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

3e

V. Joshi

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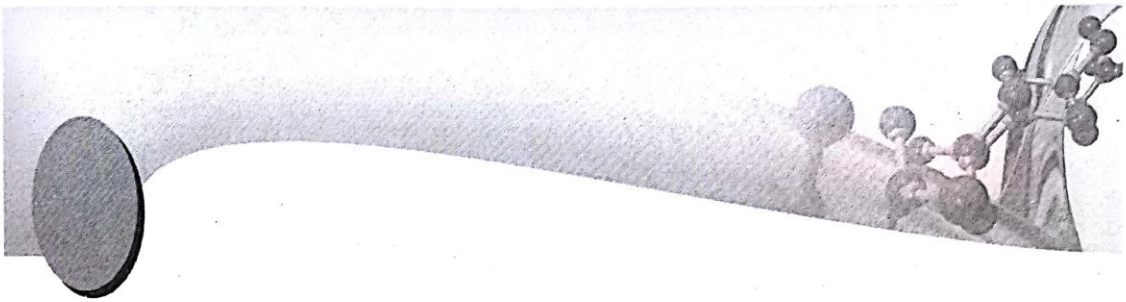
Preface

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



Contents

Preface *iii*

1. **Chemical Bonding (Part-A)** **1.1-1.78**
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**
8. **Periodic Table** **8.1-8.29**
9. **Chemical Bonding (Part-B)** **9.1-9.26**
10. **Hydrogen and Its Compounds** **10.1-10.12**
11. ***f*-Block Elements** **11.1-11.8**
12. **Quantum Number** **12.1-12.5**

5

s-Block Elements

JEE (Main) Exercises

Single Correct Answer Type

1. Electrolysis of fused NaCl will give:
   (a) Na (b) NaOH
   (c) NaClO (d) $NaClO_3$
2. Chile saltpetre is the ore of:
   (a) Iodine (b) Bromine
   (c) Sodium (d) Magnesium
3. In view of their low ionization energies, the alkali metals are:
   (a) Weak oxidizing agents
   (b) Strong reducing agents
   (c) Strong oxidizing agents
   (d) Weak reducing agents
4. Which of the following has lowest melting point?
   (a) Li (b) Na
   (c) K (d) Cs
5. Smallest among these species is:
   (a) Hydrogen (b) Helium
   (c) Lithium (d) Lithium ion
6. Which one of the following electrolytes used in Down's process of extracting sodium metal?
   (a) NaCl + KCl + KF (b) NaCl
   (c) NaOH + KCl + KF (d) NaCl + NaOH
7. Shine at freshly cut sodium is because of:
   (a) Due to oscillations of free electrons
   (b) Due to weak metallic bonding
   (c) Due to absorption of light in crystal lattice
   (d) Due to the presence of free valency at the surface
8. The solubility of alkali metal hydroxides follows the order:
   (a) LiOH < NaOH < KOH < RbOH < CsOH
   (b) LiOH > NaOH > KOH > RbOH < CsOH
   (c) LiOH > CsOH > RbOH > NaOH > KOH
   (d) None of these
9. Which of the following carbonate(s) decompose readily?
   (a) Li_2CO_3 (b) Na_2CO_3
   (c) K_2CO_3 (d) Rb_2CO_3
10. The sequence of ionic mobility in aqueous solution is:
    (a) $Rb^+ > K^+ > Cs^+ > Na^+$
    (b) $Na^+ > K^+ > Rb^+ > Cs^+$
    (c) $K^+ > Na^+ > Rb^+ > Cs^+$
    (d) $Cs^+ > Rb^+ > K^+ > Na^+$
11. Sodium peroxide which is a yellow solid, when exposed to air becomes white due to formation of:
    (a) H_2O_2 (b) Na_2O
    (c) Na_2O and O_3 (d) NaOH and Na_2CO_3
12. Among the alkali metals Cs is the most reactive because:
    (a) Its incomplete shell is nearest to the nucleus
    (b) It has a single electron in the valence shell
    (c) It is the heaviest alkali metal
    (d) Its outermost electron is more loosely bound than the outermost electron of the other alkali metals

13. Sodium hydride (NaH) when dissolved in water produces:
(a) Acidic solution (b) Basic solution
(c) Neutral solution (d) Cannot be predicted

14. The correct order of stability for the following superoxides is:
(a) $KO_2 > RbO_2 > CsO_2$ (b) $RbO_2 > CsO_2 > KO_2$
(c) $CsO_2 > RbO_2 > KO_2$ (d) $KO_2 > CsO_2 > RbO_2$

15. In the case of alkali metals, the covalent character decreases in the order:
(a) $MF > MCl > MBr > MI$
(b) $MF > MCl > MI > MBr$
(c) $MI > MBr > MCl > MF$
(d) $MCl > MI > MBr > MF$

16. The oxide of an element whose electronic configuration is $1s^2 2s^2 2p^6 3s^1$ is:
(a) Amphoteric (b) Basic
(c) Acidic (d) Neutral

17. The characteristic not related to alkali metals is:
(a) Their ions are isoelectronic with noble gases
(b) Metallic character
(c) Low electronegativity (d) High ionization energy

18. The electronic configuration of the outermost orbit in the case of alkaline earth metals is:
(a) ns^2 (b) $ns^2\ np^1$
(c) ns^1 (d) $ns^2\ np^4$

19. Plaster of Paris is:
(a) $CaSO_4$ (b) $CaSO_4 \cdot H_2O$
(c) $2CaSO_4 \cdot H_2O$ (d) $CaSO_4 \cdot 2H_2O$

20. The following compounds have been arranged in order of their increasing thermal stabilities. Identify the correct order:
K_2CO_3(I), $MgCO_3$(II), $CaCO_3$(III), $BeCO_3$ (IV)
(a) I < II < III < IV (b) IV < II < III < I
(c) IV < II < I < III (d) II < IV < III < I

21. Silica reacts with magnesium to form a magnesium compound *X*, *X* reacts with dilute HCl and forms *Y*. *Y* is:
(a) MgO (b) $MgSiO_3$
(c) $SiCl_4$ (d) $MgCl_2$

22. Among the following hydroxides, the one which has the lowest value of K_{sp} at ordinary temperature is:
(a) $Mg(OH)_2$ (b) $Ca(OH)_2$
(c) $Ba(OH)_2$ (d) $Be(OH)_2$

23. The first ionization potentials (eV) of Be and *B* respectively are:
(a) 8.29, 9.32 (b) 9.32, 9.32
(c) 8.29, 8.29 (d) 9.32, 8.29

24. Among the alkaline earth metals, the element forming predominantly covalent compound is:
(a) Ba (b) Sr
(c) Ca (d) Be

25. Chemical *A* is used for water softening to remove temporary hardness. *A* reacts with Na_2CO_3 to generate caustic soda. When CO_2 is bubbled through *A*, it turns cloudly. What is the chemical formula of *A*?
(a) $CaCO_3$ (b) CaO
(c) $Ca(OH)_2$ (d) $Ca(HCO_3)_2$

26. The set representing the correct order of the first ionization potential is:
(a) K > Na > Li (b) Be > Mg > Ca
(c) B > C > N (d) Ge > Si > C

27. Aluminium is not present in which of the following minerals?
(a) Cryolite (b) Mica
(c) Feldspar (d) Fluorspar

28. A solution of sodium metal in liquid ammonia is strongly reducing due to the presence of:
(a) Sodium hydride (b) Sodium amide
(c) Sodium (d) Solvated electrons

29. The compound insoluble in acetic acid is:
(a) Calcium oxide (b) Calcium carbonate
(c) Calcium oxalate (d) Calcium hydroxide

30. KOH is preferably used to absorb CO_2 gas because:
(a) $KHCO_3$ is soluble in water and $NaHCO_3$ is sparingly soluble in water
(b) KOH is cheaper than NaOH
(c) KOH is more soluble than NaOH in water
(d) KOH is stronger base than NaOH

31. Which of the following is correct statement?
(I) Ca^{2+} ions are important in blood clotting
(II) $Ca_3(PO_4)_2$ is a part of bones
(III) $3Ca_3(PO_4) \cdot CaF_2$ is a part of enamel of teeth
(a) (I) and (II) (b) (II) and (III)
(c) (I) and (III) (d) (I), (II), and (III)

32. Consider the following statements:
(I) Cs^+ ion is more highly hydrated than other alkali metal ions.
(II) Among the alkali metals Li, Na, K, and Rb, Li has the higher melting point.
(III) Among the alkali metals, only Li forms a stable nitride by direct combination.
(a) (I) and (III) are correct

(b) (II) and (III) are correct
(c) (I), (II), and (III) are correct
(d) (I) and (II) are correct

33. Which of the following changes occurs when excess of CO_2 gas is passed into a clear solution of lime water?
(a) A white precipitate containing both $CaCO_3$ and $Ca(HCO_3)_2$ is formed
(b) Initially a white precipitate of $CaCO_3$ is formed which changes into soluble $Ca(HCO_3)_2$ on passing excess CO_2 gas
(c) A white precipitate of $Ca(HCO_3)_2$ is formed
(d) A white precipitate of $CaCO_3$ is formed

34. In the following sequence of reactions. Identify (*E*):

$$Na_2CO_3 + H_2O + CO_2 \longrightarrow (A) \xrightarrow{\Delta, ZnCl_2} (B) \xrightarrow{\Delta} (C) + (D)\uparrow \xrightarrow{NaOH} (E)$$

(a) $NaHCO_3$ (b) Na_2O_2
(c) Na_2ZnO_2 (d) $ZnCO_3$

35. The decomposition temperatures of alkaline earth metal carbonates are given below:

$BeCO_3$	$MgCO_3$	$CaCO_3$	$SrCO_3$	$BaCO_3$
< 100°C	<	< 900°C	<	< 1300°C

The decomposition temperatures of $MgCO_3$ and $SrCO_3$ are respectively:
(a) 1290°C, 1200°C (b) 1290°C, 540°C
(c) 540°C, 1290°C (d) 540°C, 800°C

36. Aluminium is more reactive than iron because its standard reduction potential is higher. Still aluminium is less easily corroded than iron because:
(a) Al reacts with atmospheric carbon dioxide to form a self-protective layer of Al_2O_3
(b) It has higher reducing power and forms a self-protective layer of Al_2O_3
(c) It has higher reducing power and does not react with oxygen so easily
(d) Both (a) and (b)

37. Which one of the following statements is true for all the alkali metals?
(a) Their nitrates decompose on heating to give NO_2 and O_2
(b) Their carbonates decompose on heating to given CO_2 and normal oxide
(c) They react with halogens to given the halides of the type, *MX*
(d) They react with oxygen to give mainly the oxide, M_2O

38. Select correct statement:
(a) Oxides (M_2O) and peroxides (M_2O_2) of alkali metals are diamagnetic and colorless
(b) Superoxides (MO_2) of alkali metals are paramagnetic
(c) Li and Na do not form superoxides
(d) All are correct

39. Which of the following salts does not form any precipitate with excess of NaOH?
(a) $ZnCl_2$ (b) $FeCl_3$
(c) $CrCl_3$ (d) $CuSO_4$

40. Which of the following is best CO_2 absorber as well as source of O_2 in space capsule?
(a) KO_2 (b) K_2O_2
(c) KOH (d) LiOH

41. The aqueous solutions of lithium salts are poor conductor of electricity rather than other alkali metals because of:
(a) High ionization energy
(b) High electronegativity
(c) Lower ability of Li^+ ions to polarize water molecules
(d) Higher degree of hydration of Li^+ ions

42. A soft metal (*A*) gives violet flame test. When burnt in excess O_2, (*A*) gives chrome yellow powder (*B*) which on reaction with water gives alkaline solution *C* and O_2. Identify *A* and *B*:
(a) Na, Na_2O_2 (b) K, K_2O_2
(c) K, KO_2 (d) Li, Li_2O_2

43. (*X*), (*Y*), (*Z*) are elements in the third period. Oxide of (*X*) is ionic, that of (*Y*) is amphoteric, and of (*Z*) a giant molecule. (*X*), (*Y*) and (*Z*) will have atomic numbers in the order:
(a) (*X*) < (*Y*) < (*Z*) (b) (*Z*) < (*Y*) < (*X*)
(c) (*X*) < (*Z*) < (*Y*) (d) (*Y*) < (*X*) < (*Z*)

44. The inside surface of glass bottle containing caustic soda becomes dull because:
(a) Silica is present in glass. It does not dissolves in NaOH and hence forms soluble sodium silicate and thus inside surface becomes dull
(b) Silica is present in glass. It dissolves in NaOH slowly and forms soluble sodium silicate and thus inside surface becomes dull
(c) Both (a) and (b)
(d) None of the above

45. Potash alum is represented by the formula:
(a) $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$

(b) $K{\cdot}Al(SO_4)_2{\cdot}12\ H_2O$
(c) Both (a) and (b)
(d) None of these

46. Among of alkali metals, the metal with highest ionization potential is:
(a) Li (b) Na
(c) K (d) Rb

47. What is the oxidation state of K in KO_2?
(a) –1 (b) –2
(c) +1 (d) Zero

48. A metal from period IV is added to water and a vigorous reaction takes place with the evolution of a gas. Which statements are correct?
1. Oxygen is evolved.
2. Hydrogen is evolved.
3. The resulting solution is acidic.
4. The resulting solution is basic.

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

49. A solution of sodium metal in liquid ammonia is strongly reducing due to the presence of:
(a) Sodium atoms (b) Sodium hydride
(c) Sodium amide (d) Solvated electrons

50. Sodium reacts with water more vigorously than lithium because it:
(a) Has higher atomic weight
(b) Is a metal
(c) Is more electropositive
(d) More electronegative

51. The hydration energy of Mg^{2+} is greater than that of:
(a) Al^{3+} (b) Na^{+}
(c) Be^{2+} (d) Mg^{3+}

52. 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

53. A metal *M* readily forms water-soluble sulphate MSO_4, water insoluble hydroxide $M(OH)_2$ and oxide *M*O which becomes inert on heating. The hydroxide is soluble in NaOH. The metal *M* is:
(a) Be (b) Mg
(c) Ca (d) Sr

54. The paramagnetic species is:
(a) KO_2 (b) SiO_2
(c) TiO_2 (d) BaO_2

55. On dissolving moderate amount of sodium metal in liquid NH_3 at low temperature, which one of the following does not occur?
(a) Blue colored solution is obtained
(b) Na^+ ions reformed in the solution
(c) Liquid ammonia becomes good conductor of electricity
(d) Liquid ammonia remains diamagnetic

56. $Na_2S_2O_3{\cdot}5H_2O$ is used in photography to:
(a) Reduce AgBr to metallic Ag
(b) Remove reduced Ag
(c) Remove undecomposed AgBr as a soluble complex
(d) Convert metallic Ag to silver salt

57. Among LiCl, RbCl, $BeCl_2$, and $MgCl_2$ the compounds with greatest and least ionic character, respectively are:
(a) LiCl, RbCl (b) RbCl, $BeCl_2$
(c) RbCl, $MgCl_2$ (d) $MgCl_2$, $BeCl_2$

58. Thermal stability of hydrides of first group elements follows the order:
(a) LiH > NaH > KH > RbH
(b) LiH > KH > NaH > RbH
(c) LiH > RbH > KH > NaH
(d) LiH > KH > RbH > NaH

59. When sodium is treated with sufficient oxygen/air, the product obtained is:
(a) Na_2O (b) Na_2O_2
(c) NaO_2 (d) NaO

60. KO_2 (potassium superoxide) is used in oxygen cylinders in space and submarines because it:
(a) Decomposes to give oxygen
(b) Eliminates moisture
(c) Absorbs CO_2
(d) Produces ozone

61. The magnetic moment of KO_2 at room temperature is ..... B.M.
(a) 1.41 (b) 1.73
(c) 2.23 (d) 2.64

62. The reaction that takes place when Cl_2 gas is passed through conc. NaOH solution is:
(a) Oxidation (b) Reduction
(c) Displacement (d) Disproportionation

63. Calcium is extracted by the electrolysis of:
(a) Fused mixture of $CaCl_2$ and CaF_2
(b) $CaCl_2$ solution
(c) Fused mixture of $CaCl_2$ and NaF
(d) $Ca_3(PO_4)_2$ solution

JEE (Advanced) Exercises

Single Correct Answer Type

1. When CaC_2 is heated in atmospheric nitrogen in an electric furnace, the compound formed is:
   (a) $Ca(CN)_2$ (b) CaNCN
   (c) Ca_3N_2 (d) $CaNC_2$
2. Which of the following represents calcium chlorite?
   (a) $CaClO_2$ (b) $Ca(ClO_4)_2$
   (c) $Ca(ClO_3)_2$ (d) $Ca(ClO_2)_2$
3. The most electropositive element among the alkaline earth metals is:
   (a) Be (b) Mg
   (c) Ca (d) Ba
4. The right order of the solubility of sulphates of alkaline earth metals is:
   (a) Be > Ca > Mg > Ba > Sr
   (b) Mg > Be > Ba > Ca > Sr
   (c) Be > Mg > Ca > Sr > Ba
   (d) Mg > Ca > Ba > Be > Sr
5. The compound which is insoluble in dil. HCl is:
   (a) MnS (b) ZnS
   (c) $BaCO_3$ (d) $BaSO_4$
6. The first ionization energies of alkaline earth metals are higher than those of the alkali metals. This is because:
   (a) There is increase in the nuclear charge of the alkaline earth metal
   (b) There is decrease in the nuclear charge of the alkaline earth metal
   (c) There is no change in the nuclear charge
   (d) None of the above
7. Which of the following has maximum ionization energy?
   (a) $Ba \longrightarrow Ba^+ + e^-$ (b) $Be \longrightarrow Be^+ + e^-$
   (c) $Ca \longrightarrow Ca^{2+} + 2e^-$ (d) $Mg \longrightarrow Mg^{2+} + 2e^-$
8. As the alkaline earth metals (except Be) tend to lose their valence electrons readily. They act as:
   (a) Weak oxidizing agents
   (b) Weak reducing agents
   (c) Strong oxidizing agents
   (d) Strong reducing agents
9. The reaction of Cl_2 with X gives bleaching powder. X is:
   (a) CaO (b) $Ca(OH)_2$
   (c) $Ca(OCl_2)$ (d) $Ca(ClO_3)_2$
10. Which of the following carbides produces propyne on reaction with water?
    (a) CaC_2 (b) Be_2C
    (c) Al_4C_3 (d) Mg_2C_3
11. KO_2 (potassium superoxide) is used in oxygen cylinders in space and submarines because it:
    (a) Produces ozone (b) Absorbs CO_2
    (c) Absorbs CO_2 and increase O_2 contents
    (d) Eliminates moisture
12. Which of the following compounds transforms baking soda into baking powder?
    (a) $KHCO_3$ (b) $NaHCO_3$
    (c) $KHC_4H_4O_6$ (d) KCl
13. Baking powder used to make cake is a mixture of starch, $NaHCO_3$, and $Ca(H_2PO_4)_2$. The function of $Ca(H_2PO_4)_2$ is:
    (a) Being acidic in nature and gives CO_2 when moistened with $NaHCO_3$
    (b) To slow down the release of CO_2 gas
    (c) To act as a filler
    (d) None of these
14. The alkali metals form salt-like hydrides by the direct synthesis at elevated temperature. The thermal stability of these hydrides decreases in which of the following orders?
    (a) NaH > LiH > KH > RbH > CsS
    (b) LiH > NaH > KH > RbH > CsH
    (c) CsH > RbH > KH > NaH > LiH
    (d) KH > NaH > LiH > CsH > RbH
15. Which one of the following reactions is not associated with the Solvay process of manufacture of sodium carbonate?
    (a) $NaCl + NH_4HCO_3 \longrightarrow NaHCO_3 + NH_4Cl$
    (b) $2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$
    (c) $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$
    (d) $NH_3 + H_2CO_3 \longrightarrow NH_4HCO_3$
16. In the following reactions, (X) and (Y) are respectively:
    $BaC_2 + N_2 \xrightarrow{\Delta} (X)$ $CaC_2 + N_2 \xrightarrow{\Delta} (Y)$
    (a) $Na(CN)_2$ and $Ca(CN)_2$
    (b) $Ba(CN)_2$ and $CaCN_2$
    (c) $BaCN_2$ and $CaCN_2$ (d) None of these
17. In the reaction: $K_4[Fe(CN)_6] + K_2CO_3 \longrightarrow$ the product formed is:
    (a) $FeCO_3$ (b) KCN
    (c) $KFeCO_3$ (d) $K_3[Fe(CN)_6]$

18. $CO_2 + NH_3 + H_2O \longrightarrow X$
$X + NaCl \longrightarrow Y + NH_4Cl$
$2Y \longrightarrow Z + H_2O + CO_2$. '$Z$' is:
(a) Na_2CO_3 (b) $(NH_4)_2CO_3$
(c) NH_4HCO_3 (d) $NaHCO_3$

19. The aqueous solution of an inorganic compound (X) gives white precipitate with NH_4OH which does not dissolve in excess of NH_4OH. This aqueous solution also gives white precipitate with $AgNO_3$ and the precipitate is soluble in dilute HNO_3. Here, (X) is:
(a) $AlCl_3$ (b) $AlBr_3$
(c) AlN (d) $Al_2(SO_4)_3$

20. A compound (X) imparts a golden yellow flame and shows the following reactions:
Zn powder when boiled with a concentrated aqueous solution of (X) dissolves and H_2 is evolved. What is X?
(a) KOH (b) NaOH
(c) Mg(OH) (d) $Ca(OH)_2$

21. For two ionic solids CaO and KI, identify the wrong statement among the following?
(a) Lattice energy of CaO is much higher than that of KI
(b) KI is soluble in benzene
(c) CaO has high m.pt.
(d) KI has high m.pt.

