) NiS
(c) MnS (d) ZnS

66. Preparation of Na_2CO_3 extract is made for acid radical analysis because:

(a) All anions react with Na to give water soluble compound
(b) Na is more reactive
(c) Na_2CO_3 is water soluble
(d) None of the above

67. H_2S and SO_2 can be distinguished by:

(a) Litmus paper (b) MnO_4^-
(c) $Pb(CH_3COO)_2$ (d) HCl

68. On passing CrO_2Cl_2 in water and then adding $(CH_3COO)_2$ Pb, the ppt. formed is:

(a) $PbCrO_4$ (b) $PbCl_2$
(c) $CrCl_3$ (d) None of these

69. A solution on treatment with NH_3 turns blue; it contains:

(a) Cu^{2+} (b) Ca^{2+}
(c) Co^{2+} (d) Mn^{2+}

70. When solution of ZnS in dil. HCl is treated with NaOH solution, a white ppt. is formed which dissolves in excess of NaOH due to formation of:

(a) $ZnCl_2$ (b) Zn(OH)Cl
(c) Na_2ZnO_2 (d) None of these

71. Disodium hydrogen phosphate is used to test:

(a) Mg^{2+} (b) Na^+
(c) Ca^{2+} (d) All of these

72. Reddish-brown (chocolate) ppt. is formed with:

(a) Cu^{2+} and $Fe(CN)_6^{4-}$ (b) Ba^{2+} and SO_4^{2-}
(c) Pb^{2+} and I^- (d) None of these

73. Addition of KI to Pb salt in water gives ..... ppt:

(a) Yellow (b) Black
(c) White (d) Red

74. Which radicals are precipitated in $(NH_4)_2CO_3$ in presence of NH_4Cl and NH_4OH?

(a) Ca, Ba, Sr (b) Mg
(c) Both (a) and (b) (d) None of these

75. Addition of $SnCl_2$ to $HgCl_2$ gives ppt.:

(a) White turning to grey (b) Black turning to white
(c) White turning to red (d) None of these

76. If HCl is not added before passing H_2S in the second group, it may result in the:

(a) Incomplete precipitation of second group sulphide
(b) Precipitation of sulphides of cations belonging to subsequent groups
(c) Precipitation of sulphur
(d) Precipitation of lead as lead sulphide

77. Which metal gives blue ash when its salt is heated with Na_2CO_3 solid and $Co(NO_3)_2$ on a charcoal piece?

(a) Cu (b) Mg
(c) Al (d) Zn

78. To avoid the precipitation of hydroxides of Ni^{2+}, Co^{2+}, Zn^{2+}, and Mn^{2+} along with those of Fe^{3+}, Al^{3+}, and Cr^{3+} the third group solution should be:

(a) Heated with a few drops of conc. HNO_3
(b) Treated with excess of NH_4Cl
(c) Concentrated (d) None of these

79. Which gives a white precipitate with a solution of $AgNO_3$, a white precipitate with dil. H_2SO_4, and a green flame test?

(a) Copper chloride (b) Copper nitrate
(c) Lead nitrate (d) Barium chloride

80. In qualitative inorganic analysis of basic radicals, hydrochloric acid is preferred to nitric acid for preparing a solution of given substance. This is because:

(a) Nitrates are not decomposed to sulphides
(b) Nitric acid contains nitrogen
(c) Hydrochloric acid is not an oxidizing agent
(d) Chlorides are easily converted to sulphides

81. Addition of solution of oxalate to an aqueous solution of mixture of Ba^{2+}, Sr^{2+}, and Ca^{2+} will precipitate:

(a) Ca^{2+} (b) Ca^{2+} and Sr^{2+}
(c) Ba^{2+} and Sr^{2+} (d) All the three

82. Group reagent for the precipitation of group II basic radicals for the qualitative analysis is:

(a) Dil. HCl + H_2S
(b) NH_4Cl (solid) + NH_4OH (solution) + H_2S
(c) $(NH_4)_2CO_3$ solution (d) None of these

83. In the second group of qualitative analysis, H_2S is passed through a solution acidified with HCl in order to:

(a) Limit the concentration of S^{2-} ions

(b) Increase the solubility of H_2S

(c) Increase the concentration of S^{2-} ions

(d) Add the Cl^- ions

84. Few drops of a salt solution are shaken with chloroform, chlorine water. Chloroform layer becomes violet. Solution contains:

(a) NO_2^- ion (b) NO_3^- ion

(c) Br^- ion (d) I^- ion

85. The reagent that distinguishes between silver and lead salt is:

(a) H_2S gas

(b) Dil. HCl solution added after this dissolved in hot water

(c) NH_4Cl (solid) + NH_4OH (solution)

(d) NH_4Cl (solid) + $(NH_4)_2CO_3$ solution

86. Sulphide ions react with $Na_2[Fe(NO)(CN)_5]$ to form a purple colored compound $Na_4[Fe(CN)_5(NOS)]$. In the reaction, the oxidation state of iron:

(a) Changes from +2 to +3

(b) Changes from +3 to +2

(c) Changes from +2 to +4

(d) Does not change

87. Two test tubes containing a nitrate and a bromide are treated separately with H_2SO_4; brown fumes evolved are passed in water. The water will be colored by vapors evolved from the test tube containing:

(a) Nitrate (b) Bromide

(c) Both (a) and (b) (d) None of these

88. A minute quantity of cupric salt is heated on borax bead in reducing flame of Bunsen burner; the color of bead after cooling will be:

(a) Blue (b) Red

(c) Colorless (d) Green

89. A solution of white crystals gives a yellow precipitate with $AgNO_3$ but no precipitate with a solution of Na_2CO_3. The action of conc. H_2SO_4 on the crystals yields a brown gas. The crystals are of:

(a) $NaNO_3$ (b) KCl

(c) $Ca(ON_3)_2$ (d) NaBr

90. A white precipitate insoluble in conc. HNO_3 is formed when the aqueous solution of x in NaOH is treated with barium chloride and bromine water:

(a) SO_3 (b) SO_2

(c) CO_2 (d) None of these

91. Aqueous solution of $Na_2S_2O_3$ on reaction with Cl_2 water gives:

(a) $Na_2S_4O_4$ (b) Na_2SO_4

(c) $Na_2S_4O_6$ (d) NaOH

92. The product of reaction of an aq. solution of Bi^{3+} salt with sodium thiosulphate gives:

(a) BiS (b) $Bi_2(S_2O_3)_3$

(c) $Na[Bi(S_2O_3)_2]$ (d) $[Bi_2(S_2O_3)_2]Cl_2$

93. When CS_2 layer containing both Br_2 and I_2 is shaken with excess of Cl_2 water, the violet color due to I_2 disappears and a pale yellow color appears in the solution. The disappearance of violet color and appearance of pale yellow color is due to the formation of:

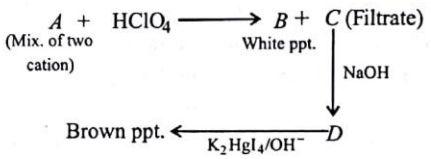
(a) I_3^- and Br_2, respectively

(b) HIO_3 and BrCl, respectively

(c) ICl and BrCl, respectively

(d) I^- and Br^-, respectively

94.



The cations present in A are:

(a) K^+ and Na^+ (b) K^+ and NH_4^+

(c) NH_4^+ and Fe^{2+} (d) Mg^{2+} and Na^+

95. Which of the following pair of acid radicals can be distinguished by using dil. H_2SO_4?

(a) $C_2O_4^{2-}$ and NO_3^- (b) NO_3^- and NO_2^-

(c) Cl^- and Br^- (d) HCO_3^- and CO_3^{2-}

96. A white colored salt forms white sublimate in dry heating test and also gives ammonia on heating with caustic soda solution. Which of the following test will be shown positive by the salt?

(a) It will give greenish yellow gas on reaction with conc. H_2SO_4

(b) It will give red gas by heating with $K_2Cr_2O_7$ and conc. H_2SO_4

(c) It will give colorless gas with dil. H_2SO_4

(d) It will give ring test

97. $Zn + \text{conc. } HNO_3 \longrightarrow Zn^{2+} + NO_2$

$Ag + \text{conc. } HNO_3 \longrightarrow Ag^+ + NO_2$

Which of the following cation has highest percentage in above reactions?

(a) Zn^{2+} (b) Ag^+

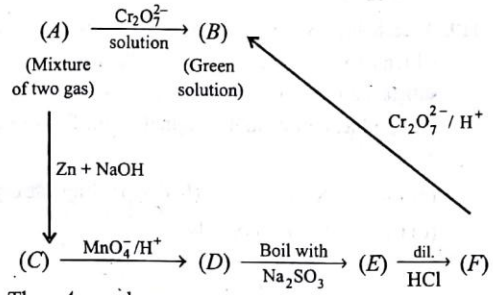
(c) Both have equal percentage

(d) None of these

98. When Au reacts with very dil. HNO_3 (6%), then product will be:

(a) $AuNO_3$, NH_4NO_3 (b) $AuNO_3$, NO
(c) $AuNO_3$, NO_2 (d) None of these

99.



Then A may have:

(a) SO_2, NO_2 (b) H_2S, SO_2
(c) Br_2, SO_2 (d) CO_2, SO_2

100. A red solid is insoluble in water. However, it becomes soluble if some KI is added to water. Heating the red solid in a test tube results in liberation of some violet colored fumes and droplets of a metal appear on cooler part of the test tube. The red solid is:

(a) Pb_3O_4 (b) HgI_2
(c) HgO (d) $(NH_4)_2Cr_2O_7$

101. When KI is added to acidified solution of sodium nitrite:

(a) NO gas is liberated and I_2 is set free
(b) N_2 gas is liberated and HI is produced
(c) N_2O gas is liberated and I_2 is set free
(d) N_2 gas is liberated and HOI is produced

102. A hydrated metallic salt (A), light green in color, gives a white anhydrous residue (B) after being heated gradually. (B) is soluble in water and its aqueous solution reacts with NO to give a dark brown compound (C). (B) on strong heating gives a brown residue (D) and a mixture of two gases (E) and (F). The gaseous mixture, when passed through acidified permanganate, discharges the pink color:

(a) $ZnSO_4 \cdot 7H_2O$ (b) $MgSO_4 \cdot 7H_2O$
(c) $FeSO_4 \cdot 7H_2O$ (d) $CuSO_4 \cdot 5H_2O$

103. A gas X occupies 22.4 liter at S.T.P. The gas turns acidified $K_2Cr_2O_7$ green and decolorizes acidified $KMnO_4$ solution. White turbidity appears when H_2S gas is passed through aqueous solution of gas; then X will be:

(a) H_2S (b) NO_2
(c) SO_2 (d) None of these

104. An aqueous solution of $FeSO_4 \cdot Al_2(SO_4)_3$ and chrome alum is heated with excess of Na_2O_2 and filtered. The materials obtained are:

(a) A colorless filtrate and a green residue
(b) A yellow filtrate and a green residue
(c) A yellow filtrate and a brown residue
(d) A green filtrate and a brown residue

105. The only cations present in a slightly acidic solution are Fe^{3+}, Zn^{2+}, and Cu^{2+}. The reagent which when added in excess of this solution would identify the separate Fe^{3+} in one step is:

(a) 2*M*HCl (b) 6*M*NH_3
(c) 6*M*NaOH (d) H_2S gas

106. The phenomenon in which white transparent crystal changes into white powder is called:

(a) Deliquescence (b) Efflorescence
(c) Allotropy (d) Sublimation

107. If Fe^{3+} and Cr^{3+} both are present in group III of qualitative analysis, then distinction can be made by:

(a) Addition of NH_4OH in presence of NH_4Cl, when only $Fe(OH)_3$ is precipitated
(b) Addition of NH_4OH in presence of NH_4Cl, when $Cr(OH)_3$ and $Fe(OH)_3$ both are precipitated; and on adding Br_2 water and NaOH, $Cr(OH)_3$ dissolves
(c) Precipitates of $Cr(OH)_3$ and $Fe(OH)_3$ as obtained in (b) are treated with conc. HCl when only $Fe(OH)_3$ dissolves
(d) Both (b) and (c) are correct

108. When calomel reacts with NH_4OH solution, the compound formed is:

(a) $NH_2(Hg)Cl$ (b) $Hg_2Cl_2NH_3$
(c) $Hg(NH_3)_2Cl_2$ (d) $HgCl_2NH_3$

109. A solution when diluted with water and boiled, gives a white precipitate. On addition of excess of NH_4Cl/NH_4OH, the volume of precipitate decreases leaving behind a white gelatinous precipitate. Identify the precipitate which dissolves in NH_4OH/NH_4Cl:

(a) $Zn(OH)_2$ (b) $Al(OH)_3$
(c) $Mg(OH)_2$ (d) $Ca(OH)_2$

110. SO_2 and CO_2 both turn lime water (A) milky, SO_2 also turns $K_2Cr_2O_7/H^+$ (B) green while O_2 is soluble in pyrogallol (C) turning it black. These gases are to be detected in order by using these reagents. The order is:

(a) (A), (B), (C) (b) (B), (C), (A)
(c) (B), (A), (C) (d) (A), (C), (B)

111. NH_4SCN can be used to test one or more out of Fe^{3+}, Co^{2+}, Cu^{2+}:

(a) Fe^{3+} only (b) Co^{2+}, Cu^{2+}

(c) Fe^{3+}, Cu^{2+} (d) All of these

112. A mixture contains Cu^{2+}, Al^{3+}, and Ni^{2+}. Following steps have been adopted but written in disorder:

I: Filter, boil off H_2S gas, and add NH_4Cl; heat and add NH_4OH.

II: Filter, add NH_4OH and pass H_2S gas.

III: Pass H_2S gas into acidified solution of mixture.

Steps will be used in the following order:

(a) I, II, III (b) III, I, II

(c) III, II, I (d) I, III, II

113. *A* is a colorless substance. Aq. solution of *A* gives reddish-orange ppt. with KI; ppt. dissolves in excess of KI forming a colorless solution. If NH_4Cl and NaOH solution is added to this colorless solution, reddish brown ppt. is formed. Substance *A* is:

(a) Epsom salt (b) Mohr's salt

(c) Calomel (d) Corrosive sublimate

114. Sb_2S_3 is:

(a) Black (b) Yellow

(c) Orange–red (d) None of these

115. Few drops of HNO_3 are added to II group before proceeding to III group in order to:

(a) Convert Fe^{2+} to Fe^{3+} (b) Convert Fe^{3+} to Fe^{2+}

(c) ppt. III group (d) None of these

116. The aqueous solution of salt gives white ppt. with lead acetate solution which is insoluble in hot water and nitric acid. The salt contains:

(a) Cl^- (b) Ba^{2+}

(c) CO_3^{2-} (d) SO_4^{2-}

117. Some pale-green crystals are strongly heated. The gases given off are passed into a container surrounded by ice and then through a solution of acidified $KMnO_4$. The $KMnO_4$ is decolorized, a waxy white solid is formed in the ice container; this is dissolved in water. The solution will:

(a) Give a precipitate with silver nitrate solution

(b) Given a precipitate with barium chloride solution

(c) Turn red litmus blue

(d) Give blue color with starch solution

118. For testing sodium carbonate solution for the presence of sulphate ions as impurities one should add:

(a) Excess hydrochloric acid and silver nitrate solution

(b) Excess sulphuric acid and silver nitrate solution

(c) Excess nitric acid and silver nitrate solution

(d) Excess hydrochloric acid and barium chloride solution

119. A reddish-pink substance on heating gives off a vapor which condenses on the sides of the test tube and the substance turns blue. If on cooling water is added to the residue, it turns to its original color. The substance is:

(a) Iodine crystals (b) Copper sulphate crystals

(c) Cobalt chloride crystals

(d) Zinc oxide

120. An inorganic Lewis acid (*X*) fumes in moist air, and intensity of fumes increases when a rod dipped in NH_4OH is brought near to it. An acidic solution of (*X*) on addition of NH_4Cl and NH_4OH gives a precipitate which dissolves in NaOH solution. An acidic solution of (*X*) does not give precipitate with H_2S. Hence, the compound (*X*) is:

(a) $FeCl_3$ (b) $AlCl_3$

(c) $SnCl_2$ (d) $ZnCl_2$

121. Aqueous solution of a salt (*Y*) is alkaline to litmus. On strong heating, it swells-up to give a glassy material. When conc. H_2SO_4 is added to a hot concentrated solution of (*Y*), white crystals of a weak acid separate out. Hence, the compound (*Y*) is:

(a) $Na_2SO_4 \cdot 10H_2O$ (b) $Ca_2P_6O_{11} \cdot 10H_2O$

(c) $Na_2B_6O_{11}$ (d) $Na_2B_4O_7 \cdot 10H_2O$

122. A colorless salt (*X*) is soluble in water and also in alcohol and amines. On strong heating, (*X*) gives a brown gas (*Y*) and a grey residue.(*X*) dissolves in ammonia to give a solution (*Z*) which gives silver mirror with aldehydes. A solution of (*X*) is easily reduced by iron (II) sulphate. A solution of (*X*) also gives a brick red precipitate with potassium dichromate solution. Hence, choose the correct alternative:

	X	*Y*	*Z*
(a)	$Pb(NO_3)_2$	NO_2	Ag_2O
(b)	$AgNO_3$	NO	$[Ag(NH_3)_2]^+$
(c)	$AgNO_3$	NO_2	Ag_2O
(d)	$AgNO_3$	NO_2	$[Ag(NH_3)_2]^+$

123. Salt-*A* $\xrightarrow{\text{Layer test}}$ If reddish-brown layers comes first, then:

(a) Br^- present (b) $Br^{\ominus}$ absent

(c) Cl^- present (d) I^- present

124. Salt mixture $\xrightarrow{\text{Dil. HCl}}$ White ppt.

Heated and filtered under hot condition → Filtrate $\xrightarrow{\text{cooled}}$ White needle like crystal

Heated and filtered under hot condition → Residue $\xrightarrow{NH_3\text{ sol.}}$ Clear solution

Salt is consisting of cations:

(a) Pb^{2+} and Hg^{2+} (b) Pb^{2+} and Hg_2^{2+}
(c) Pb^{2+} and Ag^+ (d) Pb^{2+}, Hg_2^{2+}, and Ag^+

125. $CaCO_3(s) + AcOH \xrightarrow{Na_2C_2O_4\text{ solution}} ?$
Comment on the product of this reaction?
(a) No reaction
(b) White ppt. of $Ca(OAc)_2$ is obtained
(c) White ppt. of CaC_2O_4 is formed
(d) No ppt. is obtained but not the no reaction

126. $Hg(NO_3)_2 \longrightarrow W + X + O_2$

$X + H_2O \longrightarrow HNO_2 + HNO_3$

$W + HNO_3 \longrightarrow Y + NO + H_2O$

$Y + Na_2S_2O_3\text{ (excess)} \longrightarrow Z + NaNO_3$

(a) $W = Hg$, $X = N_2O$, $Y = Hg(NO_3)_2$, $Z = Na_2[Hg(S_2O_3)_2]$
(b) $W = HgO$, $X = NO$, $Y = Hg(NO_3)_2$, $Z = Na[Hg(S_2O_3)_2]$
(c) $W = Hg$, $X = NO_2$, $Y = Hg(NO_3)_2$, $Z = Na_2[Hg(S_2O_3)_2]$
(d) $W = Hg$, $X = N_2O_3$, $Y = Hg(NO_3)_2$, $Z = Na_3[Hg(S_2O_3)_2]$

127. A metal hydroxide is precipitated as a white gelatinous substance when NH_4OH is added to the solution (after previously removing acid insoluble sulphides with H_2S). The metal in metal hydroxide is:
(a) Cr (b) Fe
(c) Al (d) Zn

128. A pale green crystalline metal salt of (*X*) dissolves freely in water. It gives a brown precipitate on the addition of aq. NaOH. The metal salt solution also gives a black precipitate on bubbling H_2S in aqueous medium. An aqueous solution of the metal salt decolorizes the pink color of the permangnetic solution. The metal in the metal salt solution is:
(a) Fe (b) Pb
(c) Cu (d) Al

129. When a reagent (*X*) reacts with Fe^{3+}, the solution turns red due to the formation of a compound (*Y*). This reagent causes no change in color with Fe^{2+} in the pure state. Here (*X*) and (*Y*) are, respectively:
(a) NH_4SCN and $[Fe(SCN)_3]$
(b) $K_4[Fe(CN)_6]$ and $Fe_4[Fe(CN)_6]_3$
(c) Na_2HPO_4 and $FeSO_4$
(d) $K_3[Fe(CN)_6]$ and $K_2Fe[Fe(CN)_6]$

130. Two different salts (*A*) [zinc nitrate] and (*B*) [potassium bromide] were separately warmed with conc. H_2SO_4. Which of them will produce reddish brown fumes that dissolve in CS_2 giving yellow solution?
(a) Both (*A*) and (*B*) (b) Only (*A*)
(c) Only (*B*) (d) Neither (*A*) nor (*B*)

131. A red solid is insoluble in water, however, it becomes soluble if some KI is added to water. Heating the red solid in a test tube results in liberation of some violet colored fumes and droplets. Metal appears on the cooler parts of the test tube. The red solid is:
(a) Pb_3O_4 (b) HgO
(c) $(NH_4)_2Cr_2O_7$ (d) HgI_2

132. A green colored water soluble substance, (*A*), forms a greenish precipitate (*B*) with NH_4OH in presence of NH_4Cl (excess). When (*B*) is oxidized with a little sodium bismuthate in presence of H_2SO_4, a orange solution is obtained. If now a little solid Na_2O_2 is added, an intensely blue-colored compound is formed, extractable with ether. (*A*) yields a bulky white precipitate with $BaCl_2$ solution. Suggest the nature of the compound (*A*):
(a) Nickel (II) sulphate (b) Copper (II) sulphate
(c) Chromium (III) sulphate
(d) Ferrous sulphate

133. A certain pale-green substance (*A*) becomes dark brown on adding $NaNO_2$ in presence of dil. H_2SO_4. Its aqueous solution gives precipitates with (I) $BaCl_2$ and (II) NaOH in separate tests.
The latter precipitate, (*B*), gradually changes color from green to brown on exposure to air. What is *A*?
(a) $NiSO_4$ (b) $FeSO_4$
(c) $CuSO_4$ (d) $Cr_2(SO_4)_3$

134. Which of the following reaction(s) are not relevant to the microcosmic salt bead test?
I. $Cr_2O_3 + 3B_2O_3 \longrightarrow 2Cr(BO_2)_3$
II. $CoO + ZnO \longrightarrow CoZnO_2$
III. $CoO + NaPO_3 \longrightarrow NaCoPO_4$
IV. $Al_2(SO_4)_3 + 3Na_2CO_3 \longrightarrow Al_2O_3 + 3Na_2SO_4 + 3CO_2$
(a) I, III, and IV (b) I, II, and IV
(c) II, III, and IV (d) II and IV only

135. Identify (P) to (R):

$$(P) \xrightarrow{KOH} (Q) + (R) \xrightarrow{Zn + KOH} (Q) \text{ gas}$$

(gas turns red litmus blue)

$(P) \xrightarrow{\Delta}$ Gas (does not support combustion)

(a) $P = (NH_4)_2SO_4$, $Q = NH_3$, $R = K_2SO_4$

(b) $P = NH_4NO_3$, $Q = NH_3$, $R = KNO_3$

(c) $P = NH_4NO_2$, $Q = NH_3$, $R = KNO_2$

(d) $P = (NH_4)_2Cr_2O_7$, $Q = NH_3$, $R = Cr_2O_3$

136. In the following reactions,

$CaCO_3\,(s) \xrightarrow[\Delta]{} A(s) + B(g)$

$A(s) + \text{carbon} \xrightarrow[\Delta]{} C(s) + D(g)$

$C(s) + H_2O \xrightarrow[\Delta]{} E(g)$

the compound E is:

(a) CO (b) CH_4

(c) H_2 (d) C_2H_2

137. Consider the following reactions:

I. $Na_2S_2O_3 + \text{dil. HCl} \xrightarrow{\Delta}$

II. $Na_2S_2O_3 + Cl_2 \text{ water} \xrightarrow{\Delta}$

III. $SO_2 + 2H_2S \xrightarrow{\Delta}$

IV. $H_2S + H_2O_2 \xrightarrow{\Delta}$

The reactions which gives yellow turbidity are:

(a) II, III, and IV (b) III and IV only

(c) I, III, and IV (d) I, II, III, and IV

138. The compound of a metal M, $M_x(NO_3)_y$, when treated with hydrogen sulphide in neutral or dilute acidic medium forms a black precipitate of M and its sulphide. Identify the metal and its sulphide.

(a) M – Cd, M_2S – CdS (b) M – Hg, MS – HgS

(c) M – Pb, MS – PbS (d) M – Cu, M_2S – Cu_2S

139. What is the magnetic moment (spin only) and hybridization of central atom in the brown ring complex $[Fe(H_2O)_5NO]SO_4$?

(a) $\sqrt{\ }$ B.M., d^2sp^3 (b) $\sqrt{\ }$ B.M., sp^3d^2

(c) $\sqrt{15}$ B.M., sp^3d^2 (d) $\sqrt{15}$ B.M., d^2sp^3

140. Consider the given sequence of reaction and identify P and Q:

$$Na_2B_4O_7 \cdot 10H_2O \xrightarrow{\Delta} P + NaBO_2 + H_2O\uparrow + \xrightarrow[\Delta]{Cr_2O_3}$$

Q (Green colored)

(a) $P = Na_3BO_3$, $Q = Cr(BO_2)_3$

(b) $P = B_2O_3$, $Q = CrBO_3$

(c) $P = Na_2B_4O_7$, $Q = Cr(BO_2)_3$

(d) $P = B_2O_3$, $Q = Cr(BO_2)_3$

Multiple Correct Answers Type

1. Which of the following anions may be identified by their ppt. reaction in aqueous solution?

(a) CrO_4^{2-} (b) SO_4^{2-}

(c) PO_4^{3-} (d) MnO_4^-

2. Which of the following anion (s) is/are interfering radicals?

(a) BO_3^{3-} (b) $F^{\ominus}$

(c) PO_4^{3-} (d) none of these

3. When Zn reacts with conc. HNO_3, then $Zn(NO_3)_2$ and NO_2 are formed; reaction(s) involved in this process is/are:

(a) Redox reaction (b) Acid–base reaction

(c) Ion-exchange reaction (d) None of these

4. Select the correct statement(s):

(a) $NaHCO_3$ is sparingly soluble in water because it has massive H-bonding

(b) When $BaCl_2$ reacts with bicarbonate, then white ppt. of $BaCO_3$ is formed

(c) $HgCl_2$ is poisonous

(d) Phenolphthalein is turned pink by soluble carbonate and colorless by soluble hydrogen carbonate

5. Select the correct statement(s):

(a) When $HgCl_2$ reacts with carbonate ion, then basic mercury (II) carbonate is formed

(b) When $HgCl_2$ reacts with carbonate ion, then pH of solution highly increases

(c) The excess of carbonate acts as buffer reacting with the hydrogen ions formed in the reaction

$$CO_3^{2-} + 2H^+ \longrightarrow CO_2\uparrow + H_2O$$

(d) White ppt. of $MgCO_3$ soluble in dil. H_2SO_4

6. Select the correct statement(s):

(a) White ppt. of $BaSO_3$ and $CaSO_3$ is soluble in dil. HNO_3, dil. HCl, and CH_3COOH

(b) On standing, the precipitate $BaSO_3$ is slowly oxidized to sulphate and then becomes insoluble in dilute mineral acids

(c) When excess of SO_2 gas is passed into the solution of $BaSO_3$ and $CaSO_3$, then white turbidity disappears

(d) The hydrogen carbonates of alkali metals are soluble in water, but are less soluble than the corresponding normal carbonates

7. Which of the following carbonates do not give metal oxide on heating?
(a) $CuCO_3$ (b) K_2CO_3
(c) Na_2CO_3 (d) $MgCO_3$

8. The ions which can be precipitated with both HCl and H_2S are:
(a) Pb^{2+} (b) Cu^{2+}
(c) Ag^+ (d) Sn^{2+}

9. Which of the following compounds are soluble in water?
(a) CaC_2O_4 (b) $SrSO_4$
(c) $BaCl_2$ (d) $(NH_4)_2C_2O_4$

10. Which of the following halides are not soluble in water?
(a) AgCl (b) AgBr
(c) $PbCl_2$ (d) AgF

11. When dimethyl glyoxime solution is added to an aqueous solution of nickel(II) chloride followed by ammonium hydroxide, then which of the following statements are incorrect?
(a) No precipitate is obtained
(b) A blue colored ppt. is obtained
(c) A rosy red colored ppt. is obtained
(d) A black colored ppt. is obtained

12. The brown ring test is performed for the qualitative detection of:
(a) Bromides (b) Iodides
(c) Nitrates (d) Nitrite

13. Which of the following respond to borax bead test?
(a) Nickel salts (b) Copper salts
(c) Cobalt salts (d) Aluminium salts

14. Concentrated aqueous sodium hydroxide cannot separate a mixture of:
(a) Al^{3+} and Sn^{2+} (b) Al^{3+} and Fe^{3+}
(c) Al^{3+} and Zn^{2+} (d) Zn^{2+} and Pb^{2+}

15. The metal ion(s) which is/are not precipitated when H_2S is passed with HCl is/are:
(a) Zn^{2+} (b) Ni^{2+}
(c) Cd^{2+} (d) Mn^{2+}

16. An aqueous solution of a substance gives a white precipitate on treatment with dil. HCl which dissolves on heating. When H_2S is passed through the hot acidic solution, a black precipitate is obtained. The substances are not:
(a) Hg_2^{2+} salt (b) Cu^{2+} salt
(c) Ag^+ salt (d) Pb^{2+} salt

17. When H_2S gas is passed through HCl containing aqueous solution of $CuCl_2$, $HgCl_2$, $BiCl_3$, and $CoCl_2$, then which of the following precipitate out?
(a) CuS (b) HgS
(c) Bi_2S_3 (d) CoS

18. In broax bead test, which compound(s) is/are not formed?
(a) Orthoborate (b) Metaborate
(c) Double oxide (d) Tetraborate

19. Mark the correct statement(s):
(a) I group basic radicals precipitate as chlorides
(b) IV group basic radicals precipitate as sulphides
(c) V group basic radicals precipitate as carbonates
(d) V group basic radicals precipitate as hydroxide

20. Which of the following sulphides is/are not yellow in color?
(a) CuS (b) CdS
(c) ZnS (d) CoS

21. Which of the following basic radicals will be precipitated by H_2S gas in the presence of NH_3?
(a) Mn^{2+} (b) Ni^{2+}
(c) Cd^{2+} (d) Ca^{2+}

22. Which of the following is/are soluble in NaOH?
(a) $Fe(OH)_3$ (b) $Zn(OH)_2$
(c) $Al(OH)_3$ (d) $Sn(OH)_2$

23. Which of the following is/are soluble in excess of NaOH? (*X*): $Pb(OH)_2$; (*Y*): CuS; (*Z*): $Al(OH)_3$
(a) *X* (b) *Y*
(c) *Z* (d) None of these

24. Aqueous solution contains $Zn(CH_3COO)_2$, $Cd(CH_3COO)_2$, and $Cu(CH_3COO)_2$. On passing H_2S gas, there is a precipitation of ..... as sulphide:
(a) Zn^{2+} (b) Cd^{2+}
(c) Cu^{2+} (d) None of these

25. Which of the following salt does give positive test for nitrate ion?
(a) KNO_3 (b) $NaNO_3$
(c) $Mg(NO_3)_2$ (d) None of these

26. Which of the following oxides is/are soluble in $NaOH_{(aq)}$:
(a) ZnO (b) Al_2O_3
(c) Fe_2O_3 (d) SnO_2

27. Ag_2CrO_4 ppt. is soluble in:
(a) Dil. HNO_3 (b) Aq. NH_3
(c) AgCl solution (d) None of these

28. Which of the following pairs can be separated by H_2S in dil. HCl?

(a) Cu^{2+} and Cd^{2+} (b) Cu^{2+} and Ni^{2+}
(c) Cu^{2+} and Zn^{2+} (d) Hg^{2+} and Al^{3+}