22. Photoelectric effect is maximum in:
(a) Cs (b) Na
(c) K (d) Li

23. Which of the following metals has most stable carbonate?
(a) Na (b) Mg
(c) Al (d) Si

24. 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^-

25. A solid compound 'X' on heating gives CO_2 gas and a residue. The residue mixed with water forms 'Y'. On passing an excess of CO_2 through 'Y' in water, a clear solution 'Z' is obtained. On boiling 'Z', compound 'X' is reformed. The compound 'X' is:
(a) $Ca(HCO_3)_2$ (b) $CaCO_3$
(c) Na_2CO_3 (d) K_2CO_3

26. One mole of magnesium nitride on reaction with an excess of water gives:
(a) One mole of ammonia
(b) One mole of nitric acid
(c) Two moles of ammonia
(d) Two moles of nitric acid

27. In certain matters, lithium differs from other alkali metals; the main reason for this is:
(a) Small size of lithium atom and Li^+
(b) Extremely high electropositivity of Li
(c) Greater hardness of Li
(d) Hydration of Li^+ ion

28. The stability of the following alkali metal chlorides follows the order:
(a) LiCl > KCl > NaCl > CsCl
(b) CsCl > KCl > NaCl > LiCl
(c) NaCl > KCl > LiCl > CsCl
(d) LiCl > NaCl > KCl > CsCl

29. Which of the following has the highest melting point?
(a) NaCl (b) NaF
(c) NaBr (d) NaI

30. Oxone is:
(a) CaO (b) N_2O
(c) Na_2O_2 (d) $NaBO_3$

31. Which of the following has the least ionization potential among these metals?
(a) Li (b) He
(c) N (d) Zn

32. Sodium carbonate on heating gives:
(a) CO_2 (b) Water vapors
(c) Carbon dioxide + water vapor
(d) None of these

33. The sodium is made by electrolysis of a molten mixture of 40% NaCl and 60% $CaCl_2$ because:
(a) $CaCl_2$ helps in the conduction of electricity
(b) Ca^{2+} can reduce NaCl to Na
(c) Ca^{2+} can displace Na from NaCl
(d) This mixture has a lower melting point than NaCl

34. A chloride dissolves appreciably in cold water. When placed on a platinum wire in Bunsen flame, no distinctive color is noticed. Which one is cation?
(a) Mg^{2+} (b) Ba^{2+}
(c) Na^+ (d) Ca^{2+}

35. Alkaline earth metal salt are:
(a) Paramagnetic (b) Diamagnetic
(c) Ferromagnetic (d) All of these

36. Halides of alkaline earth metals from hydrates such as $MgCl_2 \cdot 6H_2O$, $CaCl_2 \cdot 6H_2O$, $BaCl_2 \cdot 2H_2O$, and $SrCl_2 \cdot 2H_2O$. This shows that halides of group II elements:
(a) Are hygroscopic in nature
(b) Act as dehydrating agents
(c) Can absorbs moisture from air
(d) Cannot absorbs moisture from air

37. Which of the following gives propyne on hydrolysis?
(a) Al_4C_3 (b) Mg_2C_3
(c) B_4C (d) La_4C_3

38. A metal *X* on heating in nitrogen gas gives *Y*. *Y* on treatment with H_2O gives a colorless gas which when passed through $CuSO_4$ solution gives a blue color. *Y* is:
(a) $Mg(NO_3)_2$ (b) Mg_3N_2
(c) NH_3 (d) MgO

39. As the nuclear charge increases from neon to calcium, the orbital energies:
(a) Increase (b) Increase very rapidly
(c) Increase very slowly (d) Fall

40. Ripening of fruits can be carried out in the presence of:
(a) Na_2SO_4 (b) NaCl
(c) $CaCl_2$ (d) CaC_2

41. What are the products formed when an aqueous solution of magnesium bicarbonate is boiled?
(a) $MgCO_3$, H_2O, CO_2 (b) $Mg(HCO_3)_2$, H_2O
(c) $Mg(OH)_2$, H_2O (d) $Mg(HO)_2$, CO_2

42. The substance not likely to contain $CaCO_3$ is:
(a) Dolamite (b) Sea shell
(c) Calcined gypsum (d) Marble statue

43. Bleaching powder is obtained by treating Cl_2 with:
(a) $Ca(OH)_2$ (b) CaO
(c) $CaCO_3$ (d) $CaCl_2$

44. Dead burnt plaster is:
(a) $CaSO_4 \cdot 2H_2O$ (b) $MgSO_4 \cdot 7H_2O$
(c) $CaSO_4 \cdot 1/2\ H_2O$ (d) $CaSO_4$

45. Correct order of stability of group IIA metal carbonates is:
(a) $MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$
(b) $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3$
(c) $SrCO_3 > BaCO_3 > CaCO_3 > MgCO_3$
(d) $CaCO_3 > MgCO_3 > BaCO_3 > SrCO_3$

46. Which of the following carbides produces propyne on reaction with water?
(a) CaC_2 (b) Be_2C
(c) Al_4C_3 (d) Mg_2C_3

47. Which one of the following processes will produce hard water?
(a) Saturation of water with $CaCO_3$
(b) Addition of Na_2SO_4 to water.
(c) Saturation of water with $MgCO_3$
(d) Saturation of water with $CaSO_4$

48. Which of the following statements about anhydrous aluminium chloride is correct?
(a) It sublimes at 100°C under vacuum
(b) It exists as $AlCl_3$ molecules
(c) It is a strong Lewis base
(d) It is not easily hydrolyzed

49. The oxidation states of the most electronegative element in the products of the reaction BaO_2 with dil. H_2SO_4 are:
(a) 0 and –1 (b) –1 and –2
(c) –2 and 0 (d) –2 and +1

50. Calcium imide on hydrolysis gives gas (P) which on oxidation by bleaching powder gives gas (Q). Gas (Q) on reaction with magnesium gives compound (R) which on hydrolysis again gives gas (P). Identify (P), (Q), and (R):
(a) N_2, NH_3, MgNH (b) NH_3, N_2, Mg_3N_2
(c) NH_3, NO_2, $Mg(NO_2)_2$ (d) N_2, N_2O_5, $Mg(NO_3)_2$

51. In the electrolysis of aqueous NaCl solution, side reactions taking place are:
(I) $2OH^- + Cl_2 \longrightarrow 2OCl^- + H_2O$
(II) $2Na + 2H_2O \longrightarrow 2NaOH + H_2$
(III) $4OH^- \longrightarrow O_2 + 2H_2 + 4e^-$
Select the correct alternate:
(a) (I) and (III) (b) (II) and (III)
(c) (I) and (II) (d) (I), (II), and (III)

52. Salt $(P) + (Q) \longrightarrow (R) \xrightarrow[\text{White ppt.}]{BaCl_2}$
(*P*) is paramagnetic in nature and contains about 55% K, so (*P*) is:
(a) KO_2 (b) K_2O
(c) K_2SO_4 (d) K_2O_2

53. $(P) + H_2O \longrightarrow NaOH$
$(P) \xrightarrow{O_2, 400°C} (Q) \xrightarrow{H_2O, \text{at } 25°C} NaOH + O_2$

(*Q*) is used for oxygenating in submarine. (*P*) and (*Q*) are:

(a) Na_2O_2 and O_2 (b) Na_2O and O_2
(c) Na_2O_2 and Na_2O (d) Na_2O and Na_2O_2

54. Which of the following equations is correct?

(a) $3LiNO_3 \xrightarrow{heat} 2LiNO_2 + O_2$
(b) $NaNO_3 + NaNH_2 \xrightarrow{80°\text{-}90°C} 2NaOH + N_2O$
(c) Potassium formate is heated with free exposure to air. $2HCOOK + O_2 \longrightarrow K_2CO_3 + H_2O + CO_2$
(d) Solid $KBrO_3$ is heated with powdered charcoal. $2KBrO_3 + 3C \longrightarrow 2KBr + 3CO_2$

55. In the reaction: $Al_2(SO_4)_3 \cdot 18H_2O \xrightarrow[-18H_2O]{heat} A \xrightarrow{800°C} B + C$. The product *A*, *B* and *C* are respectively:

(a) $Al_2(SO_4)_3$, Al_2O_3, SO_3 (b) Al_2O_3, $Al_2(SO_4)_3$, SO_3
(c) Al_2SO_4, Al_2O_3, SO_3
(d) $Al_2(SO_4)_3$, Al_2O_3, SO_2

56. Which of the following reaction/s are correct here?

(I) $B + NaOH \longrightarrow 2Na_3BO_3 + H_2$
(II) $P_4 + NaOH + H_2O \longrightarrow NaH_2PO_2 + PH_3$
(III) $S + NaOH \longrightarrow Na_2S_2O_3 + Na_2S + H_2O$

(a) I only (b) III only
(c) II and III (d) I, II, and III

57. In the following sequence of reactions, identify the end product (*D*).

$Na_2CO_3 \xrightarrow{SO_2} (A) \xrightarrow{Na_2CO_3} (B) \xrightarrow{Elemental\ S,\ \Delta} (C) \xrightarrow{I_2} (D)$

(a) Na_2SO_4 (b) $Na_2S_4O_6$
(c) Na_2S (d) $Na_2S_2O_3$

58. Consider the following reactions:

$X + HCl \xrightarrow[\text{(addition)}]{\text{anhyd. } AlCl_3} C_2H_5Cl \xrightarrow[\text{(substitution)}]{\text{anhyd. } ZnCl_2/HCl} Y$

Y can be converted to *X* on heating with ..... at ..... temperature:

(a) Cu, 300°C (b) Al_2O_3, 350°C
(c) $NaOH/I_2$, 60°C (d) $Ca(OH)_2 + CaOCl_2$, 60°C

59. Consider the following reactions:

I. $2Na + 2H_2O \longrightarrow 2NaOH + H_2$;
II. $2NaOH + Cl_2 \longrightarrow NaCl + NaOCl + H_2O$;
III. $4OH^- \longrightarrow O_2 + 2H_2O + 4e^-$;
IV. $2Cl^- \longrightarrow Cl_2 + 2e^-$

In the diaphragm cell used for the electrolysis of brine, the reactions that occur would include:

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

60. A soft metal (*A*) gives violet flame test. When burnt in O_2, (*A*) gives chrome yellow powder (*B*) which on reaction with water gives alkaline solution (*C*) and O_2. Identify the metal:

(a) Na (b) Mg
(c) K (d) Ca

61. A hydrated colorless solid (*A*) is water soluble and finds use in medicine as a purgative. When a solution of (*A*) is treated with ammonium phosphate, a white precipitate is formed. (*A*) gives a pink mass is cobalt nitrate test. What is (*A*)?

(a) $FeSO_4 \cdot 7H_2O$ (b) $Na_2SO_4 \cdot 10H_2$
(c) $MgSO_4 \cdot 7H_2O$ (d) $CaSO_4 \cdot 2H_2O$

62. Select the correct basic character:

(a) $NiO < MgO < SrO < K_2O < Cs_2O$
(b) $NiO < MgO < K_2O < BrO < Cs_2O$
(c) $MgO < NiO < SrO < K_2O < Cs_2O$
(d) $SrO < NiO < MgO < K_2O < Cs_2O$

63. Calcium is obtained by the:

(a) Roasting of limestone
(b) Electrolysis of a solution of calcium chloride in H_2O
(c) Reduction of calcium chloride with carbon
(d) Electrolysis of molten anhydrous calcium chloride

Multiple Correct Answers Type

1. Sodium sulphate is soluble in water but barium sulphate is sparingly soluble because:

(a) The hydration energy of Na_2SO_4 is more than its lattice energy
(b) The lattice energy of $BaSO_4$ is more than its hydration energy
(c) The lattice energy has no role to play in solubility
(d) The lattice energy of Na_2SO_4 is more than its hydration energy

2. Be and Al have following resemblance due to diagonal relationship:

(a) Have nearly equal electronegativity
(b) Form amphoteric oxides
(c) Have same charge/radius ratio
(d) Both form dimeric halides

3. The correct statement(s) is/are:

(a) $BeCl_2$ is a covalent compound
(b) $BeCl_2$ can form dimer
(c) $BeCl_2$ is an electron deficient molecule
(d) The hybrid state of Be in $BeCl_2$ is sp^2

4. Among the following, the diamagnetic compound is/are:
(a) Na_2O_2 (b) O_3
(c) N_2O (d) KO_2

5. The carbonate that will decompose on heating is/are:
(a) Na_2CO_3 (b) $CaCO_3$
(c) $BaCO_3$ (d) $SrCO_3$

6. Highly pure dilute solution of sodium in liquid ammonia:
(a) Shows blue color
(b) Exhibits electrical conductivity
(c) Produces sodium amide
(d) Produces hydrogen gas

7. Identify the incorrect statement:
(a) Gypsum contains a lower percentage of calcium than Plaster of Paris
(b) Gypsum is obtained by heating Plaster of Paris
(c) Plaster of Paris is obtained by hydration of gypsum
(d) Plaster of Paris is obtained by partial oxidation of gypsum

8. Which one of the following processes is/are not used for the manufacture of calcium?
(a) Reduction of CaO with carbon
(b) Reduction of CaO with hydrogen
(c) Electrolysis of a mixture of anhydrous $CaCl_2$
(d) Electrolysis of molten $Ca(OH)_2$

9. Select the incorrect statement(s):
(a) Lattice energy $\propto \frac{1}{r^2}$. {where r is the interionic distance}
(b) Lattice energy $\propto q_1q_2$. {where q_1 and q_2 are the charges of co-ions}
(c) Ionic mobility of the ions in aqueous state $\propto \frac{1}{\text{radius of ions in gaseous state}}$
(d) Heat of formation of a compound depends on the number of steps involved in its formation reaction

10. Which of the following is/are amphoteric oxide?
(a) BeO (b) BaO
(c) Al_2O_3 (d) CaO

11. Sodium sulphate is soluble in water but barium sulphate is sparingly soluble because:
(a) The hydration energy of Na_2SO_4 is more than its lattice energy
(b) The lattice energy of $BaSO_4$ is more than its hydration energy
(c) The lattice energy has no role to play in solubility
(d) The lattice energy of Na_2SO_4 is more than its hydration energy

12. Select the correct statement(s) about barium:
(a) It shows photoelectric effect
(b) It is silvery white metal
(c) It forms $Ba(NO_3)_2$ which is used in preparation of green fire
(d) Its ionization energy is less than radium

13. Mg and Zn have following resemblance:
(a) MgO and ZnO are amphoteric
(b) $MgCO_3$ and $ZnCO_3$ both on heating give corresponding oxide
(c) Both are *d*-block elements
(d) Both are used to prevent corrosion

14. When dissolving moderate amount of sodium metal in liquid NH_3 at low temperature, which one of the following does occur?
(a) Blue colored solution is obtained
(b) Na^+ ions are formed in the solution
(c) Liquid NH_3 becomes good conductor of electricity
(d) Liquid NH_3 remains diamagnetic

15. Which of the following oxides is/are expected to react with sodium hydroxide?
(a) CaO (b) SiO_2
(c) BeO (d) B_2O_3

16. The compound(s) formed upon combustion of sodium metal in excess air is (are):
(a) Na_2O_2 (b) Na_2O
(c) NaO_2 (d) NaOH

17. Kieserite is not an ore of:
(a) Cu (b) Fe
(c) Mg (d) Al

18. Highly pure dilute solution of sodium in liquid ammonia:
(a) Shows blue color
(b) Exhibits electric conductivity
(c) Produces sodium amide
(d) Produces hydrogen gas

19. The addition of which metal into liquid NH_3 leads to the formation of blue solution:
(a) Li (b) Sr
(c) Cs (d) Ba

20. Which of the following element(s) is/are not react directly with nitrogen to form nitride?

(a) Na (b) Li

(c) K (d) Rb

21. Which of the following composition of minerals is/are correct:

(a) Soda ash – Na_2CO_3

(b) Carnallite – $KCl{\cdot}MgCl_2{\cdot}6H_2O$

(c) Borax – $Na_2B_4O_7{\cdot}7H_2O$

(d) Glauber's salt – $Na_2SO_4{\cdot}10H_2O$

22. The pairs of compounds which cannot exist together in aqueous solution are:

(a) NaH_2PO_4 and Na_2HPO_4

(b) Na_2CO_3 and $NaHCO_3$

(c) NaOH and NaH_2PO_4

(d) $NaHCO_3$ and NaOH

23. Which of the following is/are incorrect?

(a) Mg burns in air releasing dazzling light rich in UV-rays

(b) $CaCl_2 \cdot 6H_2O$ when mixed with ice gives freezing mixture

(c) Mg^{2+} cannot form complexes

(d) Be can form complexes due to its very small size

Comprehension Type

Comprehension-1: (Q. 1 to Q. 3)

A soft silver white metal (*A*) burns with golden yellow flame to give a yellow power *B* which on treatment with water liberates oxygen giving a clear solution *C*. The solution placed on Al attacks this metal, liberating a gas *D* and forming a water soluble compound *E*. The metal (*A*) dissolves in liquid NH_3 to form deep blue solution which is a good conductor and an excellent reducing agent.

1. Identify *C*:

(a) KOH (b) $Al(OH)_3$

(c) NaOH (d) LiOH

2. Identify *D*:

(a) N_2 (b) Cl_2

(c) NH_3 (d) H_2

3. Identify *E*:

(a) NaOH (b) $NaAlO_2$

(c) $Ca(AlO_2)_2$ (d) None of these

Comprehension-2: (Q. 4 to Q. 6)

On the basis of E.N. difference of $|X_O - X_E|$ and $|X_O - X_H|$, acidic and basic characters of E — O — H can be decided, and acidic and basic strengths are compared.

4. Correct order of acidic strength is:

(a) Na — O — H > K — O — H > Rb — O — H

(b) Na — O — H < K — O — H < Li — O — H

(c) H — O — K > H — O — Rb > Na — O — H

(d) None of these

5. Correct order of basic strength is:

(a) H — O — I < H — O — Br < H — O — Cl

(b) H — O — Cl > H — O — I > H — O — Br

(c) H — O — I > H — O — Br > H — O — Cl

(d) None of these

6. Strongest acid among the following:

(a) HClO (b) $HClO_2$

(c) $HClO_4$ (d) $HClO_3$

Comprehension-3: (Q. 7 to Q. 11)

Alkali and alkaline earth metals along with hydrogen and helium constitute *s*-block elements. They have low ionization enthalpies and hence exhibit characteristic flame colorations. They have highly negative electrode potentials and hence are strong reducing agents. Their solutions in liquid ammonia are conducting and also act as strong reducing agents. Being stronger reducing agents than hydrogen, they are usually prepared by electrolysis of their fused chlorides. Their oxides are basic and the basic strength increases down the group. The solubility of carbonates and sulphates of alkali and alkaline earth metals shows opposite trends. The carbonates of alkaline earth metals and lithium carbonate decompose on heating while the carbonates of other alkali metals do not decompose on heating. The bicarbonates of both alkali and alkaline earth metals on heating give carbonates.