29. An inorganic salt solution on treatment with HCl will not give a white precipitate of which metal ions?

(a) Hg_2^{2+} (b) Hg^{2+}
(c) Zn^{2+} (d) Al^{3+}

30. Ammonium molybdate is used to test the radical:

(a) PO_4^{3-} (b) AsO_4^{3-}
(c) Cu^{2+} (d) Ag^{+}

31. Which of the following anions are easily removed from aqueous solution by precipitation?

(a) Cl^- (b) SO_4^{2-}
(c) NO_3^- (d) CO_3^{2-}

32. Which of the following chlorides are water soluble?

(a) AgCl (b) Hg_2Cl_2
(c) $HgCl_2$ (d) NaCl

33. Which of the following metal sulphide is soluble in hot and dil. HNO_3?

(a) Ag_2S (b) PbS
(c) CdS (d) HgS

34. Which of the following ppt. is soluble in dil. HNO_3 and NH_3 solution?

(a) $Ag_2S_2O_3$ (b) Ag_2CO_3
(c) Ag_2SO_3 (d) AgI

35. Which of the following ppt. is insoluble in NH_3 solution?

(a) AgI (b) Ag_2S
(c) AgCl (d) AgBr

36. Which of the following metals are present in Devarda alloy?

(a) Cu (b) Al
(c) Zn (d) Ag

37. Which of the following reactions is/are ppt. reaction(s)?

(a) $BaS + Na_2SO_4 \longrightarrow BaSO_4 + Na_2S$
(b) $AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$
(c) $2NaNO_3 + MgCl_2 \longrightarrow 2NaCl + Mg(NO_3)_2$
(d) $MgCl_2 + Na_2SO_4 \longrightarrow 2NaCl + MgSO_4$

38. Which of the following compound(s) give(s) N_2 gas on heating?

(a) NH_4ClO_3 (b) NH_4ClO_4
(c) NH_4NO_3 (d) NH_4Cl

39. Which of the following compound(s) give(s) NH_3 gas on heating?

(a) NH_4Cl (b) CH_3COONH_4
(c) $(NH_4)_2CO_3$ (d) NH_4NO_2

40. Which of the following reaction(s) is/are example(s) of intra-redox reaction?

(a) $(NH_4)_2CO_3 \xrightarrow{\Delta} 2NH_3 + H_2CO_3$
(b) $(NH_4)_2S \xrightarrow{\Delta} 2NH_3 + H_2S$
(c) $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} 2N_2 + Cr_2O_3 + H_2O$
(d) $NH_4IO_3 \longrightarrow N_2 + I_2 + 4H_2O + O_2$

41. Which of the following metal(s) will give same gas on reaction with cold or warm water?

(a) Na (b) Mg
(c) Au (d) Fe

42. Which of the following metal(s) will produce NO_2 gas on reaction with conc. HNO_3(70%)?

(a) Ag (b) Zn
(c) Cu (d) None of these

43. Which of the following metal(s) will produce NO gas on reaction with dil. HNO_3 (20%)?

(a) Cu (b) Ag
(c) Zn (d) Fe

44. A white ppt. is obtained when:

(a) A solution of $BaCl_2$ is treated with Na_2CO_3
(b) A solution of $CaCl_2$ is treated with Na_2SO_3
(c) A solution of $ZnSO_4$ is treated with Na_2S
(d) A solution of $Pb(NO_3)_2$ is treated with Na_2CrO_4

45. Which of the following cation(s) will turn blue in oxidizing flame?

(a) Co^{2+} (b) Cr^{3+}
(c) Ni^{2+} (d) Cu^{2+}

46. Which of the following substances are green?

(a) $Fe(BO_2)_2$ (b) Cu
(c) $Cr(BO_2)_3$ (d) $Co(BO_2)_2$

47. Which pair would not be expected to form precipitate when solutions are mixed?

(a) K^+, SO_4^{2-} (b) Na^+, S^{2-}
(c) Ag^+, NO_3^- (d) Al^{3+}, OH^-

48. Borax bead test is given by:

(a) Co^{2+} (b) Zn^{2+}
(c) Cu^{2+} (d) Ni^{2+}

49. Reddish-brown gas is obtained when the following are treated with conc. H_2SO_4:

(a) $Br^{\ominus}$ (b) NO_2^-
(c) NO_3^- (d) SO_3^{2-}

50. Which of the following will be completely or partially dissolved in NH_4OH?

(a) AgCl (b) AgBr
(c) $BaSO_4$ (d) AgI

51. Which of the following cations are present in III group?

(a) Al^{3+} (b) Fe^{3+}
(c) Cr^{3+} (d) Cu^{2+}

52. Which of the following metal produces N_2O gas with 20% HNO_3.

(a) Fe (b) Cu
(c) Zn (d) Sn

53. Black sulphides are formed by:

(a) Cu^{2+} (b) Sb^{3+}
(c) Pb^{2+} (d) Ag^{+}

54. Interfering radicals interfere the test of:

(a) III group radicals only
(b) III group radicals or downward
(c) Cations which are present in II group filtrate
(d) None of the above

55. Which of the following metal(s) form NO with dil. HNO_3(20%)?

(a) Ag (b) Pb
(c) Cu (d) None of these

56. Select the correct statement(s):

(a) Normal and polysulphides of alkali metals are soluble in water
(b) The sulphides of aluminium chromium, and magnesium can only be prepared under dry conditions as they are completely hydrolyzed by water
(c) When filter paper is moistened with a solution of sodium nitroprusside made alkaline with sodium hydroxide or ammonia solution, a purple coloration is produced with free hydrogen sulphide
(d) Thiosulphate salts of Pb, Ag, and Ba are insoluble and dissolve in excess of sodium thiosulphate solution forming thiosulphate

57. $\underset{\text{(Mixture of two anions)}}{A} \xrightarrow[\text{BaCl2}]{\text{Cold}} \underset{\text{ppt.}}{\text{White}} \xrightarrow{\text{Filtered}} \text{Filtrate}$

$\xrightarrow{H_2O_2}$ Blue litmus turns red

Mixture of *A* contains:

(a) CO_3^{2-}, HCO_3^- anions (b) CO_3^{2-}, HSO_3^- anions
(c) SO_3^{2-}, HSO_3^- anions (d) None of these

58. Which of the following statement(s) is/are incorrect?

(a) Manganese salts give a violet borax bead test in reducing flame
(b) From a mixed precipitate of AgCl and AgI, ammonia solution dissolves only AgCl
(c) Ferric ions give a deep green precipitate on adding potassium ferrocyanide solution
(d) On boiling the solution having K^+, Ca^{2+}, and HCO_3^- ions, we get a precipitate of $K_2Ca(CO_3)_2$

59. When H_2S gas is passed in a metal sulphate solution in presence of NH_4OH, a white precipitate is produced. The metal is/are not identified as:

(a) Zn (b) Fe
(c) Pb (d) Hg

60. In which of the following is NH_3 used?

(a) Nessler's reagent
(b) Group reagent for analysis of IV group basic radicals
(c) Group reagent for analysis of III group basic radicals
(d) Tollen's reagent

61. The correct statement(s) is/are, with respect to chromyl chloride test:

(a) Formation of lead chromate
(b) Formation of chromyl chloride
(c) Liberation of chloride
(d) Formation of reddish-brown vapors

62. Aqueous solution of $BaBr_2$ gives yellow ppt. with:

(a) K_2CrO_4 (b) $AgNO_3$
(c) $PbCl_2$ (d) None of these

63. $\underset{\text{orange}}{Cr_2O_7^{2-}} \underset{\text{pH} = Y}{\overset{\text{pH} = X}{\rightleftharpoons}} \underset{\text{green}}{CrO_4^{2-}}$

This change is based on change in pH. Probable values of *X* and *Y* cannot be:

(a) 8, 6 (b) 8, 10
(c) 4, 6
(d) Change is independent of pH

64. Nitrite (NO_2^-) interferes in the "ring-test" of nitrate (NO_3^-). Some of the following reagents can be used for the removal of nitrite.

(a) AgF (b) $(NH_2)_2CS$ (thiourea)
(c) NH_2SO_3H (sulphamic acid)
(d) None of these

65. Which of the following is/are correct for potassium ferrocyanide?

(a) It gives a brown precipitate with Cu^{2+} ions

(b) It gives a red precipitate of mixed salt with Cd^{2+} ions

(c) It in excess gives a white precipitate with Zn^{2+}

(d) It develps a deep red coloration with Fe^{3+}

66. Which of the following statements is not correct?

(a) Lead(II) chloride is soluble in hot water and reappears on cooling

(b) In dilute HCl, the solubility of $PbCl_2$ is high than the hot water

(c) In concentrated HCl, $PbCl_2$ is insoluble

(d) Lead(II) chloride forms the complex with conc. HCl

67. Sulphuric acid is not used for preparation of original solution in analysis of basic radicals because:

(a) It is a reducing agent

(b) It forms insoluble sulphate with certain basic radicals

(c) It forms a soluble complex

(d) It is oxidizing in nature

68. If (*X*) turns lime water milky, then *X* may be:

(a) CO_2 (b) SO_2

(c) NO_2 (d) O_2

69. If (*X*) turns acidified $K_2Cr_2O_7$ solution green, then *X* may be:

(a) SO_2 (b) CO_2

(c) NO_2^- (d) Fe^{2+}

70. If (*X*) decolorizes acidified $KMnO_4$ solution, then *X* may be:

(a) S^{2-} (b) SO_3^{2-}

(c) Fe^{2+} (d) SO_2

71. If (*X*) gives white turbidity when H_2S is passed through its aqueous solution, then *X* may be:

(a) SO_2 (b) Fe^{3+}

(c) Mn^{2+} (d) Sn^{2+}

72. A solution of colorless salt H on boiling with excess NaOH produces a non-flammable gas. The gas evolution ceases after sometime. Upon addition of Zn dust to the same solution, the gas evolution restarts. The colorless salt(s) H is (are):

(a) NH_4NO_3 (b) NH_4NO_2

(c) NH_4Cl (d) $(NH_4)_2SO_4$

73. Which of the following statements is/are not true?

(a) $Fe^{2+}_{(aq)}$ gives brown color with NH_4SCN

(b) $Fe^{3+}_{(aq)}$ gives blood red color with NH_4SCN

(c) $Fe^{2+}_{(aq)}$ yields orange color with $K_3Fe(CN)_6$

(d) Ag^+ reacts with CO_3^{2-}; then black ppt. is formed

74. Which of the following react with dil. H_2SO_4?

(a) $CaCO_3$ (b) KNO_2

(c) Na_2S (d) $BaCl_2$

75. Conc. H_2SO_4 will not give any gas with:

(a) $ZnSO_4$ (b) Barium phosphate

(c) Magnesium borate (d) Sodium oxalate

76. The reagents, ammonium chloride and aqueous ammonia will precipitate:

(a) Bi^{3+} (b) Pb^{2+}

(c) Mg^{2+} (d) Fe^{3+}

77. Which of the following ppt.(s) of sulphite ion have white color?

(a) Ag_2SO_3 (b) $PbSO_3$

(c) $CaSO_3$ (d) $BaSO_3$

78. Which of the following gases have brown color?

(a) Br_2 (b) NO_2

(c) CO_2 (d) I_2

79. Which of the following compounds are having white ppt?

(a) $K_2Fe[Fe(CN)_6]$ (b) $[Fe(H_2O)_5(SCN)]^{2+}$

(c) ZnS (d) $Zn(OH)_2$

80. Which of the following compounds do not have white color in the form of ppt.?

(a) Bi_2S_3 (b) $Co[Hg(SCN)_4]$

(c) CdS (d) BiI_3

81. Select the correct statement(s):

(a) All carbonate salts are soluble except carbonate salts of alkali metals and $(NH_4)_2CO_3$

(b) All bicarbonate salts are soluble except $NaHCO_3$ which is sparingly soluble

(c) All sulphite salts are insoluble except sulphite salts of alkali metals and $(NH_4)_2SO_3$

(d) All MnO_4^- salts are insoluble

82. Select the correct statement(s):

(a) White ppt. of $BaCO_3$ and $CaCO_3$ is soluble in dil. HNO_3, dil HCl, CH_3COOH, and soda water

(b) White ppt. of $PbCO_3$ is soluble in dil. HNO_3, dil. HCl, excess of NaOH, and CH_3COOH

(c) White ppt. of Ag_2CO_3 is soluble in dil. HNO_3 and excess NH_3 solution

(d) HCN and H_3BO_3 are stronger acids than H_2CO_3

83. Select the correct statement(s):

(a) HCl is not used as acid for titration of SO_2

(b) Soda extract solution is very useful when any insoluble salt is present in a given mixture

(c) SO_2 gas is identified by a filter paper moistened with potassium iodate and starch solution

(d) When zinc and sulphuric acid react with sulphite, then hydrogen sulphide gas is evolved which may be detected by holding lead acetate paper to the mouth of the test tube

84. The salt used for performing "bead test" in qualitative inorganic analysis is:

(a) $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$

(b) $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$

(c) $Na(NH_4)HPO_4 \cdot 4H_2O$

(d) $Na_2B_4O_7 \cdot 10H_2O$

85. S^{2-} and SO_3^{2-} can be distinguished by using:

(a) $(CH_3COO)_2Pb$ (b) $Na_2[Fe(CN)_5NO]$

(c) $Cr_2O_7^{2-}$ solution (d) $CaCl_2$

86. Out of Cu^{2+}, Ni^{2+}, Co^{2+}, and Mn^{2+}, of those that dissolve in dil. HCl, only one gives a precipitate when H_2S is passed. Identify the corresponding other which do not gives precipitation:

(a) Ni^{2+} (b) Cu^{2+}

(c) Co^{2+} (d) Mn^{2+}

87.

$$\text{Colorless salt } (X) \xrightarrow{\Delta} (Y) \xrightarrow{Cu^{2+},\Delta} \text{Colored bead } (Z)$$

(X) can be:

(a) Borax (b) Microcosmic salt

(c) Copper sulphate (d) None of these

88. Consider the following reaction,

$$\text{Nitrite + acetic acid + thiourea} \longrightarrow N_2 + SCN^- + 2H_2O$$

Formation of the product in the above reaction cannot be identified by:

(a) $FeCl_3$/dil. HCl when blood-red color appears

(b) $FeCl_3$/dil. HCl when blue color appears

(c) $K_2Cr_2O_7$/HCl when green color appears

(d) $KMnO_4$/HCl when colorless solution is formed

89. Select the correct statement(s):

(a) $Ag_2S_2O_3$ appears as white precipitate when $Na_2S_2O_3$ reacts with $AgNO_3$

(b) $Ag_2S_2O_3$ is unstable turning black on standing due to formation of Ag_2S

(c) $S_2O_3^{2-}$ can form soluble complex $[Ag(S_2O_3)_2]^{3-}$ with Ag^+

(d) $Na_2S_2O_3$ is used in photography

90. Which of the following sulphides are soluble only in aqua-regia?

(a) NiS (b) CoS

(c) HgS (d) CdS

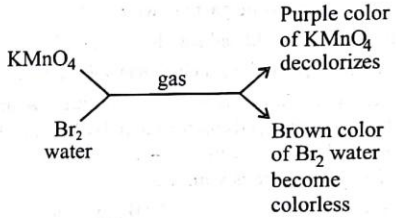
91. Aqueous solution of $X \xrightarrow{NaHC_4H_4O_6}$ White ppt

The cation(s) present in X is/are:

(a) Na^+ (b) Mg^{2+}

(c) NH_4^+ (d) K^+

92.



The gas will be:

(a) CO_2 (b) SO_2

(c) H_2S (d) SO_3

93. Which of the following combinations in an aqueous medium will give a yellow ppt.?

(a) $AgNO_3 + NaBr$

(b) $Pb(CH_3COO)_2 + Na_2CrO_4$

(c) $Fe^{3+} + \overset{\ominus}{S}CN$ (d) None of these

94. Which of the following nitrates are water soluble?

(a) $NaNO_3$ (b) $AgNO_3$

(c) $Hg(NO_3)_2$ (d) $LiNO_3$

95. Which of the following complex(s) will have blue color solution or ppt.?

(a) $[Cu(NH_3)_4]SO_4$ (b) $[Cu(NH_3)_4](OH)_2$

(c) $Co[Hg(SCN)_4]$ (d) $K_3[Co(NO_2)_6]$

96. Which of the following combination will give black ppt.?

(a) $Pb(CH_3COO)_2 + H_2S$ (b) $Cd(CH_3COO)_2 + H_2S$

(c) $Ag_2S_2O_3$ + Heat (d) $AgNO_3 + Na_2S$

97. Which of the following statement(s) is(are) true?

(a) Soluble bicarbonates gives white precipitate with $MgCl_2$ in cold

(b) Soluble calcium bicarbonate gives white precipitate with dilute ammonia solution followed by $MgSO_4$

(c) Bicarbonates are generally soluble in water

(d) Hg(II) chloride forms a reddish-brown precipitate in a solution of soluble carbonate

98. Which of the following statement(s) is(are) correct?

(a) Soluble sulphide gives black precipitate with $AgNO_3$ solution which is soluble in hot dilute nitric acid

(b) Soluble sulphide produces a yellow precipitate with a suspension of cadmium carbonate

(c) Sulphide ion reacts with sodium nitroprusside and gives a purple coloration

(d) Free H_2S gas forms white precipitate with tetrahydroxido plumbate(II) solution

99. Which of the following reagents can be use to distinguish between SO_2 and CO_2?

(a) Lime water

(b) Zinc nitroprusside paste in water

(c) Potassium iodate and starch

(d) Acidified potassium dichromate solution

100. Each of these solutions is added to a mixture of aqueous solutions of iodide and chloroform ($CHCl_3$) separately. Which will give a positive test for iodine when the solutions are vigorously mixed?

(a) NaCl solution (b) NaBr solution

(c) Chlorine water (d) Bromine water

101. Which of the following statement(s) is(are) incorrect?

(a) In thiourea test for nitrite, a green colored solution is obtained

(b) It is not necessary to carry out the chromyl chloride test in a dry test tube

(c) In $PbNO_3$, the brown ring test can be performed with its water extract

(d) Suspension of $CdCO_3$ gives black ppt. with sodium sulphide solution

102. Which of the following is(are) correct?

(a) $[Al(OH)_4]^-_{(aq)} + NH^+_{4\,(aq)} \xrightarrow{\text{Slightly heat}}$ White precipitate and liberation of ammonia

(b) $Pb^{2+}_{(aq)} + 2Br^-_{(aq)} \longrightarrow$ Red precipitate

(c) BiI_3 (black precipitate) + $H_2O\ (l) \xrightarrow{\Delta}$ Orange turbidity

(d) $Fe^{3+}_{(aq)} + K_4\,[Fe\,(CN)_6]_{(aq)} \longrightarrow$ Blue precipitate

103. Pick out the correct statement(s):

(a) Golden yellow PbI_2 dissolves in hot water to give a colorless solution

(b) Ba^{2+} and Ca^{2+} ions can be separated by adding SO_4^{2-} ion in acetic acid medium

(c) Salts of calcium, copper, and nickel give a green flame color

(d) The sulphide ion gives with alkaline sodium nitroprusside, a violet color

104. Which of the following statement(s) is(are) true?

(a) Cu^{2+} salts form soluble complex with excess KCN

(b) Cu^{2+} salts form soluble complex with aqueous ammonia

(c) Cu^{2+} salts form soluble complex with KI

(d) A piece of iron or zinc when placed in Cu^{2+} salt solution, precipitates copper

105. Which of the following statement(s) is/are true?

(a) In a mixture of Sr^{2+} and Ca^{2+}, ammonium sulphate precipitates only Sr^{2+} as $SrSO_4$ but $CaSO_4$ dissolves in ammonium sulphate forming a soluble complex

(b) Barium chromate is insoluble in dilute acetic acid

(c) $Cr(OH)_3$ is soluble in NaOH and Br_2 water while $Fe(OH)_3$ is insoluble

(d) Cu and Cd separation is based upon the fact that in presence of excess KCN, only Cd is precipitated as sulphide on passing H_2S

106.

$$\underset{\text{(Ion)}}{X} + \text{dil. HCl} \longrightarrow \underset{\text{(White turbidity)}}{Y} + SO_2\uparrow$$

$$\Big\downarrow \text{reagent}$$

$$\text{White ppt.} \xrightarrow[\text{aq. suspension}]{\text{Heat}} \text{Black ppt.}$$

Which of the following cation may be present in white ppt.?

(a) Pb^{2+} (b) Hg^{2+}

(c) Ag^+ (d) Bi^{3+}

107. For the lime water test, if the observations are positive for the unknown sample, then which of the following conclusion(s) is/are incorrect?

(a) Sample has only NO_2

(b) Sample has only SO_3

(c) Sample has CO_2 and SO_2

(d) Sample has H_2S

108.

$$CaCO_3 \xrightarrow{\Delta} A + B(\text{gas})$$

$$A + H_2O \longrightarrow C$$

$$C + B \longrightarrow \underset{\text{(White ppt.)}}{D} + H_2O$$

$$D + B(\text{gas}) \longrightarrow \underset{\text{(Water soluble)}}{E} \xrightarrow[BaCl_2]{\text{Boil}} \underset{\text{(White ppt.)}}{F}$$

Select the correct option(s) for white ppt. shown in the above reactions:

(a) $CaCO_3$ (b) $MgCO_3$

(c) $BaCO_3$ (d) Na_2CO_3

109. Which of the following statement(s) is/are correct?

(a) In $S_2O_3^{2-}$, both sulphur are different in nature

(b) Sodium acetate and lead acetate on heating giving same type of product, whereas Mn, Sn, Fe oxalate salt giving different type of products

(c) Aqueous solution OCl^-, S^{2-}, and CO_3^{2-} basic in nature

(d) NO_2^- oxidizes I^- whereas Br_2 and Cl_2 oxidizes NO_2^-

110. In reactions,

(I) $FeSO_4 + NO + H_2O \longrightarrow X$

(II) Sodium nitroprusside + $Na_2S \longrightarrow Y$

Then select the correct option(s) for X and Y:

(a) Products X and Y both are paramagnetic.

(b) In reaction (I) change of oxidation state of central metal occurs, while in reaction (II), there is no change in oxidation state.

(c) Hybridization of central metal in reaction (II) is not changed.

(d) Magnetic moment of compound X is $\sqrt{15}$ B.M.

111. Which of the following is/are correct process for the separation of given ions?

(a) Cu^{2+} from the mixture of Cu^{2+} and Cd^{2+} in aqueous solution,
$Cu^{2+} + Cd^{2+} \xrightarrow[\text{KCN}]{\text{Add excess}} \xrightarrow[\text{and filter}]{\text{Pass } HS_2} Cu^{2+}$ in the filtrate

(b) Cu^{2+} from the mixture of Cu^{2+} and Cd^{2+} in aqueous solution,
$Cu^{2+} + Cd^{2+} \xrightarrow[\text{KCN}]{\text{Add excess}} \xrightarrow[\text{and filter}]{\text{Pass } HS_2} Cu^{2+}$ in the precipitate

(c) Zn^{2+} from the mixture of Zn^{2+} and Cu^{2+} in aqueous solution,
$Zn^{2+} + Cu^{2+} \xrightarrow{H_2S + \text{dil HCl}} \xrightarrow{\text{Filter}} Zn^{2+}$ in the precipitate

(d) Fe^{3+} from the mixture of Fe^{2+} and Fe^{3+} in aqueous solution,
$Fe^{2+} + Fe^{3+} \xrightarrow{NH_4Cl + NH_3 \text{ solution and filter}} Fe^{3+}$ in the precipitate

Comprehension Type

Comprehension-1: (Q. 1 to Q. 3)

(Mixture of two anions)

$$A \xrightarrow{\text{Dil HCl}} \underset{\text{(Acidic gas)}}{B} \xrightarrow{Cr_2O_7^{2-}/H^+} \underset{\text{(Green)}}{C}$$

$$\downarrow CaCl_2$$

$$\underset{\text{(White ppt.)}}{K} + \underset{\text{(Filtrate)}}{E} \xrightarrow{BaCl_2} \underset{\text{(White)}}{S} \xrightarrow{\text{Dil HCl}} \underset{\text{Yellow turbidity}}{G}$$

$$\xrightarrow[\text{Boil}]{Na_2SO_3} H \xrightarrow{FeCl_3} I$$

$$\downarrow Pb(NO_3)_2$$

$$\underset{\text{(Black)}}{V} \xleftarrow{\text{Warming}} J$$

1. Find out V, J:
   (a) ZnS, $Ag_2S_2O_3$ (b) Ag_2S, $Ag_2S_2O_3$
   (c) $Pb_2S_2O_3$, PbS (d) None of these
2. Find out V, K, B:
   (a) ZnS, H_2S, Cr^{3+} (b) Ag_2S, $CaSO_3$, H_2S
   (c) $Pb_2S_2O_3$, $CaSO_3$, SO_2 (d) None of these
3. Find out S, B:
   (a) $BaSO_3$, SO_2 (b) $BaSO_3$, H_2S
   (c) BaS_2O_3, SO_2 (d) None of these

Comprehension-2: (Q. 4 to Q. 8)

$$\underset{\text{White ppt.}}{(E)} \xleftarrow{Na_2CO_3} (A) \xrightarrow{KI_{(aq.)}} \underset{\text{Yellow precipitate}}{(B)} \xrightarrow{BaCl_{2(aq.)}}$$

$$\downarrow \text{aqueous suspension}$$

Brown ppt.

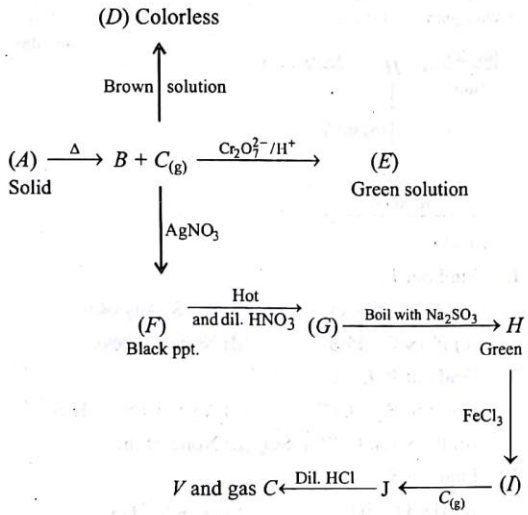
$$\underset{\text{White precipitate}}{(C)} \xrightarrow{NH_4OH \text{ excess}} \text{Solution of } (D)$$

Answer the following questions:

4. Compound (A) is:
   (a) $CuSO_4$ (b) $AgNO_3$
   (c) $Pb(NO_3)_2$ (d) $Ca(NO_3)_2$
5. Yellow precipitate (B) is:
   (a) AgI (b) PbI_2
   (c) CaI_2 (d) CH_3I
6. White precipitate (C) obtained on treatment with aqueous solution of $BaCl_2$ is:
   (a) $BaSO_4$ (b) AgCl
   (c) $PbCl_2$ (d) $CaCl_2$
7. The compound (D) obtained when (C) dissolves in excess of NH_4OH will be:
   (a) AgOH (b) $[Ag(NH_3)_2]Cl$
   (c) Ag_2O (d) $AgNO_3$

8. Molecular formula of the compound E is:
   (a) Ag_2O (b) $Pb(OH)_2$
   (c) $AgOH$ (d) Ag_2CO_3

Comprehension-3: (Q. 9 to Q. 11)



9. Find out V, J:
   (a) Ag_2S, Cr^{3+} solution (b) $FeSO_4$, $FeCl_2$
   (c) $FeCl_2$, FeS (d) None of these
10. Find out V, B:
   (a) FeS, Fe^{2+} (b) FeS, Cr^{3+}
   (c) $FeCl_2$, Cr^{3+} (d) None of these
11. Find out A, B:
   (a) $(NH_4)_2SO_4$, NH_3 (b) $(NH_4)_2S$, NH_3
   (c) $(NH_4)_2CO_3$, CO_2 (d) None of these

Comprehension-4: (Q. 12 to Q. 14)

A colorless solid (A) dissolves in water to a yellowish-brown solution. The solution gives a white ppt. with $BaCl_2$ solution, the white ppt. is insoluble in HCl or HNO_3. When NH_4OH or NaOH is added to a solution of (A), a brown ppt. is formed which does not dissolve in NaOH solution. The brown ppt. dissolves in conc. HCl to give a reddish brown solution which gives a blue ppt. with $[K_4Fe(CN)_6]$ solution. When solid (A) is heated, a colorless gas is evolved and a brown residue is left.

12. Identify A:
   (a) $FeSO_4$ (b) $Fe_2(SO_4)_3$
   (c) $FeSO_4$ (d) FeO
13. What is the formula of brown ppt?
   (a) $Fe(OH)_3$ (b) $Fe(OH)_2$
   (c) $FeCl_3$ (d) None of these
14. Which of the following complex is formed when A reacts with $K_4[(Fe(CN)_6]$:
   (a) Prussian blue (b) Turnbull's blue
   (c) Brown ring complex (d) Sodium nitroprusside

Comprehension-5: (Q. 15 to Q. 18)

A dark brown solid (A) liberates a brown gas (B) on treatment with conc. H_2SO_4. A solution of (A) gives a red-brown precipitate (C) with dilute NaOH or NH_4OH insoluble in an excess of either reagent. A solution of (A) gives a cream-colored (light yellow) precipitate (D) with $AgNO_3$ that is insoluble in dilute HNO_3.

15. Identify A:
   (a) $Fe(NO_2)_3$ (b) $ZnBr_2$
   (c) $FeBr_3$ (d) $ZnCl_2$
16. Identify B:
   (a) Cl_2 (b) Br_2
   (c) NO_2 (d) I_2
17. Identify C:
   (a) $Fe(OH)_3$ (b) Fe_2O_3
   (c) FeO (d) FeS
18. Identify D:
   (a) AgCl (b) AgF
   (c) AgBr (d) None of these

Comprehension-6: (Q. 19 to Q. 22)

An aqueous green solution (A) is treated with NH_4OH when a greenish ppt. (B) is formed which is treated with Na_2O_2 when a yellow solution (C) results. Acidification causes the color of the solution to change from yellow to orange. Addition of dilute aqueous $Pb(NO_3)_2$ to the orange solution after addition of base produces a bright yellow ppt. (D).

19. Identify A:
   (a) $AlCl_3$ (b) $Cr(OH)_3$
   (c) $CrCl_3$ (d) None of these
20. Identify B:
   (a) $CrCl_3$ (b) $Cr(OH)_3$
   (c) $Mn(OH)_2$ (d) CrO_4^{2-}
21. Identify C:
   (a) $Na_2Cr_2O_7$ (b) Na_2CrO_4
   (c) Na_2MnO_4 (d) $NaMnO_4$
22. Identify D:
   (a) PbS (b) PbI_2
   (c) $PbCrO_4$ (d) $Zn(OH)_2$

Comprehension-7: (Q. 23 to Q. 26)

A white water insoluble solid (*A*) turns yellow on heating and becomes white on cooling. Solid (*A*) gives a clear solution (*B*) when treated with HCl solution or treatment with excess NaOH solution (*C*). When H_2S is bubbled through *B* nothing is obtained; however if *B* is made neutral, H_2S causes the precipitation of white compound *D*.

23. Identify *A*:

(a) ZnS (b) ZnO
(c) MnO (d) FeO

24. Identify *B*:

(a) $FeCl_2$ (b) $NiCl_2$
(c) $ZnCl_2$ (d) $FeCl_3$

25. Identify *C*:

(a) Na_2ZnO_2 (b) $Zn(OH)_2$
(c) $Fe(OH)_3$ (d) $Fe(OH)_2$

26. Identify *D*:

(a) ZnO (b) ZnS
(c) FeO (d) FeS

Comprehension-8: (Q. 27 to Q. 30)

(i) (*A*) $\xrightarrow{\Delta}$ glassy transparent bead (*B*) on platinum wire (*B*) + $CuSO_4 \longrightarrow$ colored bead (*C*)

(ii) (*A*) + conc. H_2SO_4 + $CH_3CH_2OH \xrightarrow{\text{ignite}}$ green flame (*D*)

(iii) Aqueous solution of (*A*) is alkaline

27. Identify *A*:

(a) $NaNH_4HPO_4.4H_2O$ (b) $Na_2B_4O_7.10H_2O$
(c) $CuSO_4.5H_2O$ (d) None of these

28. What is the formula of glassy bead (*B*)?

(a) $NaPO_3$ (b) $NaBO_2$
(c) $NaBO_2 + B_2O_3$ (d) None of these

29. Identify *C*:

(a) $Cu_3(PO_4)_2$ (b) $CuSO_4$
(c) $Cu(BO_2)_2$ (d) None of these

30. Identify *D*:

(a) $(CH_3)_3BO_3$ (b) $(C_2H_5)_3BO_3$
(c) H_3BO_3 (d) none of these

Comprehension-9: (Q. 31 to Q. 33)

A colorless mixture of two salts (*A*) and (*B*) [excess] is soluble in H_2O. (*A*) turns blue litmus red and (*B*) turns red litmus blue. (*A*) gives white ppt with (*B*) which dissolves in excess of (*B*) forming (*C*). (*A*) when placed in atmosphere gives fumes and can form dimer. (*A*) gives white ppt with NH_4Cl, and NH_4OH soluble in (*B*).

31. Identify *A*:

(a) $AlCl_3$ (b) $ZnCl_2$
(c) $FeCl_3$ (d) None of these

32. Identify *B*:

(a) $Al(OH)_3$ (b) $Zn(OH)_2$
(c) NaOH (d) None of these

33. Identify *C*:

(a) Na_2ZnO_2 (b) $NaAlO_2$
(c) Na_2SnO_2 (d) None of these

Comprehension-10: (Q. 34 to Q. 36)

For the purpose of systematic qualitative analysis, cations are classified into various groups on the basis of their behavior against some reagents. The group reagents used for the classification of most common cations are hydrochloric acid, hydrogen sulphide, ammonium hydroxide, and ammonium carbonate. Classification is based on whether a cation reacts with these reagents by the formation of precipitates or not.

34. Which one among the following pairs of ions cannot be separated by H_2S in the presence of dilute hydrochloric acid?

(a) Bi^{3+}, Cd^{2+} (b) Al^{3+}, Hg^{2+}
(c) Zn^{2+}, Cu^{2+} (d) Ni^{2+}, Cu^{2+}

35. An aqueous solution contains Hg^{2+}, Hg_2^{2+}, Pb^{2+}, and Cd^{2+}. The addition of 2 M HCl will precipitate:

(a) $HgCl_2$ only (b) $PbCl_2$ only
(c) $PbCl_2$ and Hg_2Cl_2 (d) $PbCl_2$ and $CdCl_2$

36. An aqueous solution which is slightly acidic contain cations Fe^{3+}, Zn^{2+}, and Cu^{2+}. The reagent that when added in excess to this solution would identify the separate Fe^{3+} ion in one step is:

(a) 2M HCl (b) 6M NH_3
(c) 6M NaOH (d) H_2S gas

Comprehension-11: (Q. 37 to Q. 39)

The reagents like silver nitrate, potassium ferrocyanide, potassium thiocyanate, potassium iodide, potassium chromate, Nessler's reagent, etc., find extensive and very important application in qualitative analysis because these reagents form different types of products with different cations. For example, potassium iodide forms yellow precipitate with Pb^{2+} but it forms red precipitate with Hg^{2+}. Hence, these reagents are widely used in the qualitative analysis of inorganic salts:

37. Which of the following is not correctly matched?

(a) $Ag^+ + S_2O_3^{2-} \longrightarrow$ White ppt.

(b) $Pb^{2+}(aq) + 2Cl^{\ominus}(aq) \longrightarrow$ Black precipitate

(c) BiI_3 (black precipitate) + H_2O (l) $\xrightarrow{\Delta}$ Orange turbidity

(d) $Ca^{2+}(aq) + K_4[Fe(CN)_6](aq) \longrightarrow$ White precipitate

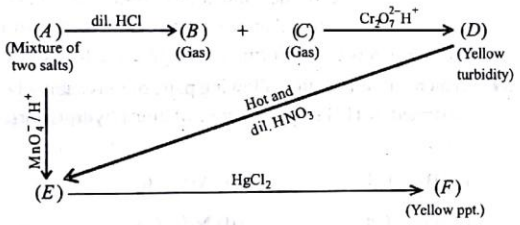
38. Which of the following cations (i.e., basic radicals) forms colored (not white) precipitates with aqueous solution of potassium iodide but precipitate does not dissolve in excess of reagent?

(a) Hg^{2+} (b) Hg_2^{2+}
(c) Bi^{3+} (d) Cu^{2+}

39. Which of the following hydroxide does not dissolve in ammonia solution but dissolves in sodium hydroxide?

(a) $Zn(OH)_2$ (b) $Cd(OH)_3$
(c) $Cu(OH)_2$ (d) $Al(OH)_3$

Comprehension-12: (Q. 40 to Q. 42)



40. Find the anion(s):

(a) SO_3^{2-} (b) SO_3^{2-}, S^{2-}
(c) SO_3^{2-}, CO_3^{2-} (d) $S_2O_3^{2-}$

41. Find out (*E*):

(a) S^{2-} (b) CO_3^{2-}
(c) $S_2O_3^{2-}$ (d) SO_4^{2-}

42. Find out (*F*):

(a) $HgSO_4 \cdot 2HgO$ (b) $HgSO_4 \cdot 3HgO$
(c) $HgSO_4$ (d) $Hg_2SO_4 \cdot 3HgO$

Comprehension-13: (Q. 43 to Q. 45)

A black colored (insoluble in H_2O) solid *A* does not dissolve in HNO_3. Aquaregia can dissolve *A* forming *B*. *B* gives yellow precipitate *C* with NaOH. *B* also gives orange ppt. *D* with KI. *D* dissolves in excess of KI forming *E*. *E* gives brown ppt. with NH_4^+ salt in presence of NaOH. *A* is precipitated if H_2S gas is passed into the solution of *B* in dil. HCl.

43. The compound *A* is:

(a) HgS (b) CuS
(c) $PbCl_2$ (d) FeS

44. The compound *C* is:

(a) $HgCl_2$ (b) $PbCl_2$
(c) HgO (d) PbO

45. The compound *E* is:

(a) PbI_2 (b) FeI_3
(c) K_2HgI_4 (d) HgI_2

Comprehension-14: (Q. 46 and Q. 47)

Cation and anion are called basic and acidic radicals, respectively, because during salt formation cation comes from base and anion comes from acid.

46. Cu^{2+} ions will be reduced to Cu^+ ions by the addition of an aqueous solution of:

(a) KI (b) KCl
(c) KSCN (d) Both (a) and (c)

47. $K_4[Fe(CN)_6]$ can be used to detect one or more out of $Fe^{2+}, Fe^{3+}, Zn^{2+}, Cu^{2+}, Cd^{2+}$:

(a) Fe^{2+}, Fe^{3+} only (b) $Fe^{3+}, Zn^{2+}, Cu^{2+}$ only
(c) All but not Cd^{2+} (d) All of these

Comprehension-15: (Q. 48 to Q. 52)

A colorless solid *A*, when placed in water, produces a heavy white turbidity *B*. Solid *A* gives a clear solution in conc. HCl. When HCl solution is added to large amount of water, *B* forms again. *B* dissolves in dilute HCl. When H_2S is passed through a suspension of *A* or *B*, a black precipitate *C* forms. Conc. H_2SO_4 added to solid *A* liberates gas *D*. Gas *D* is water-soluble and gives white precipitate *E* with a solution of mercurous salts but not with mercuric salts.

48. Identify *A*:

(a) BiOCl (b) Bi_2S_3
(c) $BiCl_3$ (d) $BaSO_4$

49. Identify *B*:

(a) BiOCl (b) BaS
(c) $BiCl_3$ (d) None of these

50. Identify *C*:

(a) BiOCl (b) Bi_2S_3
(c) $BiCl_3$ (d) H_2S

51. Identify *D*:

(a) Br_2 (b) HCl
(c) I_2 (d) Cl_2

52. Identify *E*:

(a) $Hg_2(NO_3)_2$ (b) HCl
(c) Hg_2Cl_2 (d) HNO_3

Comprehension-16: (Q. 53 to Q. 55)

An aqueous solution of an inorganic compound (*X*) gives the following reactions:

(i) With an aqueous solution of $BaCl_2$, a precipitate insoluble in dilute HCl is obtained.

(ii) Addition of excess of KI gives a brown precipitate which turns white on addition of excess hypo solution

(iii) With an aqueous solution of potassium ferrocyanide a chocolate colored ppt. is obtained.

53. Identify *X:*

(a) $CuSO_4$ (b) $BaSO_4$
(c) $BaCl_2$ (d) NaI

54. What is the formula of choclate colored ppt.?

(a) $Fe_4[Fe(CN)_6]$ (b) $Cu_2[Fe(CN)_6]$
(c) $Cu_2[Fe(CN)_4]$ (d) $Cu(CN)_2$

55. What is the formula of brown ppt.?

(a) Cu_2I_2 (b) $Cu_2I_2 + I_3^{\ominus}$
(c) CuI_2 (d) $CuSO_4$

Comprehension-17: (Q. 56 to Q. 59)

Compound (*A*) is a greenish crystalline salt which gives the following results when tested:

(a) Addition of $BaCl_2$ solution to a solution of (*A*) results in the formation of a white precipitate (*B*) which is insoluble in dilute HCl.

(b) On heating, water vapor and two gases *C* and *D* are liberated, leaving a red brown residue *E*.

(c) *E* dissolves in conc. HCl to give a yellow solution *F*.

(d) With H_2S, the solution *F* yields a yellow-white ppt. *G* which when filtrated, leaves a greenish filtrate *H*.

(e) The solution *F* gives a green solution with $SnCl_2$, and when reacted with $K_4[Fe(CN)_6]$ gives a blue ppt.

56. Identify compound *A:*

(a) $ZnSO_4 \cdot 7H_2O$ (b) $FeSO_4 \cdot 7H_2SO_4$
(c) $MgSO_4 \cdot 7H_2O$ (d) $CuSO_4 \cdot 5H_2O$

57. Gases *C* and *D* are:

(a) SO_2, SO_3 (b) SO_3, CO_2
(c) NO_2, MgO (d) ZnO, SO_3

58. Identify yellow solution *F:*

(a) Fe_2O_3 (b) $FeCl_3$
(c) $ZnCl_2$ (d) CuCl

59. Identify *G:*

(a) SO_2 (b) ZnS
(c) S (d) FeS

Comprehension-18: (Q. 60 to Q. 62)

(*A*) greenish salt soluble in water gives a greenish ppt. with NH_4OH. When this ppt. is boiled with caustic soda and bromine water (with Na_2O_2), a yellow solution is obtained. On addition of lead acetate and acetic acid to the yellow solution, a yellow ppt. is formed.

60. The formula of greenish salt is:

(a) $Cr_2(SO_4)_3$ (b) $Al_2(SO_4)_3$
(c) $FeSO_4$ (d) None of these

61. Cationic part of (*A*) greenish salt is a:

(a) I group cation (b) II group cation
(c) III group cation (d) IV group cation

62. Which of the following group reagent is used for identification of cationic part of (*A*)?

(a) $NH_4Cl + NaOH$ (b) $NH_4Cl + NH_4OH$
(c) H_2S gas in basic medium
(d) None of these

Comprehension-19: (Q. 63 to Q. 65)

A hydrate metallic salt *A*, light green in color, on careful heating, gives a white anhydrous residue *B*. *B* is soluble in water and its aqueous solution reacts with NO to give a dark brown compound *C*. *B* on strong heating gives a brown residue *D* and a mixture of two gases *E* and *F*. The gaseous mixture when passed through acidified $KMnO_4$ discharges the pink color and when passed through $BaCl_2$ solution gives a white precipitate.

63. Identify *C:*

(a) $[Fe(H_2O)_5NO]SO_4$ (b) Na_2SO_4
(c) $Na_2[Fe(CN)_5NO]$ (d) $Fe_4[Fe(CN)_6]_3$

64. Identify *B:*

(a) $ZnSO_4$ (b) $CuSO_4$
(c) $MgSO_4$ (d) $FeSO_4$

65. Identify *D:*

(a) ZnO (b) FeO
(c) Fe_2O_3 (d) CuO

Comprehension-20: (Q. 66 to Q. 69)

(*A*), an important laboratory reagent, turns red litmus blue, imparts golden yellow color in flame, and is a good precipitating agent. (*A*) reacts with Zn or Al forming H_2 gas. (*A*) gives white ppt with $ZnCl_2$ or $AlCl_3$ but ppt. dissolves in excess of (*A*).

66. Which of the following reagent is *A?*

(a) Na_2SO_4 (b) $NaNO_3$
(c) NaOH (d) KOH

67. What is the nature of *A?*

(a) Acidic (b) Basic
(c) Amphoteric (d) None of these

68. What is the formula of white ppt. When does *A* react with $ZnCl_2$?

(a) ZnS (b) $[Zn(OH)_4]^{2-}$
(c) $Zn(OH)_2$ (d) None of these

69. What is the formula of compound when *A* reacts with $AlCl_3$ in excess amount?

(a) $Al(OH)_3$ (b) Al_2O_3
(c) $Na[Al(OH)_4]$ (d) None of these

Comprehension-21: (Q. 70 to Q. 72)

Silver nitrate gives a white recipitate (*A*) with aqueous sodium thiosulphate (*B*); the precipitate dissolves in excess of thiosulphate. If the precipitate is heated with water, it turns black (*C*), and the upper layer liquid then gives a white precipitate (*D*) with acidified barium nitrate solution.

70. What is the formula of white ppt. (*A*)?

(a) Ag_2S (b) AgS_2O_3

(c) $Ag_2S_2O_3$ (d) $AgNO_3$

71. What is the formula of black ppt. *C*?

(a) HgS (b) PbS

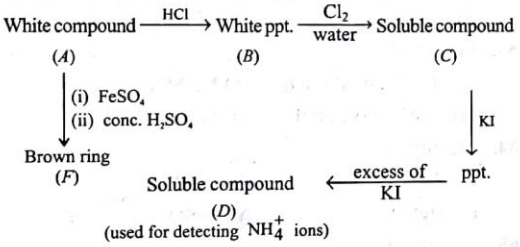
(c) Ag_2S (d) Ag_2CrO_4

72. What is the formula of (*D*)?

(a) BaS (b) $BaCl_2$

(c) $BaSO_4$ (d) $Ba(NO_3)_2$

Comprehension-22: (Q. 73 to Q. 76)



73. Compound (*A*) is:

(a) HgI_2 (b) K_2HgI_4

(c) $Hg(NO_3)_2$ (d) $Hg_2(NO_3)_2$

74. Oxidation state of Fe in compound (*F*) is:

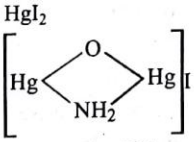
(a) +1 (b) +2

(c) +3 (d) +4

75. $(D) + (NH_4)_2SO_4 \longrightarrow$ brown ppt. (*G*)
in basic medium

Hence, compound (*G*) is:

(a) HgI_2 (b) NH_4I

(c) 

(d) $Hg(NH_2)I$

76. White ppt. (*B*) + $NH_3 \longrightarrow$ Black ppt. (*H*)

Hence, (*H*) is due to the formation of:

(a) $Hg(NH_2)Cl$ (b) Hg

(c) $Hg(NH_2)Cl + Hg$ (d) $Hg(NH_2)$

Comprehension-23: (Q. 77 to Q. 80)

A black colored compound (*A*) on reaction with dil. H_2SO_4 gives a gas (*B*) which on passing in a solution of an acid (*C*) gives a white turbidity (*D*). Gas (*B*) when passed in an acidified solution of a compound (*E*) gives a black precipitate (*F*) which is soluble in hot concentrated (*C*). After boiling this solution when excess of ammonia solution is added, a blue colored compound (*G*) is formed. To the solution of (*E*), on addition of acetic acid and aqueous potassium ferrocyanide, a chocolate brown precipitate (*H*) is formed. On addition of an aqueous solution of $BaCl_2$ to an aqueous solution of (*E*), white precipitate insoluble in HNO_3 is obtained.

77. Black colored compound (*A*) is:

(a) PbS (b) CuS

(c) Ag_2S (d) All of these

78. The gas (*B*) on passing through an acid (*C*) gives a white turbidity (*D*) because:

(a) Gas (*B*) acts as an oxidizing agent

(b) Gas (*B*) acts as an reducing agent

(c) Acid (*C*) acts as an oxidizing agent

(d) Both (b) and (c)

79. To which of the following property, will the compound(*E*) respond?

(a) It gives white precipitate with $(CH_3COO)_2Pb$ solution soluble in ammonium acetate

(b) It gives dirty white precipitate with KI

(c) Its hydrated salt effloresces

(d) All of these

80. When a piece of iron or zinc is added to the solution of compound (*F*) in hot concentrated (*C*) acid:

(a) A reddish brown precipitate is formed

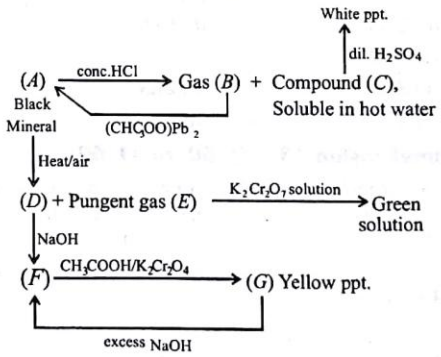
(b) A white precipitate is formed

(c) A black precipitate is formed

(d) None of these

Comprehension-24: (Q. 81 to Q. 83)

Read the following sequence of reaction.



81. Gas (*B*) on passing through $CdSO_4$ solution will give:
(a) Black ppt. (b) Yellow ppt.
(c) Orange ppt. (d) No ppt.

82. Compound (*A*), (*B*), and (*E*) are, respectively:
(a) CuS, H_2S, SO_2 (b) PbS, H_2S, SO_2
(c) PbS, H_2S, SO_3 (d) ZnS, H_2S, SO_2

83. Compound (*C*) and (*D*) are, respectively:
(a) PbO, $PbCl_2$ (b) $PbCl_2$, PbO
(c) PbO, PbO_2 (d) PbS, PbO

Comprehension-25: (Q. 84 to Q. 86)

A certain metal (*A*) is boiled in dil HNO_3 to give a salt (*B*) and oxide of nitrogen (*C*). An aqueous solution of *B* with brine solution gives a ppt. (*D*) which is soluble in NH_4OH. On adding aqueous solution of (*B*) to hypo solution a white ppt. (*E*) is obtained. *E* turns black on long standing.

84. Compound *B* on strong heating gives:
(a) Hg_2O, NO_2, O_2 (b) Hg, NO_2, O_2
(c) Ag, NO_2, O_2 (d) Ag_2O, NO_2, O_2

85. Compound *D* is insoluble in water but soluble in KCN give:
(a) $[Hg(CN)_2]^-$ (b) $[Hg(CN)_4]^{2-}$
(c) $[Ag(CN)_2]^-$ (d) AgCN

86. Compound *E* on long standing slowly converts into yellow, brown, and finally black to the formation of:
(a) Hg_2S (b) Ag_2S
(c) HgS (d) $Hg(NH_2)Cl + Hg$

Comprehension-26 [Paragraph for Q. 87 to Q. 89 (more than one correct)]

A great scientist "PHUNSUKH WANGDU" collected four sample solution in different test tube for a new discovery to achieve "Nobel Prize" (Chemistry) in the year of 2010. But his very close friend "CHATUR" all of a sudden appeared in the laboratory and kicked off a bottle of amonia solution on all these samples, which caused precipitation from all samples and spoiled the experiments. But "PHUNSUKH WANGDU" told himself "ALL IS WELL" and has not lost his enthusiasm at all and found the following observation about the precipitates:

(a) White ppt. which is soluble in excess of NH_3 solution
(b) On heating white ppt. obtained from (a) produces a compound which is white in cold but yellow on heating
(c) The cation present in (b) form white ppt. with hypo solution which gives black ppt. on heating
(d) The cation present in (c) form soluble complex with excess of NH_3 solution

87. White ppts. in (a), (b), and (c), respectively, obtained are:
(a) $Zn(OH)_2$, $Zn(OH)_2$, $HgO.Hg(NH_2)NO_3$
(b) $Cd(OH)_2$,$Zn(OH)_2$, $HgO.Hg(NH_2)NO_3$
(c) $HgO.Hg(NH_2)NO_3$, $Zn(OH)_2$, $Cd(OH)_2$
(d) $Al(OH)_3$, $Zn(OH)_2$, $Pb(OH)_2$

88. The solution initially present in (a) + H_2S (basic medium) gives ppt., then (a) may have:
(a) Zn^{2+} (b) Cd^{2+}
(c) Co^{2+} (d) Ni^{2+}

89. White ppt. in (c) and the soluble complex formed from white ppt. with the hypo solution is/are:
(a) $Pb(OH)_2$, $[Pb(S_2O_3)_2]^{2-}$
(b) Ag_2O, $[Ag(S_2O_3)_2]^{3-}$
(c) $HgO.Hg(NH_2)NO_3$, $[Hg(S_2O_3)_2]^{2-}$
(d) None of these

Comprehension-27: (Q. 90 to Q. 97)

A black colored compound (*A*) on reaction with dilute H_2SO_4 gives a gas (*B*) which on passing in a solution of an acid (*C*) gives a white turbidity (*D*). Gas (*B*) when placed in an acidified solution of a compound (*E*) gives a precipitate (*F*) soluble in dilute HNO_3. After boiling this solution, when an excess of NH_4OH is added, blue colored compound (G) is formed. To this solution on addition of CH_3COOH and aqueous $K_4[Fe(CN)_6]$, a chocolate precipitate (*H*) is obtained. On addition of an aqueous solution of $BaCl_2$ to an aqueous solution of *E*, a white ppt insoluble in HNO_3 is obtained.

90. Identify *A*:
(a) $FeCl_2$ (b) $FeCl_3$
(c) FeS (d) $FeSO_4$

91. Identify *B*:
(a) CO_2 (b) H_2S
(c) SO_2 (d) SO_3

92. Identify *C*:
(a) CH_3COOH (b) HNO_3
(c) H_2S (d) CuS

93. Identify *D*:
(a) $CuSO_4$ (b) CuS
(c) S (d) H_2S

94. Identify *E*:
(a) $CuSO_4$ (b) $BaCl_2$
(c) $Cu(OH)_2$ (d) NH_3

95. Identify *F*:

(a) $CuSO_4$ (b) $BaSO_4$

(c) CuS (d) H_2S

96. Identify *G*:

(a) $K_4[Fe(CN)_6]$ (b) $[Cu(NH_3)_4](OH)_2$

(c) $K_3[Fe(CN)_6]$ (d) None of these

97. Identify *H*:

(a) $Cu_2[Fe(CN)_6]$ (b) $[Cu(NH_3)_4](OH)_2$

(c) $BaSO_4$ (d) $Fe_4[Fe(CN)_6]_3$

Comprehension-28: (Q. 98 to Q. 100)

A colorless water insoluble solid (*A*) decomposes on heating to give a residue (*B*) with evolution of a colorless gas which turns lime water milky. (*B*) turns yellow on heating and white on cooling. When (*B*) is heated with cobalt oxide or cobalt nitrate solution on charcoal cavity, a green mass is left on the cavity.

98. Identify *A*:

(a) $ZnSO_4$ (b) $ZnCO_3$

(c) $Zn(OH)_2$ (d) None of these

99. Identify colorless gas *B*:

(a) SO_2 (b) CO_2

(c) SO_3 (d) NO_2

100. Identify the formula of green mass:

(a) $Al_2O_3 \cdot CoO$ (b) $SnO \cdot CoO$

(c) $ZnO \cdot CoO$ (d) $MgO \cdot CoO$

Comprehension-29: (Q. 101 to Q. 103)

(i) $(A) \xrightarrow[\Delta]{NaOH} (B)(g) \xrightarrow{HCl}$ White fumes.

(ii) After (*B*) is expelled completely, resultant alkaline solution again gives gas (*B*) on heating with zinc.

(iii) $(A) \xrightarrow{\Delta} N_2O + H_2O$.

101. Identify *A*:

(a) NH_4NO_2 (b) NH_4NO_3

(c) HCl (d) Na_2SO_4

102. Identify *B*:

(a) SO_2 (b) NH_3

(c) N_2O (d) NO_2

103. What is the formula of white fumes?

(a) NH_4NO_3 (b) NH_4Cl

(c) NH_4NO_2 (d) NH_3

Comprehension-30: (Q. 104 to Q. 108)

Identification of cations can also be done using a dry test called sodium carbonate-bead test which is similar to borax-bead test.

$$Na_2CO_3 \xrightarrow[\text{oxidizing flame}]{KNO_3 \text{ fuse and heat in}} \begin{cases} \xrightarrow{\text{with MnO}} A \xrightarrow{Cl_2} B \\ \xrightarrow{\text{with } Cr_2O_3} C \xrightarrow{H_2SO_4} D \end{cases}$$

104. Identify *A*, and what is the hybridization of *A*?

(a) Na_2MnO_4, d^3s (b) $NaMnO_4$, sp^3

(c) Mn_2O_7, d^3s (d) $Na_2Cr_2O_7$, d^3s

105. Identify *B*, and what is the hybridization of *B*?

(a) Na_2MnO_4, d^3s (b) $NaMnO_4$, sp^3

(c) $Nn_2Cr_2O_7$, d^3s (d) $NaMnO_4$, d^3s

106. Identify *C* and color of *C*:

(a) Na_2CrO_4, orange (b) $Na_2Cr_2O_7$ (orange)

(c) $Na_2Cr_2O_7$, (yellow) (d) Na_2CrO_4, yellow

107. Identify D, and how many unpaired $e^{\ominus}$ are present in *D*?

(a) Na_2CO_3, 1 (b) $NaMnO_4$, 2

(c) $Na_2Cr_2O_7$, zero (d) Na_2CrO_4, zero

108. What is the color of compound *A*?

(a) Yellow (b) Green

(c) Orange (d) Brown

Comprehension-31: (Q. 109 to Q. 111)

A colorless solid (*A*) when placed into water produces a heavy white turbidity to (*B*). Solid (*A*) gives a clear solution in conc. HCl when HCl solution is added to large amounts of water, (*B*) forms again. (*B*) dissolves in dilute HCl. When H_2S is passed through a suspension of (*A*) or (*B*), a black precipitate (*C*) forms, (*C*) is insoluble in yellow ammonium sulphide $(NH_4)_2S$. Conc. H_2SO_4 added to solid (*A*) liberates gas (*D*). Gas (*D*) is water-soluble and gives white precipitate with mercuric salts (*E*) and not mercuric salts. The black precipitate (*C*) dissolves in HNO_3 (1 : 1) to give a solution to which H_2SO_4 is added followed by addition of NH_4OH when a white precipitate (*F*) is formed. (*E*) gives a black ppt. (*G*) with solution of sodium stannite.

109. When compound *E* reacts with NH_4OH, then product is a:

(a) White ppt. (b) Black ppt.

(c) Yellow ppt. (d) Green ppt.

110. Compound *C* is also formed by the following reaction:

(a) $Ba^{2+} + S_2O_3^{2-} \longrightarrow E$

(b) $Bi^{3+} + S_2O_3^{2-} \longrightarrow E$

(c) $Bi_2S_2O_3 \xrightarrow{\Delta} E$ (d) None of these

111. Compound B is not soluble in:

(a) Tartaric acid (b) HCl

(c) HNO_3 (d) H_2SO_4

Comprehension-32: (Q. 112 to Q. 114)

(A) is a colorless solid; it melts when heated and gives off a colorless gas (B) which is supporter of combustion. If heating is continued, the whole of the solid disappears. When (A) is heated with an aqueous NaOH solution, an alkaline gas (C) is evolved. When gas (B) is heated with sodamine, a colorless solid (D) is formed. When (D) is heated with dil. H_2SO_4, a colorless liquid (E) is formed.

112. The compound E has:

(a) Linear structure (b) Bent structure

(c) Tetrahedral structure (d) None of these

113. The name of compound E is:

(a) Ammonia (b) Hydrazoic acid

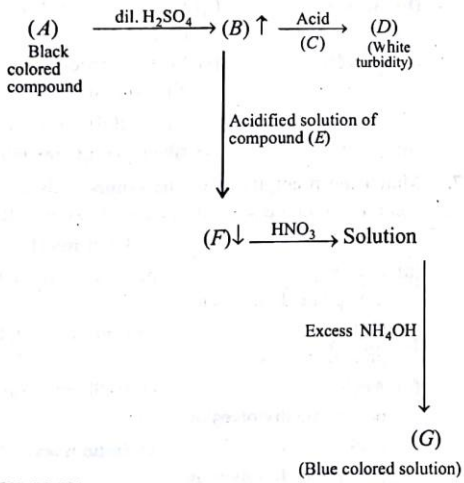
(c) Hydrogen amide (d) None of these

114. The compound C has:

(a) Linear geometry (b) Pyramidal

(c) Tetrahedral (d) None of these

Comprehension-33: (Q. 115 to Q. 117)



$(G) \xrightarrow[K_4Fe(CN)_6]{CH_3COOH} (H)$ (Chocolate ppt.)

Compound (E) (aq. solution) $\xrightarrow[\text{aq. solution}]{BaCl_2}$ White ppt. insoluble in HNO_3.

115. Compound (A) is:

(a) FeS (b) CuS

(c) NiS (d) All of these

116. Compound (G) is:

(a) $Cu(NH_3)_4(NO_3)_2$ (b) $Ni(NH_3)_4(NO_3)_2$

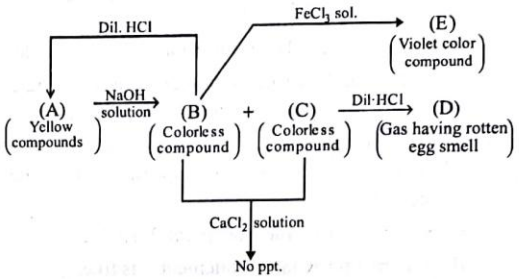
(c) $Cu(NH_3)_3NO_2$ (d) $Fe(NH_3)_2(NO_2)_2$

117. Compound (H) is:

(a) $Cu[Fe_4(CN)_6]$ (b) $Cu_2[Fe(CN)_6]$

(c) $Fe_4[Fe(CN)_6]_3$ (d) $Ni[Fe(CN)_5]$

Comprehension-34: (Q. 118 to Q. 120)



118. Compound (B) on strong heating produces compound(s) which has/have:

(a) Chain structure

(b) Tetrahedral structure

(c) Both (a) and (b)

(d) None of these

119. Which of the following statements is/are correct for gas (D)?

(I) It has the state of hybridization sp^3.

(II) Gas can be identified by $CaCl_2$ solution.

(III) Gas can be identified by $Pb(OAc)_2$ solution.

(IV) Gas can be identified by passing through sodium nitroprusside solution.

(a) I, IV (b) I, III

(c) III only (d) I, II, IV

120. Compound (B) on reaction with $[Ni(en)_3](NO_3)_2$ gives a colored complex exhibiting:

(a) Optical isomerism

(b) Geometrical isomerism

(c) Linkage isomerism

(d) No isomerism

Assertion-Reasoning Type

1. **Statement-1:** A solution of AgCl in NH_4OH gives a white precipitate with HNO_3.

Statement-2: $[Ag(NH_3)_2]^+$ decomposes in the presence of HNO_3.

(a) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true; statement-2 is NOT a correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

2. **Statement-1:** The solubility of $Zn(OH)_2$ is enhanced in acidic as well as in basic medium as compared to water.

Statement-2: $Zn(OH)_2$ is an amphoteric hydroxide.