7. The compound insoluble in acetic acid is:

(a) Calcium oxide (b) Calcium carbonate

(c) Calcium oxalate (d) Calcium hydroxide

8. The following compounds have been arranged in order of their increasing thermal stabilities. Identify the correct order: K_2CO_3 (I), $MgCO_3$ (II), $CaCO_3$ (III), $BeCO_3$ (IV):

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

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

9. Property of alkaline earth metals that increases with their atomic number is:
   (a) Ionization energy
   (b) Solubility of their hydroxides
   (c) Solubility of their sulphates
   (d) Electronegativity

10. Which of the following process is used in the extractive metallurgy of magnesium?
   (a) Fused salt electrolysis
   (b) Self-reduction
   (c) Aqueous solution electrolysis
   (d) Thermite reduction

11. Identify the correct order of acidic strengths of CO_2, CuO, CaO, H_2O:
   (a) $CaO < CuO < H_2O < CO_2$
   (b) $H_2O < CuO < CaO < CO_2$
   (c) $CaO < H_2O < CuO < CO_2$
   (d) $H_2O < CO_2 < CaO < CuO$

Comprehension-4: (Q. 12 to Q. 14)

A colorless solid *A* liberates a brown gas *B* on acidification, a colorless alkaline gas *C* on treatment with NaOH solution, and colorless inactive gas *D* on heating.

12. What is the formula of colorless alkaline gas *C*?
   (a) N_2 (b) NH_3
   (c) NO (d) None of these

13. What is the formula of colorless inactive gas *D*?
   (a) N_2 (b) H_2
   (c) NH_3 (d) NO

14. What is the formula of gas *B*?
   (a) Br_2 (b) N_2
   (c) N_2O (d) NO_2

Comprehension-5: (Q. 15 to Q. 17)

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.

15. When CO_2 gas passed into the alkaline solution, then which of the following product will be formed?
   (a) $BaCO_3$ (b) $CaCO_3$
   (c) $SrCO_3$ (d) None of these

16. The gas *A* is:
   (a) N_2 (b) NH_3
   (c) N_2O (d) None of these

17. Find out *B*.
   (a) CaO (b) $CaCO_3$
   (c) Ca_3N_2 (d) None of these

Comprehension-6: (Q. 18 to Q. 21)

A colorless water soluble crystalline solid (*A*) on heating gives O_2 and gives a water soluble crystalline solid (*B*). Both *A* and *B* impart violet coloration to the Bunsen flame. When *B* is heated with NH_4Cl, inactive gas (*C*) is obtained but when *A* is heated with NH_4Cl, a gas (*D*) which supports combustion is formed. When gas (*D*) is heated with soda amide, solid substance *E* is obtained. The solid *E*, when heated with dil. H_2SO_4, forms a monobasic acid *F*; *F* and its salts are explosive.

18. Identify *A*:
   (a) KNO_2 (b) KNO_3
   (c) $AgNO_3$ (d) $NaNO_2$

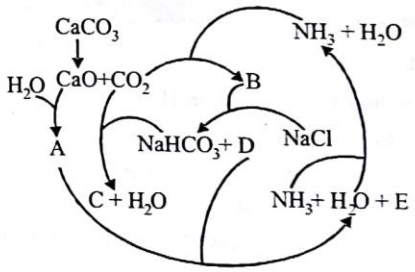
19. Identify *C*:
   (a) N_2 (b) H_2
   (c) O_2 (d) N_2O

20. Identify *E*:
   (a) K_3N (b) NaN_3
   (c) $NaHSO_4$ (d) None of these

21. Identify *F*:
   (a) HF (b) NH_3
   (c) HN_3 (d) None of these

Comprehension-7: (Q. 22 to Q. 25)

The Solvay process can be represented by the following scheme:



22. Find out *A*:
   (a) CaO (b) $Ca(OH)_2$
   (c) $CaCO_3$ (d) None of these

23. Find out *B*:
   (a) $(NH_4)_2CO_4$ (b) NH_4HCO_3
   (c) $(NH_4)_2C_2O_4$ (d) NH_4Cl

24. Find out *D*:
   (a) NH_4Cl (b) $CaCl_2$
   (c) $NH_4H\ CO_3$ (d) $Ca(OH)_2$

25. Find out *E*:
   (a) NaCl (b) $NaCO_3$
   (c) $CaCl_2$ (d) $Ca(OH)_2$

Assertion-Reasoning Type

1. **Statement-1:** The ionic mobility of $Na^+_{(aq)}$ is lower than that of $K^+_{(aq)}$

   Statement-2: $r_{Na^+(aq.)} > r_{K^+(aq.)}$

   (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:** Lithium chloride is predominately covalent compound.

   Statement-2: Electronegativity difference between Li and Cl is small.

   (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) Li	(p) Radioactive
(b) Na	(q) Atomic number 11
(c) K	(r) Cation of element which has higher degree of hydration among the elements
(d) Fr	(s) ns^1 configuration
	(t) First element of group-I

2. Match the column:

Column-I	Column-II
(a) Cs	(p) Nitride formed when metal react with N_2
(b) K	(q) Cation which is formed mainly superoxide
(c) Li	(r) Salts of cation are mostly hydrated
(d) Mg	(s) Violet color in to the flame

3. Match the column:

Column-I	Column-II
(a) Flame coloration	(p) $Be(OH)_2$
(b) Amphoteric character	(q) Li Cl
(c) Soluble in organic solvents	(r) $BeCl_2$
(d) Evolves CO_2 on heating	(s) $Al(OH)_3$
(e) Forms superoxide on heating with oxygen	(t) K
	(u) Li_2CO_3

4. Match the column:

Column-I	Column-II
(a) Ionic compound	(p) HCl (vap.)
(b) Non-polar covalent compound	(q) SiO_2
(c) Polar covalent compound having sigma bond only	(r) KNO_3
	(s) NO

5. Match the column:

Column-I	Column-II
(a) $Li^+(aq)$	(p) Metal(s) readily react vigorously with halogens to from ionic halides
(b) $Na^+(aq)$	(q) Highest ionic mobility among the ions
(c) $K^+(aq)$	(r) Highest hydrated size among the ions
(d) $Rb^+(aq)$	(s) Highest hydration energy among the cation
	(t) Lowest ionic mobility among the ion

6. Match the column:

Column-I	Column-II
(a) Be	(p) Show diagonal relationship with other elements
(b) Mg	(q) Highest hydration energy of cation among the element
(c) Ca	(r) Cation has lowest hydrated size in aqueous solution
(d) Sr	(s) Metal(s) which dissolve in liquid ammonia to give deep blue solution
	(t) *s*-block elements

7. Match the column:

Column-I	Column-II
(a) L i	(p) Metal(s) dissolve in liquid ammonia giving deep blue solution
(b) Na	(q) Very low solubility of fluoride salts in water
(c) K	(r) Diagonal relationship with Mg
(d) Cs	(s) Golden yellow color in flame
	(t) Superoxide ion is stable in the presence of larger cation(s)

8. Match the column:

Column-I	Column-II
(a) Alkali metal carbonate which does not decompose on heating	(p) $MgCO_3$
(b) Alkali metal carbonate which decomposes on heating	(q) Na_2CO_3
(c) K/liq. NH_3 is blue color solution which conducts electricity	(r) Li_2CO_3
	(s) Solvated electrons

Integer Answer Type

1. The number of covalent bonds formed by beryllium is _____.
2. Find the number of amphoteric hydroxide(s) from the following:
   $Be(OH)_2$, $Mg(OH)_2$, $Al(OH)_3$, LiOH, $B(OH)_3$, $Zn(OH)_2$
3. Find the number of chloride(s) which do not impart color to the flame from the following:
   $BeCl_2$, $SrCl_2$, $MgCl_2$, $CaCl_2$, $BaCl_2$
4. Find the number of element(s) which is/are present in group-II:
   Ba, K, Ca, Cs, Rb, Na
5. What is the most common oxidation state of alkali metals?
6. How many $3C - 4e^-$ bonds are present in dimer of $BeCl_2$?
7. How many water moelcule(s) is/are present in gypsum?
8. Find the number of peroxide molecule(s) in the following:
   MgO, CaO, Li_2O, BaO_2
9. Find the number of element(s) which is/are present in group-I:
   Be, Li, Mg, Al, Na, Ca, Cs
10. What is the most common oxidation state of alkaline earth metals?
11. When Mg_3N_2 react with H_2O, then how many type of gaseous product(s) is/are formed?
12. How many water molecule(s) is/are present in dead burnt plaster?
13. When Mg_2C_3 undergoes hydrolysis, how many carbon atoms is/are present in product?
14. When $BeCl_2$ undergoes hydrolysis in alkaline medium, then what is the co-ordination number of Be in product?
15. When CaC_2 undergoes hydrolysis, then how many π bonds are present in gaseous product?
16. When alkaline earth metals react with phosphorous, then how many phosphorus atom(s) is/are present in product side?
17. How many *p*-orbital(s) is/are involved in hydridization of solid $BeCl_2$?
18. $Mg + N_2 \xrightarrow{\text{Heat}} X$

    $$\underset{\text{Colorless gas}}{X} \xrightarrow{H_2O} Z \xrightarrow{H_2O} \text{Solution} \xrightarrow{CuSO_4} \underset{\text{Blue colored}}{(A)}$$

    What is the coordination number of the central atom of compound having blue colored solution?

NCERT Exemplar Exercises

Single Correct Answer Type

1. The alkali metals are low melting. Which of the following alkali metal is expected to melt if the room temperature rises to 30°C?
   (a) Na (b) K
   (c) Rb (d) Cs
2. Alkali metals react with water vigorously to form hydroxides and dihydrogen. Which of the following alkali metals reacts with water least vigorously?
   (a) Li (b) Na
   (c) K (d) Cs
3. The reducing power of a metal depends on various factors. Suggest the factor which makes Li, the strongest reducing agent in aqueous solution.
   (a) Sublimation enthalpy
   (b) Ionization enthalpy
   (c) Hydration enthalpy
   (d) Electron-gain enthalpy
4. Metal carbonates decompose on heating to give metal oxide and carbon dioxide. Which of the metal carbonates is most stable thermally?
   (a) $MgCO_3$ (b) $CaCO_3$
   (c) $SrCO_3$ (d) $BaCO_3$
5. Which of the carbonates given below is unstable in air and is kept in CO_2 atmosphere to avoid decomposition.
   (a) $BeCO_3$ (b) $MgCO_3$
   (c) $CaCO_3$ (d) $BaCO_3$

6. Metals form basic hydroxides. Which of the following metal hydroxide is the least basic?
   (a) $Mg(OH)_2$ (b) $Ca(OH)_2$
   (c) $Sr(OH)_2$ (d) $Ba(OH)_2$

7. Some of the Group 2 metal halides are covalent and soluble in organic solvents. Among the following metal halides, the one which is soluble in ethanol is:
   (a) $BeCl_2$ (b) $MgCl_2$
   (c) $CaCl_2$ (d) $SrCl_2$

8. The order of decreasing ionization enthalpy in alkali metals is:
   (a) Na > Li > K > Rb (b) Rb < Na < K < Li
   (c) Li > Na > K > Rb (d) K < Li < Na < Rb

9. The solubility of metal halides depends on their nature, lattice enthalpy and hydration enthalpy of the individual ions. Amongst fluorides of alkali metals, the lowest solubility of LiF in water is due to:
   (a) Ionic nature of lithium fluoride
   (b) High lattice enthalpy
   (c) High hydration enthalpy for lithium ion
   (d) Low ionization enthalpy of lithium atom

10. Amphoteric hydroxides react with both alkalies and acids. Which of the following Group 2 metal hydroxides is soluble in sodium hydroxide?
   (a) $Be(OH)_2$ (b) $Mg(OH)_2$
   (c) $Ca(OH)_2$ (d) $Ba(OH)_2$

11. In the synthesis of sodium carbonate, the recovery of ammonia is done by treating NH_4Cl with $Ca(OH)_2$. The by-product obtained in this process is:
   (a) $CaCl_2$ (b) NaCl
   (c) NaOH (d) $NaHCO_3$

12. When sodium is dissolved in liquid ammonia, a solution of deep blue color is obtained. The colour of the solution is due to:
   (a) Ammoniated electron
   (b) Sodium ion
   (c) Sodium amide
   (d) Ammoniated sodium ion

13. By adding gypsum to cement:
   (a) Setting time of cement becomes less
   (b) Setting time of cement increases
   (c) Color of cement becomes light
   (d) Shining surface is obtained

14. Dead burnt plaster is:
   (a) $CaSO_4$ (b) $CaSO_4 \cdot 4H_2O$
   (c) $CaSO_4 \cdot H_2O$ (d) $CaSO_4 \cdot 2H_2O$

15. Suspension of slaked lime in water is known as:
   (a) Lime water
   (b) Quick lime
   (c) Milk of lime
   (d) Aqueous solution of slaked lime

16. Which of the following elements does not form hydride by direct heating with dihydrogen?
   (a) Be (b) Mg
   (c) Sr (d) Ba

17. The formula of soda ash is:
   (a) $Na_2CO_3 \cdot 10H_2O$
   (b) $Na_2CO_3 \cdot 2H_2O$
   (c) $Na_2CO_3 \cdot H_2O$
   (d) Na_2CO_3

18. A substance which gives brick red flame and breaks down on heating to give oxygen and a brown gas is
   (a) Magnesium nitrate (b) Calcium nitrate
   (c) Barium nitrate (d) Strontium nitrate

19. Which of the following statements is true about $Ca(OH)_2$?
   (a) It is used in the preparation of bleaching powder
   (b) It is a light blue solid
   (c) It does not possess disinfectant property
   (d) It is used in the manufacture of cement

20. A chemical **A** is used for the preparation of washing soda to recover ammonia. When CO_2 is bubbled through an aqueous solution of **A**, the solution turns milky. It is used in white washing due to disinfectant nature. What is the chemical formula of **A**?
   (a) $Ca(HCO_3)_2$ (b) CaO
   (c) $Ca(OH)_2$ (d) $CaCO_3$

21. Dehydration of hydrates of halides of calcium, barium and strontium i.e., $CaCl_2 \cdot 6H_2O$, $BaCl_2 \cdot 2H_2O$, $SrCl_2 \cdot 2H_2O$, can be achieved by heating. These become wet on keeping in air. Which of the following statements is correct about these halides?
   (a) Act as dehydrating agent
   (b) Can absorb moisture from air
   (c) Tendency to form hydrate decreases from calcium to barium
   (d) All of the above

Multiple Correct Answers Type

In the following questions two or more options may be correct.

1. Metallic elements are described by their standard electrode potential, fusion enthalpy, atomic size, etc. The alkali metals are characterized by which of the following properties?
   (a) High boiling point
   (b) High negative standard electrode potential
   (c) High density
   (d) Large atomic size
2. Several sodium compounds find use in industries. Which of the following compounds are used for textile industry?
   (a) Na_2CO_3 (b) $NaHCO_3$
   (c) NaOH (d) NaCl
3. Which of the following compounds are readily soluble in water?
   (a) $BeSO_4$ (b) $MgSO_4$
   (c) $BaSO_4$ (d) $SrSO_4$
4. When Zeolite, which is hydrated sodium aluminium silicate is treated with hard water, the sodium ions are exchanged with which of the following ion(s)?
   (a) H^+ ions (b) Mg^{2+} ions
   (c) Ca^{2+} ions (d) SO_4^{2-} ions
5. Identify the correct formula of halides of alkaline earth metals from the following.
   (a) $BaCl_2 \cdot 2H_2O$ (b) $BaCl_2 \cdot 4H_2O$
   (c) $CaCl_2 \cdot 6H_2O$ (d) $SrCl_2 \cdot 4H_2O$
6. Choose the correct statements from the following.
   (a) Beryllium is not readily attacked by acids because of the presence of an oxide film on the surface of the metal
   (b) Beryllium sulphate is readily soluble in water as the greater hydration enthalpy of Be^{2+} overcomes the lattice enthalpy factor
   (c) Beryllium exhibits coordination number more than four
   (d) Beryllium oxide is purely acidic in nature
7. Which of the following are the correct reasons for anomalous behavior of lithium?
   (a) Exceptionally small size of its atom
   (b) Its high polarizing power
   (c) It has high degree of hydration
   (d) Exceptionally low ionization enthalpy

Short Answer Type

1. How do you account for the strong reducing power of lithium in aqueous solution?
2. When heated in air, the alkali metals form various oxides. Mention the oxides formed by Li, Na, and K.
3. Complete the following reactions
   (a) $O_2^{2-} + H_2O \rightarrow$ (b) $O_2^- + H_2O \rightarrow$
4. Lithium resembles magnesium in some of its properties. Mention two such properties and give reasons for this resemblance.
5. Name an element from Group 2 which forms an amphoteric oxide and a water soluble sulphate.
6. Discuss the trend of the following:
   (a) Thermal stability of carbonates of Group 2 elements.
   (b) The solubility and the nature of oxides of Group 2 elements.
7. Why are $BeSO_4$ and $MgSO_4$ readily soluble in water while $SrSO_4$ and $BaSO_4$ are insoluble?
8. All compounds of alkali metals are easily soluble in water but lithium compounds are more soluble in organic solvents. Explain.
9. In the Solvay process, can we obtain sodium carbonate directly by treating the solution containing $(NH_4)_2CO_3$ with sodium chloride? Explain.
10. Write Lewis strucure of O_2^- ion and find out oxidation state of each oxygen atom? What is the average oxidation state of oxygen in this ion?
11. Why do beryllium and magnesium not impart colour to the flame in the flame test?
12. What is the structure of $BeCl_2$ molecule in gaseous and solid state?

Matching Column Type

In the following questions more than one option of Column-I and Column-II may be correlated.

1. Match the elements given in Column-I with the properties mentioned in Column-II.

Column-I	Column-II
(a) Li	(p) Insoluble sulphate
(b) Na	(q) Strongest monoacidic base among these

(c) Ca	(r) Most negative E^0 value among alkali metals
(d) Ba	(s) Insoluble oxalate
	(t) $6s^2$ outer electronic configuration

2. Match the compounds given in Column-I with their uses mentioned in Column-II.

Column-I	Column-II
(a) $CaCO_3$	(p) Dentistry, ornamental work
(b) $Ca(OH)_2$	(q) Manufacture of sodium carbonate from caustic soda
(c) CaO	(r) Manufacture of high quality paper
(d) $CaSO_4$	(s) Used in white washing

3. Match the elements given in Column-I with the colour they impart to the flame given in Column-II.

Column-I	Column-II
(a) Cs	(p) Apple green
(b) Na	(q) Violet
(c) K	(r) Brick red
(d) Ca	(s) Yellow
(e) Sr	(t) Crimson red
(f) Ba	(u) Blue

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):** The carbonate of lithium decomposes easily on heating to form lithium oxide and CO_2.

   Reason (R): Lithium being very small in size polarises large carbonate ion leading to the formation of more stable Li_2O and CO_2.

   (a) Both A and R are correct and R is the correct explanation of A.
   (b) Both A and R are correct but R is not the correct explanation of A.
   (c) Both A and R are not correct
   (d) A is not correct but R is correct.

2. **Assertion (A):** Beryllium carbonate is kept in the atmosphere of carbon dioxide.

   Reason (R): Beryllium carbonate is unstable and decomposes to give beryllium oxide and carbon dioxide.

   (a) Both A and R are correct and R is the correct explanation of A.
   (b) Both A and R are correct but R is not the correct explanation of A.
   (c) Both A and R are not correct.
   (d) A is not correct but R is correct.

Long Answer Type

1. The *s*-block elements are characterized by their larger atomic sizes, lower ionization enthalpies, invariable + 1 oxidation state and solubilities of their oxosalts.In the light of these features describe the nature of their oxides, halides, and oxosalts.