(a) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1.
(b) Statement-1 is true, statement-2 is true; statement-2 is NOT a correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

Matching Column Type

1. Match the column:

Column-I	Column-II
(a) Fe^{2+} react with $K_3[Fe(CN)_6]$	(p) Cherry red ppt.
(b) Fe^{3+} react with $K_4[Fe(CN)_6]$	(q) Turn bull's blue
(c) Ni^{2+} react with DMG	(r) Prussian blue
(d) Cu^{2+} react with NH_3 solution	(s) Blue solution

2. Match the column:

Column-I	Column-II
(a) Ag^+	(p) Zero group radical
(b) Pb^{2+}	(q) I group radical
(c) Fe^{3+}	(r) II group radical
(d) NH_4^+	(s) III group radical
	(t) IV group radical

3. Match the column:

Column-I	Column-II
(a) $PbSO_4$	(p) Water insoluble
(b) $BaSO_4$	(q) Water soluble
(c) AgCl	(r) Blue colored
(d) $CuSO_4$	(s) White ppt.
	(t) Compound having *d*-block cation

4. Match the column:

Column-I (Radical)	Column-II (Group reagent)
(a) Ag^+	(p) dil. HCl
(b) Al^{3+}	(q) H_2S gas in acidic medium
(c) Zn^{2+}	(r) NH_4OH in presence of NH_4Cl
(d) Cu^{2+}	(s) H_2S gas in basic medium
	(t) $(NH_4)_2CO_3$

5. There are certain chemical reagents which are used in the qualitative analysis of specific acid, i.e., anionic radicals. Match the reagent listed in column-I with acid radicals listed in column-II:

Column-I (Reagent)	Column-II (Anion)
(a) Silver nitrate solution	(p) CO_3^{2-}
(b) Barium chloride solution	(q) SO_3^{2-}
(c) Lead nitrate solution	(r) S^{2-}
(d) Acidified potassium permangnate solution	(s) NO_2^-

6. Match the salts listed in column (I) with the color of the precipitate and reagent(s) listed in column (II):

Column-I	Column-II
(a) $FeSO_4$	(p) Brown precipitate with NaOH
(b) $Bi(NO_3)_3$	(q) White precipitate with $Pb(NO_3)_2$
(c) $AgNO_3$	(r) Yellow precipitate with NH_4NO_2 and CH_3COOH on warming
(d) $CoCl_2$	(s) Black precipitate with H_2S

7. Match the precipitates of the compounds listed in column-I with the solvent(s) listed in column-II.

Column-I	Column-II
(a) $Zn(OH)_2$ precipitate dissolves in	(p) Potassium cyanide
(b) $Cr(OH)_3$ precipitate dissolves in	(q) Ammonia solution
(c) AgCl precipitate dissolves in	(r) Sodium hydroxide
(d) CuS precipitate dissolves in	(s) Sodium peroxide

8. Match the column:

Column-I	Column-II
(a) White ppt.	(p) $Fe^{3+} + SO_2 \longrightarrow$
(b) Black ppt.	(q) $Pb^{2+} + Na_2S \longrightarrow$
(c) Yellow ppt.	(r) $SO_3^{2-} + Pb(NO_3)_2 \longrightarrow$
(d) Green colouration	(s) $PbSO_3 + O_2 \xrightarrow{\text{boil}}$
	(t) $Cd^{2+} + Na_2S \longrightarrow$

9. Match the column:

Column-I	Column-II
(a) Violet color gas	(p) SO_2
(b) Rotten egg smell	(q) NO_2
(c) Brown color	(r) I_2
(d) Suffocating smell	(s) H_2S
	(t) Br_2

10. Match the column:

Column-I	Column-II
(a) PbO_2	(p) Soluble in excess alkali solution
(b) ZnO	(q) Form blue color hydroxide with alkali solution
(c) $HgCl_2$	(r) Reacts with NaOH to form colored ppt.
(d) $CuSO_4$	(s) Yellow on heating

11. Match the column:

Column-I	Column-II
(a) $NH^+_{4(aq)}\,[Co(NO_2)6]^{3-}{}_{(aq)} \longrightarrow$ complex	(p) Colorless water soluble complex
(b) $Cr(OH)_3\downarrow + NH_{3(aq)} \longrightarrow$ complex	(q) Yellow colored water insoluble complex
(c) $Fe(SCN)_{3(aq)} + F^-{}_{(aq)} \longrightarrow$ complex	(r) Value of oxidation state of metal ion and number of unpaired electrons are same
(d) $Ni(OH)_2\downarrow + NH_{3(aq)} \longrightarrow$ complex	(s) d^2sp^3-hybridization
	(t) sp^3d^2-hybridization

12. Match the substances given in column-II based on reactions given in column-I and select correct answer from the alternate:

Column-I	Column-II
(a) A white, waxy solid, normally stored under water because it spontaneously inflames in air	(p) HNO_3
(b) A viscous liquid that reacts with $BaCl_2$, giving a white ppt.	(q) Cl_2
(c) An acid that reacts with copper metal, releasing brown fumes	(r) P
(d) A pale greenish yellow gas that dissolves in aqueous NaOH to give a solution used as a bleach	(s) H_2SO_4

13. Match the column:

Column-I	Column-II
(a) HgS	(p) Black ppt.
(b) PbS	(q) White ppt.
(c) Ag_2S	(r) ppt. of II group cation
(d) ZnS	(s) Salt having *p* block cation
	(t) Salt having *d* block cation

14. Match the column

Column–I	Column–II
(a) Pb^{2+}	(p) 1st group
(b) Cu^{2+}	(q) zero group
(c) NH_4^+	(r) 3rd group
(d) Al^{3+}	(s) 2nd group

15. Column (I) contains some reagents which when taken in excess produce precipitate with radical(s) given in column (II). Accordingly match column (I) with column (II):

Column–I (Reagent)	Column–II (Radical)
(a) KCN (aq)	(p) Pb^{2+}
(b) NaOH (aq)	(q) Ag^+
(c) KI (aq)	(r) Hg_2^{2+}
(d) K_2CrO_4 (aq)	(s) Cu^{2+}

16. Match the column:

Column-I	Column-II
(a) Green coloration	(p) $HCO_3^- + BaCl_2 \xrightarrow{\text{boil}}$
(b) White ppt.	(q) $SO_3^{2-} + BaCl_2 \longrightarrow$
(c) Black ppt.	(r) $SO_2 + Cr_2O_7^{2-} \longrightarrow$
	(s) $Na_2S + Ag^+ \longrightarrow$

17. Match the column:

Column-I	Column-II
(a) Deep blue color	(p) $[Cu(NH_3)_4]SO_4$
(b) Yellow ppt.	(q) $[Cu(NH_3)_4](OH)_2$
(c) Blue ppt.	(r) $Co[Hg(SCN)_4]$
	(s) $K_3[Co(NO_2)_6]$

18. Match the column:

Column-I	Column-II
(a) White ppt.	(p) $HgSO_4{\cdot}2HgO$
(b) Yellow ppt.	(q) Ag_2CrO_4
(c) Brick red ppt.	(r) $(NH_4)_3\,P(Mo_3O_{10})_4$
(d) Blue color	(s) $MgNH_4PO_4$
	(t) CrO_5

19. Match the column:

Column-I (Reagents)	Column-II (Observation)
(a) $K_4[Fe(CN)_6]$	(p) Produces deep blue solution with $CuSO_4$ solution

(b) $(NH_4)_2S$	(q) Produces deep blue ppt. with $FeSO_4$ solution
(c) NH_4OH(excess)	(r) Produces deep blue ppt. with $FeCl_3$ solution
(d) NaOH(excess)	(s) Produces colorless solution or white ppt. with $ZnSO_4$ solution
	(t) Produces chocolate brown ppt. with $CuSO_4$ solution

20. Match the column:

Column-I (Reaction)	**Column-II (Precipitate obtained as one of the products)**
(a) $Hg^{2+}_{(aq)} + I^-_{(aq)} \longrightarrow$	(p) Yellow precipitate
(b) $Cu^{2+}_{(aq)} + [Fe(CN)_6]^{4-}_{(aq)} \longrightarrow$	(q) Brown precipitate
(c) $Mg^{2+}_{(aq)} + NH_{3(aq)} + HPO_4^{2-}{}_{(aq)} \longrightarrow$	(r) White precipitate
(d) $Pb^{2+}_{(aq)} + CrO_4^{2-}{}_{(aq)} \longrightarrow$	(s) Red precipitate

21. Match the column:

Column-I	**Column-II**
(a) Chromyl chloride test	(p) H_2S
(b) Rotten egg smell	(q) SO_2
(c) Suffocating smell	(r) $K_4[Fe(CN)_6]$
(d) Brown chocolate test of Cu^{2+}	(s) CrO_2Cl_2
	(t) $K_2Cr_2O_7$

22. Match the column:

Column–I	**Column–II**
(a) Canary yellow with ammonium molybdate	(p) PO_4^{3-}
(b) Brown ring test	(q) AsO_4^{3-}
(c) Acid radical decomposed by dil. H_2SO_4	(r) NO_3^-
(d) Acid radical decomposed by conc. H_2SO_4	(s) NO_2^-

23. Match the reactions listed in column (I) with the color of the precipitate(s) listed in column (II):

Column–I	**Column–II**
(a) $Cu^{2+}_{(aq)} + 2SCN^-_{(aq)} \xrightarrow{\text{allow to stand for sometime}}$	(p) Brown
(b) $Pb^{2+} + CrO_4^{2-} \longrightarrow$	(q) Reddish brown ppt.
(c) $CO_3^{2-} + 4Hg^{2+} + 3H_2O \longrightarrow$	(r) Yellow
(d) $Mn^{2+}_{(aq)} + 2OH^-_{(aq)} \xrightarrow{\text{air}}$	(s) White

24. Match the color of precipitates listed in column (I) with the reagent(s) listed in column (II):

Column–I	**Column–II**
(a) Bi^{3+} gives black precipitate with	(p) Saturated solution of H_2S in water
(b) Cu^{2+} gives black precipitate with	(q) Potassium thiocyanate solution
(c) Zn^{2+} gives white precipitate with	(r) Potassium iodide solution
(d) Ag^+ gives white precipitate with	(s) Potassium ferrocyanide solution

25. Match the column:

Column-I	**Column-II**
(a) White ppt.	(p) $CO_3^{2-} + BaCl_2 \longrightarrow$
(b) Brown ppt.	(q) $CO_3^{2-} + Pb(NO_3)_2 \longrightarrow$
(c) Reddish-brown ppt.	(r) $Ag_2CO_3 \xrightarrow{\Delta} Ag_2O$
	(s) $CO_3^{2-} + 4Hg^{2+} + 3H_2O \longrightarrow$

26. Match the column:

Column-I	**Column-II**
(a) White turbidity	(p) $IO_3^- + SO_2 + \text{starch} \longrightarrow$
(b) Rotten egg smell	(q) $SO_2 + MnO_4^- \longrightarrow$
(c) Colorless solution	(r) $Zn + NaOH + SO_2 \longrightarrow$
(d) Blue color	(s) $SO_2 + Br_2 \longrightarrow$
	(t) $CO_2 + Ca(OH)_2 \longrightarrow$

27. Match the column:

Column-I	**Column-II**
(a) Pale green solution	(p) $Na_2S + Hg(NO_3)_2 \longrightarrow$
(b) Black ppt.	(q) $Na_2S + Na_2[Fe(CN)_5NO] \longrightarrow$
(c) Finally purple color	(r) $Na_2S_2O_3 + BaCl_2 \longrightarrow$
(d) White ppt.	(s) $Na_2S_2O_3 + Pb(NO_3)_2 \longrightarrow$
	(t) $Fe^{3+} + S_2O_3^{2-} \longrightarrow$

28. Match the column:

Column-I	**Column-II**
(a) $3Fe^{3+} + 6CH_3COO^- \xrightarrow{\text{boil}}$	(p) White ppt.
(b) $S_2O_3^{2-} + [Ni(en)_3](NO_3)_2 \longrightarrow$	(q) Blood red color

(c) $Fe^{3+} + \overset{\ominus}{S}CN \longrightarrow$ (r) Violet ppt.

(d) $CH_3COO^- + AgNO_3 \longrightarrow$ (s) Brownish red ppt.

29. Match the column:

Column-I	Column-II
(a) $NH_3 + NaOCl \xrightarrow{\Delta}$	(p) N_2O
(b) $NH_4NO_2 + NaOH \longrightarrow$	(q) N_2
(c) $NH_4NO_3 \xrightarrow{\Delta}$	(r) NH_3
(d) $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta}$	(s) H_2O

Integer Answer Type

1. Find the number of ions which are identified by dil HCl from the following:

(I) CO_3^{2-} (II) SO_3^{2-} (III) SO_4^{2-}

2. $NaCl + \text{Solid } K_2Cr_2O_7 + \text{conc. } H_2SO_4 \longrightarrow X$
(few drops) (Reddish-brown fumes)

(i) How many axial *d*-orbitals are involved in hybridization of *X*?

(ii) How many *s*-orbital involved in hybridization of *X*?

(iii) Find the number of unpaired $e^{\ominus}$ in axial *d*-orbitals of *X*?

(iv) How many non axial *d*-orbitals are involved in hybridization of *X*?

(v) Find the value of magnetic moment of *X*?

(vi) What is the formula of *X* if

1. represents CrO_4^{2-} 2. represents CrO_5
3. represents $Cr_2O_7^{2-}$ 4. represents CrO_2Cl_2

3. Find the number of donor atoms in thionitro ligand $(\overset{\ominus}{NOS})$.

4. Find the number of reducing agents from the following:
H_2S, SO_3, CrO_4^{2-}, Fe^{2+}, MnO_4^-.

5. Find the number of compounds which have yellow color ppt. from the given compounds:
Ag_2CrO_4, $PbCrO_4$, Hg_2CrO_4, $BaCrO_4$

6. $Na_2S + X \longrightarrow Na_4[Fe(CN)_5(NOS)]$
(purple color)

(i) The name of *X* is ..... if –

1. represents sodium thiosulphate
2. represents brown ring complex
3. represents sodium nitroprusside
4. represents prussian blue

(ii) Find the value of magnetic moment of *X*.

(iii) The reason of color of *X* is ..... if –

1. represents *d–d* transition
2. represents charge transfer
3. represents colorless compound

(iv) Find the number of $e^{\ominus}$(s) in non-axial *d*-orbitals.

7. Na_2SO_3, NaCl, $Na_2C_2O_4$, Na_2HPO_4, Na_2CrO_4, $NaNO_2$, CH_3CO_2Na are separately treated with $AgNO_3$ solution. In how many cases is/are white ppt. obtained?

8. How many water moelcule(s) is/are present in micro cosmic salt?

9. When aqueous solution of borax forms a complex compound, then what is the coordination number in that particular complex?

10. An aqueous solution contains Hg^{2+}, Hg_2^{2+}, Pb^{2+}, and Cd^{2+}. Out of these, how many ions will produce white precipitate with dilute HCl?

11. How many water of crystallization is(are) present in the ore carnallite?

12. The oxidation number of Cr in the product of alkaline oxidative fusion of $FeCr_2O_4$ is:

13. How many compounds liberate NH_3 on heating from the following?

$(NH_4)_2SO_4$, $(NH_4)_2CO_3$, NH_4Cl, NH_4NO_3, $(NH_4)_2Cr_2O_7$

14. $Na_2S + Na_2[Fe(CN)_5NO] \longrightarrow X$ (purple color)

(i) How many ligands are present in compound *X*?

(ii) Find the number of type of ambidentate ligands in *X*.

(iii) How many *d*-orbitals are involved in hybridization of *X*?

(iv) Find the value of magnetic moment of *X*.

(v) How many axial *d*-orbitals are involved in hybridization of *X*?

(vi) Find the number of total possible linkage isomer of *X*. Ambident behaviour of CN^- is not considered.

(vii) What is the formula of *X*? if –

1. represents $Fe_4[Fe(CN)_6]$
2. represents $[Fe(H_2O)_5NO]SO_4$
3. represents $[Fe(H_2O)_5NO]SO_4$
4. represents $Na_4[Fe(CN)_5(NOS)]$

15. $Ag_2S + 2NaCN \overset{air}{\rightleftharpoons} X + Na_2S$

(i) How many *d* orbitals are involved in hybridization of *X*?

(ii) Predict the geometry of compound *X*; if –

1. represents linear geometry
2. represents tetrahedral geometry
3. represents octahedral geometry
4. represents square planar geometry

(iii) Find the value of magnetic moment of X.

16. $2Fe_2(SO_4)_3 + 3K_4[Fe(CN)_6] \longrightarrow X + 6K_2SO_4$

(i) How many d-orbitals are involved in hybridization?

(ii) The reason of color of X; if –

1. represents d–d transition
2. represents charge transfer
3. represents colorless compound

(iii) What is the color of X? if –

1. represents brown color
2. represents green color
3. represents blue color
4. represents yellow color

(iv) What is the name of X? if –

1. represents brown ring complex
2. represents sodium nitroprusside
3. represents prussian blue
4. represents chromyl chloride

17. What will be the n-factor of the reactant in the following reaction?

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2 + Cr_2O_3 + 4H_2O$$

18. BO_3^{3-} +conc. $H_2SO_4 + CH_3-CH_2-OH \xrightarrow[\text{Green flame}]{\text{ignite}} (A)$

What is the oxidation number of central atom that is responsible for green flame in compound (A)?

19. Na_2SO_3, $Na_2S_2O_3$, Na_2CO_3, Na_2CrO_4 are separately treated with Ag NO_3 solution. In how many cases is/are red ppt. obtained?

20. How many water moelcule(s) is/are present in compound which is used in borax bead test?

21. A solution of Hg^{2+} ion on treatment with a solution of cobalt(II) thiocyanate gives rise to a deep blue crystalline precipitate. Then the coordination number of mercury in the deep blue colored compound is:

22. In how many of the following reactions, one of the products is obtained as a yellow precipitate?

$$Ba^{2+} + CrO_4^{2-} \longrightarrow \text{Product}$$

$$Hg^{2+} + Co^{2+} + SCN^- \longrightarrow \text{Product}$$

$$NH_4^+ + [PtCl_6]^{2-} \longrightarrow \text{Product}$$

$$Ag^+ + CrO_4^{2-} \longrightarrow \text{Product}$$

$$NH_4^+ + [Co(NO_2)_6]^{3-} \longrightarrow \text{Product}$$

23. $Fe^{2+}(aq) + NO_3^-(aq) + H_2SO_4(conc) \longrightarrow$ Brown ring.

The oxidation number of iron in brown ring complex is:

24. $Cr_2O_7^{2-} + 4H_2O_2 + 2H^+ \xrightarrow[\text{solvent}]{\text{organic}} X + 5H_2O$

(i) How many peroxy linkage(s) is/are present in X?

(ii) How many d-orbitals are involved in hybridization of CrO_4^{2-}?

(iii) Find the value of magnetic moment of X.

(iv) What is the color of X? if–

1. represents green color
2. represents blue color
3. represents red color
4. represents brown color

25. When white ppt. of Ag_2CO_3 is dissolved in NH_3 solution, then compound X is formed.

(i) How many d-orbitals are involved in hybridization of X?

(ii) Predict the geometry of compound X; if –

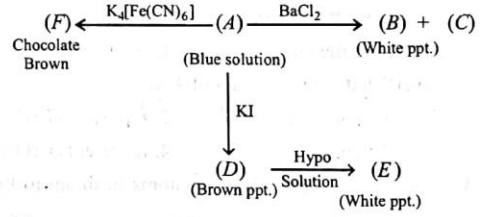
1. represents linear geometry
2. represents tetrahedral geometry
3. represents octahedral geometry
4. represents square planar geometry

(iii) Find the value of magnetic moment of X.

26. $S^{2-} + Na_2[Fe(CN)_5NO] \rightarrow$ Complex is having violet/purple coloration (X).

The total number of possible isomers for complex X is ..... provided the ambident behavior of CN^- is not considered.

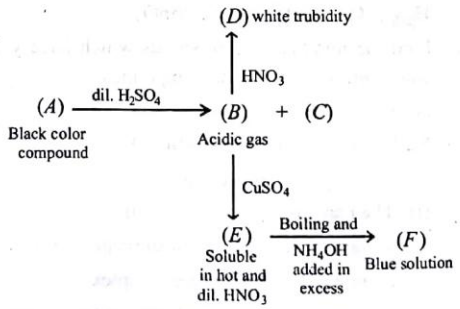
27.



(A) ..... (B) ..... (C) .....

(D) ..... (E) ..... (F) .....

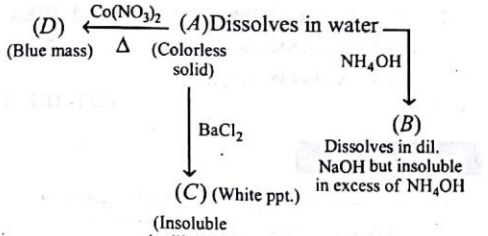
28.



(A) ..... (B) ..... (C) .....

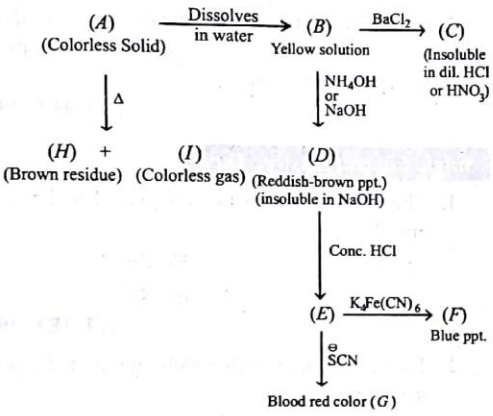
(D) ..... (E) ..... (F) .....

29.



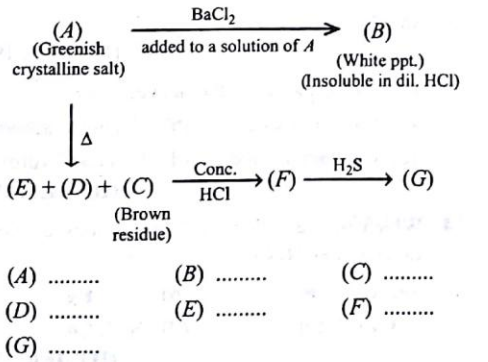
(A) ..... (B) ..... (C) .....
(D) .....

30.



(A) ..... (B) ..... (C) .....
(D) ..... (E) ..... (F) .....
(G) ..... (H) ..... (I) .....

31.



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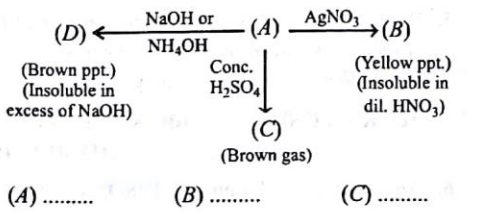
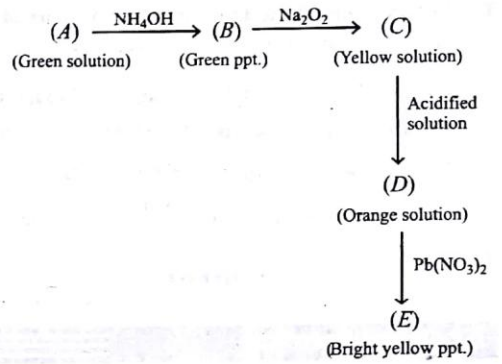
(D) ..... (E) ..... (F) .....
(G) .....

32.



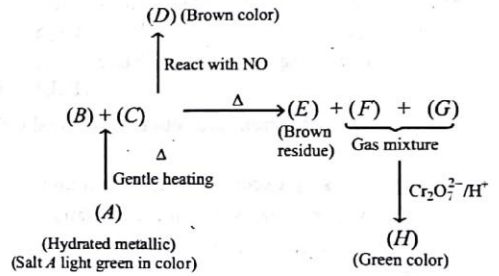
(A) ..... (B) ..... (C) .....
(D) .....

33.



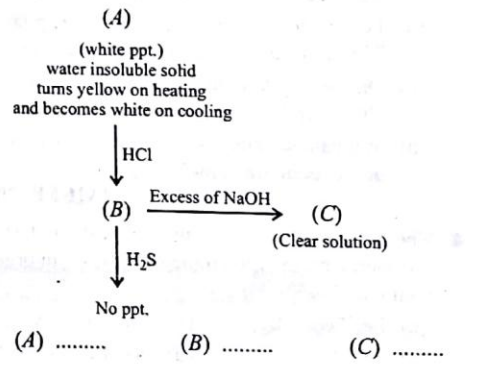
(A) ..... (B) ..... (C) .....
(D) ..... (E) .....

34.



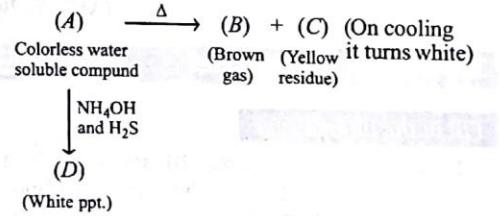
(A) ..... (B) ..... (C) .....
(D) ..... (E) ..... (F) .....
(G) ..... (H) .....

35.



(A) ..... (B) ..... (C) .....

36.



37. In how many of the following reactions one of the products is obtained as a black precipitate?

(i) $Bi(OH)_3 \downarrow + [Sn(OH)_4]^{2-}$ (aq) $\longrightarrow$ Products

(ii) Bi^{3+} (aq) + I^- (aq) (not in excess) $\longrightarrow$ Products

(iii) Ag^+ (aq) + H_2S (g) $\xrightarrow{H^+}$ Products

(iv) $[BiI_4]^-$ (aq) + H_2O (l) $\xrightarrow{\text{Dilution}}$ Products

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. When H_2S is passed through Hg_2S, we get:
   (a) HgS (b) HgS + Hg_2S
   (c) Hg_2S + Hg (d) None of these
   (AIEEE, 2002)

2. How do we differentiate between Fe^{3+} and Cr^{3+} in group III?
   (a) By taking excess of NH_4OH solution
   (b) By increasing NH_4^+ ion concentration
   (c) By decreasing OH^- ion concentration
   (d) Both (b) and (c)
   (AIEEE, 2002)

3. Which one of the following statements is correct?
   (a) From a mixed precipitate of AgCl and AgI, ammonia solution dissolves only AgCl
   (b) Ferric ions give a deep green precipitate on adding potassium ferrocyanide solution
   (c) On boiling a solution having K^+, Ca^{2+}, and HCO_3^- ions, we get a precipitate of $K_2Ca(CO_3)_2$
   (d) Manganese salts give a violet borax bead test in the reducing flame
   (AIEEE, 2003)

4. The compound formed in the positive test for nitrogen with the Lassaigne solution of an organic compound is
   (a) $Fe_4[Fe(CN)_6]_3$ (b) $Na_3[Fe(CN)_6]$
   (c) $Fe(CN)_3$ (d) $Na_4[Fe(CN)_5NOS]$
   (AIEEE, 2004)

JEE (Advanced) Exercises

Fill in the Blanks Type

1. If metal ions of group III are precipitated by NH_4Cl and NH_4OH without prior oxidation by concentrated HNO_3, _____ is not completely precipitated.
   (IIT-JEE, 1984)

2. The formula of the deep-red liquid formed on warming dichromate with KCl in concentrated sulphuric acid is _____.
   (IIT-JEE, 1993)

True/False Type

1. The addition of ammonium chloride to a solution containing ferric and magnesium ions is essential for selective precipitation of ferric hydroxide by aqueous ammonia.
   (IIT-JEE, 1985)

2. From the solution containing copper (+2) and zinc (+2) ions, copper can be selectively precipitated using sodium sulphide.
   (IIT-JEE, 1987)

Single Correct Answer Type

1. The ion that cannot be precipitated by both HCl and H_2S is:
   (a) Pb^{2+} (b) Cu^+
   (c) Ag^+ (d) Sn^{2+}
   (IIT-JEE, 1982)

2. The pair of compounds which cannot exist together in solution is:
   (a) $NaHCO_3$ and NaOH
   (b) Na_2CO_3 and $NaHCO_3$
   (c) Na_2CO_3 and NaOH
   (d) $NaHCO_3$ and NaCl
   (IIT-JEE, 1986)

3. The compound insoluble in acetic acid is:
   (a) Calcium oxide (b) Calcium carbonate
   (c) Calcium oxalate (d) Calcium hydroxide
   (IIT-JEE, 1986)

4. Which of the following pairs of ions cannot be separated by H_2S in dilute HCl?
   (a) Bi^{3+}, Sn^{4+} (b) Al^{3+}, Hg^{2+}
   (c) Zn^{2+}, Cu^{2+} (d) Ni^{2+}, Cu^{2+}
   (IIT-JEE, 1986)

5. Which compound is formed when excess of KCN is added to an aqueous solution of copper sulphate?
   (a) $Cu(CN)_2$ (b) $K_2[Cu(CN)_4]$
   (c) $K[Cu(CN)_2]$ (d) $K_3[Cu(CN)_4]$
   (IIT-JEE, 1995)

6. An aqueous solution of $FeSO_4 \cdot Al_2(SO_4)_3$ and chrome alum is heated with excess of Na_2O_2 and filtered. The materials obtained are:
   (a) A colorless filtrate and a green residue

(b) A yellow filtrate and a green residue
(c) A yellow filtrate and a brown residue
(d) A green filtrate and a brown residue

(IIT-JEE, 1996)

7. An aqueous solution of a substance gives a white precipitate on treatment with dilute hydrochloric acid, which dissolves on heating. When hydrogen sulphide is passed through the hot acidic solution, a black precipitate is obtained. The substance is a:
(a) Hg_2^+ salt (b) Cr^{2+} salt
(c) Ag^+ salt (d) Pb^{2+} salt

(IIT-JEE, 2000)

8. A gas X is passed through water to form a saturated solution. The aqueous solution on treatment with silver nitrate gives a white precipitate. The saturated aqueous solution also dissolves magnesium ribbon with the evolution of a colorless gas Y. Identify X and Y:
(a) $X = CO_2$, $Y = Cl_2$ (b) $X = Cl_2$, $Y = CO_2$
(c) $X = Cl_2$, $Y = H_2$ (d) $X = H_2$, $Y = Cl_2$

(IIT-JEE, 2002)

9. $[X] + H_2SO_4 \rightarrow [Y]$ Colorless gas with irritating smell
$[Y] + H_2SO_4 + K_2Cr_2O_7 \rightarrow$ Green solution
$[X]$ and $[Y]$ are:
(a) SO_3^{2-}, SO_2 (b) Cl^-, HCl
(c) S^{2-}, H_2S (d) CO_3^{2-}, CO_2

(IIT-JEE, 2003)

10. A sodium salt of an unknown anion when treated with $MgCl_2$ gives white precipitate only on boiling. The anion is:
(a) SO_4^{2-} (b) HCO_3^-
(c) CO_3^{2-} (d) NO_3^-

(IIT-JEE, 2004)

11. A metal nitrate reacts with KI to give a black precipitate which on addition of excess of KI converts to an orange color solution. The cation of metal nitrate is:
(a) Hg^{2+} (b) Bi^{3+}
(c) Pb^{2+} (d) Cu^+

(IIT-JEE, 2005)

12. $CuSO_4$ decolorizes on addition of KCN; the product is:
(a) $[Cu(CN)_4]^{2-}$
(b) Cu^{2+} get reduced to form $[Cu(CN)_4]^{3-}$
(c) $Cu(CN)_2$
(d) CuCN

(IIT-JEE, 2006)

13. A solution when diluted with H_2O and boiled, gives a white precipitate. On the addition of excess NH_4Cl/NH_4OH, the volume of the precipitate decreases leaving behind a white gelatinous precipitate. Identify the precipitate which dissolves in NH_4OH/NH_4Cl:
(a) $Zn(OH)_2$ (b) $Al(OH)_3$
(c) $Mg(OH)_2$ (d) $Ca(OH)_2$

(IIT-JEE, 2006)

14. The species present in the solution when CO_2 is dissolved in water are:
(a) CO_2, H_2CO_3, HCO_3^-, CO_3^{2-}
(b) H_2CO_3, CO_3^{2-}
(c) CO_3^{2-}, HCO_3^- (d) CO_2, H_2CO_3

(IIT-JEE, 2006)

15. A solution of a metal ion when treated with KI gives a red precipitate which dissolves in excess KI to give a colorless solution. Moreover, the solution of metal ion on treatment with a solution of cobalt(II) thiocyanate gives rise to a deep-blue crystalline precipitate. The metal ion is:
(a) Pb^{2+} (b) Hg^{2+}
(c) Cu^{2+} (d) CO^2

(IIT-JEE, 2007)

16. Upon treatment with ammonical H_2S, the metal ion that precipitates as a sulfide is:
(a) Fe(III) (b) Al(III)
(c) Mg(II) (d) Zn (II)

(JEE Advanced, 2013)

17. Consider the following list of reagents:
Acidified $K_2Cr_2O_7$, alkaline $KMnO_4$, $CuSO_4$, H_2O_2, Cl_2, O_3, $FeCl_3$, HNO_3 and $Na_2S_2O_3$. The total number of reagents that can oxidize aqueous iodide to iodine is.

(JEE Advanced, 2014)

Multiple Correct Answers Type

1. The reagents NH_4Cl and aqueous NH_3 will precipitate:
(a) Ca^{2+} (b) Al^{3+}
(c) Bi^{3+} (d) Mg^{2+}
(e) Zn^{2+}

(IIT-JEE, 1991)

2. Which of the following statements is/are correct with reference to the ferrous and ferric ions?
(a) Fe^{3+} gives brown color with potassium ferricyanide

(b) Fe^{2+} gives blue precipitate with potassium ferricyanide

(c) Fe^{3+} gives red color with potassium thiocyanate

(d) Fe^{2+} gives brown color with ammonium thiocyanate

(IIT-JEE, 1998)

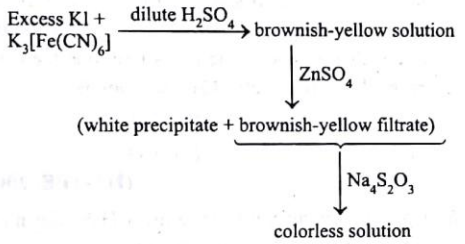
3. A solution of colorless salt *H* on boiling with excess NaOH produces a non-flammable gas. The gas evolution ceases after sometime. Upon addition of Zn dust to the same solution, the gas evolution restarts. The colorless salt(s) *H* is/are:

(a) NH_4NO_3 (b) NH_4NO_2

(c) NH_4Cl (d) $(NH_4)_2SO_4$

(IIT-JEE, 2008)

4. For the given aqueous reaction, which of the statement(s) is(are) true?



(a) The first reaction is a redox reaction

(b) White precipitate is $Zn_3[Fe(CN)_6]_2$

(c) Addition of filtrate to starch solution gives blue color

(d) White precipitate is soluble in NaOH solution

(IIT-JEE, 2012)

Comprehension Type

Paragraph for Questions 1 and 2

An aqueous solution of a mixture of two inorganic salts, when treated with dilute HCl, gave a precipitate (P) and a filtrate (Q). The precipitate P was found to dissolve in hot water. The filtrate (Q) remained unchanged, when treated with H_2S in a dilute mineral acid medium. However, it gave a precipitate (R) with H_2S in an ammoniacal medium. The precipitate R gave a colored solution (S), when treated with H_2O_2 in an aqueous NaOH medium.

1. The colored solution S contains:

(a) $Fe_2(SO_4)_3$ (b) $CuSO_4$

(c) $ZnSO_4$ (d) Na_2CrO_4

(JEE Advanced, 2013)

2. The precipitate P contains:

(a) Pb^{2+} (b) Hg_2^{2+}

(c) Ag^+ (d) Hg^{2+}

(JEE Advanced, 2013)

Assertion-Reasoning Type

Read the following questions and answer as per the directions given below:

(a) Statement-I is true; Statement-II is also true; Statement-II is the correct explanation for Statement-I.

(b) Statement-I is true; Statement -II is true; Statement-II is not the correct explanation for Statement-I.

(c) Statement-I is true; Statement-II is false.

(d) Statement-I is false; Statement-II is true.

1. **Statement-I:** A very dilute acidic solution of Cd^{2+} and Ni^{2+} gives yellow precipitate of CdS on passing H_2S.

Statement-II: The solubility product of CdS is more than that of NiS.

(IIT-JEE, 1989)

2. **Statement-I:** Sulphate is estimated as $BaSO_4$, not as $MgSO_4$.

Statement-II: Ionic radius of Mg^{2+} is smaller than that of Ba^{2+}.

(IIT-JEE, 1998)

Integer Answer Type

1. Among PbS, CuS, HgS, MnS, Ag_2S, NiS, CoS, Bi_2S_3, and SnS_2 the total number of **BLACK** coloured sulphides is.

(JEE Advanced, 2014)

Subjective Type

1. The precipitation of second group sulphides in qualitative analysis is carried out with hydrogensulphide in the presence of hydrochloric acid but not with nitric acid. Explain.

(IIT-JEE, 1979)

2. A white amorphous powder *A* on heating yields a colorless, non-combustible gas *B* and a solid *C*. The latter compound assumes a yellow color on heating and changes to white on cooling. *C* dissolves in dilute hydrochloric acid and the resulting solution gives a white precipitate with $K_4Fe(CN)_6$ solution. *A* dissolves in dilute HCl with the evolution of gas, which is identical in all respect with *B*. The

gas B turns lime water milky, but the milkiness disappears with the continuous passage of gas. The solution of A as obtained above gives a white precipitate D on the addition of excess of NH_4OH and passing H_2S. Another portion of the solution gives initially a white precipitate E on the addition of NaOH solution, which dissolves on further addition of base. Identify the compounds A, B, C, D, and E.

(IIT-JEE, 1979)

3. Explain the following in not more than two sentences:
"A solution of $FeCl_3$ in water gives a brown precipitate on standing."

(IIT-JEE, 1980)

4. Compound A is a light-green crystalline solid. It gives the following tests:

(i) It dissolves in dilute sulphuric acid. No gas is produced.

(ii) A drop of $KMnO_4$ is added to the above solution. The pink color disappears.

(iii) Compound A is heated strongly. Gases B and C, with pungent smell, come out. A brown residue D is left behind.

(iv) The gas mixture (B and C) is passed into a dichromate solution. The solution turns green.

(v) The green solution from step (iv) gives a white precipitate E with a solution of barium nitrate.

(vi) Residue D from step (iii) is heated on charcoal in a reducing flame. It gives a magnetic substance.

Name the compounds A, B, C, D, and E.

(IIT-JEE, 1980)

5. When 16.8 g of white solid X was heated, 4.4 g of acid gas A that turned lime water milky was driven off together with 1.8 g of a gas B which condensed to a colorless liquid. The solid that remained, Y, dissolved in water to give an alkaline solution, which with excess barium chloride solution gave a white precipitate Z. The precipitate effervesced with acid giving carbon dioxide. Identify A, B, and Y, and write the equations for the thermal decomposition of X.

(IIT-JEE, 1984)

6. What happens when

(i) Hydrogen sulphide is bubbled through an aqueous solution of sulphur dioxide.

(ii) Aqueous ammonia is added dropwise to a solution of copper sulphate till it is in excess.

(iii) Tin is treated with concentrated nitric acid.

(iv) $CrCl_3$ solution is treated with sodium hydroxide and then with hydrogen peroxide.

(v) Pb_3O_4 is treated with nitric acid.

(IIT-JEE, 1985)

7. Write the balanced equations for the reactions, when "a mixture of potassium chlorate, oxalic acid, and sulphuric acid is heated."

(IIT-JEE, 1985)

8. Mention the products formed in the following:

(i) Zinc oxide is treated with excess of sodium hydroxide solution.

(ii) Iodine is added to a solution of stannous chloride.

(iii) Sulphur dioxide gas, water vapor, and air are passed over heated sodium chloride.

(IIT-JEE, 1986)

9. Write the balanced equation for the following. "Potassium permanganate is reacted with warm solution of oxalic acid in the presence of sulphuric acid."

(IIT-JEE, 1987)

10. A mixture of two salts was treated as follows:

(i) The mixture was heated with manganese dioxide and concentrated sulphuric acid, when a yellowish-green gas was liberated.

(ii) The mixture on heating with sodium hydroxide solution gave a gas which turned red litmus blue.

(iii) Its solution in water gave a blue precipitate with potassium ferricyanide and red coloration with ammonium thiocyanate.

(iv) The mixture was boiled with potassium hydroxide and the liberated gas was bubbled through an alkaline solution of K_2HgI_4 to give a brown precipitate.

Identify the two salts. Give ionic equations for the reactions involved in the tests (i), (ii), and (iii).

(IIT-JEE, 1988)

11. Write the balanced chemical equations for the following:

(i) Silver chloride is treated with aqueous sodium cyanide and the product thus formed is allowed to react with zinc in an alkaline medium.

(ii) Cobalt(II) solution reacts with KNO_2 in acetic acid medium.

(IIT-JEE, 1989)

12. The gas liberated, on heating a mixture of two salts with NaOH, gives a reddish-brown precipitate

with an alkaline solution of K_2HgI_4. The aqueous solution of the mixture on treatment with $BaCl_2$ gives a white precipitate which is sparingly soluble in concentrated HCl. On heating the mixture with $K_2Cr_2O_7$ and concentrated H_2SO_4, red vapors of *A* are produced. The aqueous solution of the mixture gives a deep-blue coloration *B* with potassium ferricyanide solution. Identify the radicals in the given mixture and write the balanced equations for the formation of *A* and *B*.

(IIT-JEE, 1991)

13. Give reason in one or two sentences for the following:
"The hydroxides of aluminium and iron are insoluble in water. However, NaOH is used to separate one from the other."

(IIT-JEE, 1991)

14. In the following reaction, identify the compounds/reaction conditions represented by *A* and *B*.

$$PbS \xrightarrow[\text{air}]{\text{Heat in}} A + PbS \xrightarrow{B} Pb + SO_2$$

(IIT-JEE, 1991)

15. A light bluish-green crystalline compound responds to the following tests:

(i) Its aqueous solution gives a brown precipitate or coloration with alkaline $K_2[HgI_4]$ solution.

(ii) Its aqueous solution gives a blue color with $K_3[Fe(CN)_6]$ solution.

(iii) Its solution in hydrochloric acid gives a white precipitate with $BaCl_2$ solution.

Identify the ions present and suggest the formula of the compound.

(IIT-JEE, 1992)

16. The acidic aqueous solution of ferrous ion forms a brown complex in the presence of NO_3^- by the following two steps:

$$[Fe(H_2O)_6]^{2+} + NO_3^- + H^+ \rightarrow \cdots + [Fe(H_2O)_6]^{3+} + H_2O$$

$$[Fe(H_2O)_6]^{2+} + \cdots \rightarrow \cdots + H_2O$$

Complete and balance the equations.

(IIT-JEE, 1993)

17. An orange solid *A* on heating gave a green residue *B*, a colorless gas *C*, and water vapor. The dry gas *C* on passing over heated Mg gave a white solid *D*. *D* on reaction with water gave a gas *E* which formed dense white fumes with HCl. Identify *A* to *E* and give the reactions involved.

(IIT-JEE, 1993)

18. A scarlet compound *A* is treated with concentrated HNO_3 to give a chocolate-brown precipitate *B*. The precipitate is filtered and the filtrate is neutralized with NaOH. Addition of KI to the resulting solution gives a yellow precipitate *C*. The brown precipitate *B* on warming with concentrated HNO_3 in the presence of $Mn(NO_3)_2$ produces a pink colored solution due to the formation of *D*. Identify *A*, *B*, *C*, and *D*. Write the reaction sequence.

(IIT-JEE, 1995)

19. The gradual addition of KI solution to $Bi(NO_3)_3$ solution initially produces a dark brown precipitate which dissolves in excess of KI to give a yellow solution. Write the chemical equations for the above reactions.

(IIT-JEE, 1996)

20. Calcium burns in nitrogen to produce a white powder which dissolves in sufficient water to produce a gas *A* and an alkaline solution. The solution on exposure to air produces a thin solid layer of *B* on the surface. Identify the compounds *A* and *B*.

(IIT-JEE, 1996)

21. A colorless inorganic salt *A* decomposes completely at about 250°C to give only two products *B* and *C*, leaving no residue. The oxide *C* is a liquid at room temperature and neutral to moist litmus paper, while the gas *B* is a neutral oxide. White phosphorus burns in excess of *B* to produce a strong white dehydrating agent. Write the balanced equations for the reactions involved in the above process.

(IIT-JEE, 1996)

22. Element *A* burns in nitrogen to give an ionic compound *B*. Compound *B* reacts with water to give *C* and *D*. A solution of *C* becomes 'milky' on bubbling carbon dioxide. Identify *A*, *B*, *C*, and *D*.

(IIT-JEE, 1997)

23. During the qualitative analysis of a mixture containing Cu^{2+} and Zn^{2+} ions, H_2S gas is passed through an acidified solution containing these ions in order to test Cu^{2+} alone. Explain.

(IIT-JEE, 1998)

24. An aqueous solution containing 1 mol of HgI_2 and 2 mol of NaI is orange in color. On addition of excess NaI, the solution becomes colorless. The orange color reappears on subsequent addition of NaOCl.

(IIT-JEE, 1999)

25. A white solid is either Na_2O or Na_2O_2. A piece of red litmus paper turns white when it is dipped into a freshly made aqueous solution of the white solid.

(i) Identify the substance and explain with balanced equations.

(ii) Explain what would happen to the red litmus if the white solid were the other compound.

(IIT-JEE, 1999)

26. Write the chemical reactions associated with the "brown ring test."

(IIT-JEE, 2000)

27. An aqueous blue-colored solution of a transition metal sulphate reacts with H_2S in acidic medium to give a black precipitate *A* which is insoluble in warm aqueous solution of KOH. The blue solution on treatment with KI in weakly acidic medium turns yellow and produces a white precipitate *B*. Identify the transition metal ion. Write the chemical reactions involved in the formation of *A* and *B*.

(IIT-JEE, 2000)

28. Write the chemical reactions associated with the "borax beat test" of cobalt(II) oxide.

(IIT-JEE, 2000)

29. A white substance *A* reacts with dilute H_2SO_4 to produce a colorless gas *B* and a colorless solution *C*. The reaction between *B* and acidified $K_2Cr_2O_7$ solution produces a green solution and a slightly colored precipitate *D*. The substance *D* burns in air to produce a gas *E* which reacts with *B* to yield *D* and a colorless liquid. Anhydrous copper sulphate is turned blue on addition of this colorless liquid. Addition of aqueous NH_3 of NaOH to *C* produces first a precipitate which dissolves in the excess of the respective reagent to produce a clear solution in each case. Identify *A*, *B*, *C*, *D*, and *E*. Write the equations of the reactions involved.

(IIT-JEE, 2001)

30. When a white crystalline compound *X* is heated with $K_2Cr_2O_7$ and concentrated H_2SO_4, a reddish-brown gas *A* is evolved. On passing *A* into caustic soda solution, a yellow-colored solution *B* is obtained. Neutralizing the solution of *B* with acetic acid and on subsequent addition of lead acetate, a yellow precipitate *C* is obtained. When *X* is heated with NaOH solution, a colorless gas is evolved and on passing this gas into K_2HgI_4 solution, a reddish-brown precipitate *D* is formed. Identify *A*, *B*, *C*, *D*, and *X*. Write the equations of the reactions involved.

(IIT-JEE, 2002)

31. Identify the following:

$$Na_2CO_3 \xrightarrow{SO_2} A \xrightarrow{Na_2CO_3} B$$
$$\xrightarrow{\text{Elemental S}} C \xrightarrow{I_2} D$$

Also, mention the oxidation state of S in all the compounds.

(IIT-JEE, 2003)

32. A mixture consists *A* (yellow solid) and *B* (colorless solid) which gives lilac color in flame.

(a) The mixture gives black precipitate *C* on passing H_2S gas.

(b) *C* is soluble in aquaregia and on evaporation of aquaregia and adding $SnCl_2$ gives greyish-black precipitate D.

(c) The salt solution with NH_4OH gives a brown precipitate.

(i) The sodium extract of the salt with CCl_4/ $FeCl_3$ gives a violet layer.

(ii) The sodium extract gives yellow precipitate with $AgNO_3$ solution which is insoluble in NH_3.

Identify *A* and *B* and the precipitates *C* and *D*.

(IIT-JEE, 2003)

33. AlF_3 is insoluble in anhydrous HF but when little KF is added to the compound it becomes soluble. On addition of BF_3, AlF_3 is precipitated. Write the balanced chemical equations.

(IIT-JEE, 2004)

34.

$$\underset{\substack{\text{(White fumes}\\ \text{having smell)}}}{B} \xleftarrow{\text{Moist air}} \underset{\substack{M = \text{(Transition}\\ \text{element colorless)}}}{MCl_4} \xrightarrow{Zn} \underset{\substack{\text{(Purple}\\ \text{color)}}}{A}$$

Identify the metal *M* and hence MCl_4. Explain the difference in colors of MCl_4 and *A*.

(IIT-JEE, 2005)

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

68. (a) $MgSO_4 + NH_4OH + Na_2HPO_4 \longrightarrow \underset{\text{(white ppt.)}}{Mg(NH_4)PO_4} + Na_2SO_4 + H_2O$

69. (a) $Zn^{2+} + 4NH_4OH \longrightarrow [Zn(NH_3)_4]^{2+} + 4H_2O$

87. (b) $PbSO_4$ and $PbCl_2$ are insoluble in cold water.

88. (a) $AgCl + 2NH_3 \longrightarrow [Ag(NH_3)_2]Cl$

89. (b) $2KNO_2 + H_2SO_4 \longrightarrow K_2SO_4 + 2HNO_2$

$2KI + H_2SO_4 \longrightarrow K_2SO_4 + 2HI$

$2HNO_2 + 2HI \longrightarrow 2H_2O + I_2 + 2NO$

$I_2 + \text{Starch} \longrightarrow \text{Blue color}$

90. (a) $CuSO_4 + 4NH_4OH \longrightarrow [Cu(NH_3)_4]SO_4 + 4H_2O$

91. (b) $2Fe_2(SO_4)_3 + 3K_4[Fe(CN)_6] \longrightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_6]_3} + 6K_2SO_4.$

92. (b) Chromyl chloride test fails in case of chlorides of Hg, Sn, Ag, Pb, and Sb.

93. (c) $BaCrO_4$ is yellow; $BaSO_4$ is white.

94. (a) These are characteristics of bromide ion.

95. (b) K^+ imparts violet flame color.

96. (c) $BaSO_4$ is insoluble in acidic medium.

97. (c) $BaSO_3 + 2HCl\ (\text{dil.}) \longrightarrow 2NaCl + H_2O + SO_2;$

$K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \longrightarrow K_2SO_4 + \underset{\text{Green}}{Cr_2(SO_4)_3} + H_2O.$

98. (c) Group. reagent for V group is ammonium carbonate in the presence of NH_4Cl and NH_4OH.

99. (d) $KNO_3 + H_2SO_4 \longrightarrow KHSO_4 + HNO_3;$

$4HNO_3 \longrightarrow 2H_2O + \underset{\text{(Brown)}}{4NO_2} + O_2.$

100. (b) $2Fe_2(SO_4)_3 + 3K_4[Fe(CN)_6] \longrightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_6]_3} + 6K_2SO_4.$

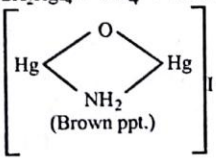
101. (a) So that only Fe, Cr, and Al are precipitated as their hydroxides.

102. (b) ZnS is white.

104. (d) As_2S_3 is soluble in yellow ammonium sulphide.

105. (c) Sb_2S_3 is orange.

106. (d) $2K_2HgI_4 + NH_4^+ + 4KOH \longrightarrow$



$I + 7HI + K^+ + 3H_2O.$

107. (b) Al^{3+}, Zn^{2+}, and Cr^{3+} form a soluble complex with excess of NaOH, whereas Fe^{3+} does not.

108. (d) $Fe(SCN)_3$ is formed which is red.

109. (d) Follow cobalt nitrate charcoal test.

$ZnSO_4 + Na_2CO_3 \longrightarrow ZnCO_3 + Na_2SO_4;$

$ZnCO_3 \longrightarrow ZnO + CO_2;$

$2Co(NO_3)_2 \longrightarrow 2CoO + 4NO_2 + O_2;$

$CoO + ZnO \longrightarrow \underset{\text{(Green)}}{CoZnO_2}$

110. (d) The more is K_{sp}, the higher is solubility. Also in the presence of HCl, H_2S gives less $[S^{2-}]$ which is sufficient only to cross over the K_{sp} of II group sulphide.

111. (b) Alkali metal salts are water soluble.

112. (d) Pb forms $PbCl_2$ in I group and PbS in II group. Lead salts are partially soluble in water.

114. (a) $CuCl_2 + H_2S \longrightarrow \underset{\text{(Black)}}{CuS} + 2HCl.$

115. (a) $(CH_3COO)_2Pb + H_2S \longrightarrow 2CH_3COOH + \underset{\text{(Black)}}{PbS}$

116. (c) $PbCrO_4$, a yellow precipitate, is formed. This is chromyl chloride test.

117. (b) On heating $(NH_4)_2Cr_2O_7$, N_2 is given out with Cr_2O_3 powder at higher rate, giving a look of artificial volcano.

118. (a) $Fe(SCN)_3$ is a red salt soluble in water.

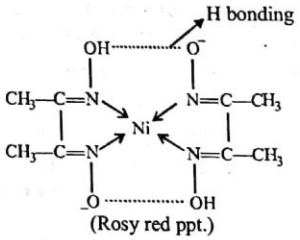
119. (a) $2Na_3BO_3 + 3H_2SO_4 \longrightarrow 3Na_2SO_4 + 2H_3BO_3;$

$H_3BO_3 + 3C_2H_5OH \longrightarrow \underset{\text{Burns with green edge flame}}{(C_2H_5)_3BO_3} + 3H_2O.$

120. (a) All are white in color.

121. (a) Yellow ammonium sulphide is a solvent for As, Sb, Sn sulphides.

124. (c) $NiCl_2 + 2\begin{matrix} CH_3-C=NOH \\ | \\ CH_3-C=NOH \end{matrix} + 2NH_4OH \longrightarrow$



(Rosy red ppt.)

125. (d) AgCl forms soluble complex $[Ag(NH_3)_2]Cl$ with NH_3.

126. (d) HgS is insoluble in conc. HNO_3. It is soluble in aquaregia.

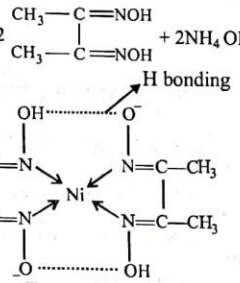
127. (a) $KBr + H_2SO_4 \longrightarrow KHSO_4 + HBr,$

$2HBr + H_2SO_4 \longrightarrow Br_2 + 2H_2O + SO_2$

128. (a) $2Na_3BO_3 + 3H_2SO_4 \longrightarrow 3Na_2SO_4 + 2H_3BO_3;$

$H_3BO_3 + 3C_2H_5OH \longrightarrow \underset{\text{Burns with green edge flame}}{(C_2H_5)_3BO_3} + 3H_2O.$

129. (b) $Hg_2Cl_2 + 2NH_4OH \longrightarrow \underbrace{Hg + HgO.Hg(NH_2)Cl}_{\text{Black}} + NH_4Cl + 2H_2O$

130. (d) $NiCl_2 + 2$ 

(Rosy red ppt.)

132. (a) H_2S in neutral medium provides sufficient S^{2-} to precipitate Cu, Cd, Zn, and Mn as sulphide.

133. (c) Hg_2Cl_2 is white insoluble salt.

$Hg_2Cl_2 + 2NH_4OH \longrightarrow \underbrace{Hg + HgO.Hg(NH_2)Cl}_{\text{Black}} + NH_4Cl + 2H_2O$

134. (c) $Fe(OH)_3$ is brown.

135. (b) FeS is soluble in HCl. Also Fe^{2+} salts are green.

136. (a) Some nitrates on heating give NO_2 which bleaches most litmus paper due to its oxidizing nature.

137. (b) Any ammonium salt on heating with any alkali loses NH_3.

138. (c) It is a reason for the given fact.

139. (a) Mn^{2+} is oxidized to Mn^{7+} forming $HMnO_4$.

140. (c) $Sb_2S_3 + 6HCl \longrightarrow 2SbCl_3 + 3H_2S$;

$SbCl_3 + H_2O \longrightarrow SbOCl + 2HCl$.

JEE (Advanced) Exercises

Single Correct Answer Type

1. (b) It is a fact. HgS is soluble in aquaregia.

2. (a) $PbCl_2$ is insoluble in cold water but soluble in hot water.

3. (a) $Na_2S + Na_2[Fe(CN)_5NO] \longrightarrow \underset{\text{(Violet)}}{Na_4[Fe(CN)_5NOS]}$

4. (d) $AgNO_3 \longrightarrow Ag + NO_2 + \frac{1}{2}O_2$;

$AgNO_3 + KI \longrightarrow AgI + KNO_3$;

$BaCl_2 + 2AgNO_3 \longrightarrow 2AgCl + Ba(NO_3)_2$

6. (b) Cu^+ disproportionates in the aqueous solution to a very large extent.

$2Cu^+ \rightleftharpoons Cu^{2+} + Cu$

$K = \frac{[Cu^{2+}]}{[Cu^+]^2} = 1.6 \times 10^6$

Thus, the concentration of Cu^+ ion is very small, and hence it cannot be precipitated.

7. (d) $As_2S_3 + 4NaOH \longrightarrow NaAsO_2 + \underset{\text{(Brick red)}}{3NaAsS_2} + 2H_2O$

8. (d) $Pb^{2+} + 2HCl \longrightarrow \underset{\text{White ppt. dissolves on boiling}}{PbCl_2\downarrow} \xrightarrow{H_2S} \underset{\text{Black ppt}}{PbS\downarrow}$

10. (a) Solubility order: AgF > AgCl > AgBr > AgI.

11. (c) $S^{2-} + 2HCl \xrightarrow{\Delta} H_2S\downarrow + 2Cl^-$

Rotten egg smell (Specific smell)

$S_2O_3^{2-} + 2HCl \xrightarrow{\Delta} \underset{\text{Suffocating smell of burning sulphur}}{SO_2\uparrow} + 2Cl^- + \underset{\text{Yellow turbidity or white turbidity}}{S\downarrow} + H_2O$

$CO_3^{2-} + 2HCl \xrightarrow[\text{or cold}]{\Delta} CO_2\uparrow + H_2O + 2Cl^-$

Odorless gas evolves with brisk effervescences

HCO_3^- also behave similarly

$NO_2^- + HCl \xrightarrow{\Delta} HNO_2 + Cl^-$

$\downarrow$

$NO\uparrow$ (colourless)

$\downarrow$ atmospheric air

$NO_2\uparrow$ (Brown color gas)

28. (c) A = $FeSO_4$; B = Fe_2O_3; C = SO_2; D = SO_3; E = $Fe(OH)_2$; F = $Fe(OH)_3$

54. (b) $AgNO_{3(aq.)} + KI_{(aq.)} \longrightarrow \underset{\text{(Yellow ppt.)}}{AgI} + KNO_3$

55. (a) $NaCl + AgNO_3 \longrightarrow \underset{\text{(White)}}{AgCl}$; CH_3Cl does not give ppt.

56. (b) $MgCl_2 + Na_2HPO_4 + NH_4OH \longrightarrow \underset{\text{White ppt.}}{Mg(NH_4)PO_4} + 2NaCl + H_2O$.

57. (c) Phosphate interferes in the usual inorganic analysis after II group.

58. (b) III group radicals are precipitated as hydroxides.

60. (d) Na_2CO_3 furnishes appreciable $[CO_3^{2-}]$ to precipitate Mg.

61. (a) $CoCl_2$ is pink in color.

62. (b) $2NO + O_2 \longrightarrow 2NO_2$ (Brown).

63. (a) HBr and HI are strong reducing agents and are oxidized by H_2SO_4 to Br_2 and I_2, respectively.

64. (d) $\underset{\text{Sodium nitroprusside}}{Na_2[Fe(CN)_5NO]} + Na_2S \longrightarrow \underset{\text{Sodium thio nitroprusside (Purple)}}{Na_4[Fe(CN)_5NOS]}$

67. (c) H_2S reacts with lead acetate to give black PbS.

68. (a) Pb CrO_4, a yellow precipitate is formed.

69. (a) $[Cu(NH_3)_4]^{2+}$ is blue in color.

70. (c) $ZnS + 2HCl \longrightarrow ZnCl_2 + H_2S$;

$ZnCl_2 + 2NaOH \longrightarrow Zn(OH)_2 + 2NaCl$;

$Zn(OH)_2 + 2NaOH \longrightarrow \underset{\text{(soluble)}}{Na_2ZnO_2} + 2H_2O$

71. (a) $MgCl_2 + Na_2HPO_4 + NH_4OH \longrightarrow \underset{\text{White ppt.}}{Mg(NH_4)PO_4} + 2NaCl + H_2O$.

72. (a) $Cu_2[Fe(CN)_6]$ is chocolate color insoluble compound.

73. (a) PbI_2 is yellow insoluble solid.

74. (a) $(NH_4)_2CO_3$ is group reagent for V group radicals in presence of NH_4Cl and NH_4OH.

75. (a) Hg_2Cl_2 formed is white which later on turns to Hg grey due to further reduction.

76. (b) H_2S, although weak electrolyte, furnishes appreciable $[S^{2-}]$ to precipitate subsequent group radicals as sulphides.

77. (c) $CoAlO_2$ is formed which is blue. Follow cobalt nitrate–charcoal test.

78. (b) The presence of NH_4Cl in excess reduces degree of dissociation of NH_4OH to a considerable amount, and thus, $[OH^-]$ is just sufficient to cross over the ionic concentration product of hydroxides of III group elements to their $K_{sp.}$

79. (d) Ba gives green falme. AgCl and $BaSO_4$ are white ppt. formed respectively.

80. (c) HNO_3 is an oxidizing agent but HCl is not.

81. (d) Oxalate of these metals are insoluble.

82. (a) In II group, sulphides are precipitated in acidic medium.

83. (a) The dissociation of H_2S is suppressed in the presence of HCl due to common ion effect, and thus, only II group radicals are precipitated.

84. (d) $2KI + Cl_2 \longrightarrow 2KCl + I_2$;

$I_2 + CCl_4 \longrightarrow$ Violet solution.

85. (b) $PbCl_2$ is insoluble in cold water but soluble in hot water, whereas AgCl is insoluble in both states.

86. (d) No change in oxidation number of Fe.

87. (b) $Br_2 + H_2O \longrightarrow$ Brown color;

$NO_2 + H_2O \longrightarrow$ Colorless.

Br_2 impart brown color to the aqueous solution while NO_2 does not.

88. (d) These are characteristics of NaBr. Br_2 is given out with H_2SO_4.

90. (b) $SO_2 + 2NaOH \longrightarrow Na_2SO_3 + H_2O$

$Na_2SO_3 + BaCl_2 \longrightarrow BaSO_3 + 2NaCl$

$Br_2 + H_2O \longrightarrow 2HBr + [O]$

$BaSO_3 + [O] \longrightarrow \underset{\text{white ppt.}}{BaSO_4}$

(Insoluble in conc. HNO_3)

91. (b) $S_2O_3^{2-} + 4Cl_2 + 5H_2O \longrightarrow S + SO_4^{2-} + Cl^{\ominus}$

92. (b) $3Na_2S_2O_3 + 2BiCl_3 \longrightarrow Bi_2(S_2O_3)_3 + 6NaCl$

$Bi_2(S_2O_3)_3 + 3H_2O \longrightarrow Bi_2S_3 + 3H_2SO_4$

94. (b) $\underset{\text{Mixture of two cations } (A)}{(K^+ + NH_4^+)} \xrightarrow{HClO_4} \underset{\text{White } (B)}{KClO_4\downarrow} + \underset{(C)}{NH_4^+}$

$\xrightarrow{\Delta,\ NaOH} \underset{(D)}{NH_3\uparrow} \xrightarrow[KOH]{K_2[HgI_4]} \underset{\text{(Brown ppt.)}}{HgO \cdot Hg(NH_2)I\downarrow}$

95. (b) (a): $\rightarrow C_2O_4^{2-} + 2H^+ \xrightarrow{\text{dil. } H_2SO_4}$ No vapors or gas is evolved

$\rightarrow NO_3^-$: No reaction with dil. H_2SO_4

(b): $\rightarrow NO_3^-$: No reaction with dil. H_2SO_4

$\rightarrow NO_2^- + H^+ \xrightarrow{\text{dil. } H_2SO_4} HNO_2$

$\xrightarrow{\text{disproportionation}} HNO_3 + NO\uparrow$

$\xrightarrow{\text{atm. air}} \underset{\text{Light brown}}{NO_2\uparrow}$

Hence, distinction is possible.

(c) Both Cl^- and Br^- have no reaction with dil. H_2SO_4.

(d) Both HCO_3^- and CO_3^{2-} produce $CO_2\uparrow$ which evolves with effervescences.

115. (a) Fe^{2+} is oxidized to Fe^{3+} in order to precipitate $Fe(OH)_3$.

116. (d) $PbSO_4$ is white and insoluble in HNO_3 and hot water.

117. (b) Assume green crystal of $FeSO_4$

$FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2 + SO_3$

$SO_2 + MnO_4^- \longrightarrow Mn^{2+} + SO_4^{2-}$

SO_3 forms waxy white solid (H_2SO_4) in ice container which is dissolved in water and gives SO_4^{2-} ion. When $BaCl_2$ reacts with SO_4^{2-} ion, it forms white ppt. of $BaSO_4$.

118. (d) $SO_4^{2-} + BaCl_2 \longrightarrow \underset{\text{(White ppt.)}}{BaSO_4} + 2Cl^-$.