2. Present a comparative account of the alkali and alkaline earth metals with respect to the following characteristics:
   (a) Tendency to form ionic / covalent compounds
   (b) Nature of oxides and their solubility in water
   (c) Formation of oxosalts
   (d) Solubility of oxosalts
   (e) Thermal stability of oxosalts

3. When a metal of group 1 was dissolved in liquid ammonia, the following observations were obtained:
   (a) Blue solution was obtained initially.
   (b) On concentrating the solution, blue colour changed to bronze colour. How do you account for the blue color of the solution? Give the name of the product formed on keeping the solution for some time.

4. The stability of peroxide and superoxide of alkali metals increase as we go down the group. Explain giving reason.

5. When water is added to compound (A) of calcium, solution of compound (B) is formed. When carbon dioxide is passed into the solution, it turns milky due to the formation of compound (C). If excess of carbon dioxide is passed into the solution milkiness disappears due to the formation of compound (D). Identify the compounds A, B, C and D. Explain why the milkiness disappears in the last step.

6. Lithium hydride can be used to prepare other useful hydrides. Beryllium hydride is one of them. Suggest a route for the preparation of beryllium hydride starting from lithium hydride. Write chemical equations involved in the process.

7. An element of group 2 forms covalent oxide which is amphoteric in nature and dissolves in water to give an amphoteric hydroxide. Identify the element and write chemical reactions of the hydroxide of the element with an alkali and an acid.

8. Ions of an element of group 1 participate in the transmission of nerve signals and transport of sugars and aminoacids into cells. This element imparts yellow colour to the flame in flame test and forms an oxide and a peroxide with oxygen. Identify the element and write chemical reaction to show the formation of its peroxide. Why does the element impart colour to the flame?

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. KO_2 (potassium super oxide) is used in oxygen cylinders in space and submarines because it:
   (a) Absorbs CO_2 and increases O_2 content
   (b) Eliminates moisture
   (c) Absorbs CO_2
   (d) Produces ozone

(AIEEE, 2002)

2. The metallic sodium dissolves in liquid ammonia to form a deep blue-colored solution. The deep blue colour is due to formation of:
   (a) Solvated electron, $e(NH_3)\bar{x}$
   (b) Solvated atomic sodium, $Na(NH_3)_y$
   (c) $(Na^+ + Na^-)$
   (d) $NaNH_2 + H_2$

(AIEEE, 2002)

3. A metal M readily forms its sulphate MSO_4, which is water soluble. It forms its oxide MO that becomes inert on heating. It forms an insoluble hydroxide $M(OH_2)$ that is soluble in NaOH solution. The M is:
   (a) Mg (b) Ba
   (c) Ca (d) Be

(AIEEE, 2002)

4. In curing cement plasters, water is sprinkled from time to time. This helps in:
   (a) Developing interlocking needle-like crystals of hydrated silicates
   (b) Hydrating sand and gravel mixed with cement
   (c) Converting sand into silicic acid
   (d) Keeping it cool

(AIEEE, 2003)

5. The substance that not likely to contain $CaCO_3$ is:
   (a) Calcined gypsum
   (b) Sea shells
   (c) Dolomite
   (d) A marble statue

(AIEEE, 2003)

6. The solubilities of carbonates decrease down the magnesium group due to decrease in:
   (a) Hydration energies of cations
   (b) Interionic attraction
   (c) Entropy of solution formation
   (d) Lattice energy of solids

(AIEEE, 2003)

7. Which one of the following processes will produce hard water?
   (a) Saturation of water with $MgCO_3$
   (b) Saturation of water with $CaSO_4$
   (c) Addition of Na_2SO_4 to water
   (d) Saturation of water with $CaCO_3$

(AIEEE, 2003)

8. One mole of magnesium nitride on the reaction with an excess of water gives:
   (a) Two moles of ammonia
   (b) One mole of nitric acid
   (c) One mole of ammonia
   (d) Two moles of nitric acid

(AIEEE, 2004)

9. Which of the following species is diamagnetic in nature?
   (a) H_2^- (b) H_2^+
   (c) H_2 (d) He_2^+

(AIEEE, 2005)

10. Based on lattice energy and other considerations, which one of the following alkali metal chlorides is expected to have the highest melting point?
   (a) RbCl (b) KCl
   (c) NaCl (d) LiCl

(AIEEE, 2005)

11. Which of the following statements in relation to the hydrogen atom is correct:
   (a) 3s-, 3p-, and 3d-orbitals all have the same energy
   (b) 3s- and 3p-orbitals are of lower energy than 3d-orbital
   (c) 3p-orbital is lower in energy than 3d-orbital
   (d) 3d-orbital is lower in energy than 3p-orbital

(AIEEE, 2005)

12. The ionic mobility of alkali metal ions in aqueous solution is maximum for:
(a) Li^+ (b) Na^+
(c) K^+ (d) Rb^+
(AIEEE, 2006)

13. In context with the industrial preparation of hydrogen from water gas ($CO + H_2$), which of the following is the correct statement?
(a) CO and H_2 are fractionally separated using differences in their densities
(b) CO is removed by absorption in aqueous Cu_2Cl_2 solution
(c) H_2 is removed through occlusion with Pd
(d) CO is oxidized to CO_2 with steam in the presence of a catalyst followed by absorption of CO_2 in alkali
(AIEEE, 2008)

14. The products obtained on heating $LiNO_2$ will be:
(a) $Li_2O + NO_2 + O_2$ (b) $Li_3N + O_2$
(c) $Li_2O + NO + O_2$ (d) $LiNO_3 + O_2$
(AIEEE, 2011)

15. What is the best description of the change that occurs when $Na_2O(s)$ is dissolved in water?
(a) Oxide ion accepts sharing in a pair of electrons
(b) Oxide ion donates a pair of electrons
(c) Oxidation number of oxygen increases
(d) Oxidation number of sodium decreases
(AIEEE, 2011)

16. Which of the following on thermal decomposition yields a basic as well as an acidic oxide?
(a) $NaNO_3$ (b) $KClO_3$
(c) $CaCO_3$ (d) NH_4NO_3
(AIEEE, 2012)

17. Very pure hydrogen (99.9) can be made by which of the following processes?
(a) Reaction of methane with steam
(b) Mixing natural hydrocarbons of high molecular weight
(c) Electrolysis of water
(d) Reaction of salts like hydrides with water
(AIEEE, 2012)

JEE (Advanced) Exercises

Fill in the Blanks Type

1. Anhydrous $MgCl_2$ is obtained by heating the hydrated salt with _____.
(IIT-JEE, 1980)

2. The increase in the solubility of iodine in an aqueous solution of potassium iodide is due to the formation of _____.
(IIT-JEE, 1982)

3. The adsorption of hydrogen by palladium is commonly known as _____.
(IIT-JEE, 1983)

4. Sodium gets dissolved in liquid ammonia because of _____. **(IIT-JEE, 1985)**

5. Hydrogen gas is liberated by the action of aluminium with concentrated solution of _____. **(IIT-JEE, 1987)**

True/False Type

1. $MgCl_2 \cdot 6H_2O$ on heating gives anhydrous $MgCl_2$.
(IIT-JEE, 1982)

2. Sodium when burnt in excess of oxygen gives sodium oxide.
(IIT-JEE, 1987)

Single Correct Answer Type

1. The temporary hardness of water due to calcium bicarbonate can be removed by adding:
(a) $CaCO_3$ (b) $Ca(OH)_2$
(c) $CaCl_2$ (d) HCl
(IIT-JEE, 1979)

2. Calcium is obtained by:
(a) Electrolysis of molten $CaCl_2$
(b) Electrolysis of a solution of $CaCl_2$ in water
(c) Reduction of $CaCl_2$ with carbon
(d) Roasting of limestone
(IIT-JEE, 1980)

3. A solution of sodium metal in liquid ammonia is strongly reducing due to the presence of:
(a) Sodium atoms (b) Sodium hydride
(c) Sodium amide (d) Solvated electrons
(IIT-JEE, 1981)

4. Heavy water is:
(a) H_2O^{18}
(b) Water obtained by repeated distillation
(c) D_2O
(d) Water at 4°C
(IIT-JEE, 1983)

5. The molecular formula of Glauber's salt is:
(a) $MgSO_4 \cdot 7H_2O$ (b) $CuSO_4 \cdot 5H_2O$
(c) $FeSO_4 \cdot 7H_2O$ (d) $Na_2SO_4 \cdot 10H_2O$
(IIT-JEE, 1985)

6. Nitrogen dioxide cannot be obtained by heating:
   (a) KNO_3 (b) $Pb(NO_3)_2$
   (c) $Cu(NO_3)_2$ (d) $AgNO_3$
   (IIT-JEE, 1985)

7. A solution of sodium sulphate in water is electrolyzed using inert electrodes. The products at the cathode and anode are, respectively:
   (a) H_2, O_2 (b) O_2, H_2
   (c) O_2, Na (d) O_2, SO_2
   (IIT-JEE, 1987)

8. The metallic luster exhibited by sodium is explained by:
   (a) Diffusion of sodium ions
   (b) Oscillation of loose electron
   (c) Excitation of free protons
   (d) Existence of body-centered cubic lattice
   (IIT-JEE, 1987)

9. The following compounds have been arranged in the order of their increasing thermal stabilities. Identify the correct order.
   K_2CO_3 (I), $MgCO_3$ (II), $CaCO_3$ (III), $BeCO_3$ (IV)
   (a) I < II < III < IV (b) IV < II < III < I
   (c) IV < II < I < III (d) II < IV < III < I
   (IIT-JEE, 1996)

10. Sodium thiosulphate is prepared by:
   (a) Reducing Na_2SO_4 solution with H_2S
   (b) Boiling Na_2SO_3 solution with S in alkaline medium
   (c) Neutralizing $H_2S_2O_3$ solution with NaOH
   (d) Boiling Na_2SO_3 solution with S in acidic medium
   (IIT-JEE, 1996)

11. One mole of calcium phosphide on reaction with excess water gives:
   (a) 1 mol of phosphine
   (b) 2 mol of phosphoric acid
   (c) 2 mol of phosphine
   (d) 1 mol of phosphorus pentoxide
   (IIT-JEE, 1999)

12. Polyphosphates are used as water softening agents because they:
   (a) Form soluble complexes with anionic species
   (b) Precipitate anionic species
   (c) Form soluble complexes with cationic species
   (d) Precipitate cationic species
   (IIT-JEE, 2002)

13. An aqueous solution of $Na_2S_2O_3$ on reaction with Cl_2 gives:
   (a) $Na_2S_4O_6$ (b) $NaHSO_4$
   (c) NaCl (d) NaOH
   (IIT-JEE, 2008)

14. $MgSO_4$ 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) $MgCl_2 \cdot MgSO_4$ (d) $MgSO_4$
   (IIT-JEE, 2006)

15. The reagent used for softening the temporary hardness of water is/are:
   (a) $Ca_3(PO_4)_2$ (b) $Ca(OH)_2$
   (c) Na_2CO_3 (d) NaOCl
   (IIT-JEE, 2010)

Multiple Correct Answers Type

1. Sodium sulphate is soluble in water, whereas barium sulphate is sparingly soluble because:
   (a) The hydration energy of sodium sulphate is more than its lattice energy
   (b) The lattice energy of barium sulphate is more than its hydration energy
   (c) The lattice energy has no role to play in solubility
   (d) The hydration energy of sodium sulphate is less than its lattice energy
   (IIT-JEE, 1989)

2. When zeolite, which is hydrated sodium aluminium silicate, is treated with hard water, the sodium ions are exchanged with:
   (a) H^+ ions (b) Ca^{2+} ions
   (c) SO_4^{2-} ions (d) Mg^{2+} ions
   (e) OH^- ions
   (IIT-JEE, 1990)

3. The material used in solar cells contains:
   (a) Cs (b) Si
   (c) Sn (d) Ti
   (IIT-JEE, 1993)

4. Highly pure dilute solution of sodium in liquid ammonia:
   (a) Shows blue color
   (b) Exhibits electrical conductivity
   (c) Produces sodium amide
   (d) Produces hydrogen gas
   (IIT-JEE, 1998)

5. Sodium nitrate decomposes above ≈ 800°C to give:
   (a) N_2 (b) O_2
   (c) NO_2 (d) Na_2O
   (IIT-JEE, 1998)

6. The compound(s) formed upon combustion of sodium metal in excess air is/are:
   (a) Na_2O_2 (b) Na_2O
   (c) NaO_2 (d) NaOH
   (IIT-JEE, 2009)

7. The pair(s) of reagents that yield paramagnetic species is/are:
   (a) Na and excess of NH_3
   (b) K and excess of O_2
   (c) Cu and dilute HNO_3
   (d) O_2 and 2-ethylanthraquinol

Assertion-Reasoning Type

Read the following questions and answer as per the directions given below:

(a) Statement-I is true; Statement-II is 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:** The alkali metals can form ionic hydrides which contain the hydride ion, H^-.
   Statement-II: The alkali metals have low electronegativity, their hydrides conduct electricity when fused and liberate hydrogen at the anode.
   (IIT-JEE, 1994)

2. **Statement-I:** LiCl is predominantly a covalent compound.
   Statement-II: Electronegativity difference between Li and Cl is too small.
   (IIT-JEE, 1998)

3. **Statement-I:** Alkali metals dissolve in liquid ammonia to give blue solutions.
   Statement-II: Alkali metals in liquid ammonia give solvated species of the type $[M(NH_3)_n]^+$ (M = alkali metals).
   (IIT-JEE, 2007)

Subjective Type

1. Give reasons for the following:
   "Sodium carbonate is prepared by Solvay process but the same process is not extended to the manufacture of potassium carbonate".
   (IIT-JEE, 1981)

2. Write down the balanced equations for the reaction when calcium phosphate is heated with a mixture of sand and carbon.
   (IIT-JEE, 1985)

3. Give reasons in one or two sentences for the following
   "H_2O_2 is a better oxidising agent than water".
   (IIT-JEE, 1986)

4. Explain the following in one or two sentences only.
   (i) Magnesium oxide is used for the lining of steel making furnace.
   (ii) The mixture of hydrazine and hydrogen peroxide with a copper(II) catalyst is used as a rocket propellant.
   (iii) The molecule of magnesium chloride is linear, whereas that of stannous chloride is angular.
   (IIT-JEE, 1987)

5. Give balanced equations for the following:
   "Carbon dioxide is passed through a concentrated aqueous solution of sodium chloride saturated with ammonia".
   (IIT-JEE, 1988)

6. Write the balanced chemical equations for the following reactions.
   (i) An aqueous solution of sodium nitrate is heated with zinc dust and caustic soda solution.
   (ii) Sodium iodate is added to a solution of sodium bisulphite.
   (IIT-JEE, 1990)

7. Arrange the following as stated.
   Increasing order of basic character: MgO, SrO, K_2O, NiO, Cs_2O
   (IIT-JEE, 1991)

8. Complete and balance the following chemical reactions:
   Anhydrous potassium nitrate is heated with excess of metallic potassium.
   $KNO_3(s) + K(s) \rightarrow$
   (IIT-JEE, 1992)

9. 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)

10. 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)

11. The crystalline salts of alkaline earth metals contain more water of crystallization than the corresponding alkali metal salts. Why?

(IIT-JEE, 1997)

12. Arrange the following sulphates of alkaline earth metals in order of decreasing thermal stability: $BeSO_4$, $MgSO_4$, $CaSO_4$, $SrSO_4$

(IIT-JEE, 1997)

13. Work out the following using chemical equations: "Chlorination of calcium hydroxide produces bleaching powder".

(IIT-JEE, 1998)

14. Hydrogen peroxide acts both as an oxidizing and as a reducing agent in alkaline solution towards certain first-row transition metal ions. Illustrate both these properties of H_2O_2 using chemical equations.

(IIT-JEE, 1998)

15. 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 was the other compound.

(IIT-JEE, 1999)

16. Give reasons for the following in one or two sentences only:
"$BeCl_2$ can be easily hydrolyzed".

(IIT-JEE, 1999)

17. Write the balanced chemical equation for developing photographic films.

(IIT-JEE, 2000)

18. Hydrogen peroxide solution (20 mL) reacts quantitatively with a solution of $KMnO_4$ (20 mL) acidified with dilute H_2SO_4. The same volume of the $KMnO_4$ solution is just decolorized by 10 mL of $MnSO_4$ in neutral medium simultaneously forming a dark brown precipitate of hydrated MnO_2. The brown pecipitate is dissolved in 10 mL of 0.2 M sodium oxalate under boiling condition in the presence of dilute H_2SO_4. Write the balanced equations involved in the reactions and calculate the molarity of H_2O_2.

(IIT-JEE, 2001)

19. Identify *X* in the following synthetic scheme and write their structures.

$$Ba\overset{*}{C}O_3 + H_2SO_4 \rightarrow X(\text{gas})(C^* \text{ denotes } C^{14})$$

(IIT-JEE, 2001)

20. Identify the following:

$$Na_2CO_3 \xrightarrow{SO_2} A \xrightarrow{Na_2CO_3} B \xrightarrow[\Delta]{\text{Elemental S}} C \xrightarrow{I_2} D$$

Also mention the oxidation state of S in all the compounds.

(IIT-JEE, 2003)

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

13. (b) $NaH + H_2O \longrightarrow NaOH + H_2$

43. (a) For third period, "*s*" block will form ionic oxide, 13th group forms amphoteric oxide, and 14th group element will form giant oxide (SiO_2).

$(X) < (Y) < (Z)$

JEE (Advanced) Exercises

Single Correct Answer Type

10. (d) (a) $CaC_2 + H_2O \longrightarrow Ca(OH)_2 + HC \equiv CH \uparrow$

(b) $Be_2C + 2H_2O \longrightarrow 2\,BeO + CH_4 \uparrow$

(c) $Al_4C_3 + 12H_2O \longrightarrow 4Al(OH)_3 + 3CH_4 \uparrow$

(d) $Mg_2C_3 + 4H_2O \longrightarrow 2Mg(OH)_2 + H_3C\text{–}C \equiv CH \uparrow$

34. (a) Both Mg^{2+} and Be^{2+} ions do not impart any color to the flame.

Multiple Correct Answers Type

9. (a), (c), (d)

(a) Lattice energy $\propto \frac{1}{r}$. Hence (a) is wrong

(b) Correct

(c) Ionic mobility in aqueous state

$$\propto \frac{1}{\text{radius of ion in aqueous state (Hydration Radii)}}$$

Hence (c) is wrong

(d) Violating Hess law. Hence wrong.

10. (a), (c)

Because both react with acid and base.

16. (a), (b)

$$4Na + O_2 \longrightarrow 2Na_2O,$$
$$4Na + 2O_2 \longrightarrow 2Na_2O_2$$

19. (a), (b), (c), (d)

$$m + X \cdot NH_3 \rightarrow M^+ + \bar{e} \cdot xNH_3$$

Ammoniated electron responsible for blue color

Comprehension Type

4. (a) In hydroxide, down the group basic nature increaes. Therefore, acidic nature decreases; thus,

$Na-O-H > K-O-H > Rb-O-H$

5. (c) In hydroxide, down the group basic nature increases

$H-O-I > H-O-Br \gtrsim H-O-Cl$

6. (c) The more the electronegativity of an atom, the more is its oxidation atom. Hence, Cl is a better acid and will liberate H^+ more easily.

15–17. Ca burns in air to form CaO and Ca_3N_2.

$$2Ca + O_2 \longrightarrow 2CaO$$
$$3Ca + N_2 \longrightarrow Ca_3N_2$$

Calcium nitride on hydrolysis with H_2O gives ammonia (A)

$$Ca_3N_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + \underset{(A)}{2NH_3}$$

The alkaline solution of $Ca(OH)_2$ thus formed reacts with CO_2 present in the air to form $CaCO_3$(B).

$$Ca(OH)_2 + CO_2 \longrightarrow \underset{(B)}{CaCO_3} + H_2O$$

Thus, $A = NH_3$ and $B = CaCO_3$ (white powder)

18–21.

$$\underset{(A)}{KNO_3} \xrightarrow{\Delta} \underset{(B)}{KNO_2} + \frac{1}{2}O_2$$
$$KNO_2 + NH_4Cl \longrightarrow NH_4NO_2 + KCl$$
$$NH_4NO_2 \xrightarrow{\Delta} \underset{(C)}{N_2} + 2H_2O$$
$$KNO_3 + NH_4Cl \longrightarrow NH_4NO_3 + KCl$$
$$NH_4NO_3 \xrightarrow{\Delta} \underset{(D)}{N_2O} + 2H_2O$$
$$N_2O + NaNH_2 \longrightarrow \underset{(E)}{NaN_3} + H_2O$$
$$2NaN_3 + H_2SO_4 \xrightarrow{\Delta} \underset{(F)}{2HN_3} + NaSO_4$$

22–25.