119. (c) It is a property of $COCl_2$.

120. (b) (X) is $AlCl_3$

$\underset{\text{(moisture)}}{AlCl_3} + 3H_2O \longrightarrow Al(OH)_3\downarrow + \underset{\text{(fumes)}}{3HCl}$

$AlCl_3 + 3NH_4OH \longrightarrow Al(OH)_3\downarrow + 3NH_4Cl$

$Al(OH)_3 + NaOH \longrightarrow NaAlO_2 + 2H_2O$

$AlCl_3 + H_2S + H^+ \longrightarrow$ No ppt.

121. (d) $Na_2B_4O_7 + 7H_2O \longrightarrow \underbrace{\underset{\text{Strong base}}{2NaOH} + \underset{\text{Weak acid}}{4H_3BO_3}}_{\text{Alkaline}}$

$Na_2B_4O_7 \xrightarrow{\Delta} \underbrace{2NaBO_2 + B_2O_3}_{\text{Glassy-bead}}$

$Na_2B_4O_7 + H_2SO_4 + 5H_2O \longrightarrow Na_2SO_4 + 4H_3BO_3$
(white crystals)

122. (d) $\underset{(X)}{AgNO_3} \xrightarrow{\Delta} \underset{\text{(grey residue)}}{2Ag\downarrow} + 2NO_2\uparrow + \underset{(Y)}{O_2\uparrow}$

$AgNO_3 + NH_4OH \longrightarrow [Ag(NH_3)_2]^+$

$2[Ag(NH_3)_2]^+ + CH_3CHO + H_2O \longrightarrow 2Ag\downarrow + CH_3COO^- + 3\,NH_4^+ + NH_3$

$Ag^+ + Fe^{2+} \longrightarrow Ag\downarrow + Fe^{3+}$

$2AgNO_3 + K_2CrO_4 \longrightarrow \underset{\text{(Brick red)}}{Ag_2CrO_4\downarrow} + 2KNO_3$

123. (a) $2Br^- \xrightarrow[\text{water}]{Cl_2} Br_2$; CCl_4 layer becomes red or reddish-brown.
I^- ion is oxidized preferebly compared to Br^-. Hence I^- is absent.

124. (c)

$\underbrace{Pb^{2+},\ Ag^+}_{\text{Salt mixture}}$
↓ dil. HCl
$\underbrace{AgCl, PbCl_2}_{\text{White ppt.}}$
↓ Heated with distilled water and filter in hot

- ppt. AgCl → Excess NH_3 solution → $[Ag(NH_3)_2]^+$ Clear solution
- Filtrate $PbCl_2$ → Cooled → $PbCl_2\downarrow$ (W) Needle like crystals

125. (c) $CaCO_3 \xrightarrow{AcOH} \underset{\text{Soluble}}{Ca^{2+}} + CO_2\uparrow$

$\xrightarrow{Na_2C_2O_4} CaC_2O_4\downarrow \xrightarrow{AcOH}$ No dissolution of ppt.

126. (c) $Hg(NO_3)_2 \xrightarrow{\Delta} \underset{(W)}{Hg(l)} + \underset{(X)}{NO_2\uparrow} + O_2\uparrow$

$2NO_2 + H_2O \longrightarrow HNO_2 + HNO_3$

$\underset{(W)}{Hg} + \underset{\text{(dil.)}}{4HNO_3} \xrightarrow{\Delta} \underset{(Y)}{Hg(NO_3)_2} + 2NO\uparrow + 2H_2O$

$Hg(NO_3)_2 + Na_2S_2O_3 \longrightarrow \underset{\text{Soluble}}{Na_2[Hg(S_2O_3)_2]} + 2NaNO_3$

Multiple Correct Answers Type

28. (b), (c), (d)
Both Cu^{2+} and Cd^{2+} are precipitated in II group by H_2S in dil. HCl.

29. (b), (c), (d)
Hg_2Cl_2 is insoluble.

30. (a), (b)
Both PO_4^{3-} and AsO_4^{3-} give yellow ppt. with ammonium molybdate.

31. (a), (b), (d)
Nitrates of all the metals are water soluble and cannot be precipitated.

47. (a), (b), (c)
$Al(OH)_3$ is insoluble in water.

48. (a), (c), (d)
White salts or ions giving colorless beads do not give borax bead test.

49. (a), (b), (c)
Br^- gives Br_2 · NO_3^- and NO_3^- gives NO_2 gas which are brown in color.

50. (a), (b)
AgCl is completely soluble while AgBr is partially soluble in NH_4OH.

52. (a), (c)
$M + \underset{(20\%)}{\text{dil. } HNO_3} \longrightarrow M(NO_3)_2 + N_2O$
where M is metals which are more electropositive than hydrogen except Sn and Pb.

$Sn + \underset{(20\%)}{\text{dil. } HNO_3} \longrightarrow Sn(NO_3)_2 + NH_4NO_3$

66. (b), (c)
The solubility of $PbCl_2$ is already very low in water and is suppressed appreciably in the presence of dil. HCl.
$PbCl_2 + \text{conc. } HCl \rightleftharpoons \underset{\text{soluble complex}}{[PbCl_4]^{2-}}$

67. (b), (d)
It is a reason for the given fact.

72. (a), (b)
$NH_4NO_3 + NaOH \longrightarrow NH_3 + NaNO_3 + H_2O$
$7NaOH + NaNO_3 + 4Zn \longrightarrow 4Na_2ZnO_2 + NH_3 + 2H_2O$
$NH_4NO_2 + NaOH \longrightarrow NaNO_2 + NH_3 + H_2O$
$3Zn + 5NaOH + NaNO_2 \longrightarrow 3Na_2ZnO_2 + NH_3 + H_2O$

74. (a), (b), (c), (d)
All these salts react with dil. H_2SO_4.

75. (a), (b), (c)

SO_4^{2-}, PO_4^{3-}, and BO_3^{3-} do not react with conc. H_2SO_4.

76. (a), (b), (d)

(a) $Bi^{3+} + 3NH_4OH \longrightarrow Bi(OH)_3\downarrow$ (white) $+ 3NH_4^+$

(b) $Pb^{2+} + 2NH_4OH \longrightarrow Pb(OH)_2\downarrow$ (white) $+ 2NH_4^+$

(c) Due to common ion effect of NH_4^+, the OH^- ion concentration is not excess enough to precipitate Mg^{2+} as $Mg(OH)_2$ because of its high solubility product.

(d) $Fe^{3+} + 3NH_4OH \longrightarrow Fe(OH)_3\downarrow$ (reddish-brown) $+ 3NH_4^+$

90. (a), (b), (c)

These are soluble in aquaregia only.

97. (b), (c), (d)

(a) $2HCO_3^- + Mg^{2+} \xrightarrow{\text{Cold}} Mg(HCO_3)_2$(soluble) $\xrightarrow{\Delta} MgCO_3\downarrow + CO_2 + 2H_2O$

(b) $Ca(HCO_3)_2 + 2NH_3 \longrightarrow (NH_4)_2CO_3 + CaCO_3\downarrow$

(c) True statement.

(d) $CO_3^{2-} + 4Hg^{2+} + 3H_2O \longrightarrow Hg_4O_3CO_3\downarrow$ (reddish-brown) $+ 6H^+$

or

$HgCO_3 \cdot 3HgO$

Basic mercury(II) carbonate

98. (a), (b), (c)

(a) $S^{2-} + Ag^+ \longrightarrow Ag_2S$; $Ag_2S + HNO_3 \longrightarrow AgNO_3 + S + NO + H_2O$

(b) $S^{2-} + Cd^{2+} \longrightarrow CdS\downarrow$ (yellow)

(c) $S^{2-} + Na_2[\overset{II}{Fe}(CN)_5NO^+] \longrightarrow Na_4[\overset{II}{Fe}(CN)_5NOS]$

(d) $[Pb(OH)_4]^{2-} + H_2S \longrightarrow PbS\downarrow$ (black) $+ 2OH^- + 2H_2O$

99. (b), (c), (d)

(b) Red color compound of unknown composition is formed when moist SO_2 is brought in contact with $Zn[Fe(CN)_5NO]$ (salmon color) paste in water. No color change with CO_2.

(c) $5SO_2 + 2IO_3^- + 4H_2O \longrightarrow I_2 + 5SO_4^{2-} + 8H^+$; I_2 + starch $\longrightarrow$ blue color.

No color change observed with CO_2.

(d) $3SO_2 + Cr_2O_7^{2-} + 2H^+ \longrightarrow 2Cr^{3+}$(green solution) $+ 3SO_4^{2-} + H_2O$.

No color change observed with CO_2.

100. (c), (d)

$2I^- + Cl_2 \longrightarrow I_2$ (purple/violet)

$2I^- + Br_2 \longrightarrow I_2$ (purple/violet).

101. (a), (b), (c), (d)

(a) It is deep red coloration due to the formation of $Fe(SCN)_3$.

(b) In presence of moisture, following reaction will occur: $CrO_2Cl_2 + H_2O \longrightarrow H_2CrO_4 + HCl$; so test is carried out only in dry test tube.

(c) White precipitate of $PbSO_4$ is formed and hence brown ring is not visible.

(d) Gives yellow precipitate of CdS.

102. (a), (c), (d)

(a) $[Al(OH)_4]^- + NH_4^+ \longrightarrow Al(OH)_3$ (white) $+ NH_3\uparrow + H_2O$

(b) $Pb^{2+}{}_{(aq)} + 2Br^-{}_{(aq)} \longrightarrow PbBr_2\uparrow$ (white)

(c) $BiI_3\downarrow$ (black precipitate) $+ H_2O \xrightarrow{\Delta} BiOI\downarrow$ (orange)

(d) $4Fe^{3+} + 3K_4[Fe(CN)_6] \longrightarrow Fe_4[Fe(CN)_6]_3\downarrow$ blue $+ 12K^-$

104. (a), (b), (d)

(c) is incorrect as with KI, Cu^{2+} salts form a brown precipitate of Cu_2I_2 and $I_3^{\ominus}$.

105. (a), (b), (c), (d)

(a) $CaSO_4 + (NH_4)_2SO_4 \longrightarrow (NH_4)_2[Ca(SO_4)_2]$ (soluble)

(b) $BaCrO_4$ is insoluble in dilute acetic acid and thus gets precipitated with K_2CrO_4 (low K_{sp} in K_2CrO_4 solution in acetic acid).

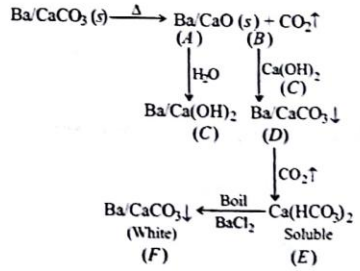
(c) $Cr(OH)_3$ is soluble in NaOH and Br_2 water forming sodium chromate while $Fe(OH)_3$ is insoluble.

(d) $[Cu(CN)_4]^{3-}$ is more stable than $[Cd(CN)_4]^{2-}$; so $[Cd(CN)_4]^{2-}$ gives yellow precipitate with H_2S.

107. (a), (b), (d)

Either CO_2 or SO_2 or ($CO_2 + SO_2$) can give lime water test.

108. (a), (c)



Comprehension Type

Comprehension-4:

12–14. $\underset{(A)}{Fe_2(SO_4)_3} \xrightarrow{\Delta} Fe_2O_3 + 3SO_3$

$Fe_2(SO_4)_3 + 3NH_4OH \longrightarrow \underset{\text{Reddish-brown ppt.}}{2Fe(OH)_3\downarrow} + 3(NH_4)_2SO_4$

$2Fe(OH)_3 + 6HCl \longrightarrow \underset{\text{reddish brown solution}}{2FeCl_3} + 3H_2O$

$4FeCl_3 + 3K_4Fe(CN)_6 \longrightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_6]} + 12KCl$

Comprehension-5:

15–17.

$\underset{(A)}{FeBr_3} + 3AgNO_3 \longrightarrow \underset{(D)}{Fe(NO_3)_3} + 3AgBr\downarrow$ (light yellow ppt.)

$2FeBr_3 + 3H_2SO_4 \longrightarrow \underset{(B)}{Fe_2(SO_4)_3} + 3Br_2$

$FeBr_3 + 3NH_4OH \longrightarrow \underset{(C)}{Fe(OH)_3\downarrow} + 3NH_4Br$

Comprehension-6:

18–22. $\underset{\text{Green solution}}{CrCl_3} + 3NH_4OH \longrightarrow \underset{\text{Greenish ppt.}}{Cr(OH)_3\downarrow} + 3NH_4Cl$

$Na_2O_2 + H_2O \longrightarrow 2NaOH + [O] \times 3$

$2Cr(OH)_3 + 4NaOH + 3[O] \longrightarrow 2Na_2CrO_4 + 5H_2O$

$2Cr(OH)_3 + 3Na_2O_2 \longrightarrow \underset{\text{Yellow solution}}{2Na_2CrO_4} + 2NaOH + 2H_2O$

$\underset{\text{Yellow}}{2CrO_4^{2-}} + 2H^+ \longrightarrow \underset{\text{Orange}}{Cr_2O_7^{2-}} + H_2O$

$Cr_2O_7^{2-} + 2OH^- + 2Pb^{2+} \longrightarrow \underset{\text{(Bright yellow ppt.)}}{2PbCrO_4} + H_2O$

Note: $CrBr_3$ (greenish black) and chromic iodide (red) are crystalline solids.

Comprehension-7:

23–26. Zinc oxide turns yellow on heating and white on cooling. (*A*) is ZnO which is not soluble in water. ZnO is called Chinese white, zincite, Philosopher's wool.

$ZnO + 2HCl \longrightarrow \underset{(B)}{ZnCl_2} + H_2O$

$ZnO + 2NaOH \longrightarrow \underset{(C)}{Na_2ZnO_2} + H_2O$

ZnO is amphoteric.

$\underset{(B)}{ZnCl_2} + H_2S \longrightarrow$ no ppt.

This is because ZnS. is precipitated in basic medium with sufficient $[S^{2-}]$ concentration.

$\underset{\text{(Neutral or basic solution)}}{ZnCl_2} + H_2S \xrightarrow{NH_4OH} \underset{(D)}{ZnS\downarrow} + 2HCl$

Comprehension-8:

27–30. (i) (*A*) forms glassy transparent bead which is characteristic property of borax.

$\Rightarrow$ (*A*) is borax ($Na_2B_4O_7 \cdot 10H_2O$)

$Na_2B_4O_7 \cdot 10H_2O \xrightarrow{\Delta} \underbrace{NaBO_2 + B_2O_3}_{\text{(B) Glassy bead}} + 10H_2O$

$B_2O_3 + CuSO_4 \xrightarrow{\Delta} \underset{\text{Colored bead (C)}}{Cu(BO_2)_2} + SO_3\uparrow$

(ii) $Na_2B_4O_7 + H_2SO_4 + 5H_2O \longrightarrow Na_2SO_4 + 4H_3BO_3$

$H_3BO_3 + 3C_2H_5OH \longrightarrow \underset{\text{Green flame (on ignition)}}{\underset{(D)}{(C_2H_5)_3BO_3}} + 3H_2O$

(iii) $Na_2B_4O_7 + 5H_2O \longrightarrow \underset{\text{Weak acid}}{2H_3BO_3} + 2Na[B(OH)_4]$

$Na[B(OH)_4]$ reacts with acid (HCl); hence aqueous solution of (*A*) is alkaline.

Comprehension-9:

31–33. (*A*) gives white ppt. with NH_4Cl and NH_4OH

(*A*) is Al^{3+}

ppt. is of $Al(OH)_3$

$Al(OH)_3$ is soluble in (*B*) $\Rightarrow$ (*B*) is NaOH

(*C*) is $NaAlO_2$ (sodium meta-aluminate)

(*A*) forms dimer indicating (*A*) is electron-deficient, which is the possible case of $AlCl_3$.

(*A*) is thus $AlCl_3$ (acidic due to hydrolysis, turns blue litmus red)

(*B*) is NaOH (alkaline, turns red litmus blue)

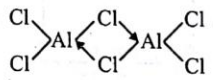
$\underset{(A)}{AlCl_3} + \underset{(B)}{3NaOH} \longrightarrow \underset{\text{White ppt.}}{Al(OH)_3} + 3NaCl$

$Al(OH)_3 + \underset{\text{(Excess)}}{NaOH} \longrightarrow \underset{\text{Soluble (C)}}{NaAlO_2} + H_2O$

$AlCl_3 + 3H_2O \longrightarrow Al(OH)_3 + 3HCl\uparrow$ (fumes)

$AlCl_3 + 3NH_4OH \xrightarrow{NH_4Cl} Al(OH)_3\downarrow + 3NH_4Cl$

$2AlCl_3 \longrightarrow Al_2Cl_6$



Comprehension-10:

34. (a) Both Bi^{3+} and Cd^{2+} will be precipitated as Bi_2S_3 (black) and CdS (yellow) by H_2S as both have low values of K_{sp} than Al^{3+}, Zn^{2+}, and Ni^{2+} (as sulphides).

35. (c) 2*M* HCl is group reagent for group I cations. $PbCl_2$ and Hg_2Cl_2 will get precipitated, as their solubility products (K_{sp}) are less than that of other radical.

36. (b) $Fe^{3+} + 3NH_4OH \longrightarrow Fe(OH)_3\downarrow$ (reddish-brown) + $3NH_4^+$

$Cu^{2+} + 4NH_3 \longrightarrow [Cu(NH_3)_4]^{2+}$ (blue color soluble complex)

$Zn^{2+} + 4NH_3 \longrightarrow [Zn(NH_3)_4]^{2+}$ (colorless soluble complex)

Comprehension-11:

37. (b)

(a) $Ag^+ + S_2O_3^{2-} \longrightarrow Ag_2S_2O_3$ (White ppt.)

(b) $Pb^{2+}{}_{(aq)} + 2Cl^{\ominus}{}_{(aq)} \longrightarrow PbCl_2\downarrow$

(c) $BiI_3\downarrow$ (black precipitate) $+ H_2O \xrightarrow{\Delta} BiOI\downarrow$ (orange)

(d) $Ca^{2+} + 2K^+ + [Fe(CN)_6]^{4-} \longrightarrow K_2Ca[Fe(CN)_6]\downarrow$ (white)

38. (b)

(a) $Hg^{2+} + 2I^- \longrightarrow HgI_2\downarrow$ (red / scarlet)

$HgI_2 + 2I^- \longrightarrow [HgI_4]^{2-}$ (soluble complex)

(b) $Hg_2^{2+} + 2I^- \longrightarrow Hg_2I_2\downarrow$ (green)

$Hg_2I_2 + 2I^- \longrightarrow [HgI_4]^{2-} + Hg\downarrow$ (black)

(c) $Bi^{3+} + 3I^- \longrightarrow BiI_3\downarrow$ (black)

$BiI_3^-\downarrow + I^- \longrightarrow [BiI_4]^-$ (orange color soluble complex)

(d) $2Cu^{2+} + 5I^- \longrightarrow 2CuI\downarrow$ (white) $+ I_3^-$

39. (d) (a) $Zn(OH)_2$ dissolves in both NaOH and NH_3 forming $[Zn(OH)_4]^{2-}$ and $[Zn(NH_3)_4]^{2+}$ respectively.

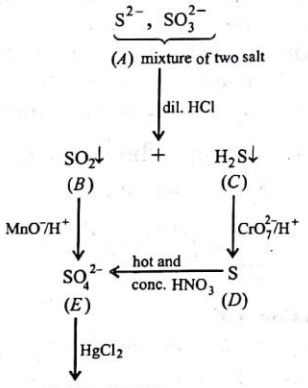
(b) $Cd(OH)_2$ dissolves in ammonia but does not dissolve in NaOH.

(c) $Cu(OH)_2 + NH_3 \longrightarrow [Cu(NH_3)_4]^{2+}$, which is a soluble complex but does not dissolve in NaOH.

(d) $Al(OH)_3 + OH^- \longrightarrow [Al(OH)_4]^-$, which is a soluble complex but does not dissolve in NH_3.

Comprehension-12:

40–42.



Comprehension-15:

48–52.

$$\underset{(A)}{BiCl_3} + H_2O \longrightarrow \underset{\substack{\text{White ppt.}\\(B)\\\text{(Redissolves in HCl)}}}{BiOCl\downarrow} + 2HCl$$

$$2BiCl_3 + 3H_2S \longrightarrow \underset{\substack{\text{black ppt.}\\(C)}}{Bi_2S_3} + 6HCl$$

$$\underset{(A)}{2BiCl_3} + 3H_2SO_4 \xrightarrow{\Delta} \underset{(D)}{Bi_2(SO_4)_3} + 6HCl$$

$$Hg_2(NO_3)_2 + 2HCl \longrightarrow \underset{(E)}{Hg_2Cl_2\downarrow} + 2HNO_3$$

Comprehension-16:

53–55.

(i) $CuSO_4 + BaCl_2 \longrightarrow BaSO_4\downarrow + 2HCl$

(ii) $2CuSO_4 + 4KI \longrightarrow 2K_2SO_4 + \underset{\text{White ppt.}}{CuI_2\downarrow} + I_2\downarrow$

$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$

(iii) $2Cu^{2+} + K_4[Fe(CN)_6] \longrightarrow \underset{\substack{\text{Red-brown (chocolate)}\\\text{ppt.}}}{Cu_2[Fe(CN)_6]} + 4K^+$

Comprehension-17:

56–59. (A) is $FeSO_4{\cdot}7H_2O$

$$FeSO_4 + BaCl_2 \longrightarrow \underset{(B)}{BaSO_4\downarrow} + FeCl_2$$

$$2FeSO_4 \xrightarrow{\Delta} \underset{(E)}{Fe_2O_3} + \underset{(C)}{SO_2} + \underset{(D)}{SO_3}$$

$$Fe_2O_3 + 6HCl \longrightarrow \underset{(F)}{2FeCl_3} + 3H_2O$$

$$2FeCl_3 + H_2S \longrightarrow \underset{(H)}{2FeCl_2} + \underset{(G)}{2HCl + S}$$

$$2FeCl_3 + SnCl_2 \longrightarrow 2FeCl_2 + SnCl_4$$

$$4FeCl_3 + 3K_4Fe(CN)_6 \longrightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_6]_3} + 12KCl$$

Note: $FeCl_3$ gives blood red coloration with thiocyanate ion:

$$FeCl_3 + \underset{\substack{\text{Potassium}\\\text{thiocyanate}}}{3KSCN} \longrightarrow \underset{\substack{\text{Blood red}\\\text{coloration}}}{Fe(SCN)_3} + 3KCl$$

Comprehension-18:

60–62. $\underset{\text{Greenish salt}}{Cr_2(SO_4)_3} + 6NH_4OH \longrightarrow \underset{\text{Greenish ppt.}}{2Cr(OH)_3} + 3(NH_4)_2SO_4$

$$Br_2 + 2NaOH \longrightarrow NaBr + NaBrO + H_2O$$

$$NaBrO \longrightarrow NaBr + O$$

$$2Cr(OH)_3 + 4NaOH + 3[O] \longrightarrow 2Na_2CrO_4 + 5H_2O$$

or $2Na_2O_2 + 2H_2O \longrightarrow 4NaOH + O_2$

$$2Cr(OH)_3 + 4NaOH + [O] \longrightarrow \underset{\text{Yellow solution}}{2Na_2CrO_4} + 5H_2O$$

$$Na_2CrO_4 + (CH_3COO)_2Pb \xrightarrow{CH_3COOH} \underset{\text{Yellow ppt.}}{PbCrO_4\downarrow} + 2CH_3COONa$$

Comprehension-19:

63–65. (A) is $FeSO_4{\cdot}7H_2O$

$$\underset{\substack{\text{Light green}\\(A)}}{FeSO_4{\cdot}7H_2O} \xrightarrow{\text{Gentle heating}} \underset{\substack{\text{Colourless}\\(B)}}{FeSO_4} + 7H_2O$$

$FeSO_4 + NO \longrightarrow \underset{\text{Brown } (C)}{FeSO_4.NO}$

$2FeSO_4 \xrightarrow{\Delta} \underset{(D)}{Fe_2O_3} + \underset{(E)}{SO_2} + \underset{(F)}{SO_3}$

$2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$

$SO_2 + H_2O + O \longrightarrow [H_2SO_4] \times 5$

$\underset{\text{(Pink)}}{2KMnO_4} + 2H_2O + 5SO_2 \longrightarrow K_2SO_4 + \underset{\text{(Almost colorless)}}{2MnSO_4} + 2H_2SO_4$

$SO_3 + H_2O \longrightarrow H_2SO_4$; $H_2SO_4 + BaCl_2 \longrightarrow BaSO_4\downarrow + 2HCl$

Comprehension-20:

66–69. (A) turns blue litmus red $\Rightarrow$ (A) is basic in nature.

(A) imparts golden yellow color in flame $\Rightarrow$ (A) has Na^+.

(A) gives H_2 gas with Zn or Al $\Rightarrow$ (A) is NaOH.

Explanation:

$2NaOH + Zn \longrightarrow Na_2ZnO_2 + H_2\uparrow$

$2NaOH + 2H_2O + 2Al \longrightarrow 2NaAlO_2 + 3H_2\uparrow$

$ZnCl_2 + 2NaOH \longrightarrow \underset{\text{White ppt.}}{Zn(OH)_2\downarrow} + 2NaCl$

$Zn(OH)_2 + 2NaOH \longrightarrow Na_2[Zn(OH)_4]$ or $\underset{\text{Sodium zincate}}{Na_2ZnO_2}$

$AlCl_3 + 3NaOH \longrightarrow \underset{\text{White ppt.}}{Al(OH)_3\downarrow} + 3NaCl$

$Al(OH)_3 + NaOH \longrightarrow Na[Al(OH)_4]$ or $\underset{\text{Sodium meta-aluminate}}{NaAlO_2}$

Comprehension-21:

70–72. $2AgNO_3 + \underset{(B)}{Na_2S_2O_3} \longrightarrow \underset{\text{White ppt. } (A)}{Ag_2S_2O_3\downarrow} + 2NaNO_3$

White ppt. dissolves in excess of (B) forming a complex.

$Ag_2S_2O_3 + 3Na_2S_2O_3 \longrightarrow \underset{\text{Soluble}}{2Na_3[Ag(S_2O_3)_2]}$

When (A) is heated with water, there is disproportionation of $S_2O_3^{2-}$ to SO_4^{2-} and S^{2-}

$Ag_2S_2O_3 + H_2O \longrightarrow \underset{(C)\text{ Black ppt.}}{Ag_2S\downarrow} + \underset{\text{Soluble}}{H_2SO_4}$

H_2SO_4 remains in the upper layer and gives white ppt. (D) with a $Ba(NO_3)_2$ solution.

$H_2SO_4 + Ba(NO_3)_2 \longrightarrow \underset{(D)}{BaSO_4\downarrow} + 2HNO_3$

Comprehension-23:

77. (d) All are black and give gas with dil. H_2SO_4.

$S^{2-} + 2H^+ \longrightarrow H_2S\uparrow$

78. (d) (c) $2\overset{+5}{HNO_3} \longrightarrow H_2O + 2\overset{+4}{NO_2} + [O]$;

(b) $H_2\overset{-2}{S} + [O] \longrightarrow H_2O + \overset{0}{S}\downarrow$

79. (d) (a) $SO_4^{2-} + (CH_3COO)_2Pb \longrightarrow PbSO_4\downarrow + 2CH_3COO^-$

(b) $2CuSO_4 + 4KI \longrightarrow 2K_2SO_4 + Cu_2I_2\downarrow + I_2$

(c) $CuSO_4 \cdot 5H_2O \xrightarrow[-2H_2O]{} CuSO_4 \cdot 3H_2O$

80. (a) $\underset{(A)}{Ag_2S, FeS, CuS \text{ or } PbS} + H_2SO_4 \longrightarrow FeSO_4 + \underset{(B)}{H_2S}$

$H_2S + \underset{(C)}{2HNO_3} \longrightarrow 2NO_2 + 2H_2O + \underset{(D)}{S}$

$\underset{(E)}{CuSO_4} + BaCl_2 \longrightarrow CuCl_2 + BaSO_4\downarrow$ (white)

$CuSO_4 + H_2S \longrightarrow \underset{(F)}{CuS}\downarrow$ (black) $+ H_2SO_4$

$3CuS\downarrow + 8HNO_3 \longrightarrow 3Cu^{2+} + 6NO_3^- + 3S\downarrow + 2NO\uparrow + 4H_2O$

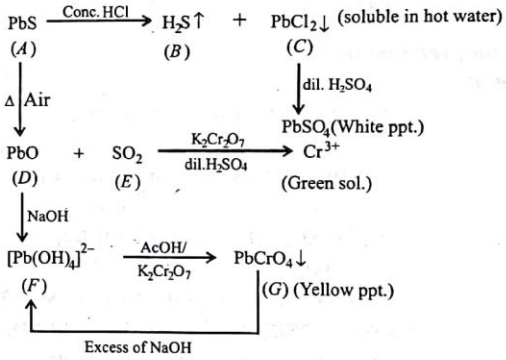
$Cu^{2+} + 4NH_3 \longrightarrow \underset{(G)}{[Cu(NH_3)_4]^{2+}}$ (blue color soluble complex)

$Cu^{2+} + [Fe(CN)_6]^{4-} \longrightarrow \underset{(H)}{Cu_2[Fe(CN_6)]}\downarrow$ (chocolate brown)

$Cu(NO_3)_2 + Zn \longrightarrow Zn(NO_3)_2 + Cu\downarrow$ (reddish-brown)

Comprehension-24:

81–83.



Comprehension-26:

89. (a), (c)

For test tube "a"

- If it contains Cd^{2+} then

$Cd^{2+} \xrightarrow[\text{Solution}]{NH_3} \underset{(W)}{Cd(OH)_2}\downarrow$

$\downarrow$ Excess of NH_3 solution

$\underset{\text{Colorless solution}}{[Cd(NH_3)_4]^{2+}}$

- If it contains Zn^{2+} then

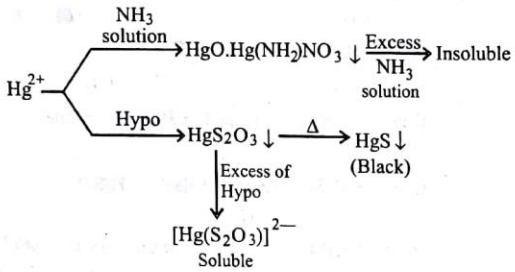
$Zn^{2+} \xrightarrow[\text{Solution}]{NH_3} Zn(OH)_2 \xrightarrow[\text{of } NH_3 \text{ solution}]{\text{Excess}} \underset{\text{(colorless solution)}}{[Zn(NH_3)_4]^{2+}}$

For test tube "b"

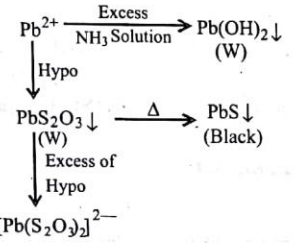
$Zn^{2+} \xrightarrow[\text{Solution}]{NH_3} \underset{\text{(white)}}{Zn(OH)_2}\downarrow \xrightarrow{\Delta} ZnO$ (White : cold) (Yellow : Hot)

For test tube "c"

- If it contains Hg^{2+} then



- If this test contains Pb^{2+}, then



Comprehension-27:

90–97.

$$\underset{(A)}{FeS} + H_2SO_4 \longrightarrow FeSO_4 + \underset{(B)}{H_2S}$$

$$\underset{(C)}{2HNO_3} + 3H_2S \longrightarrow 2NO + \underset{(D)}{3S\downarrow} + 4H_2O$$

$$\underset{(E)}{CuSO_4} + \underset{(B)}{H_2S} \longrightarrow \underset{(F)}{CuS\downarrow} + H_2SO_4$$

$$3CuS + 8HNO_3 \longrightarrow 2Cu(NO_3)_3 + 2NO + 3S$$

$$Cu(NO_3)_2 + 2NH_4OH \longrightarrow Cu(OH)_2 + 2NH_4NO_3$$

$$Cu(OH)_2 + 4NH_3 \longrightarrow \underset{\substack{\text{(Blue complex solution)}\\(G)}}{[Cu(NH_3)_4](OH)_2}$$

$$2Cu^{2+} + K_4Fe(CN)_6 \longrightarrow \underset{(H)}{Cu_2[Fe(CN)_6]} + 4K^+$$

$$BaCl_2 + CuSO_4 \longrightarrow BaSO_4\downarrow + CuCl_2$$

Comprehension-28:

98–100. (A) is $ZnCO_3$ and (B) is ZnO

$$\underset{(A)}{ZnCO_3} \longrightarrow \underset{(B)}{ZnO} + CO_2$$

$$ZnO + 2NaOH \longrightarrow Na_2ZnO_2 + H_2O$$

$$2Co(NO_3)_2 \longrightarrow 2CoO + 4NO_2 + O_2$$

$$ZnO + CoO \xrightarrow[\text{cavity}]{\text{On charcoal}} ZnO \cdot CoO$$

Comprehension-29:

101–103. By (iii) (A) gives $N_2O + 2H_2O$ on heating, hence (A) is NH_4NO_3

$$NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$$

(i) $$NH_4NO_3 + NaOH \xrightarrow{\Delta} NaNO_3 + \underset{(B)}{NH_3} + H_2O$$

$$NH_3 + HCl \longrightarrow \underset{\text{White fumes}}{NH_4Cl} + H_2O$$

(ii) $$2NaOH + Zn \xrightarrow{\Delta} Na_2ZnO_2 + 2H$$

$$NaNO_3 + 8H \xrightarrow{\Delta} NaOH + \underset{(B)}{NH_3} + 2H_2O$$

(NH_3 gas is obtained due to reduction of NO_3^-.)