(i) $CaO + H_2O \longrightarrow \underset{(A)}{Ca(OH)_2}$

(ii) $NH_3 + H_2O + CO_2 \longrightarrow \underset{(B)}{NH_4HCO_3}$

(iii) $2NaHCO_3 \longrightarrow \underset{(C)}{Na_2CO_3} + CO_2 + H_2O$

(iv) $NH_4HCO_3 + NaCl \longrightarrow NaHCO_3 + \underset{(D)}{NH_4Cl}$

(v) $2NH_4Cl + Ca(OH)_2 \longrightarrow 2NH_3 + 2H_2O + \underset{(E)}{CaCl_2}$

Thus, $A = Ca(OH)_2$, $B = NH_4HCO_3$, $C = Na_2CO_3$, $D = NH_4Cl$, and $E = CaCl_2$

Assertion-Reasoning Type

1. (a) If hydrated size is more, then ionic mobility is less:

$\therefore$ $Na^+_{(aq)} < K^+_{(aq)}$ (order of ionic mobility)

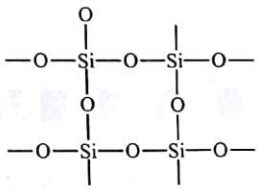
and $r_{Na^+(aq.)} > r_{K^+(aq.)}$ is true a statement

Matching Column Type

4. (a) r; (b) q; (c) p

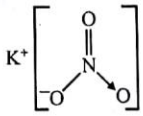
(p) $\overset{\delta+}{H}-\overset{\delta-}{Cl}$ (Polar covalent compound)

(q)



3-D network like structure; each Si is sp^3-hybridized. Therefore, non-polar compound.

(r)



ionic compound with σ and π bonds.

(s) $:\dot{N}=\ddot{O}:$

Integer Answer Type

11. (1) $Mg_3N_2 + H-OH \longrightarrow Mg(OH)_2 + NH_3$

12. (0) $CaSO_4$ (dead burnt plaster)

13. (3) $Mg_2C_3 + 4H - OH \longrightarrow 2Mg(OH)_2 + C_3H_4$
14. (4) $BeCl_2 + NaOH \longrightarrow [Be(OH)_4]^{2-}$
15. (2) $CaC_2 + H_2O \longrightarrow Ca(OH)_2 + H - C \equiv C - H$
16. (2) $3M + 2P \longrightarrow M_3P_2$

NCERT Exemplar Exercises

Short Answer Type

3. (a) $O_2^{2+} + 2H_2O \rightarrow 2OH^- + H_2O_2$
   (b) $2O_2^- + 2H_2O \rightarrow 2OH^- + H_2O_2 + O_2$

Long Answer Type

5. Compound: A: CaO; B: Ca $(OH)_2$; C: $CaCO_3$; D: $Ca(HCO_3)_2$

   $Ca(HCO_3)_2$ is soluble in water. Hence, milkiness of solution disappears on passing excess carbon dioxide into the solution of compound B.
6. $8\ LiH + Al_2Cl_6 \rightarrow 2LiAlH_4 + 6LiCl$

   $LiAlH_4 + 2BeCl_2 \rightarrow 2BeH_2 + LiCl + AlCl_3$
7. The element is beryllium
8. The element is sodium.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (a) $2KO_3 \xrightarrow{H_2O} 2KOH + \frac{3}{2}O_2$

   $KOH + CO_2 \rightarrow K_2CO_3 + H_2O$
2. (a) Deep blue color is due to solvoted e^-, which absorbs energy in the visible region of light, and thus, imparts blue color to the solution.

   $M + (x + y)\ NH_3 \rightarrow [M(NH_3)_x]^+ + [e(NH_3)_y]^-$
3. (d) Sulphate of metal M is soluble but its hydroxide is insoluble. In alkaline earth metals, solubility of sulphates decreases down the group, whereas solubility of hydroxides increases down the group.

   As the hydroxide is soluble in NaOH, thus, it must be amphoteric in nature. Be is the only element in II group which is amphoteric due to diagonal relationship with Al.
4. (a) When mixed with water, the setting of cement takes place to give a hard mass. This is due to hydration of the molecules of the constituents and their rearrangement to develop interlocked needle-like crystals of hydrated silicates.
5. (a) Calcined gypsum is $CaSO_4$ and gypsum is $CaSO_4 \cdot 2H_2O$
6. (a) As we move down in magnesium group, both hydration energies of cations and lattice energies of solids decrease but the decrease in hydration energies dominates, and as a result, solubility of carbonates decreases down the group.
7. (b) Sulphates of 2nd group causes hardness of water.
8. (a) Magnesium nitride is Mg_3N_2.

   $Mg_2N_2 + H_2O \rightarrow 3Mg(OH)_2 + 2NH_3 \uparrow$
9. (c) According to MOT, that is, molecular orbital theory, H_2 has all electrons paired, so it is diamagnetic
10. (c) LiCl has covalent character in it. For other three salt, anion is same and for cations higher the charge density on cations, higher will be lattice energy, which increases the melting point of the solid.
12. (d) Due to less charge density on Rb ion, its hydration is low. So the size of hydrated $Rb^{\oplus}$ is the smallest of all. Hence, it has maximum mobility.
13. (d) Mixture of $(CO + H_2)$ is called water gas. The production of dihydrogen can be done by reacting CO of this mixture with steam in the presence of iron chromates as catalyst.

    $CO_{(g)} + H_{2(g)}O \xrightarrow[\text{Catalyst}]{673\ K} CO_{2(g)} + H_{2(g)}$

    CO_2 is removed by scrubbing with sodium arsenite solution that is absorption of CO_2 in alkali
14. (a) $LiNO_2 \xrightarrow{\Delta} Li_2O + NO_2 + O_2$
15. (b) $Na_2O_{(s)} + H_2O \rightarrow NaOH$

    Oxide ion donates e^- to $H^{\oplus}$. So, the answer is option (b).
16. (c) $CaCO_3 \xrightarrow{\Delta} \underset{\text{basic oxide}}{CaO} + \underset{\text{acidic oxide}}{CO_2}$
17. (d) Reaction of ionic hydrides like NaH with water

    $NaH + H_2O \rightarrow NaOH + H_2$

JEE (Advanced) Exercises

Fill in the Blanks Type

1. Anhydrous $MgCl_2$ is obtained by heating the hydrated salt with **dry HCl**.

   $MgCl_2 \cdot 6H_2O \xrightarrow{\text{Dry HCl}} MgCl_2 + 6H_2O$
2. The increase in the solubility of iodine in an aqueous solution of potassium iodide is due to the formation of $\mathbf{KI_3}$.

   $KI + I_2 \rightarrow KI_3$
3. The adsorption of hydrogen by palladium is commonly known as **occlusion**.

4. Sodium gets dissolved in liquid ammonia because of **ammoniated electrons**.
The alkali metals dissolve in liquid ammonia without the evolution of hydrogen. The color of the dilute solutions is blue.
$$Na^+ + (x+y)NH_3 \rightarrow [Na(NH_3)_x]^+ + \underset{\text{Ammoniated electrons}}{[e(NH_3)_y]^-}$$
On heating, its blue color changes to bronze.
It is the ammoniated electron that is responsible for the color and other properties. The solutions are good conductors of electricity and have strong reducing properties. The solutions are paramagnetic in nature.
5. Hydrogen gas is liberated by the action of aluminium with concentrated solution of **sodium hydroxide**.
$$2Al + 2NaOH + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$$

True/False Type

1. **False.**
On heating, $MgCl_2 \cdot 6H_2O$ undergoes partial hydrolysis.
$$MgCl_2 \cdot 6H_2O \rightleftharpoons Mg(OH)Cl + HCl + 5H_2O$$
Anhydrous $MgCl_2$ is obtained by heating the hydrated salt with dry HCl.
$$MgCl_2 \cdot 6H_2O \xrightarrow{\text{Dry HCl}} MgCl_2 + 6H_2O$$
2. **False.**
Sodium when burnt in excess of oxygen gives sodium peroxide (Na_2O_2).
Lithium gives oxide, sodium gives peroxide, and other alkali metals form superoxides in this reaction.

Single Correct Answer Type

1. (b) Temporary hardness of water is due to the presence of bicarbonates of calcium and magnesium.
$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$$
The temporary hardness of water can be removed by the addition of calculated quantity of milk of lime which converts soluble bicarbonates into insoluble carbonates which can be removed.
2. (a) Calcium is obtained by the electrolysis of a fused mass consisting of six parts calcium chloride and one part calcium fluoride at about 700°C in an electrolytic cell made of graphite which acts as anode and a water-cooled cathode of iron which is suspended from the top in the fused mass. On passing current, calcium is discharged at the cathode.
$$CaCl_2 \rightleftharpoons Ca^{2+} + 2Cl^-$$
At cathode: $Ca^{2+} + 2e^- \rightarrow Ca$
At anode: $2Cl^- \rightarrow 2Cl + 2e^-$
3. (d) The alkali metals dissolve in liquid ammonia without the evolution of hydrogen. The color of the dilute solutions is blue.
$$Na^+ + (x+y)NH_3 \rightarrow [Na(NH_3)_x]^+ + \underset{\text{Ammoniated electrons}}{[e(NH_3)_y]^-}$$
On heating, its blue color changes to bronze.
It is the ammoniated electron that is responsible for the color and other properties. The solutions are good conductors of electricity and have strong reducing properties. The solutions are paramagnetic in nature.
4. (c) Heavy water is an oxide of heavy hydrogen, which is called deuterium. It is D_2O.
5. (d) Glauber's salt is $Na_2SO_4 \cdot 10H_2O$.
6. (a) Alkali metal nitrates, except lithium, decompose upon strong heating to give oxygen gas and a metal nitrite.
7. (a) At cathode, hydrogen is evolved. At anode, oxygen gas is evolved.
8. (d) The metallic luster of sodium and other metals is due to the oscillation of loosely bound electrons. When light falls upon the electrons, they absorb energy and are set into oscillations, and they emit radiations which are responsible for the metallic luster.
9. (b) $BeCO_3 < MgCO_3 < CaCO_3 < K_2CO_3$
Alkali metal carbonates are more stable than carbonates of alkaline earth metals, and they do not decompose on heating; therefore potassium carbonate is thermally most stable.
10. (b) One of the methods to prepare sodium thiosulphate is to heat sodium sulphate with sulphur in alkaline medium.
$$Na_2SO_3 + S \xrightarrow{OH^-, \Delta} Na_2S_2O_3$$
11. (c) Phosphine gas is obtained.
$$Ca_3P_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2PH_3$$
12. (c) Polyphosphates are used as water softening agents because they form soluble complexes with cations responsible for the hardness of water.
$$2CaSO_4 + Na_2[Na_4(PO_3)_6] \rightarrow Na_2[Ca_2(PO_3)_6] + 2Na_2SO_4$$
$$2MgSO_4 + Na_2[Na_4(PO_3)_6] \rightarrow Na_2[Mg_2(PO_3)_6] + 2Na_2SO_4$$

13. (b) $Na_2S_2O_3 + 4Cl_2 + 5H_2O \rightarrow 2NaHSO_4 + 8HCl$

14. (a) A white precipitate of magnesium ammonium phosphate is formed.

$$MgSO_4 + Na_2HPO_4 + NH_4OH \rightarrow \underset{\text{White ppt.}}{Mg(NH_4)PO_4\downarrow} + Na_2SO_4 + H_2O$$

15. (b) Temporary hardness of water is due to the presence of bicarbonates of calcium and magnesium.

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$$

The temporary hardness of water can be removed by the addition of calculated quantity of milk of lime which converts soluble bicarbonates into insoluble carbonates, which can be removed.

Multiple Correct Answers Type

1. (a), (b) When the hydration energy is more than the lattice energy, the salt is soluble in water and vice versa.

2. (b), (d) When zeolite, which is hydrated sodium aluminium silicate, is treated with hard water, the sodium ions are exchanged with both Ca^{2+} and Mg^{2+} ions.

3. (b) Silicon is used in solar cells.

4. (a), (b) The alkali metals dissolve in liquid ammonia without the evolution of hydrogen. The color of the dilute solution is blue.

$$Na^+ + (x+y)NH_3 \rightarrow [Na(NH_3)_x]^+ + \underset{\text{Ammoniated electrons}}{[e(NH_3)_y]^-}$$

On heating, its blue color changes to bronze.
It is an ammoniated electron which is responsible for the color and other properties. The solutions are good conductors of electricity and have strong reducing properties. The solutions are paramagnetic in nature.

5. (a), (b), (d)

$$2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2$$

$$2NaNO_3 \xrightarrow{800°C} Na_2O + N_2 + \frac{5}{2}O_2$$

6. (a), (b) Sodium when heated in dry air, first forms sodium oxide, then sodium peroxide.

7. (a, b, c) If ammonia considered as a gas then reaction will be:

(a) $Na + \underset{\text{(excess)}}{NH_3} \rightarrow NaNH2 + \frac{1}{2}H_2$

($NaNH_2 + \frac{1}{2}H_2$ are diamagnetic)

If ammonia considered as a liquid then reaction will be

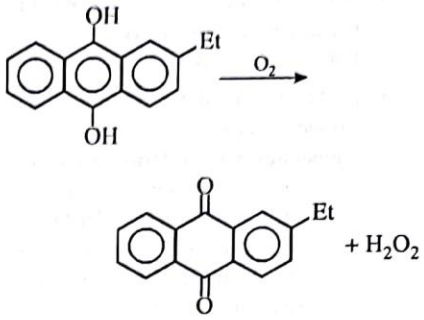
$$M + (x+y)NH_3 \rightarrow [M(NH_3)_x]^+ + [e(NH_3)y]^-$$

ammoniated e^-
blue colour
paramagnetic
S.R.A

(b) $K + \underset{\text{excess}}{O_2} \rightarrow KO_2\ (K^+, O_2^-)$

(c) $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

(d)



In (a) products are diamagnetic
(b) KO_2 is paramagnetic
(c) $Cu(NO_3)_2$, NO are paramagnetic
(d) produts are diamagnetic

Assertion-Reasoning Type

1. (a) Statement-I and Statement-II are correct and Statement-II gives the correct explanation.

2. (c) According to Fajan rule, the smaller the cation, the more is the polarizing power and, therefore, more is the polarization which leads to more covalent character. Due to the smaller size of lithium, it forms covalent chloride. There is a high difference between the electronegativities of Li and Cl.

3. (b) The alkali metals dissolve in liquid ammonia without the evolution of hydrogen. The color of the dilute solutions is blue.

$$Na^+ + (x+y)NH_3 \rightarrow [Na(NH_3)_x]^+ + \underset{\text{Ammoniated electrons}}{[e(NH_3)_y]^-}$$

On heating, its blue color changes to bronze.
It is an ammoniated electron which is responsible for the color and other properties. The solutions are good conductors of electricity and have strong reducing properties. The solutions are paramagnetic in nature.

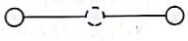
Subjective Type

1. The Solvay process is used for the manufacture of sodium carbonate. It cannot be used for the manufacture of potassium carbonate as potassium bicarbonate is very soluble and does not crystallize like sodium bicarbonate. Therefore, potassium bicarbonate cannot be filtered out.

2. Calcium silicate and phosphorus are formed.

$$2Ca_3(PO_4)_2 + 6SiO_2 + 10C \rightarrow 6CaSiO_3 + 10CO + P_4$$

3. H_2O_2 is a better oxidizing agent than water because it can provide nascent oxygen easily.
$H_2O_2 \rightarrow H_2O + [O]$

4. (i) MgO is used for the lining of steel making furnace because it is stable at very high temperatures and it forms slag with impurities. In this manner, it helps in removing the impurities.
(ii) $N_2H_4 + 2H_2O_2 \rightarrow N_2 + 4H_2O$
The mixture of N_2H_4 and H_2O_2 (in the presence of Cu(II) catalyst) is used as a rocket propellant because of two reasons:
   (a) The reaction is highly exothermic.
   (b) Large volume of gases are evolved.
(iii) $MgCl_2$ 
sp-Hybridization
Linear shape
$SnCl_2$
sp^2-Hybridization
Two bond pairs, one lone pair
V-shaped
In the molecule of magnesium chloride, the valence orbital of magnesium is *sp*-hybridized (i.e., the molecule is linear). In the molecule of stannous chloride, valence orbital of tin is sp^2-hybridized (i.e., the molecule is angular).

5. $NaCl + NH_4OH + CO_2 \rightarrow NH_4Cl + NaHCO_3$
Sodium bicarbonate is formed. This reaction is used in the Solvay process for the manufacture of sodium carbonate.

6. (i) Ammonia is produced.
$$Zn + NaNO_2 + NaOH \rightarrow Na_2ZnO_2 + NH_3 + H_2O$$
(ii) Iodine is formed.
$$2NaIO_3 + 5NaHSO_3 \rightarrow 3NaHSO_4 + 2Na_2SO_4 + I_2 + H_2O$$

7. In the periodic table, the basic character of oxides decreases from left to right. Also the basic character of oxides increases down the group. Therefore, following is the increasing order of basic character of the given oxides:
$$NiO < MgO < SrO < K_2O < Cs_2O$$

8. $2KNO_3(s) + 10K(s) \rightarrow 6H_2O + N_2$

9. Gas *A* is ammonia and Solid *B* is calcium carbonate.
$3Ca + N_2 \rightarrow Ca_3N_2$
$Ca_3N_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3$
$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

10. 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.

11. The size of alkaline earth metal ions is lower than the size of alkali metal ions. The lower the size of the cation, the higher is the hydration energy.
So the salts of alkaline earth metals have more water molecules of crystallization than those of alkali metals.

12. Sulphates decompose on heating to give the corresponding oxide.
$$MgSO_4 \xrightarrow{\Delta} MgO + SO_2 + \frac{1}{2}O_2$$
The stability increases as the basic nature of the metal increases. This is clear from the increasing decomposition temperatures down the group.
$$SrSO_4 > CaSO_4 > MgSO_4 > BeSO_4$$

13. $Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$
When chlorine is passed over dry slaked lime, bleaching powder is produced.

14. 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.

15. (i) $Na_2O_2 + 2H_2O \rightarrow 2NaOH + H_2O_2$

$H_2O_2 \rightarrow H_2O + [O]$

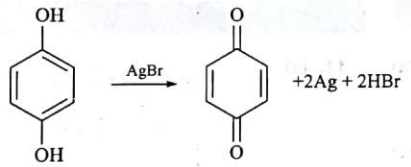
H_2O_2 turns the color of red litmus paper to white due to its bleaching action by oxidation. Therefore, the given substance is Na_2O_2.

(ii) $Na_2O + H_2O \rightarrow 2NaOH$

If the given substance was Na_2O, it would form only NaOH, which turns the color of red litmus paper to blue.

16. Beryllium ion is very small in size, and so it has a very high polarizing power (Fajan rules). Also, vacant *p*-orbitals are available. So beryllium chloride is readily hydrolyzed.

17. The light sensitized photographic film is treated with hydroquinone which is a very mild reducing agent. It does not affect the unexposed silver bromide.



Unexposed AgBr is dissolved in $Na_2S_2O_3$ (hypo) to give sodium argentothiosulphate.

$AgBr + 2Na_2S_2O_3 \rightarrow Na_3[Ag(S_2O_3)_2] + NaBr$

18. $2KMnO_4 + 3H_2SO_4 + 5H_2O_2 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O$

$2KMnO_4 + 3MnSO_4 + 2H_2O \rightarrow 5MnO_2 + 2H_2SO_4 + K_2SO_4$

$MnO_2 + Na_2C_2O_4 + 2H_2SO_4 \rightarrow MnSO_4 + Na_2SO_4 + 2H_2O + 2CO_2$

Millimoles of $Na_2C_2O_4 = 10 \times 0.2 = 2$

mEq of $Na_2C_2O_4 = 4$
mEq of $MnO_2 = 4$
mEq of $KMnO_2 = 4$
mEq of $H_2O_2 = 4$
Millimoles of $H_2O_2 = 2$
Millimoles of H_2O_2 = Molarity $\times V_{mL}$
$\therefore$ 2 = Molarity $\times$ 20
or Molarity = 0.1

19. $BaC^*O_3 + H_2SO_4 \rightarrow BaSO_4 + C^*O_2 + H_2O$

Carbon dioxide has a linear structure as follows:
O═C═O

20. $Na_2CO_3 + 2SO_2 + H_2O \rightarrow 2NaHSO_3 + CO_2$

$2NaHSO_3 + Na_2CO_3 \rightarrow 2Na_2SO_3 + H_2O + CO_2$

$Na_2SO_3 + S \rightarrow Na_2S_2O_3$

$2Na_2S_2O_3 + I_2 \xrightarrow{\Delta} Na_2S_4O_6 + 2NaI$

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)

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (a)	2. (c)	3. (b)	4. (d)	5. (d)	6. (a)	7. (a)	8. (a)	9. (a)	10. (d)
11. (d)	12. (d)	13. (b)	14. (c)	15. (c)	16. (b)	17. (d)	18. (a)	19. (c)	20. (b)
21. (d)	22. (d)	23. (d)	24. (d)	25. (c)	26. (b)	27. (d)	28. (d)	29. (c)	30. (a)
31. (d)	32. (b)	33. (b)	34. (c)	35. (c)	36. (b)	37. (c)	38. (d)	39. (a)	40. (a)
41. (d)	42. (c)	43. (a)	44. (b)	45. (c)	46. (a)	47. (c)	48. (c)	49. (d)	50. (c)
51. (b)	52. (c)	53. (a)	54. (a)	55. (d)	56. (c)	57. (b)	58. (a)	59. (b)	60. (a)
61. (b)	62. (d)	63. (a)							

JEE (Advanced) Exercises

Single Correct Answer Type

1. (b)	2. (d)	3. (d)	4. (c)	5. (d)	6. (a)	7. (d)	8. (d)	9. (b)	10. (d)
11. (c)	12. (c)	13. (a)	14. (b)	15. (b)	16. (b)	17. (b)	18. (a)	19. (a)	20. (b)
21. (d)	22. (a)	23. (a)	24. (b)	25. (b)	26. (c)	27. (a)	28. (d)	29. (b)	30. (c)
31. (a)	32. (d)	33. (d)	34. (a)	35. (b)	36. (d)	37. (b)	38. (b)	39. (d)	40. (d)
41. (a)	42. (c)	43. (a)	44. (d)	45. (b)	46. (d)	47. (d)	48. (a)	49. (b)	50. (b)
51. (a)	52. (a)	53. (d)	54. (c)	55. (a)	56. (d)	57. (b)	58. (b)	59. (b)	60. (c)
61. (c)	62. (a)	63. (d)							

Multiple Correct Answers Type

1. (a), (b)	2. (a), (b), (c), (d)	3. (a), (b), (c)	4. (a), (b), (c)	5. (b), (c), (d)
6. (a), (b)	7. (b), (c), (d)	8. (a), (b), (d)	9. (a), (c), (d)	10. (a), (c)
11. (a), (b)	12. (b), (c), (d)	13. (b), (d)	14. (a), (b), (c)	15. (b), (c), (d)
16. (a), (b)	17. (a), (b), (d)	18. (a), (b)	19. (a), (b), (c), (d)	20. (a), (c), (d)
21. (a), (b), (d)	22. (c), (d)	23. (a), (b), (d)		

Comprehension Type

Comprehension-1	1. (c)	2. (d)	3. (b)		
Comprehension-2	4. (a)	5. (c)	6. (c)		
Comprehension-3	7. (c)	8. (b)	9. (b)	10. (a)	11. (a)
Comprehension-4	12. (b)	13. (a)	14. (d)		
Comprehension-5	15. (b)	16. (b)	17. (b)		
Comprehension-6	18. (b)	19. (a)	20. (b)	21. (c)	
Comprehension-7	22. (b)	23. (b)	24. (a)	25. (c)	

Assertion-Reasoning Type

1. (a) 2. (c)

Matching Column Type

1. (a) r, s, t; (b) q, s; (c) s; (d) p, s
2. (a) q; (b) q, s; (c) p, r; (d) p, r
3. (a) q, t, u; (b) p, s; (c) q, r; (d) u; (e) t
4. (a) r; (b) q; (c) p
5. (a) p, r, s, t; (b) p; (c) p; (d) p, q
6. (a) p, q, t; (b) p, t; (c) s, t; (d) r, s, t
7. (a) p, q, r; (b) p, s; (c) p, t; (d) p, t
8. (a) q; (b) p, r; (c) s

Integer Answer Type

1. (2)	2. (3)	3. (2)	4. (2)	5. (1)	6. (2)	7. (2)	8. (1)	9. (3)	10. (2)
11. (1)	12. (0)	13. (3)	14. (4)	15. (2)	16. (2)	17. (3)	18. (4)		

NCERT Exemplar Exercises

Single Correct Answer Type

1. (d) 2. (a) 3. (c) 4. (d) 5. (a) 6. (a) 7. (a) 8. (c) 9. (b) 10. (a)
11. (a) 12. (a) 13. (b) 14. (a) 15. (c) 16. (a) 17. (d) 18. (b) 19. (a) 20. (c)
21. (d)

Multiple Correct Answers Type

1. (b), (d) 2. (a), (c) 3. (a), (b) 4. (b), (c) 5. (a), (c) 6. (a), (b) 7. (a), (b)

Matching Column Type

1. (a) → (r); (b) → (q); (c) → (p), (s), (t); (d) → (p), (s), (t)
2. (a) → (r); (b) → (s); (c) → (q); (d) → (p)
3. (a) → (u); (b) → (s); (c) → (q); (d) → (r); (e) → (t); (f) → (p)

Assertion-Reasoning Type

1. (a) 2. (a)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (a) 2. (a) 3. (d) 4. (a) 5. (a) 6. (a) 7. (b) 8. (a) 9. (c) 10. (c)
11. (a) 12. (d) 13. (d) 14. (a) 15. (b) 16. (c) 17. (d)

JEE (Advanced) Exercises

Single Correct Answer Type

1. (b) 2. (a) 3. (d) 4. (c) 5. (d) 6. (a) 7. (a) 8. (d) 9. (b) 10. (b)
11. (c) 12. (c) 13. (b) 14. (a) 15. (b)

Multiple Correct Answers Type

1. (a), (b) 2. (b), (d) 3. (b) 4. (a), (b) 5. (a), (b), (d)
6. (a), (b) 7. (a), (b), (c)

Assertion-Reasoning Type

1. (a) 2. (c) 3. (b)

6

p-Block Elements

JEE (Main) Exercises

Single Correct Answer Type

1. Which is true for an element present in group 13 of the periodic table?
   (a) It is gas at room temperature
   (b) It has oxidation state of 4+
   (c) It forms R_2O_3 (d) It forms RX_2
2. Borax is prepared by treating colemanite with:
   (a) $NaNO_3$ (b) NaCl
   (c) $NaHCO_3$ (d) Na_2CO_3
3. On the addition of mineral acid to an aqueous solution of borax, the following compound is formed:
   (a) Boron hydride (b) Ortho-boric acid
   (c) Meta-boric acid (d) Pyro-boric acid
4. Three centered bond is present in:
   (a) NH_3 (b) B_2H_6
   (c) BCl_3 (d) $AlCl_3$
5. Boron compounds behave as Lewis acids because of their:
   (a) Acidic nature (b) Covalent nature
   (c) Ionic nature (d) Vacant orbital
6. Which of the following is not a Lewis acid?
   (a) SiF_4 (b) $FeCl_3$
   (c) BF_3 (d) C_2H_4
7. $AlCl_3$ on hydrolysis gives:
   (a) $Al_2O_3 \cdot H_2O$ (b) $Al(OH)_3$
   (c) Al_2O_3 (d) $AlCl_3 \cdot 6H_2O$
8. Thallium shows different oxidation states because:
   (a) Of its high reactivity
   (b) Of inert pair of electrons
   (c) Of its amphoteric nature
   (d) It is a transition metal
9. H_3BO_3 is:
   (a) Monobasic and weak Lewis acid
   (b) Monobasic and weak Bronsted acid
   (c) Monobasic acid and strong Lewis acid
   (d) Tribasic acid and weak Bronsted acid
10. Which of the following compound is known as inorganic benzene?
    (a) B_6H_6 (b) C_5H_5B
    (c) $C_3N_3H_3$ (d) $B_3N_3H_6$
11. The structure and hybridization of $Si(CH_3)_4$ are:
    (a) Bent, *sp* (b) Trigonal, sp^2
    (c) Octahedral, sp^3d^2 (d) Tetrahedral, sp^3
12. Which of the following is not hydrolyzed?
    (a) CCl_4 (b) $SiCl_4$
    (c) $SnCl_4$ (d) $PbCl_4$
13. Which of the following halides is least stable and has doubtful existence?
    (a) CI_4 (b) SnI_4
    (c) GeI_4 (d) PbI_4
14. The number and type of bonds between two carbon atoms in CaC_2 are:
    (a) One sigma and one pi bond
    (b) One sigma and two pi bonds

(c) One sigma and one and a half pi bond
(d) One sigma bond

15. The material used in solar cells contains:
(a) Si (b) Sn
(c) Ti (d) Cs

16. Which of the following is correct composition of water gas?
(a) $CO + Cl_2$ (b) $CO + N_2$
(c) $CO + H_2$ (d) $CO + H_2 + N_2$

17. What is the formula for carbon suboxide?
(a) CO (b) CO_2
(c) C_2O_4 (d) C_3O_2

18. Percentage of lead in lead pencil is:
(a) Zero (b) 20
(c) 80 (d) 70

19. CCl_4 is used as fire extinguisher because:
(a) Its m.pt. is high (b) It forms covalent bond
(c) Its b.pt. is low
(d) It gives incombustible vapors

20. Marsh gas contains:
(a) CH_4 (b) CO_2
(c) C_2H_6 (d) N_2

21. Which of the following is most stable?
(a) Sn^{2+} (b) Ge^{2+}
(c) Si^{2+} (d) Pb^{2+}

22. Carborundum is:
(a) Al_2O_3 (b) SiC
(c) BF_3 (d) B_4C

23. The acid which contains a peroxo linkage is:
(a) Sulphurous acid (b) Pyrosulphuric acid
(c) Dithionic acid (d) Caro's acid

24. Graphite is a soft solid lubricant extremely difficult to melt. The reason for this anomalous behavior is that graphite:
(a) Has molecules of variable molecular masses like polymers
(b) Has carbon atoms arranged in large plated of rings of strongly bonded carbon atoms with weak interplate bonds
(c) Is a non-crystalline substance
(d) Is an allotropic form of diamond

25. In SiF_6^{2-} and $SiCl_6^{2-}$, which one is known and why?
(a) SiF_6^{2-} because of small size of F
(b) SiF_6^{2-} because of large size of F
(c) SiF_6^{2-} because of small size of Cl
(d) SiF_6^{2-} because of large size of Cl

26. Which is likely to show inert pair effect?
(a) K (b) Mg
(c) Al (d) Pb

27. The stability of dihalides of Si, Ge, Sn, and Pb increases steadily in the sequence:
(a) $PbX_2 < SnX_2 < GeX_2 < SiX_2$
(b) $GeX_2 < SiX_2 < SnX_2 < PbX_2$
(c) $SiX_2 < GeX_2 < PbX_2 < SnX_2$
(d) $SiX_2 < GeX_2 < SnX_2 < PbX_2$

28. Diamond is hard because:
(a) All the four valence electrons are bonded to each carbon atoms by covalent bonds
(b) It is a small molecule
(c) It is made up of carbon atoms
(d) It cannot be burnt

29. Products formed when $Pb(NO_3)_2$ is heated are:
(a) PbO, N_2, O_2 (b) $Pb(NO_2)_2$, O_2
(c) PbO, NO_2, O_2 (d) Pb, N_2, O_2

30. Which one of the following pairs is obtained on heating ammonium dichromate?
(a) N_2 and H_2O (b) H_2O and H_2O
(c) NO_2 and H_2O (d) NO and NO_2

31. Silver chloride dissolves in excess of NH_4OH. The cation present in solution is:
(a) Ag^+ (b) $[Ag(NH_3)_4]^+$
(c) $[Ag(NH_3)_2]^+$ (d) $[Ag(NH_3)_6]^+$

32. The catalyst used in the manufacture of ammonia by Haber's process is:
(a) Pt (b) Fe
(c) Mo (d) V_2O_5

33. Industrial preparation of nitric acid by Ostwald's process involves:
(a) Oxidation of NH_3
(b) Reduction of NH_3
(c) Hydrogenation of NH_3
(d) hydrolysis of NH_3

34. White phosphorus reacts with caustic soda. The products are PH_3 and NaH_2PO_2. This reaction is an example of:
(a) Oxidation (b) Reduction
(c) Neutralization (d) Disproportionation

35. Which one of the following is the strongest base?
(a) AsH_3 (b) SbH_3
(c) PH_3 (d) NH_3

36. When zinc reacts with very dilute nitric acid it produces:
(a) NH_4NO_3 (b) NO
(c) NO_2 (d) H_2

37. Nitrogen molecule is chemically less active because of its:
(a) small atomic energy
(b) high dissociation energy
(c) high electronegativity
(d) stable electronic configuration

38. Which of the following oxides of nitrogen is the anhydride of nitrous acid?
(a) NO (b) N_2O_3
(c) N_2O_4 (d) N_2O_5

39. Which of the following fluorides does not exist?
(a) NF_5 (b) PF_5
(c) AsF_5 (d) SbF_5

40. When ammonia is passed over heated CuO, it is oxidized to:
(a) HNO_2 (b) N_2O
(c) N_2 (d) NO_2

41. The CN^- ion 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

42. Which oxide does not act as a reducing agent?
(a) NO (b) NO_2
(c) N_2O (d) N_2O_5

43. When $AgNO_3$ is heated strongly, the products formed are:
(a) NO and NO_2 (b) NO_2 and N_2O
(c) NO_2 and O_2 (d) NO and O_2

44. Aqueous solution of ammonia consists of:
(a) H^+ only (b) OH^- only
(c) NH_4^+ only (d) NH_4^+ and OH^-

45. Which of the following species is paramagnetic?
(a) O_2^{2-} (b) NO
(c) CO (d) CN^-

46. The BCl_3 is a planar molecule, whereas NCl_3 is pyramidal because:
(a) N—Cl bond is more covalent than B—Cl bond
(b) B—Cl bond is more polar than N—Cl bond
(c) Nitrogen atom is smaller than boron
(d) BCl_3 has no lone pair but NCl_3 has a lone pair of electron

47. 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

48. In which of the following the bond angle is maximum?
(a) NH_3 (b) NH_4^+
(c) PCl_3 (d) SCl_2

49. The hybridization state of the central atom in PCl_5 is:
(a) sp^3d (b) sp^3d^2
(c) sp^3 (d) d^2sp^3

50. Cl—P—Cl bond angles in PCl_5 molecule are:
(a) 120° and 90° (b) 60° and 90°
(c) 60° and 120° (d) 120° and 30°

51. Phosphine acetylene and ammonia can be formed by treating water with:
(a) Mg_3P_2, Al_4C_3, Li_3N
(b) Ca_3P_2, CaC_2, Mg_3N_2
(c) Ca_3P_2, CaC_2, $CaCN_2$
(d) Ca_3P_2, Mg_2C, NH_4NO_3

52. The shape of PCl_3 molecule is:
(a) Trigonal bipyramidal (b) Tetrahedral
(c) Pyramidal (d) Square planar

53. Atoms in P_4 molecule of white phosphorus are arranged regularly in the following way:
(a) At the corners of a cube
(b) At the corners of an octahedron
(c) At the corners of a tetrahedron
(d) At the center and corners of a tetrahedron

54. Correct order of bond angles for the following is:
(a) $NH_3 > PCl_3 > BCl_3$ (b) $BCl_3 > CH_4 > PCl_3$
(c) $BCl_3 > PCl_3 > NH_3$ (d) $PCl_3 > BCl_3 > NH_3$

55. The reaction of elemental P_4 in aqueous NaOH gives:
(a) PH_3, NaH_2PO_2 (b) PH_3, Na_3PO_4
(c) NaH_2PO_4, Na_3PO_4 (d) Na_3P, Na_3PO_4

56. Which of the following oxides is amphoteric in character?
(a) CaO (b) CO_2
(c) SiO_2 (d) SnO_2

57. The geometry of H_2S and its dipole moment are:
(a) Angular and non-zero (b) Angular and zero
(c) Linear and zero (d) Linear and non-zero

58. The oxidation number of sulphur in S_8, S_2F_2, H_2S respectively, are:
(a) 0, +1 and –2 (b) +2, +1 and –2
(c) 0, +1 and +2 (d) –2, +1 and –2

59. Which of the following has $p_\pi - d_\pi$ bonding?
(a) NO_3^- (b) SO_3^{2-}
(c) BO_3^{3-} (d) CO_3^{2-}

60. In the species O_2, O_2^+, O_2^- and O_2^{2-}, the correct decreasing order of bond strength is:
(a) $O_2 > O_2^+ > O_2^- > O_2^{2-}$
(b) $O_2^+ > O_2 > O_2^- > O_2^{2-}$
(c) $O_2^{2-} > O_2^- > O_2^+ > O_2$
(d) $O_2^- > O_2^{2-} > O_2 > O_2^+$

61. The correct order of O—O bond length in O_2, H_2O_2 and O_3 is:
(a) $O_3 > H_2O_2 > O_2$ (b) $O_2 > H_2O_2 > O_3$
(c) $O_2 > O_3 > H_2O_2$ (d) $H_2O_2 > O_3 > O_2$

62. Oxidizing action increases in the following order:
(a) Cl < Br < I < F (b) Cl < I < Br < F
(c) I < F < Cl < Br (d) I < Br < Cl < F

63. Which of the following statements 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

64. When iodine is dissolved in CCl_4, the color that results is:
(a) Brown (b) Bluish green
(c) Violet (d) Colorless

65. Hydrogen bonding does not play any role in the boiling point of:
(a) NH_3 (b) H_2O
(c) HI (d) HF

66. The following acids have been arranged in order of decreasing acid strength. Identify the correct order:
ClOH(I) BrOH(II) IOH(III)
(a) I > II > III (b) II > I > III
(c) III > II > I (d) I > III > II

67. Hydrogen fluoride is a liquid unlike other hydrogen halides because:
(a) H—F bond is strong
(b) F-atom is small in size
(c) Hydrogen bonding is present
(d) HF is a weak acid

68. Which of the following possesses the highest bond energy?
(a) F_2 (b) Cl_2
(c) Br_2 (d) I_2

69. Order of boiling point is:
(a) HF > HI > HBr > HCl
(b) HF > HBr > HI > HCl
(c) HCl > HBr > HI > HF
(d) HCl > HI > HBr > HF

70. Which of the following is a pseudohalogen?
(a) IF_7 (b) CN^-
(c) ICl_2 (d) I_3^-

71. Which of the following is the strongest acid?
(a) HBr (b) HF
(c) H_2S (d) PH_3

72. Which is formed when $K_2Cr_2O_7$, $CaCl_2$, and conc. H_2SO_4 are heated?
(a) $Cr_2(SO_4)_3$ (b) $CrCl_3$
(c) CrO_2Cl_2 (d) K_2CrO_4

73. On heating $KClO_3$ we get:
(a) $KClO_2 + O_2$ (b) $KCl + O_2$
(c) $KCl + O_3$ (d) $KCl + O_2 + O_3$

74. The correct order of thermal stability of hydrogen halides (H—*X*) is:
(a) HI > HBr > HCl > HF
(b) HF > HCl > HBr > HI
(c) HCl > HF > HBr > HI
(d) HI > HCl > HF > HBr