Comprehension-30:

104–108. $$Na_2CO_3 + O_2 \text{ (from } KNO_3) + MnO \longrightarrow \underset{A\text{ (Green)}}{Na_2MnO_4} + CO_2$$

$$\underset{A}{2Na_2MnO_4} + Cl_2 \longrightarrow \underset{B\text{ (Purple)}}{2NaMnO_4} + 2NaCl$$

$$2Cr_2O_3 + 4Na_2CO_3 + 3O_2 \longrightarrow \underset{C\text{ (Yellow)}}{4Na_2CrO_4} + 4CO_2$$

$$\underset{(C)}{2Na_2CrO_4} + H_2SO_4 \longrightarrow \underset{D\text{ (Orange)}}{Na_2Cr_2O_7} + Na_2SO_4 + H_2O$$

Comprehension-31:

109–111. $$\underset{(A)}{BiCl_3} + H_2O \longrightarrow \underset{\text{white ppt. }(B)}{BiOCl\downarrow} + 2HCl$$

$$\underset{(B)}{BiOCl} + 2HCl \longrightarrow \underset{(A)}{BiCl_3} + H_2O$$

$$2BiCl_3 + 3H_2S \longrightarrow \underset{\substack{\text{brown-black ppt.}\\(C)}}{Bi_2S_3\downarrow} + 6HCl$$

$$Bi_2S_3 + 8HNO_3 \longrightarrow 2Bi(NO_3)_3 + 3S\downarrow + 2NO + 4H_2O$$

$$2Bi(NO_3)_3 + 3H_2SO_4 \longrightarrow Bi_2(SO_4)_3 + 6HNO_3$$

$$Bi_2(SO_4)_3 + 6NH_4OH \longrightarrow \underset{\substack{\text{white ppt.}\\(F)}}{2Bi(OH)_3\downarrow} + 3(NH_4)_2SO_4$$

$$2Bi(OH)_3 + 3Na_2SnO_2 \longrightarrow \underset{\substack{(G)\\\text{black ppt.}}}{2Bi} + 3Na_2SnO_3 + H_2O$$

$$2BiCl_3 + 3H_2SO_4 \longrightarrow \underset{(D)}{Bi_2(SO_4)_3} + 6HCl$$

$$Hg_2(NO_3)_2 + 2HCl \longrightarrow \underset{\substack{\text{white ppt.}\\(E)}}{Hg_2Cl_2\downarrow} + 2HNO_3$$

Comprehension-32:

112–114. (A) is NH_4NO_3, reactions are:

(i) $$\underset{(A)}{NH_4NO_3} \xrightarrow{\Delta} \underset{(B)}{N_2O} + 2H_2O$$

$$N_2O + Mg \longrightarrow MgO + N_2$$

(ii) $$NH_4NO_3 + NaOH \xrightarrow{\text{heat}} \underset{(C)}{NH_3\uparrow} + NaNO_3 + H_2O$$

(iii) $$\underset{(B)}{N_2O} + NaNH_2 \longrightarrow \underset{\text{Sod. azide }(D)}{NaN_3} + H_2O$$

$$NaN_3 + H_2SO_4 \longrightarrow NaHSO_4 + \underset{(E)\text{ hydrazoic acid}}{HN_3}$$

$Pb(N_3)_2$, AgN_3 (azides) are explosive.

Matching Column Type

5. (a) p, q, r, s; (b) p, q; (c) p, q, r; (d) q, r, s

(a) $Ag_2CO_3 \downarrow$ (white), $Ag_2SO_3 \downarrow$ (white), $Ag_2S \downarrow$ (black), $AgNO_2 \downarrow$ (white)

(b) $BaCO_3 \downarrow$ (white), $BaSO_3 \downarrow$ (white), BaS (soluble), $Ba(NO_2)_2$ (soluble)

(c) $PbCO_3 \downarrow$ (white), $PbSO_3 \downarrow$ (white), $PbS \downarrow$ (black), $Pb(NO_2)_2$ (soluble)

(d) No reaction; other decolorizes pink color of $KMnO_4$

6. (a) p, q, s; (b) s; (c) z, p, s; (d) r, s

(a) $Fe(OH)_2 \downarrow$ green; $PbSO_4 \downarrow$ white; $FeS \downarrow$ black.

(b) $Bi_2S_3 \downarrow$ black

(c) Ag_2O brown, Ag_2S(black)

(d) $(NH_4)_3[Co(NO_2)_6] \downarrow$ yellow; $CoS \downarrow$ black.

7. (a) p, q, s; (b) r, s; (c) p, q; (d) p, s

(a) $Zn(OH)_2 \downarrow + 4KCN \longrightarrow K_2[Zn(CN)_4] + 2KOH$
Colorless soluble complex

$Zn(OH)_2 \downarrow + 4NH_3 \longrightarrow [Zn(NH_3)_4](OH)_2$
Colorless soluble complex

$Zn(OH)_2 \downarrow 2NaOH \longrightarrow Na_2[Zn(OH)_4]$
Colorless soluble complex

(b) It is slightly soluble in cold

$Cr(OH)_3 \downarrow + 6NH_3 \longrightarrow [Cr(NH_3)_6]^{3+} + 3OH^-$
(Pink or violet soluble complex)

$Cr(OH)_3 \downarrow + OH^- \longrightarrow [Cr(OH)_4]^-$
Green soluble complex

$2Cr(OH)_3 \downarrow + 3Na_2O_2 \longrightarrow 2Na_2CrO_4 + 2NaOH + 2H_2O$
Yellow solution

(c) $AgCl \downarrow + 2NH_3 \longrightarrow [Ag(NH_3)_2]Cl$

$AgCl + 2CN^- \longrightarrow [Ag(CN)_2]^- + Cl^-$

r, s $\longrightarrow$ No

(d) $2CuS \downarrow + 8CN^- \longrightarrow 2[Cu(CN)_4]^{3-} + S_2^{2-}$ colorless soluble complex (Redox reaction).

$CuS + Na_2O_2 \xrightarrow{H_2O} CuSO_4 + NaOH$

$CuS \downarrow + H_2O \longrightarrow CuSO_4$ soluble compound

15. (a) p, r; (b) q, r, s; (c) q, r, s; (d) p, q, r

(a) $Pb(CN)_2 \downarrow$ (white), not soluble in excess of reagent.
$AgCN \downarrow$ (white), soluble in excess of reagent
$Hg + Hg(CN)_2 \downarrow$ (black), not soluble in excess reagent.

$Cu(CN)_2 \downarrow$ (yellow) $\xrightarrow{\text{Excess}} K_3[Cu(CN)_4]$ soluble.

(b) $Pb(OH)_2 \downarrow$ white $\xrightarrow{\text{Excess}} Na_2[Pb(OH)_4]$ soluble.
$Ag_2O \downarrow$ brown, $Hg_2O \downarrow$ black, $Cu(OH)_2 \downarrow$ blue

(c) $PbI_2 \downarrow$ yellow $\xrightarrow{\text{Excess}} [PbI_4]^{2-}$ soluble complex only with concentrated solution of KI(4M).

$AgI \downarrow$ yellow $\xrightarrow{\text{Excess}}$ No reaction

$Hg_2I_2 \downarrow$ green $\xrightarrow{\text{Excess}} [HgI_4]^- + Hg \downarrow$ black.

$\underbrace{CuI \downarrow \text{ white} + I_3^-}$ $\longrightarrow$ White ppt in brown colored solution.

(d) $PbCrO_4 \downarrow$ yellow
$Ag_2CrO_4 \downarrow$ (brick red/brownish red)
$Hg_2CrO_4 \downarrow$ red (with hot solution of K_2CrO_4)
In cold, brown precipitate is obtained.

19. (a) r, s, t; (b) s; (c) p, s; (d) s

(a) $4Fe^{3+} + 3[Fe(CN)_6]^{4-} \longrightarrow \overset{III}{Fe_4}[\overset{II}{Fe}(CN)_6]_3 \downarrow$
Blue ppt. (Prussian blue)

$3Zn^{2+} + 2K_4[Fe(CN)_6] \longrightarrow K_2Zn_3[Fe(CN)_6]_2 \downarrow + 6K^+$
(white)

$Cu^{2+} + K_4[Fe(CN)_6] \longrightarrow Cu_2[Fe(CN)_6] \downarrow$
(Chocolate brown)

(b) $(NH_4)_2S + ZnSO_4 \longrightarrow ZnS \downarrow + (NH_4)_2SO_4$
(White)

(c) $Cu^{2+} + 2NH_4OH \longrightarrow Cu(OH)_2 \downarrow + 2NH_4^+$
(Blue)
$\downarrow$ Excess of NH_3 solution
$[Cu(NH_3)_4]^{2+}$
Deep blue solution

$Zn^{2+} + 2NH_4OH \xrightarrow[\text{of } NH_4Cl]{\text{Absence}} Zn(OH)_2 \downarrow + 2NH_4^+$
(White)
$\xrightarrow[\text{of } NH_3 \text{ solution}]{\text{Excess}} [Zn(NH_3)_4]^{2+}$
colorless solution

(d) $Zn^{2+} + 2NaOH \longrightarrow Zn(OH)_2 \downarrow$
white
$\downarrow$ Excess
$[Zn(OH)_4]^{2-}$
colorless solution

23. (a) s; (b) r; (c) q; (d) p

(a) $Cu^{2+} + 2SCN^- \longrightarrow Cu(SCN)_2 \downarrow$ (black)

$2\,Cu(SCN)_2 \downarrow \longrightarrow 2CuSCN \downarrow$ (white) $+ (SCN)_2 \uparrow$

(b) $Pb^{2+} + CrO_4^{2-} \longrightarrow PbCrO_4$(yellow)

(c) $CO_3^{2-} + 4Hg^{2+} + 3H_2O \longrightarrow Hg_4O_3CO_3 \downarrow + 6H^+$
Reddish brown

(d) $Mn^{2+}(aq.) + 2OH^-(aq.) \longrightarrow Mn(OH)_2 \downarrow$ (white)

$Mn(OH)_2 \downarrow + O_2 \longrightarrow 2MnO(OH)_2 \downarrow$ (brown)

24. (a) p, r; (b) p; (c) p, s; (d) q, s

(a) $2Bi^{3+} + 3H_2S \longrightarrow Bi_2S_3 \downarrow$ Black $+ 6H^+$

$Bi^{3+} + 3I^- \longrightarrow BiI_3 \downarrow$ Black

(b) $Cu^{2+} + H_2S \longrightarrow CuS \downarrow$ Black $+ 2H^+$

$Cu^{2+} + 2SCN^- \longrightarrow Cu(SCN)_2 \downarrow$ Black

Which on standing slowly changes to white

$2Cu(SCN)_2 \longrightarrow 2Cu(SCN) \downarrow$ white $+ (SCN)_2$

Cu_2I_2 is white precipitate, and $Cu_2[Fe(CN)_6]$ brown precipitate.

(c) $Zn^{2+} + H_2S \longrightarrow ZnS \downarrow$ white $+ 2H^+$

$2K^+ + 2[Fe(CN)_6]^{4-} + 3Zn^{2+} \longrightarrow K_2Zn_3[Fe(CN)_6]_2 \downarrow$ white

$ZnI_2 \longrightarrow$ soluble

(d) $4Ag^+ + [Fe(CN)_6]^{4-} \longrightarrow Ag_4[Fe(CN)_6] \downarrow$ white

$Ag^+ + SCN^- \longrightarrow AgSCN \downarrow$ white

$Ag_2S \downarrow$ black; $AgI \downarrow$ yellow

Integer Answer Type

9. (4)

$Na_2B_4O_7 + 5H_2O \longrightarrow 2H_3BO_3 + 2Na[B(OH)_4]$

18. (3)

$B(OCH_2\text{–}CH_3)_3$

23. (1)

Oxidation number of iron is one $[Fe(H_2O)_5(NO)]SO_4$

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (c) $Hg_2S + H_2S \rightleftharpoons Hg + HgS$

2. (b) $Cr_3 + NH_4^{\oplus} \rightarrow \underset{\text{Violet or pink solution}}{[Cr_3(NH_3)_6]^{3+}}$

$Fe^{3+} + NH_4^{\oplus} \rightarrow \underset{\text{Reddish brown gelatinous ppt}}{Fe(OH)_3 \downarrow}$

3. (a) $AgCl + NH_3 \rightarrow \underset{\text{Soluble Complex}}{[Ag(NH_3)_2]^+}$

$AgI + NH_3 \rightarrow$ Insoluble

4. (a) $Na + C + N \xrightarrow{\Delta} NaCN$

$CN^- + Fe^{2+} \rightarrow [Fe(CN)_6]^{4-}$

$Fe^{3+} + [Fe(CN)_6]^{4-} \longrightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_6]_3\, xH_2O}$

JEE (Advanced) Exercises

Fill in the Blanks Type

1. If metal ions of group III are precipitated by NH_4Cl and NH_4OH without prior oxidation by concentrated HNO_3, **ferric ion** not completely precipitated. Nitric oxide oxidizes ferrous to ferric ions.

2. The formula of the deep-red liquid formed on warming dichromate with KCl in concentrated sulphuric acid is **chromyl chloride**.

$K_2CrO_7 + 2H_2SO_4 \rightarrow 2KHSO_4 + 2CrO_3 + H_2O$

$KCl + H_2SO_4 \rightarrow KHSO_4 + HCl$

$CrO_3 + 2HCl \rightarrow \underset{\text{Orange-red vapors}}{CrO_2Cl_2} + H_2O$

True/False Type

1. True.

The addition of ammonium chloride to a solution containing ferric and magnesium ions is essential for selective precipitation of ferric hydroxide by aqueous ammonia.

2. True.

From the solution containing copper (+2) and zinc (+2) ions, copper can be selectively precipitated using sodium sulphide.

Single Correct Answer Type

1. (c) Sn^{2+} cannot be precipitated by HCl, but is precipitated by H_2S as a chocolate-colored precipitate of SnS, soluble in yellow ammonium sulphide.

2. (a) $NaHCO_3$ and NaOH cannot coexist in solution because $NaHCO_3$ is an acid salt. It reacts with the base NaOH as follows:

$NaHCO_3 + NaOH \rightarrow Na_2CO_3 + H_2O$

3. (c) Acetic acid, being an acid, reacts with calcium oxide, hydroxide, and calcium carbonate. No reaction with calcium oxalate.

4. (a) In the presence of HCl, both the ions are precipitated by H_2S.

$Bi^{3+} + H_2S \xrightarrow{HCl} \underset{\text{Brown}}{Bi_2S_3 \downarrow}$

$Sn^{4+} + H_2S \xrightarrow{HCl} \underset{\text{Yellow}}{SnS_2 \downarrow}$

5. (d) $2CuSO_4 + 10KCN$

$\rightarrow 2K_3[Cu(CN)_4] + 2K_2SO_4 + (CN)_2$

First, $Cu(CN)_2$ is formed which decomposes to form $(CN)_2$ and $Cu_2(CN)_2$. $Cu_2(CN)_2$ then combines with KCN to form $K_3[Cu(CN)_4]$.

6. (c) In the presence of peroxide, chromium ions are oxidized to chromate ions which give a yellow filtrate. Ferric ions form brown precipitate of $Fe(OH)_3$.

7. (d) A white precipitate which is soluble in hot water is lead chloride.

$$Pb^{2+} + 2HCl \rightarrow \underset{\text{White}}{PbCl_2 \downarrow} + 2H^+$$

$$\underset{\text{Hot solution}}{PbCl_2} + H_2S \xrightarrow{H^+} \underset{\text{Black}}{PbS \downarrow} + 2HCl$$

8. (c) The first gas is chlorine and the second gas is hydrogen.

$$Cl_2 + H_2O \rightarrow HCl + HOCl$$

$$HCl + AgNO_3 \rightarrow \underset{\text{White}}{AgCl \downarrow} + HNO_3$$

$$Mg + 2HCl + \rightarrow MgCl_2 + H_2 \uparrow$$

9. (a) $[X] + H_2SO_4 \rightarrow [Y]$ colorless gas with irritating smell

$[Y] + H_2SO_4 + K_2Cr_2O_7 \rightarrow$ Green solution

Sulphite ions give sulphur dioxide gas with sulphuric acid, which turns acidified potassium dichromate to green.

$$SO_3^{2-} + H_2SO_4 \rightarrow SO_2 + H_2O + SO_4^{2-}$$

$$3SO_2 + K_2Cr_2O_7 + H_2SO_4$$

$$\rightarrow K_2SO_4 + \underset{\text{Green}}{Cr_2(SO_4)_3} + H_2O$$

10. (b) It must be a bicarbonate ion because first magnesium bicarbonate is formed which is soluble, then on heating, magnesium carbonate is formed which is insoluble and forms a precipitate.

$$MgCl_2 + 2NaHCO_3 \rightarrow \underset{\text{Soluble}}{Mg(HCO_3)_2} + 2NaCl$$

$$Mg(HCO_3)_2 \xrightarrow{\Delta} \underset{\text{White}}{MgCO_3 \downarrow} + H_2O + CO_2$$

11. (b) $Bi^{3+} + 3KI \rightarrow \underset{\text{Black}}{BiI_3 \downarrow} + 3K^+$

$$BiI_3 + KI \rightarrow \underset{\text{Orange solution}}{K[BiI_4]}$$

12. (d) $2CuSO_4 + 10KCN \rightarrow 2K_3[Cu(CN)_4] + 2K_2SO_4 + (CN)_2$

First, $Cu(CN)_2$ is formed which decomposes to form $(CN)_2$ and $Cu_2(CN)_2$. $Cu_2(CN)_2$ then combines with KCN to form $K_3[Cu(CN)_4]$.

13. (a) $Zn^{2+} + 2H_2O \rightarrow \underset{\text{White}}{Zn(OH)_2 \downarrow} + 2H^+$

$$Zn(OH)_2 + 2NH_4Cl + 2NH_4OH$$

$$\rightarrow \underset{\text{(Soluble)}}{[Zn(NH_3)_4]Cl_2} + 4H_2O$$

$Zn(OH)_2$ precipitate dissolves in excess of NH_4OH in the presence of NH_4Cl to form tetrammine soluble complex.

14. (a) $CO_2 + H_2O \rightleftharpoons H_2CO_3$

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$$

15. (b) $Hg^{2+} + 2I^- \rightarrow HgI_2 \downarrow$ (Scarlet red precipitate)

$$HgI_2 + 2I^- \rightarrow [HgI_4]^{2-}$$

$$Hg^{2+} + Co(SCN)_2 \rightarrow \underset{\text{Deep blue crystalline}}{Hg(SCN)_2 \downarrow} + Co^{2+}$$

16. (d) Only Zn^{2+} gives white ppt. of ZnS with ammonical H_2S, while

$$2Fe^{3+} + S^{2-} \longrightarrow 2Fe^{2+} + S \downarrow$$

$$Fe^{2+} + S^{2-} \longrightarrow FeS \downarrow$$

Here the sulphide of Fe^{3+} is not obtained

$$Al^{3+} + S^{2-} + H_2O \longrightarrow \underset{\text{white ppt.}}{Al(OH)_3 \downarrow} + S^-$$

$$Mg^{2+} + S^{2-} \longrightarrow \text{No reaction}$$

17. Acidified $K_2Cr_2O_7$, $CuSO_4$, H_2O_2, Cl_2, O_3 $FeCl_3$, HNO_3 oxidize aq. iodide to iodine. Alkaline $KMnO_4$ oxidize aq. iodide to IO_3^-

No reaction between iodine and $Na_2S_2O_3$

Multiple Correct Answers Type

1. (b), (c) Al^{3+} and Bi^{3+} are precipitated as their hydroxides $[Al(OH)_3, Bi(OH)_3]$ with ammonium hydroxide in the presence of ammonium chloride.

2. (b), (c)

$$Fe^{2+} + K_3\left[Fe(CN)_6\right] \rightarrow KFe^{II}\left[Fe^{III}(CN)_6\right] + 2K^+$$

Turnbull's blue is formed.

$$Fe^{3+} + 3KCNS \rightarrow [Fe(CNS)_3] + 3K^+$$

Blood-red color is formed.

3. (a), (b) The gas is ammonia, and the salt can be nitrate or nitrite as suggested by the following reactions:

$$NH_4NO_3 + NaOH \rightarrow NaNO_3 + NH_3 + H_2O$$

$$NaNO_3 + 8[H] \rightarrow NaOH + NH_3 + 2H_2O$$

$$NH_4NO_2 + NaOH \rightarrow NaNO_2 + NH_3 + H_2O$$

$$NaNO_2 + 6[H] \rightarrow NaOH + NH_3 + H_2O$$

4. (a), (c), (d)

$$KI_{(aq)} + K_3[Fe(CN)_6]_{(aq)} \longrightarrow \underset{\text{Brownish yellow}}{KI_{3(aq)}} + K_4[Fe(CN)_{6(aq)}]$$

$$\downarrow$$

$$\underset{\text{white ppt}}{K_2Zn_3[Fe(CN)_6]_2 \downarrow} + KI_{3(aq)}$$

OR

$$\{K_2Zn[Fe(CN)_6]\downarrow\}$$

$$\downarrow Na_2S_2O_3$$

$$\underset{\text{colorless}}{I^-_{(aq)} + S_4O_6^{2-}{}_{(aq)}}$$

Comprehension Type

1. (d) According to the options given the cation present in filtrate Q may be Fe^{+2} or Cu^{+2} or Zn^{+2} or Cr^{+3} because Q remains unchanged with H_2S in dil. mineral acid medium but gives ppt with alk. H_2S, the cation can not be Cu^{+2}

   Hence $Fe^{+2} \rightarrow FeS \downarrow$

   $Zn^{+2} \rightarrow ZnS \downarrow$

   $Cr^{+3} \rightarrow Cr(OH)_3 \downarrow$

   Among these three ppt. only $Cr(OH)_3$ gives colored solution with H_2O_2 in alk. medium,

   i.e. $Cr(OH)_3 \downarrow + OH^{\ominus} \rightarrow [Cr(OH)_4]^{\ominus}$

   $[Cr(OH)_4]^{\ominus} + H_2O_2 \rightarrow \underset{\text{yellow solution}}{CrO_4^{-2}} + H_2O$

   Note: (i) Zn^{+2} cannot produce any colored solution due to d^{10} configuration.

   (ii) FeS may be oxidized by H_2O_2 in basic medium into Fe^{3+} and SO_4^{2-} and Fe^{3+} must give raddish brown ppt. of $Fe(OH)_3$, not colored solution.

2. (a) (Unknown salt) + dil HCl $\rightarrow$ P + Q

   (ppt.) (filtrate)

   ppt. (P) is $PbCl_2$ because it is insoluble in cold water but soluble in hot water.

Assertion-Reasoning Type

1. (c) In qualitative analysis of basic radicals, cation Cd^{2+} belongs to group II and Ni^{2+} belongs to group IV. Group II radicals are precipitated by passing H_2S in acidic solution. They have low values of solubility products. But that of group IV are precipitated by passing H_2S in alkaline solution, and have high values of solubility products.

   Therefore, on passing H_2S in acidic solution a yellow precipitate of CdS is formed.

2. (b) Sulphate is estimated as $BaSO_4$, not as $MgSO_4$ because $MgSO_4$ is soluble in water and does not form a precipitate. The ionic radius of Mg^{2+} is smaller than that of Ba^{2+} because on moving down in a group ionic radii increase.

Integer Answer Type

1. (6, 7) PbS, CuS, HgS, Ag_2S, NiS, CoS are black

   MnS – dirty pink/Buff

   SnS_2 – yellow

   Bi_2S_3 – brown/black (brownish black)

Subjective Type

1. The precipitation of second group sulphides in qualitative analysis is carried out with hydrogen sulphide in the presence of hydrochloric acid but not in nitric acid.

   Nitric acid is a strong oxidizing agent and oxidizes H_2S into S. So it cannot be used in the reactions involving hydrogen sulphide.

2. *A*: $ZnCO_3$

   B: CO_2

   C: ZnO

   D: ZnS

   E: $Zn(OH)_2$

   The solid that is yellow when hot and white when cold is zinc oxide. The gas is carbon dioxide, from its behavior towards lime water. In alkaline medium, zinc sulphide is precipitated by hydrogen sulphide gas. The precipitate of zinc hydroxide is soluble in excess of sodium hydroxide due to the formation of sodium zincate.

   $A \xrightarrow{\Delta} ZnO + B$

   $ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$

   $2ZnCl_2 + K_4[Fe(CN)_6] \rightarrow 4KCl + Zn_2[Fe(CN)_6]\downarrow$

   $CO_2 + Ca(OH)_2 \rightarrow H_2O + \underset{\text{Milkiness}}{CaCO_3} \downarrow$

   $CaCO_3 + CO_2 + H_2O \rightarrow \underset{\text{Soluble}}{Ca(HCO_3)_2}$

   $ZnCO_3 + HCl \rightarrow CO_2 \uparrow + ZnCl_2$

   $ZnCl_2 + H_2S \xrightarrow{NH_4OH} 2HCl + ZnS\downarrow$

   $ZnCl_2 + NaOH \rightarrow Zn(OH)_2 \downarrow + 2NaCl$

   $Zn(OH)_2 \xrightarrow{NaOH} NaZnO_2(\text{soluble})$

3. A brown precipitate of ferric hydroxide is formed due to hydrolysis.

   $FeCl_3 + H_2O \rightleftharpoons Fe(OH)_3 \downarrow + HCl$

4. *A*: $FeSO_4$

   B: SO_2

   C: SO_3

   D: Fe_2O_3

   E: $BaSO_4$

   A light-green crystalline solid is expected to be ferrous sulphate. There is no reaction with dilute sulphuric acid. With potassium permanganate, ferrous sulphate is oxidized to ferric sulphate and the pink color disappears. On strong heating, it gives two gases which are two oxides of sulphur, along with a brown residue, ferric oxide. When gases are passed through acidified potassium dichromate, it is reduced by sulphur dioxide to give a green solution of chromium sulphate. On adding barium sulphate, the green solution of sulphate gives a white precipitate of barium sulphate. In charcoal cavity test, ferric oxide is reduced to iron which is magnetic.

$FeSO_4$ + dil. $H_2SO_4 \rightarrow$ No reaction

$$\underset{\text{(Pink)}}{FeSO_4 + KMnO_4} \xrightarrow{H_2SO_4} Fe_2(SO_4)_3 + \underset{\text{(Colorless)}}{Mn^{2+}}$$

$$FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2\uparrow + SO_3\uparrow$$

$$K_2Cr_2O_7 + SO_2 \xrightarrow{H_2SO_4} \underset{\text{Green}}{Cr_2(SO_4)_3}$$

$$H_2O + SO_3 \rightarrow H_2SO_4$$

$$H_2SO_4 + Ba(NO_3)_2 \rightarrow 2HNO_3 + \underset{\text{White}}{BaSO_4}\downarrow$$

5. *X*: $NaHCO_3$
Y: Na_2CO_3
A: CO_2
B: H_2O

$$2MHCO_3 \xrightarrow{\Delta} M_2CO_3 + CO_2 + H_2O$$

The gas *A* is carbon dioxide coming from a bicarbonate along with water *B*.
4.4 g CO_2 comes from 16.8 g of salt.
Then, 44 g (1 mol) CO_2 must be coming from

$$\frac{16.8}{4.4} \times 44 = 168 \text{ g of salt.}$$

So the molecular mass of the salt is 168/2 = 84.
Accordingly, *M* should be sodium.

$$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$$

$$CO_2 + Ca(OH)_2 \rightarrow \underset{\text{Milkiness}}{CaCO_3}\downarrow + H_2O$$

$$Na_2CO_3 + BaCl_2 \rightarrow \underset{\text{White}}{BaCO_3}\downarrow + NaCl$$

$$BaCO_3 + 2HCl \rightarrow BaCl_2 + H_2O + CO_2$$

6. (i) Sulphur is precipitated.

$$SO_2 + 2H_2S \rightarrow 3S + 2H_2O$$

(ii) Ammonia gives deep-blue color with copper sulphate due to the formation of a complex.

$$CuSO_4 + 2NH_4OH \rightarrow Cu(OH)_2 + (NH_4)_2SO_4$$

$$Cu(OH)_2 + 2NH_4OH + (NH_4)_2SO_4 \rightarrow \underset{\text{Blue}}{[Cu(NH_3)_4]SO_4} + 4H_2O$$

(iii) Metastannic acid is formed.

$$Sn + 3HNO_3 \text{ (conc.)} \rightarrow H_2SnO_3 + 4NO_2 + H_2O$$

(iv) A yellow solution of sodium chromate is produced.

$$H_2O_2 \rightarrow H_2O + O$$

$$2CrCl_3 + 10NaOH + 3[O] \rightarrow 2NaCrO_4 + 6NaCl + 3H_2O$$

(v) Lead dioxide is precipitated.

$$Pb_3O_4 + 4HNO_3 \rightarrow 2Pb(NO_3)_2 + 2H_2O + PbO_2\downarrow$$

7. $3KClO_3 + 3H_2SO_4$ (conc.)

$$\xrightarrow{\Delta} 3KHSO_4 + HClO_4 + 2ClO_2 + H_2C$$

$$(COOH)_2 \xrightarrow{\text{conc } H_2SO_4} CO + CO_2 + H_2O$$

8. (i) Sodium zincate is formed.

$$ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$$

(ii) Stannous chloride is a good reducing agent. It reduces iodine to iodide.

$$SnCl_2 + 2HCl + I_2 \rightarrow SnCl_4 + 2HI$$

(iii) Sodium sulphate is formed.

$$SO_2 + H_2O + \underset{\text{Air}}{\frac{1}{2}O_2} + 2NaCl \rightarrow Na_2SO_4 + 2HCl$$

9. $2KMnO_4 + 3H_2SO_4$

$$\rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$

$$[(COOH)_2 + [O] \rightarrow 2CO_2 + H_2O] \times 5$$

$$2KMnO_4 + 3H_2SO_4 + 5(COOH)_2 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 10CO_2$$

10. The mixture contains Fe^{2+}, NH_4^+, and Cl^- ions (with an impurity of Fe^{3+} ions).

(i) The mixture was heated with manganese dioxide and concentrated sulphuric acid, when a yellowish-green gas was liberated. This gas must be chlorine, suggesting chloride.

$$2Cl^- + MnO_2 + H_2SO_4 + 2H^+ \rightarrow MnSO_4 + Cl_2\uparrow + 2H_2O$$

(ii) The mixture on heating with sodium hydroxide solution gave a gas which turned red litmus blue. This alkaline gas must be ammonia coming from an ammonium salt.

$$NH_4^+ + NaOH \xrightarrow{\Delta} NH_3 + H_2O + Na^+$$

(iii) Its solution in water gave a blue precipitate with potassium ferricyanide. This is due to the presence of ferrous ions.

$$3Fe^{2+} + 2[Fe(CN)_6]^{3-} \rightarrow Fe_3[Fe(CN)_6]_2$$

Red coloration with ammonium thiocyanate indicates ferric ions, probably formed by oxidation of ferrous.

(iv) The mixture was boiled with potassium hydroxide and the liberated gas was bubbled through an alkaline solution of K_2HgI_4 to give a brown precipitate. The gas is ammonia which gives a brown precipitate with Nessler's reagent.