75. The set with correct order of acidity is:
(a) $HClO < HClO_2 < HClO_3 < HClO_4$
(b) $HClO_4 < HClO_3 < HClO_2 < HClO$
(c) $HClO < HClO_4 < HClO_3 < HClO_2$
(d) $HClO_4 < HClO_2 < HClO_3 < HClO$

76. The reaction,
$$3ClO^-_{(aq.)} \longrightarrow ClO_3^-{}_{(aq.)} + 2Cl^-_{(aq.)}$$
is an example of:
(a) Oxidation reaction (b) Reduction reaction
(c) Disproportionation (d) Decomposition reaction

77. Hydrogen bond is strongest in:
(a) F—H—O (b) F—H—N
(c) F—H—F (d) All are equally strong

78. Which of the following has highest bond strength?
(a) HI (b) HCl
(c) HF (d) HBr

79. Shape and hybridization of IF_5 respectively are:
(a) Trigonal bipyramidal, sp^3d
(b) See-saw, sp^3d
(c) Square pyramidal, sp^3d^2
(d) Pentagonal pyramidal, sp^3d^3

80. The oxidation states of iodine in HIO_4, H_3IO_5, and H_5IO_6 are respectively:
(a) +1, + 3, +7 (b) +7, +7, +3
(c) +7, +7, +7 (d) +7, +5, +3

81. The electron affinity values (in kJ mol^{-1}) of three halogens *X*, *Y*, and *Z* are respectively –349, –333 and –325. *X*, *Y*, and *Z* respectively are:
(a) F_2, Cl_2, Br_2 (b) Cl_2, F_2 and Br_2
(c) Cl_2, Br_2, F_2 (d) Br_2, Cl_2 and F_2

82. Which one of the following reactions does not occur?
(a) $F_2 + 2Cl^- \longrightarrow 2F^- + Cl_2$
(b) $Cl_2 + 2F^- \longrightarrow 2Cl^- + F_2$
(c) $Br_2 + 2I^- \longrightarrow 2Br^- + I_2$
(d) $Cl_2 + 2Br^- \longrightarrow 2Cl^- + Br_2$

83. Select the correct order from the following:
(a) $N_2O < N_2O_3 < NO$; Acidic character
(b) $MgO > Al_2O_3 > SiO_2$; Basic character
(c) $Fe^{2+} < Fe^{3+} < Mn^{2+}$; Ionic radius order
(d) Sc > La > *Y*; Ionisation energy order

84. Which of the following is the correct order of strength of H-bonding in the given compound?
(a) $HF < NH_3$ (b) $H_2O > H_2O_2$
(c) $H_2O_2 > H_2O$ (d) $NH_3 > H_2O$

85. In which of the following molecules central atom involve expansion of octet?
(a) PCl_3 (b) NCl_3
(c) ClF_3 (d) None of these

86. If pure "*p*" orbitals are involved in molecule formation, then the shape of H_3O^+ will be:
(a) Pyramidal (b) Tetrahedral
(c) Angular (d) Planar

87. Select the correct statement:
(a) NH_3 has higher bond dipole than NF_3
(b) CCl_4 is polar molecule
(c) SF_4 is polar molecule
(d) IF_7 is polar molecule

88. Arrange the following species according to their bond angle order:
(I) O_3 (II) NO_2^- (III) FNO
(a) I > II > III (b) II > I > III
(c) III > II > I (d) II > III > I

89. The species which is not tetrahedral in shape is:
(a) ICl_4^- (b) BI_4^-
(c) AlH_4^- (d) $\overset{+}{N}F_4$

90. Which of the following statements is/are correct regarding IF_5 molecule?
(I) There is only one lone pair present in equatorial
(II) All ∠FIF angles are identical
(III) There are eight faces in this molecule
(IV) The number ∠ FIF angles less than 90° is 8
(a) I, II, and III (b) II, III, and IV
(c) III and IV (d) III only

91. When a solution of sodium hydroxide is added in excess to the solution of potash alum, we obtain:
(a) A white precipitate (b) Bluish white precipitate
(c) A clear solution (d) A crystalline mass

92. B—H—B bridge in B_2H_6 is formed by the sharing of:
(a) 2 electrons (b) 4 electrons
(c) 1 electron (d) 3 electrons

93. The bonds present in borazole are:
(a) 12σ, 3π (b) 9σ, 6π
(c) 6σ, 6π (d) 9σ, 9π

94. BCl_3 does not exist as dimer but BH_3 exists as dimer (B_2H_6) because:
(a) Chlorine is more electronegative than hydrogen
(b) There is $p_\pi - p_\pi$ back bonding in BCl_3, but BH_3 does not contain such multiple bonding
(c) Large-sized chlorine atoms do not fit in between the small boron atoms, whereas small-sized hydrogen atoms fit between boron atoms
(d) None of these

95. Lead chromate is:
(a) Red (b) Yellow
(c) White (d) Black

96. Which of the following is methanide:
(a) Be_2C (b) CaC_2
(c) Mn_3C (d) Mg_3C_2

97. Red lead is:
(a) PbO (b) Pb_3O_4
(c) PbO_2 (d) HgS

98. Laborer's working with phosphorus suffer from a disease in which bones decay. It is known as:

(a) Arthritis (b) Phossy jaw
(c) Rickets (d) Cancer

99. Pure phosphine is not combustible while impure phosphine is combustible; this combustibility is due to the presence of:
(a) P_2H_4 (b) N_2
(c) PH_5 (d) P_2O_5

100. Bond energies in NO, NO^+, and NO^- are such that:
(a) $NO > NO^+ > NO^-$ (b) $NO^- > NO > NO^+$
(c) $NO^+ > NO^- > NO$ (d) $NO^+ > NO > NO^-$

101. Which of the following are not known?
(a) PH_5 (b) PI_5
(c) NCl_5 (d) All of these

102. The most stable and basic hydride of 15th group is:
(a) NH_3 (b) PH_3
(c) AsH_3 (d) BiH_3

103. The gas which is supposed to be acidic anhydride:
(a) NO_2 (b) CO
(c) N_2O (d) NO

104. Bones glow in the dark because:
(a) They contain shining material
(b) They contain red phosphorus
(c) White phosphorus undergoes slow combustion in contact with air
(d) White phosphorus changes into red form

105. P_4O_{10} on reacting with water does not form:
(a) Tetra metaphosphoric acid
(b) Phosphorous acid
(c) Orthophosphoric acid
(d) Pyrophosphoric acid

106. The number of P—O—P bonds in cyclic metaphosphoric acid is:
(a) Zero (b) Two
(c) Three (d) Four

107. The correct order for acid strength is:
(a) $Al_2O_3 < SiO_2 < P_2O_3 < SO_2$
(b) $SiO_2 < SO_2 < Al_2O_3 < P_2O_3$
(c) $Al_2O_3 < SiO_2 < SO_2 < P_2O_3$
(d) $SO_2 < P_2O_3 < SiO_2 < Al_2O_3$

108. The number of S—S bonds in sulphur trioxide trimer (S_3O_9) is:
(a) 3 (b) 2
(c) 1 (d) 0

109. NH_3 cannot be obtained by:
(a) Heating of NH_4NO_3 or NH_4NO_2
(b) Heating of NH_4Cl or $(NH_4)_2CO_3$
(c) Heating of NH_4NO_3 with NaOH
(d) Reaction of AIN or Mg_3N_2 or $CaCN_2$ with H_2O

110. An aqueous solution of BCl_3 is:
(a) Weak acid (b) Weak base
(c) Neutral (d) Strong base

111. In diborane:
(a) 4 bridged hydrogens and two terminal hydrogens are present
(b) 2 bridged hydrogens and four terminal hydrogens are present
(c) 3 bridged hydrogens and three terminal hydrogens are present
(d) None of the above

112. Which of the following metals burns in air at high temperature with the evolution of much heat?
(a) Cu (b) Hg
(c) Pb (d) Al

113. Aluminium (III) chloride forms a dimer because aluminium:
(a) Cannot form a trimer
(b) Has high ionization energy
(c) Belongs to third group
(d) Can have higher coordination number

114. Alum helps in purifying water by:
(a) Forming Si complex with clay particles
(b) Sulphate part which combines with the dirt and removes it
(c) Aluminium which coagulates the mud particles
(d) Making the mud, water soluble

115. The ion(s) that act/s as oxidizing agent in solution is/are:
(a) Tl^+ and Al^{3+} (b) B^{3+} and Al^{3+}
(c) Tl^{3+} only (d) B^{3+} only

116. The stability of +1 oxidation state increases in the sequence:
(a) Tl < In < Ga < Al (b) In < Tl < Ga < Al
(c) Ga < In < Al < Tl (d) Al < Ga < In < Tl

117. An example of major air pollutant is:
(a) O_2 (b) CO_2
(c) CO (d) He

118. The color imparted by Co(II) compounds to glass is:
(a) Deep blue (b) Green
(c) Yellow (d) Red

119. When PbO_2 reacts with conc. HNO_3, the gas evolved is:

(a) NO_2 (b) O_2
(c) N_2 (d) N_2O

120. Graphite is soft and lubricant, extremely difficult to melt. The reason for this anomalous behavior is that graphite:
(a) Has carbon atoms arranged in large plates of rings of strongly bound carbon atoms with weak interpellate bonds
(b) Is a non-crystalline substance
(c) Is an allotrope form of carbon
(d) Has molecules of variable molecular masses like polymers

121. Which one of the following is present in the chain structure of silicates?
(a) $(Si_2O_5^{2-})_n$ (b) $(SiO_3^{2-})_n$
(c) $(SiO_4)^{4-}$ (d) $Si_2O_7^{6-}$

122. Which of the following has the highest calorific value?
(a) Coal gas (b) Water gas
(c) Producer gas (d) Carbon dioxide gas

123. Among the following substituted silanes the one which will give rise to cross-linked silicone polymer on hydrolysis is:
(a) R_3SiCl (b) R_4Si
(c) $RSiCl_3$ (d) R_2SiCl_2

124. C—C bond length is maximum in:
(a) Diamond (b) Graphite
(c) Naphthalene (d) Fullerene

125. NH_3 has much higher boiling point than PH_3 because:
(a) NH_3 has much higher molecular mass
(b) NH_3 forms hydrogen bonds
(c) NH_3 contains ionic bonds while PH_3 contains covalent bonds
(d) NH_3 undergoes umbrella inversion

126. By the action of conc. H_2SO_4, phosphorus changes to:
(a) Phosphorus acid (b) Metaphosphoric acid
(c) Orthophosphoric acid (d) Pyrophosphoric acid

127. Among the following oxides, the lowest acidic is:
(a) P_4O_6 (b) P_4O_{10}
(c) As_4O_6 (d) As_4O_{10}

128. The basic character of the hydrides of Vth group elements decreases in the order:
(a) $NH_3 > PH_3 > AsH_3 > SbH_3$
(b) $SbH_3 > AsH_3 > PH_3 > NH_3$
(c) $NH_3 > SbH_3 > PH_3 > AsH_3$
(d) $SbH_3 > PH_3 > AsH_3 > NH_3$

JEE (Advanced) Exercises

Single Correct Answer Type

1. Nitrogen forms N_2 but phosphorus is converted into P_4 from P_2. The reason for this is:
(a) Triple bond is present between phosphorus atoms
(b) $p\pi$–$p\pi$ bonding is weak
(c) $p\pi$–$p\pi$ bonding is strong
(d) Multiple bond is formed easily

2. The element which forms oxides in all the oxidation states from +1 to +5 is:
(a) N (b) P
(c) As (d) Sb

3. N_2 forms NCl_3, whereas P can form both PCl_3 and PCl_5. Why?
(a) P has *d*-orbitals which can be used for bonding but N_2 does not have
(b) N atom is larger in size than P
(c) P is more reactive towards Cl than N
(d) None of the above

4. Which of the following compound is responsible for catching fire spontaneously in Holme's singal?
(a) P_2H_4 (b) PH_3
(c) C_2H_4 (d) All of these

5. Which is in the decreasing order of boiling points of Vth group hydrides?
(a) $NH_3 > PH_3 > AsH_3 > SbH_3$
(b) $SbH_3 > AsH_3 > PH_3 > NH_3$
(c) $PH_3 > NH_3 > AsH_3 > SbH_3$
(d) $SbH_3 > NH_3 > AsH_3 > PH_3$

6. Which compound acts as an oxidizing as well as a reducing agent?
(a) SO_2 (b) Mn_2O_7
(c) Al_2O_3 (d) CrO_3

7. Hydrolysis of one mole of peroxydisulphuric acid produces:
(a) Two moles of sulphuric acid
(b) Two moles of peroxymonosulphuric acid
(c) One mole of sulphuric acid and one mole of peroxymonosulphuric acid
(d) One mole of sulphuric acid, one mole of peroxymonosulphuric acid, and one mole of hydrogen peroxide

8. Which of the following is the most powerful oxidizing agent?

(a) H_2SO_4 (b) H_3BO_3
(c) HPO_3 (d) H_3PO_4

9. The most powerful oxidizing agent is:
(a) Fluorine (b) Chlorine
(c) Bromine (d) Iodine

10. Which one of the hydracids does not form any precipitate with $AgNO_3$?
(a) HF (b) HCl
(c) HBr (d) HI

11. The strongest reducing agent is:
(a) F^- (b) Cl^-
(c) Br^- (d) I^-

12. HBr and HI can reduce H_2SO_4, HCl can reduce $KMnO_4$, and HF can reduce:
(a) $K_2Cr_2O_7$ (b) $KMnO_4$
(c) H_2SO_4 (d) None of these

13. $Na_2S_2O_3$ is oxidized by I_2 to:
(a) Na_2S (b) Na_2SO_4
(c) $NaHSO_3$ (d) $Na_2S_4O_6$

14. Which of the possible molecule/species is having maximum values for dipole moment (where "*A*" is the central atom)?
(a) AX_3 (having one lone pair on central atom)
(b) AX_4 (Tetrahedral)
(c) AX_4Y (having no lone pair on central atom)
(d) Cannot be predicted

15. Which of the following is incorrect match?
(a) SiF_4 : Can act as lewis acid
(b) Benzyne : All C-atoms are sp^2 hybridized
(c) PBr_3 : Non polar
(d) $CHF = C = CHF$: Nodal planes of π-bonds are not lying in same plane

16. Which of the following molecule/species is having minimum number of lone pair on its central atom?
(a) BrF_3 (b) BrF_4^-
(c) XeF_5^+ (d) I_3^-

17. Select the correct statement:
(a) Basicity of phosphorous acid is three
(b) Perbromic acid is having only one peroxy linkage
(c) β–SO_3 is having cyclic structure
(d) Borazine is having zero dipole moment

18. Which of the following statement is not correct regarding SF_2Cl_2 molecule?
(a) Two axial bond lengths are longer compared to two equatorial bond lengths
(b) Two S–F bond lengths are identical
(c) Two S–Cl bond lengths are identical
(d) Lone pair is not changing its position

19. Select the correct statement regarding oxides:
(a) As the electronegativity of element increases, acidic character of oxide increases
(b) Down the group the acidic nature of oxide increases
(c) Both B_2O_3 and Al_2O_3 are acidic oxides
(d) Nitrogen forms all the three types of oxides (neutral, basic, and acidic)

20. Which of the following structure is non-planar?
(a) $Na_3B_3O_6$
(b) I_2Cl_6
(c) Sheet silicates
(d) Inorganic graphite layer

21. Alumina on heating with carbon in nitrogen atmosphere gives:
(a) Al + CO (b) Al + CO_2
(c) AlN + CO (d) Al + CO + N_2

22. Which of the following has the minimum heat of dissociation?
(a) $[(CH_3)_3N \longrightarrow BF_3]$
(b) $[(CH_3)_3N \longrightarrow B(CH_3)F_2]$
(c) $[(CH_3)_3N \longrightarrow B(CH_3)_2F]$
(d) $[(CH_3)_3N \longrightarrow B(CH_3)_3]$

23. Anhydrous $AlCl_3$ is obtained from:
(a) Hydrochloric acid and aluminium metal
(b) Dry hydrogen chloride gas and aluminium metal
(c) Alumina and chlorine gas
(d) None of these

24. Aluminium vessel should not be washed with materials containing washing soda because:
(a) Washing soda is expensive
(b) Washing soda is easily decomposed
(c) Washing soda reacts with aluminium to form soluble aluminate
(d) Washing soda reacts with aluminium to form insoluble aluminium oxide

25. In the reaction $LiH + AlH_3 \longrightarrow LiAlH_4$, AlH_3 and LiH act as:
(a) Lewis acid and Lewis base
(b) Lewis base and Lewis acid
(c) Bronsted base and Bronsted acid
(d) None of these

26. The solution of borax in water is:
(a) Neutral (b) Acidic
(c) Alkaline (d) Amphoteric

27. Al_2O_3 can be converted into anhydrous $AlCl_3$ by heating:
(a) A mixture of Al_2O_3 and carbon in dry Cl_2 gas
(b) Al_2O_3 with Cl_2 gas
(c) Al_2O_3 with HCl gas
(d) Al_2O_3 with NaCl solid state

28. The reaction,
$B(OH)_3 + NaOH \longrightarrow Na[B(OH)_4]$ can be made to proceed in forward direction by:
(a) Adding *cis*-1, 2-diol (b) Adding borax
(c) Adding *trans*-1, 2-diol
(d) Adding Na_2HPO_4

29. Aluminium chloride exists as dimer, Al_2Cl_6, in solid state as well as in solution of non-polar solvents such as C_6H_6. When dissolved in water it gives:
(a) $Al_2O_3 + 6HCl$ (b) $[Al(H_2O)_6] + 3Cl^-$
(c) $[Al(OH)_6]^{3-} + 3HCl$ (d) $Al^{3+} + 3Cl^-$

30. Carbon burns in air and forms two oxides CO and CO_2. This shows that carbon has:
(a) Two allotropic forms (b) Two oxidation states
(c) Two isotopes
(d) Four electrons in valence shell

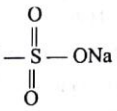
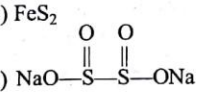
31. By addition of excess of sodium hydroxide solution to stannous chloride solution, we obtain:
(a) $Sn(OH)_2$ (b) $SnO_2 \cdot H_2O$
(c) Na_2SnO_3 (d) Na_2SnO_2

32. Man dies in an atmosphere of carbon monoxide because it:
(a) Combines with the O_2 present in the body to form CO_2.
(b) Reduces the organic matter of tissues.
(c) Combines with hemoglobin of blood, making it incapable of absorbing O_2.
(d) Dries up the blood.

33. Which statement is correct with respect to the property of the elements with increase in atomic number in the carbon family?
(a) Their metallic character decreases.
(b) The stability of 2+ oxidation state increases.
(c) Their ionization energy increases.
(d) Their atomic size decreases.

34. Which gas is essential constituent of almost all fuel gases?
(a) CO_2 (b) N_2
(c) CO (d) H_2O

35. Regular use of which of the following fertilizer increases the acidity of soil:
(a) Potassium nitrate (b) Urea
(c) Superphosphate of lime
(d) Ammonium sulphate

36. The oxidation state (O.S.) of S–atom is –1 in:
(a) FeS (b) FeS_2
(c)  (d) 

37. In silicon dioxide:
(a) Each silicon atom is surrounded by four oxygen atoms and each oxygen atom is bonded to two silicon atoms
(b) Each silicon atom is surrounded by two oxygen atoms and each oxygen atom is bonded to two silicon atoms
(c) Silicon atom is bonded to two oxygen atoms
(d) There are double bonds between silicon and oxygen atoms

38. Name the structure of silicate in which three oxygen atoms of $[SiO_4]^{4-}$ are shared:
(a) Pyrosilicate (b) Sheet silicate
(c) Linear chain silicate
(d) Three dimensional silicate

39. Which one is not an acid salt?
(a) NaH_2PO_2 (b) NaH_2PO_3
(c) NaH_2PO_4 (d) None of these

40. Sodium nitrate on heating with zinc dust and caustic soda gives:
(a) $NaNO_2$ (b) NH_3
(c) NO_2 (d) N_2O

41. The most thermodynamically stable allotropic form of phosphorus is:
(a) Red (b) White
(c) Black (d) Yellow

42. Which of the following statement regarding sulphur is incorrect?
(a) At 600°C, the gas mainly consists of S_2 molceules
(b) The oxidation state of sulphur is never less than +4 in its compounds
(c) S_2 molecule is paramagnetic
(d) The vapor at 200°C consists mostly of S_8 rings

43. Which is an ozonide?

(a) KO_3 (b) NH_4O_3

(c) Cr_2O_3 (d) Both (a) and (b)

44. Identify the incorrect statement among the following:

(a) Ozone reacts with SO_2 to give SO_3.