11. (i) Silver goes into the complex, and then it is displaced with zinc.

$AgCl + 2NaCN \rightarrow NaCl + Na[Ag(CN)_2]$

$2Na[Ag(CN)]_2 + Zn \rightarrow Na_2[Zn(CN)_4] + 2Ag\downarrow$

(ii) A yellow precipitate is formed.

$KNO_2 + CH_3COOH \rightarrow CH_3COOK + HNO_2$

$CoCl_2 + 2KNO_2 \rightarrow Co(NO_2)_2 + 2KCl$

$Co(NO_2)_2 + 2HNO_2 \rightarrow Co(NO_2)_3 + NO + H_2O$

$Co(NO_2)_3 + 3KNO_2 + K_3[Co(NO_2)_6]$

12. The gas liberated on heating a mixture of two salts with NaOH gives a reddish-brown precipitate with an alkaline solution of K_2HgI_4. This must be ammonia gas coming from an ammonium salt.

The aqueous solution of the mixture on treatment with $BaCl_2$ gives a white precipitate which is sparingly soluble in concentrated HCl. This must be barium sulphate suggesting sulphate ions.

On heating the mixture with K_2Cr_2O and concentrated H_2SO_4, red vapors *A* are produced. These are chromyl chloride vapors suggesting chloride ions.

The aqueous solution of the mixture gives a deep-blue coloration *B* with potassium ferricyanide solution. This suggests ferric ions.

$NH_4^+ + NaOH \rightarrow Na^+ + NH_3 + H_2O$

$NH_3 + K_2HgI_4 \rightarrow I—Hg—O—Hg—NH_2$

Brown iodide of Millon's base

$SO_4^{2-} + BaCl_2 \rightarrow \underset{\text{White}}{BaSO_4\downarrow} + 2Cl^-$

$K_2Cr_2O_7 + 4Cl^- + \underset{\text{(Conc.)}}{6H_2SO_4} \rightarrow 2CrO_2Cl_2 + 2KHSO_4 + 4HSO_4^- + 3H_2O$

$Fe^{2+} + [Fe(CN)_6]^{3-} \rightarrow \underset{\text{Blue}}{Fe_4[Fe(CN)_6]_3}$

13. In NaOH, the hydroxide of Al becomes soluble due to the formation of sodium meta-aluminate.

$Al(OH)_3 + NaOH \rightarrow NaAlO_2 + 2H_2O$

Hydroxide of iron does not dissolve in NaOH.

14. $PbS \xrightarrow{\text{Heat in air}} PbO + PbS$

$PbO + PbS \xrightarrow{\text{Heat in the absence of air}} Pb + SO_2$

15. Its aqueous solution gives a brown precipitate or coloration with alkaline $K_2[HgI_4]$ solution. This suggests ammonium ions.

Its aqueous solution gives a blue color with $K_3[Fe(CN)_6]$ solution. This suggests ferrous ions.

Its solution in hydrochloric acid gives a white precipitate with $BaCl_2$ solution. This suggests sulphate ions. The formula of the compound can be $FeSO_4 \cdot (NH_4)_2 SO_4 \cdot 6H_2O$ (Mohr's salt).

16. $3[Fe(H_2O)_6]^{2+} + NO_3^- + 4H^+ \rightarrow NO + 3[Fe(H_2O)_6]^{3+} + 2H_2O$

$[Fe(H_2O)_6]^{2+} + NO \rightarrow [Fe(H_2O)_5NO]^{2+} + H_2O$

17. The gas *E* must be ammonia, so *D* is magnesium nitride, and gas *C* is nitrogen. It is expected that the orange solid *A* is ammonium dichromate. The green residue *B* is Cr_2O_3.

$(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + N_2 + 4H_2O$

$N_2 + 3Mg \rightarrow Mg_3N_2$

$Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$

$NH_3 + HCl \rightarrow NH_4Cl$ (Dense white fumes)

18. *A*: Pb_3O_4

B: PbO_2

C: PbI_2

D: $Pb(MnO_4)_2$

The pink-colored compound is permanganate salt which is formed by the oxidation of manganese salt with lead dioxide. The yellow precipitate is of lead iodide. This shows the original compound to be red lead.

$Pb_3O_4 + 4HNO_3 \rightarrow PbO_2\downarrow + \underset{\text{Filtrate}}{2Pb(NO_3)_2} + 2H_2O$

$Pb(NO_3)_2 + 2KI \rightarrow \underset{\text{Yellow}}{PbI_2\downarrow} + 2KNO_3$

$5PbO_2 + 2Mn(NO_3)_2 + 4HNO_3 \rightarrow Pb(MnO_4)_2 + 4Pb(NO_3)_2 + 2H_2O$

19. The gradual addition of KI solution of $Bi(NO_3)_3$ solution initially produces a dark-brown precipitate which dissolves in excess of KI to give a yellow solution. Iodide is oxidized to iodine which dissolves in KI to give a yellow solution of KI_3.

$Bi^{3+} + H_2O \rightleftharpoons Bi(OH)^{2+} + H^+$

$[NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O] \times 2$

$[2I^- \rightarrow I_2 + 2e^-] \times 3$

$2NO_3^- + 8H^+ + 6I^- \rightarrow 2NO + 4H_2O + 3I_2$

$KI + I_2 \rightarrow KI_3$

20. *A* is ammonia and *B* is calcium carbonate.

$Ca + N_2 \rightarrow Ca_3N_2$

$Ca_3N_2 + H_2O \rightarrow Ca(OH)_2 + NH$

$Ca(OH)_2 \xrightarrow{CO_2} CaCO_3 + H_2O$

21. A colorless inorganic salt *A* decomposes completely at about 250°C to give only two products *B* and *C*, leaving no residue. The oxide *C* is a liquid at room

temperature and neutral to moist litmus paper; hence, it must be water. Gas *B* is a neutral oxide; it must be nitrous oxide. So, *A* must be ammonium nitrate. White phosphorus burns in excess of nitrous oxide to produce a strong white dehydrating agent, phosphorous pentoxide.

$$NH_4NO_3 \xrightarrow{250°C} N_2O\uparrow + 2H_2O\uparrow$$

No residue left.

$$P_4 + 10N_2O \rightarrow P_4O_{10} + 10N_2$$

22. The given data suggest the following reactions:

$3Ca + N_2 \rightarrow Ca_3N_2$

$Ca_3N_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3$

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

It is given that a solution of *C* becomes "milky" on bubbling carbon dioxide. Therefore, it must be calcium or barium hydroxide which is more soluble than magnesium hydroxide.

23. $H_2S \rightleftharpoons 2H^+ + S^{2-}$

$HCl \rightarrow H^+ + Cl^-$

K_{sp} (solubility product) of CuS is less than K_{sp} of ZnS. Due to common ion effect, the ionization of H_2S is suppressed and the S^{2-} concentration decreases.

Only those metal sulphides get precipitated which have low K_{sp}. So, ZnS is not precipitated.

24. HgI_2 is having orange/scarlet color.

It dissolves in sodium iodide due to the formation of a complex.

$HgI_2 + 2NaI \rightarrow Na_2HgI_4$

With NaOCl, again a precipitate of HgI_2 is formed.

$$3Na_2HgI_4 + 2NaOCl + 2H_2O \rightarrow 3HgI_2 + 2NaI_3 + 4NaOH + 2NaCl$$

25. $Na_2O_2 + 2H_2O \rightarrow 2NaOH + H_2O_2$

$H_2O_2 \rightarrow H_2O + [O]$

H_2O_2 turns the color of red litmus paper to white due to its bleaching action by oxidation.

Therefore, the given substance is Na_2O_2.

26. Brown ring test is done for the detection of nitrates. To a solution containing the salt and freshly prepared ferrous sulphate, concentrated sulphuric acid is added gradually along the sides of the tube. A brown ring appears at the junction of the two liquids.

$2NaNO_3 + H_2SO_4 \rightarrow NaHSO_4 + HNO_3$

$2HNO_3 + 6FeSO_4 + 3H_2SO_4 \rightarrow 3Fe_2(SO_4)_3 + 2NO + 4H_2O$

$FeSO_4 + NO \rightarrow [Fe(NO)SO_4]$ (Brown ring)

27. An aqueous blue-colored solution of a transition metal sulphate reacts with H_2S in acidic medium to give a black precipitate *A* which is insoluble in warm aqueous solution of KOH. It must be a black precipitate of CuS because copper sulphate is blue colored also. The blue solution on treatment with KI in weakly acidic medium turns yellow and produces a white precipitate *B*. In this reaction, cupric iodide is formed first which decomposes to give white cuprous iodide and iodine.

$$CuSO_4 + H_2S \xrightarrow{\text{Acidic medium}} \underset{\text{Black}}{CuS\downarrow} + H_2SO_4$$

$CuSO_4 + 2KI \rightarrow CuI_2 + K_2SO_4$

$2CuI_2 \rightarrow Cu_2I_2\downarrow + I_2$

28. When borax is heated, a colorless glassy bead is formed of the following composition:

$$Na_2B_4O_7 \cdot 10H_2O \xrightarrow{\Delta} Na_2B_4O_7 + 10H_2O$$

$$Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$$

$$Co(II)\text{salt} \xrightarrow{\Delta} CoO + \text{Some gas}$$

$$CoO + B_2O_3 \xrightarrow{\Delta} Co(BO_2)_2$$

A blue-colored bead of cobalt metaborate is formed.

29. $A = ZnS$

$B = H_2S$

$C = ZnSO_4$

$D = S$

$E = SO_2$

A white substance *A* reacts with dilute H_2SO_4 to produce a colorless gas *B* and a colorless solution *C*. The reaction between *B* and acidified $K_2Cr_2O_7$ solution produces a green solution and a slightly colored precipitate *D*. This precipitate must be sulphur. So gas *B* must be hydrogen sulphide, and the white substance *A* must be some metal sulphide. Sulphur burns in air to produce sulphur dioxide (gas) which reacts with hydrogen sulphide to yield sulphur again and a colorless liquid water. Anhydrous copper sulphate is turned blue on addition of water. Addition of aqueous NH_3 or NaOH to *C* produces, first, a precipitate which dissolves in excess of the respective reagent to produce a clear solution in each case. This suggests that *C* must be sulphate of either zinc or aluminium. So, *A* may be zinc sulphide.

$ZnS + H_2SO_4 \rightarrow H_2S + ZnSO_4$

$K_2Cr_2O_7 + 4H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$

$$[H_2S + (O) \rightarrow H_2O + S] \times 3$$

$$K_2Cr_2O_7 + 4H_2SO_4 + 3H_2S \rightarrow K_2SO_4 + \underset{\text{Green solution}}{Cr_2(SO_4)_3} + 7H_2O + 3S\downarrow$$

$$S + O_2 \rightarrow SO_2$$

$$SO_2 + 2H_2S \rightarrow 2H_2O + 3S$$

$$ZnSO_4 + 2NaOH \rightarrow \underset{\text{White}}{Zn(OH)_2\downarrow} + Na_2SO_4$$

$$Zn(OH)_2 + 2NaOH \rightarrow Na_2ZnO_2 + 2H_2O$$

30. *X*: NH_4Cl

A: CrO_2Cl_2

B: Na_2CrO_4

C: $PbCrO_4$

D: $H_2N—Hg—O—Hg—I$

When a white crystalline compound *X* is heated with $K_2Cr_2O_7$ and concentrated H_2SO_4, a reddish-brown gas *A* is evolved. This must be chromyl chloride coming from a chloride salt. On passing *A* into caustic soda solution, a yellow-colored solution *B* is obtained. This is sodium chromate. Neutralizing the solution of *B* with acetic acid and on subsequent addition of lead acetate, a yellow precipitate *C* is obtained. This is lead chromate. When *X* is heated with NaOH solution, a colorless gas is evolved and on passing this gas into K_2HgI_4 solution, a reddish-brown precipitate *D* is formed. The gas is ammonia, so *A* is ammonium chloride. *D* is iodide of Millon's base.

$$K_2Cr_2O_7 + 2H_2SO_4 \rightarrow 2KHSO_4 + 2CrO_3 + H_2O$$

$$NH_4Cl + H_2SO_4 \rightarrow NH_4HSO_4 + HCl$$

$$CrO_3 + 2HCl \rightarrow \underset{\text{Orange-red vapors}}{CrO_2Cl_2} + H_2O$$

$$NaOH + CrO_2Cl_2 \rightarrow \underset{\text{Yellow solution}}{Na_2CrO_4} + NaCl + H_2O$$

$$Pb(CH_3COO)_2 + Na_2CrO_4 \rightarrow \underset{\text{Yellow ppt.}}{PbCrO_4\downarrow} + CH_3COONa$$

$$NH_4Cl + NaOH \rightarrow NaCl + H_2O + NH_3$$

$$2K_2HgI_4 + NH_3 + 3KOH \rightarrow H_2N—Hg—O—Hg—I + 7KI + 2H_2O$$

$H_2N—Hg—O—Hg—I$ is brown colored iodide of Millon's base.

31. $Na_2CO_3 + 2SO_2 + H_2O \rightarrow 2NaHSO_3 + CO_2$

$$2NaHSO_3 + Na_2CO_3 \rightarrow 2Na_2SO_3 + H_2O + CO_2$$

$$Na_2SO_3 + S \rightarrow Na_2S_2O_3$$

$$2Na_2S_2O_3 + I_2 \xrightarrow{\Delta} Na_2S_4O_6 + 2NaI$$

Oxidation states of sulphur:

$NaHSO_3$ (+6)

Na_2SO_3 (+6)

$Na_2S_2O_3$ (+2) or (+5 and −1)

$Na_2S_4O_6$ (+2) or (+5 and 0)

32. *A*: KI

B: HgI_2

C: HgS

D: Hg

A mixture consists of *A* (yellow solid) and *B* (colorless solid) which gives lilac color in flame. Lilac color comes from potassium ions. Mixture gives black precipitate *C* on passing H_2S gas. *C* is soluble in aquaregia, and hence, it must be HgS. On evaporation of aquaregia and adding $SnCl_2$, it gives a greyish-black precipitate *D*. This must be mercury.

The salt solution with NH_4OH gives a brown precipitate. It must be iodide of Millon's base, and the salt mixture must be potassium iodide and mercuric iodide. The sodium extract of the salt with $CCl_4/FeCl_3$ gives a violet layer. This confirms iodide. The sodium extract gives a yellow precipitate with $AgNO_3$ solution which is insoluble in NH_3. This also confirms iodide.

$$HgI_2 + H_2S \longrightarrow \underset{\text{Black}}{HgS\downarrow} + 2HI$$

$$HgS \xrightarrow{\text{Aquaregia}} HgCl_2\text{(Soluble)}$$

$$HgCl_2 \xrightarrow{SnCl_2} SnCl_4 + \underset{\text{Black}}{Hg}$$

$$2KI + HgI_2 \rightarrow K_2HgI_4$$

Nessler's reagent

$$K_2HgI_4 \xrightarrow{NH_3} H_2N—Hg—O—Hg—I$$

Iodide of Millon's base

With sodium extract:

$$2NaI + 2Fe^{3+} \xrightarrow{CCl_4} I_2 + 2Na^+ + Fe^{2+}$$

$$AgNO_3 + NaI \rightarrow AgI\downarrow + NaNO_3$$

AgI is the yellow precipitate insoluble in ammonium hydroxide.

33. Anhydrous HF is stabilized due to intermolecular H bonding and is less dissociated. AlF_3 is soluble in HF in the presence of KF due to the formation of $[AlF_6]^{3-}$.

$$3KF + AlF_3 \rightarrow K_3[AlF_6]$$

BF_3 displaces out F^- from $[AlF_6]^{3-}$ because it is more acidic than AlF_3.

$$K_3[AlF_6] + BF_3 \rightarrow AlF_3\downarrow + 3KBF_4$$

34. $\underset{\text{(White fumes having smell)}}{B} \xleftarrow{\text{Moist air}} \underset{\text{M = (transition element colorless)}}{MCl_4} \xrightarrow{Zn} \underset{\text{(Purple color)}}{A}$

$M = Ti$, $MCl_4 = TiCl_4$

$A = [Ti(H_2O)_6]^{3+}$

$B = TiO_2$

Ti (IV) ion contains no *d*-electron, so it is colorless.

Ti (III) ion contains one *d*-electron, so it is colored.

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (c)	2. (d)	3. (b)	4. (d)	5. (a)	6. (b)	7. (d)	8. (c)	9. (d)	10. (b)
11. (b)	12. (c)	13. (b)	14. (d)	15. (b)	16. (b)	17. (b)	18. (c)	19. (c)	20. (c)
21. (c)	22. (c)	23. (d)	24. (c)	25. (a)	26. (b)	27. (c)	28. (b)	29. (c)	30. (d)
31. (b)	32. (a)	33. (d)	34. (c)	35. (d)	36. (d)	37. (b)	38. (d)	39. (c)	40. (a)
41. (c)	42. (a)	43. (d)	44. (a)	45. (b)	46. (a)	47. (a)	48. (b)	49. (b)	50. (c)
51. (c)	52. (a)	53. (b)	54. (a)	55. (c)	56. (c)	57. (d)	58. (b)	59. (c)	60. (c)
61. (d)	62. (b)	63. (b)	64. (b)	65. (c)	66. (d)	67. (d)	68. (a)	69. (a)	70. (c)
71. (c)	72. (a)	73. (d)	74. (a)	75. (b)	76. (a)	77. (d)	78. (c)	79. (a)	80. (c)
81. (b)	82. (d)	83. (b)	84. (c)	85. (b)	86. (b)	87. (b)	88. (a)	89. (b)	90. (a)
91. (b)	92. (b)	93. (c)	94. (c)	95. (b)	96. (c)	97. (c)	98. (c)	99. (d)	100. (b)
101. (a)	102. (b)	103. (d)	104. (d)	105. (c)	106. (d)	107. (b)	108. (d)	109. (d)	110. (d)
111. (b)	112. (d)	113. (b)	114. (a)	115. (a)	116. (c)	117. (b)	118. (a)	119. (a)	120. (a)
121. (a)	122. (a)	123. (a)	124. (c)	125. (d)	126. (d)	127. (a)	128. (a)	129. (b)	130. (d)
131. (c)	132. (a)	133. (c)	134. (c)	135. (b)	136. (a)	137. (b)	138. (c)	139. (a)	140. (c)

JEE (Advanced) Exercises

Single Correct Answer Type

1. (b)	2. (a)	3. (a)	4. (d)	5. (b)	6. (b)	7. (d)	8. (d)	9. (a)	10. (a)
11. (c)	12. (a)	13. (c)	14. (b)	15. (a)	16. (a)	17. (b)	18. (a)	19. (b)	20. (c)
21. (a)	22. (d)	23. (d)	24. (c)	25. (b)	26. (b)	27. (c)	28. (c)	29. (c)	30. (c)
31. (d)	32. (b)	33. (c)	34. (b)	35. (a)	36. (b)	37. (c)	38. (d)	39. (c)	40. (b)
41. (c)	42. (a)	43. (d)	44. (d)	45. (a)	46. (b)	47. (b)	48. (c)	49. (d)	50. (a)
51. (b)	52. (b)	53. (a)	54. (b)	55. (a)	56. (b)	57. (c)	58. (b)	59. (b)	60. (d)
61. (a)	62. (b)	63. (a)	64. (d)	65. (d)	66. (a)	67. (c)	68. (a)	69. (a)	70. (c)
71. (a)	72. (a)	73. (a)	74. (a)	75. (a)	76. (b)	77. (c)	78. (b)	79. (d)	80. (c)
81. (d)	82. (a)	83. (a)	84. (d)	85. (b)	86. (d)	87. (b)	88. (d)	89. (d)	90. (b)
91. (b)	92. (b)	93. (b)	94. (b)	95. (b)	96. (b)	97. (b)	98. (d)	99. (b)	100. (b)
101. (a)	102. (c)	103. (c)	104. (c)	105. (b)	106. (b)	107. (b)	108. (a)	109. (a)	110. (c)
111. (d)	112. (b)	113. (d)	114. (c)	115. (a)	116. (d)	117. (b)	118. (d)	119. (c)	120. (b)
121. (d)	122. (d)	123. (a)	124. (c)	125. (c)	126. (c)	127. (c)	128. (a)	129. (a)	130. (c)
131. (d)	132. (c)	133. (b)	134. (b)	135. (c)	136. (d)	137. (d)	138. (b)	139. (c)	140. (d)

Multiple Correct Answers Type

1. (a), (b), (c)	2. (a), (b), (c)	3. (a), (b)	4. (a), (c), (d)	5. (a), (c), (d)
6. (b), (c), (d)	7. (b), (c)	8. (a), (c)	9. (c), (d)	10. (a), (b), (c)
11. (a), (b), (d)	12. (c), (d)	13. (a), (b), (c)	14. (a), (c), (d)	15. (a), (b), (d)

16. (a), (b), (c)	**17.** (a), (b), (c)	**18.** (a), (c), (d)	**19.** (a), (b), (c)	**20.** (a), (c), (d)
21. (a), (b), (c)	**22.** (b), (c), (d)	**23.** (a), (c)	**24.** (a), (b), (c)	**25.** (a), (b), (c)
26. (a), (b), (d)	**27.** (a), (b)	**28.** (b), (c), (d)	**29.** (b), (c), (d)	**30.** (a), (b)
31. (a), (b), (d)	**32.** (c), (d)	**33.** (a), (b), (c)	**34.** (a), (b), (c)	**35.** (a), (b)
36. (a), (b), (c)	**37.** (a), (b)	**38.** (a), (b)	**39.** (a), (b), (c)	**40.** (c), (d)
41. (a), (b)	**42.** (a), (b), (c)	**43.** (a), (b)	**44.** (a), (b), (c)	**45.** (a), (d)
46. (a), (c)	**47.** (a), (b), (c)	**48.** (a), (c), (d)	**49.** (a), (b), (c)	**50.** (a), (b)
51. (a), (b), (c)	**52.** (a), (c)	**53.** (a), (c), (d)	**54.** (b), (c)	**55.** (a), (b), (c)
56. (a), (b), (c), (d)	**57.** (b), (c)	**58.** (a), (c), (d)	**59.** (b), (c), (d)	**60.** (b), (c), (d)
61. (a), (b), (d)	**62.** (a), (b),c)	**63.** (b), (c), (d)	**64.** (a), (b), (c)	**65.** (a), (c)
66. (b), (c)	**67.** (b), (d)	**68.** (a), (b)	**69.** (a), (c), (d)	**70.** (a), (b), (c), (d)
71. (a), (b)	**72.** (a), (b)	**73.** (a), (c),d)	**74.** (a), (b), (c), (d)	**75.** (a), (b), (c)
76. (a), (b), (d)	**77.** (a), (b), (c), (d)	**78.** (a), (b)	**79.** (a), (c), (d)	**80.** (a), (b), (c), (d)
81. (b), (c)	**82.** (a), (c)	**83.** (a), (b), (c), (d)	**84.** (c), (d)	**85.** (a), (b), (d)
86. (a), (c), (d)	**87.** (a), (b)	**88.** (b), (c), (d)	**89.** (a), (b), (c), (d)	**90.** (a), (b), (c)
91. (c), (d)	**92.** (b), (c)	**93.** (a), (b)	**94.** (a), (b), (c), (d)	**95.** (a), (b), (c)
96. (a), (c), (d)	**97.** (b), (c), (d)	**98.** (a), (b), (c)	**99.** (b), (c), (d)	**100.** (c), (d)
101. (a), (b), (c), (d)	**102.** (a), (c), (d)	**103.** (a), (b), (d)	**104.** (a), (b), (d)	**105.** (a), (b), (c), (d)
106. (a), (b), (c)	**107.** (a), (b), (d)	**108.** (a), (c)	**109.** (a), (c), (d)	**111.** (b), (c), (d)
111. (a), (d)				

Comprehension Type

Comprehension-1	**1.** (d)	**2.** (d)	**3.** (c)						
Comprehension-2	**4.** (b)	**5.** (a)	**6.** (b)	**7.** (b)	**8.** (d)				
Comprehension-3	**9.** (c)	**10.** (d)	**11.** (b)						
Comprehension-4	**12.** (b)	**13.** (a)	**14.** (a)						
Comprehension-5	**15.** (c)	**16.** (b)	**17.** (a)						
Comprehension-6	**18.** (c)	**19.** (c)	**20.** (b)	**21.** (b)	**22.** (c)				
Comprehension-7	**23.** (b)	**24.** (c)	**25.** (a)	**26.** (b)					
Comprehension-8	**27.** (b)	**28.** (c)	**29.** (c)	**30.** (b)					
Comprehension-9	**31.** (a)	**32.** (c)	**33.** (b)						
Comprehension-10	**34.** (a)	**35.** (c)	**36.** (b)						
Comprehension-11	**37.** (b)	**38.** (b)	**39.** (d)						
Comprehension-12	**40.** (b)	**41.** (d)	**42.** (a)						
Comprehension-13	**43.** (a)	**44.** (c)	**45.** (c)						
Comprehension-14	**46.** (d)	**47.** (d)							
Comprehension-15	**48.** (c)	**49.** (a)	**50.** (b)	**51.** (b)	**52.** (c)				
Comprehension-16	**53.** (a)	**54.** (b)	**55.** (b)						
Comprehension-17	**56.** (b)	**57.** (a)	**58.** (b)	**59.** (c)					
Comprehension-18	**60.** (a)	**61.** (c)	**62.** (b)						
Comprehension-19	**63.** (a)	**64.** (d)	**65.** (c)						
Comprehension-20	**66.** (c)	**67.** (b)	**68.** (c)	**69.** (c)					
Comprehension-21	**70.** (c)	**71.** (c)	**72.** (c)						
Comprehension-22	**73.** (d)	**74.** (a)	**75.** (c)	**76.** (c)					
Comprehension-23	**77.** (d)	**78.** (d)	**79.** (d)	**80.** (a)					
Comprehension-24	**81.** (b)	**82.** (b)	**83.** (b)						
Comprehension-25	**84.** (c)	**85.** (c)	**86.** (b)						
Comprehension-26	**87.** (a), (b)	**88.** (a), (b)	**89.** (a), (c)						
Comprehension-27	**90.** (c)	**91.** (b)	**92.** (b)	**93.** (c)	**94.** (a)	**95.** (c)	**96.** (b)	**97.** (a)	
Comprehension-28	**98.** (b)	**99.** (b)	**100.** (c)						
Comprehension-29	**101.** (b)	**102.** (b)	**103.** (b)						

Comprehension-30 **104.** (a) **105.** (d) **106.** (d) **107.** (c) **108.** (b)
Comprehension-31 **109.** (b) **110.** (c) **111.** (a)
Comprehension-32 **112.** (b) **113.** (b) **114.** (b)
Comprehension-33 **115.** (a) **116.** (a) **117.** (b)
Comprehension-34 **118.** (c) **119.** (c) **120.** (a)

Assertion-Reasoning Type

1. (a) **2.** (a)

Matching Column Type

1. (a) q; (b) r; (c) p; (d) s
2. (a) q; (b) q, r; (c) s; (d) p
3. (a) p, s; (b) p, s; (c) p, s, t; (d) q, r, t
4. (a) p; (b) r; (c) s; (d) q
5. (a) p, q, r, s; (b) p, q; (c) p, q, r; (d) q, r, s
6. (a) p, q, s; (b) s; (c) p, s; (d) r, s
7. (a) p, q, r; (b) r, s; (c) p, q; (d) p, s
8. (a) r, s; (b) q; (c) t; (d) p
9. (a) r; (b) s; (c) q, t; (d) p
10. (a) p; (b) p, s; (c) r; (d) q, r
11. (a) q, s; (b) r, s; (c) p, t; (d) r, t
12. (a) r; (b) s; (c) p; (d) q
13. (a) p, r, t; (b) p, r, s; (c) p ,t; (d) q, t
14. (a) p, s; (b) s; (c) q; (d) r
15. (a) p, r; (b) q, r, s; (c) q, r, s; (d) p, q, r
16. (a) r; (b) p, q; (c) s
17. (a) p, q; (b) s; (c) r
18. (a) s; (b) p, r; (c) q; (d) t
19. (a) r, s, t; (b) s; (c) p, s; (d) s
20. (a) s; (b) q; (c) r; (d) p
21. (a) s, t; (b) p; (c) q; (d) r
22. (a) p, q; (b) r, s; (c) s; (d) r, s
23. (a) s; (b) r; (c) q; (d) p
24. (a) p, r; (b) p; (c) p, s; (d) q, s
25. (a) p, q; (b) r; (c) s
26. (a) t; (b) r; (c) q, s; (d) p
27. (a) t; (b) p; (c) q; (d) r, s
28. (a) s; (b) r; (c) q; (d) p
29. (a) q, s; (b) r, s; (c) p, s; (d) q, s

Integer Answer Type

1. 2 **2.** (i) 0, (ii) 1 (iii) 0, (iv) 3, (v) 0, (vi) 4 **3.** 3 **4.** 2 **5.** 2
6. (i) 3, (ii) 0, (iii) 2, (iv) 6 **7.** 5 **8.** 4 **9.** 4 **10.** 2 **11.** 6 **12.** 6 **13.** 3
14. (i) 6, (ii) 2, (iii) 2, (iv) 0, (v) 2, (vi) 3, (vii) 4 **15.** (i) 0, (ii) 1, (iii) 0 **16.** (i) 2, (ii) 2, (iii) 3, (iv) 3
17. 6 **18.** 3 **19.** 1 **20.** 10 **21.** 4 **22.** 3 **23.** 1
24. (i) 2, (ii) 3, (iii) 0 (iv) 2 **25.** (i) 0, (ii) 1, (iii) 0 **26.** 3

27. (*A*) $CuSO_4$ (*B*) $BaSO_4$ (*C*) HCl (*D*) ($Cu_2I_2 + I_3^-$) (*E*) $Cu_2I_2 + I^- + S_4O_6^{2-}$ (*F*) $Cu_2[Fe(CN)_6]$
28. (*A*) FeS (*B*) H_2S (*C*) $FeSO_4$ (*D*) S (*E*) CuS (*F*) $[Cu(NH_3)_4](OH)_2$
29. (*A*) $Al_2(SO_4)_3$ (*B*) $Al(OH)_3$ (*C*) $BaSO_4$ (*D*) CoO. Al_2O_3
30. (*A*) $Fe_2(SO_4)_3$ (*B*) $Fe_2(SO_4)_3$ solution (*C*) $BaSO_4$ (*D*) $Fe(OH)_3$
(*E*) $FeCl_3$ (*F*) $Fe_4[Fe(CN)_6]_3$ (*G*) $Fe(SCN)_3$ (*H*) Fe_2O_3
(*I*) SO_3
31. (*A*) $FeSO_4$ (*B*) $BaSO_4$ (*C*) Fe_2O_3 (*D*) SO_2
(*E*) SO_3 (*F*) $FeCl_3$ (*G*) S
32. (*A*) $FeBr_3$ (*B*) AgBr (*C*) Br_2 (*D*) $Fe(OH)_3$
33. (*A*) $CrCl_3$ (*B*) $Cr(OH)_3$ (*C*) Na_2CrO_4 (*D*) $Na_2Cr_2O_7$
(*E*) $PbCrO_4$
34. (*A*) $FeSO_4.7H_2O$ (*B*) $FeSO_4$ (*C*) $7H_2O$ (*D*) $Fe[(H_2O)_5NO]SO_4$
(*E*) Fe_2O_3 (*F*) SO_2 (*G*) SO_3 (*H*) Cr^{3+} solution
35. (*A*) ZnO (*B*) $ZnCl_2$ (*C*) Na_2ZnO_2
36. (*A*) $Zn(NO_3)_2$ (*B*) NO_2 (*C*) ZnO (*D*) ZnS
37. 3

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (c) **2.** (b) **3.** (a) **4.** (a)

JEE (Advanced) Exercises

Single Correct Answer Type

1. (c) **2.** (a) **3.** (c) **4.** (a) **5.** (d) **6.** (c) **7.** (d) **8.** (c) **9.** (a) **10.** (b)
11. (b) **12.** (d) **13.** (a) **14.** (a) **15.** (b) **16.** (d) **17.** (7)

Multiple Correct Answers Type

1. (b), (c) **2.** (b), (c) **3.** (a), (b) **4.** (a), (c), (d)

Comprehension Type

1. (d) **2.** (a)

Assertion-Reasoning Type

1. (c) **2.** (b)

Integer Answer Type

1. (6, 7)