(b) Silicon reacts with NaOH(aq.) in the presence of air to give Na_2SiO_3 and H_2O.

(c) Cl_2 reacts with excess of NH_3 to give N_2 and HCl.

(d) Br_2 reacts with hot and strong NaOH solution to give NaBr, $NaBrO_4$, and H_2O.

45. When Na_2S is added to sodium nitroprusside solution:

(a) Beautiful violet color is produced

(b) A complex $[Fe(CN)_5NOS]^{4-}$

(c) The complex $Na_4[Fe(CN)_5NOS]$ is formed

(d) All of these

46. One gas bleaches the color of the flowers by reduction while the other by oxidation. The gases are:

(a) CO and CO_2 (b) H_2S and Br_2

(c) SO_2 and Cl_2 (d) NH_3 and SO_3

47. $[X] + H_2SO_4 \longrightarrow [Y]$ a colorless gas with irritating smell,

$[Y] + K_2Cr_2O_7 + H_2SO_4 \longrightarrow$ Green solution, $[X]$ and $[Y]$ is:

(a) SO_3^{2-}, SO_2 (b) Cl^-, HCl

(c) S^{2-}, H_2S (d) CO_3^{2-}, CO_2

48. Which of the following is not oxidized by O_3?

(a) KI (b) $FeSO_4$

(c) $KMnO_4$ (d) K_2MnO_4

49. The halide which does not give a precipitate with $AgNO_3$ is:

(a) F^- (b) Cl^-

(c) Br^- (d) I^-

50. Which ion can bring about the highest oxidation state of a transition metal?

(a) F^- (b) Cl^-

(c) Br^- (d) I^-

51. Which halogen can be purified by sublimation?

(a) F_2 (b) Cl_2

(c) Br_2 (d) I_2

52. The ion that cannot undergo disproportionation is:

(a) ClO_4^- (b) ClO_3^-

(c) ClO_2^- (d) ClO^-

53. In the reaction between Cl_2 and hot conc. NaOH, which is correct:

(a) The oxidation number of Cl_2 changes from 0 to +5 and 0 to –1

(b) Cl_2 undergoes disproportionation

(c) Cl_2 undergoes self or auto redox change

(d) All of these

54. The correct order of acidic nature is:

(a) $Cl_2O_7 > SO_3 > P_4O_{10}$ (b) $CO_2 > N_2O_5 > SO_3$

(c) $Na_2O > MgO > Al_2O_3$ (d) $K_2O > CaO > MgO$

55. The product of oxidation of I^- with MnO_4^- in alkaline medium is:

(a) IO_3^- (b) I_2

(c) IO^- (d) IO_4^-

56. The numer of hydrogen atoms attached to phosphorus atom in hypophosphorous acid is:

(a) Zero (b) Two

(c) One (d) Three

57. Which of the following is only acidic in nature?

(a) $Be(OH)_2$ (b) $Mg(OH)_2$

(c) $B(OH)_3$ (d) $Al(OH)_3$

58. Which one of the following statements regarding helium is incorrect?

(a) It is used to produce and sustain powerful superconducting magnets

(b) It is used as a cryogenic agent for carrying out experiments at low temperatures

(c) It is used to fill gas balloons instead of hydrogen because it is lighter than hydrogen and is non-inflammable

(d) It is used in gas-cooled nuclear reactors

59. Which products are expected from the disproportionation of hypochlorous acid?

(a) $HClO_3$ and Cl_2O (b) $HClO_2$ and HClO

(c) HCl and Cl_2O (d) HCl and $HClO_3$

60. In view of the signs of Δ_rG° for the following reactions

$PbO_2 + Pb \rightarrow 2\ PbO,\ \Delta_rG^\circ < 0$

$SnO_2 + Sn \rightarrow 2\ SnO,\ \Delta_rG^\circ > 0$

Which oxidation states are more characteristic for lead and tin?

(a) For lead + 4, for tin + 2

(b) For lead + 2, for tin + 2

(c) For lead + 4, for tin + 4

(d) For lead + 2, for tin + 4

61. Select the correct statement about elements of group 15:

(a) The order of stability of oxidation state for +3 is $Bi^{3+} > Sb^{3+}$ and for +5 is $Bi^{5+} < Sb^{5+} < As^{5+}$

(b) In the case of nitrogen, all oxidation states from +1 to +4 tend to disproportionate in acid solution.

(c) There is a considerable increase in covalent radius from N to P but from As to Bi only a small increase in covalent radius is observed.

(d) All of these

62. Aluminium chloride exists as dimer, Al_2Cl_6, in solid state as well as in solution of non-polar solvents such as benzene. When dissolved in water, it gives

(a) $Al^{3+} + 3Cl^-$ (b) $[Al(H_2O)_6]^{3+} + 3Cl^-$

(c) $[Al(OH)_6]^{3-} + 3HCl$ (d) $Al_2O_3 + 6HCl$

63. By the action of conc H_2SO_4, phosphorus changes to:

(a) Phosphorus acid (b) Orthophosphoric acid

(c) Metaphosphoric acid (d) Pyrophosphoric acid

64. The liquefied metal expanding on solidification is:

(a) Al (b) Ga

(c) Zn (d) Cu

65. A layer of coke is spread over bauxite during extraction of aluminium. This acts as a/an:

(a) Flux

(b) Slag to remove impurities

(c) Reducing agent

(d) Insulation and does not allow heat to escape

66. BF_3 is used as catalyst in several industrial processes due to its:

(a) Strong reducing nature (b) Weak reducing action

(c) Strong Lewis acid nature

(d) Weak Lewis acid character

67. The chemical formula of feldspar is:

(a) $KAlSi_3O_8$ (b) Na_3AlF_6

(c) $NaAlO_2$

(d) $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 4Al(OH)_3$

68. A mixture of boron trichloride and hydrogen is subjected to silent electric discharge to form '*A*' and HCl. '*A*' is mixed with NH_3 and heated to 200°C to form '*B*'. The formula of '*B*' is:

(a) H_3BO_3 (b) B_2O_3

(c) B_2H_6 (d) $B_3N_3H_6$

69. In aluminium extraction by the Baeyer's process, alumina is extracted from bauxite by sodium hydroxide at high temperature and pressure.

$$Al_2O_{3(s)} + 2OH^-_{(aq)} \longrightarrow 2AlO_2^-{}_{(aq)} + H_2O_{(l)}$$

Solid impurities such as Fe_2O_3 and SiO_2 are removed and then $Al(OH)_3$ is reprecipitated.

$$2Al(OH)_4^- \longrightarrow Al_2O_3 \cdot 3H_2O_{(s)} + 2OH^-_{(aq)}$$

In the industrial world:

(a) Carbon dioxide is added to precipitate the alumina

(b) Temperature and pressure are dropped and the super saturated solution seeded

(c) Both (a) and (b) are practised

(d) The water is evaporated

70. Solder is an alloy of:

(a) 70 % Pb, 30 % Sn (b) 33 % Pb, 67 % Sn

(c) 80 % Pb, 20 % Sn (d) 90 % Cu, 10 % Sn

71. Which of the following halide of carbon is used as refrigerant?

(a) CCl_4 (b) CF_4

(c) CH_2Cl_2 (d) CF_2Cl_2

72. Butter of tin is:

(a) $SnCl_2 \cdot 5H_2O$ (b) $SnCl_2 \cdot 2H_2O$

(c) $SnCl_4 \cdot 4H_2O$ (d) $SnCl_4 \cdot 5H_2O$

73. Me_2SiCl_2 on hydrolysis followed by polymerization will produce:

(a) $Me_2Si(OH)_2$ (b) $Me_2Si{=}O$

(c) $—[—O—(Me)_2Si—O—]_n$

(d) $Me_2SiClOH$

74. Litharge is chemically:

(a) PbO (b) PbO_2

(c) Pb_3O_4 (d) $Pb(CH_3COO)_2$

75. The straight chain polymer is formed by:

(a) Hydrolysis of CH_3SiCl_3 followed by condensation polymerization

(b) Hydrolysis of $(CH_3)_4Si$ followed by addition polymerization

(c) Hydrolysis of $(CH_3)_2SiCl_2$ followed by condensation polymerization

(d) Hydrolysis of $(CH_3)_3SiCl$ followed by condensation polymerization

76. On heating $K_4Fe(CN)_6$ with conc. H_2SO_4 gives the gas:

(a) SO_2 (b) CO_2

(c) CO (d) NO_2

77. Blasting of TNT is done by mixing:

(a) NH_4Cl (b) NH_4NO_3

(c) NH_4NO_2 (d) $(NH_4)_2SO_4$

78. Which of the following is the incorrect statement for PH_3?

(a) It is less basic than NH_3

(b) It has rotten fish smell

(c) It has pyramidal structure

(d) It does not show reducing properties

79. A pale blue liquid which is obtained by reacting equimolar mixture of two gases at –30°C is:

(a) N_2O_3 (b) N_2O

(c) N_2O_4 (d) N_2O_5

80. $(NH_4)_2Cr_2O_7$ on heating liberates a gas. The same gas will be obtained by:

(a) Heating NH_4NO_2 (b) Heating NH_4NO_3

(c) Treating Mg_3N_2 with H_2O

(d) Heating H_2O_2 on $NaNO_2$

81. Which one of the following oxides of nitrogen is solid?

(a) NO_2 (b) N_2O

(c) N_2O_3 (d) N_2O_5

82. Which is used to produce smoke screens?

(a) Zinc sulphide (b) Calcium phosphide

(c) Zinc phosphide (d) Sodium carbonate

83. The percentage of *p*-character in the orbitals forming P—P bonds in P_4 is:

(a) 25 (b) 33

(c) 50 (d) 75

84. Which of the following is the correct order of increasing enthalpy of vaporization?

(a) $NH_3 < PH_3 < AsH_3$ (b) $AsH_3 < PH_3 < NH_3$

(c) $PH_3 < AsH_3 < NH_3$ (d) $NH_3 < AsH_3 < PH_3$

85. Chlorine reacts with excess of ammonia to form:

(a) NH_4Cl (b) $N_2 + HCl$

(c) $N_2 + NH_4Cl$ (d) $N_2 + NCl_3$

86. The reaction of P_4 with *X* leads selectively to P_4O_6. The *X* is:

(a) A dry O_2 (b) A mixture of O_2 and N_2

(c) Moist O_2

(d) O_2 in presence of aqueous NaOH

87. Which shows maximum catenation property?

(a) Te (b) Se

(c) S (d) O

88. There is no S—S bond in:

(a) $S_2O_4^{2-}$ (b) $S_2O_5^{2-}$

(c) $S_2O_3^{2-}$ (d) $S_2O_7^{2-}$

89. Which of the following bonds has the highest energy?

(a) Se—Se (b) Te—Te

(c) S—S (d) O—O

90. Which of the following does not have S—S linkage?

(a) $S_2O_8^{2-}$ (b) $S_2O_6^{2-}$

(c) $S_2O_5^{2-}$ (d) $S_2O_3^{2-}$

91. The element evolving two different gases on reaction with conc. H_2SO_4 is:

(a) P (b) C

(c) Hg (d) S

92. The function of $Fe(OH)_3$ in the contact process is:

(a) To detect colloidal impurity

(b) To remove moisture

(c) To remove dust particles

(d) To remove arsenic impurity

93. Aqueous solution of $Na_2S_2O_3$ on reaction with Cl_2 gives:

(a) $Na_2S_4O_6$ (b) $NaHSO_4$

(c) NaCl (d) NaOH

94. In which of the following molecule, the number of possible $\angle XAX$ angles is maximum in the anionic part of their solid state? [*A*: Central atom; *X*: surrounding atom]

(a) PBr_5 (b) N_2O_5

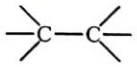
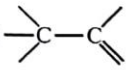
(c) PCl_5 (d) Cl_2O_6

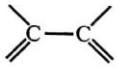
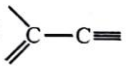
95. Which of the following compound have *X*—O—*X* linkage where '*X*' is the so called central atom like P, S etc?

(a) $P_2O_8^{4-}$ (b) $S_2O_3^{2-}$

(c) γ-SO_3 (d) $S_2O_5^{2-}$

96. In which of the following type of bond, C—C bond distance will be minimum?

(a)  (b) 

(c)  (d) 

97. Which of the following is pseudo alum?

(a) $(NH_4)_2SO_4 \cdot Fe_2(SO_4)_3 \cdot 24H_2O$

(b) $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$

(c) $MnSO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$

(d) None of these

98. Among the halides.

1. BCl_3 2. $AlCl_3$

3. $GaCl_3$ 4. $InCl_3$

The order of decreasing Lewis acid character is:

(a) 1, 2, 3, 4 (b) 4, 3, 2, 1

(c) 3, 4, 2, 1 (d) 2, 3, 4, 1

99. Which of the following has smell resembling to bleaching powder?

(a) NO_2 (b) HNO_4

(c) HNO_3 (d) None of these

100. Which of the following statement about boron carbide is wrong?

(a) Its molecular formula is B_4C.

(b) It is also called Norbia.

(c) It is the hardest substance.

(d) It is used for cutting glasses.

101. Which one of the following methyl diboranes does not exist?

(a) $B_2H_4(CH_3)_2$ (b) $B_2H_3(CH_3)_3$

(c) $B_2H_2(CH_3)_4$ (d) $B_2H(CH_3)_5$

102. Borax on heating strongly above its melting point melts to a liquid, 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 metaborate

(d) Mixture of sodium metaborate and boric anhydride

103. For H_3PO_3 and H_3PO_4, the correct choice is:

(a) H_3PO_3 is dibasic and reducing agent

(b) H_3PO_3 is dibasic and non-reducing agent

(c) H_3PO_4 is tribasic and reducing agent

(d) H_3PO_3 is tribasic and non-reducing agent

104. A certain compound when burnt gave three oxides. The first turned lime water milky, the second turned cobalt chloride paper pink and the third formed an aqueous solution of pH 3 nearly. The elements present in the compound are:

(a) C, S, O (b) C, H, Na

(c) C, H, S (d) C, H, Ca

105. The number of S—S bonds in polythionic acid ($H_2S_nO_6$):

(a) n (b) $n-1$

(c) $n-2$ (d) None of these

106. Which of the following halogen oxides is ionic?

(a) I_4O_9 (b) I_2O_5

(c) BrO_2 (d) ClO_3

107. When Cl_2 water is added to an aqueous solution of potassium halide in the presence of chloroform, a violet color is obtained. On adding more of Cl_2 water, the violet color disappears and a colorless solution is obtained. This test confirms the presence of the following in aqueous solution:

(a) Iodide (b) Bromide

(c) Chloride (d) Iodide and bromide

108. Antichlor is a compound:

(a) which absorbs chlorine

(b) Which removes excess of Cl_2 from a material

(c) Which liberates Cl_2 from bleaching powder

(d) Which acts as a catalyst in the manufacture of Cl_2

109. Superhalogen is:

(a) F_2 (b) Cl_2

(c) Br_2 (d) I_2

110. Concentrated hydrochloric acid when kept in open air sometimes produces a cloud of white fumes. This is due to:

(a) Strong affinity of HCl gas for moisture in air results in forming of droplets of liquid solution which appears like a cloudy smoke

(b) Strong affinity for water, conc. HCl pulls moisture of air towards itself. The moisture forms droplets of water and hence the cloud

(c) Conc. HCl emits strongly smelling HCl gas all the time

(d) Oxygen in air reacts with emitted HCl gas to form a cloud of Cl_2 gas

111. Which products are expected from the disproportionation of hypochlorous acid?

(a) $HClO_3$ and Cl_2O (b) $HClO_2$ and $HClO_4$

(c) HCl and Cl_2O (d) HCl and $HClO_3$

112. $B(OH)_3 + NaOH \longrightarrow Na[B(OH)_4]_{(aq)}$

Then addition of which of the following proceeds the reaction in the forward direction:

(a) *cis*-1, 2 diol (b) *trans* 1, 2 diol

(c) Borax (d) Na_2HPO_4

113. Which of the following statements about anhydrous aluminium chloride is correct?

(a) It fumes in moist air

(b) It exists as dimer both in the vapor state below 350°C and in non-polar solvents

(c) It is prepared by heating Al_2O_3 in a stream of sulphur chloride (S_2Cl_2) vapor and chlorine

(d) All of these

114. Aqueous solution of ortho-boric acid can be titrated against sodium hydroxide using phenolphthalein indicator only in presence of:

(a) *trans*-glycerol (b) Catechol

(c) *cis*-glycerol (d) Both (b) and (c)

115. $Mg_3B_2 \xrightarrow{HCl_{(aq)}} [X] + MgCl_2$ for $[X]$ and $[Y]$ the incorrect choice is:

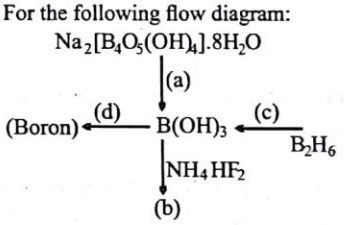
(a) $[X] + H_2O \xrightarrow{HCl_{(aq)}} [Y] + H_2$

(b) $[X]$ is BCl_3 and $[Y]$ is H_3BO_3

(c) [X] with air and [Y] on strong heating (red heat) give same compound

(d) In [Y], boron completes its octet by removing H^+ from water molecule

116. For the following flow diagram:



Which of the following options correctly describes the reagents, products, and the reaction conditions given in parentheses as small alphabets?

Option	(a)	(b)	(c)	(d)
(1)	Acidic hydrolysis	NH_3 and NH_4BF_4	Hydrolysis	Heating only
(2)	Acidic hydrolysis	NH_4BF_4	Hydrolysis	Heating in presence of Mg or Fe
(3)	Alkaline hydrolysis	NH_4BF_4	Hydrolysis	Heating only
(4)	Alkaline hydrolysis	$N_2 + BF_3$	Hydrolysis	Heating in presence of Mg or Fe

(a) 1 (b) 2

(c) 3 (d) 4

117. Which of the following statements regarding orthoboric acid (H_3BO_3) is false?

(a) It acts as a weak monobasic acid

(b) It is soluble in hot water

(c) It has a planar structure

(d) It acts as a tribasic acid

118. Peroxoborate in aqueous solution provides:

(a) $[B(OH)_4]^- + H_2O_2$ (b) $Na_2B_4O_7 \cdot 10H_2O$

(c) HBO_2 (d) $Na[B_3O_3(OH)_4]$

119. Which of the following statement about anhydrous aluminium chloride is correct?

(a) Its anhydrous form is deliquescent and fumes in air

(b) It is not easily hydrolyzed

(c) It sublimes at 20°C under vacuum

(d) It is a strong Lewis base

120. Al dissolves in molten NaOH with the formation of:

(a) Sodium aluminate (Na_3AlO_3)

(b) Sodium metaluminate ($NaAlO_2$)

(c) Aluminium hydroxide

(d) Alumina

121. Which reaction cannot give anhydrous $AlCl_3$?

(a) Heating of $AlCl_3 \cdot 6H_2O$

(b) Passing dry HCl over heated aluminium powder

(c) Passing dry Cl_2 over heated aluminium powder

(d) Heating a mixture of alumina and coke in a current of dry Cl_2

122. A brown colored mixture of two gases is obtained by the reduction of 6N nitric acid with metallic copper. This mixture on cooling condense to a blue liquid which on freezing (−30°) gives a blue solid. The correct choice for blue liquid or solid is:

(a) It is referred to as the anhydride of nitrous acid

(b) It is an acidic oxide and hence dissolves in alkalies producing nitrites

(c) It can also be prepared by the action of 50% HNO_3 on arsenious oxide and then cooling to 250 K

(d) All of these

123. Select the incorrect statement:

(a) Nitrous oxide supports combustion more vigorously than air

(b) Phosphorus pentaoxide dehydrates nitric acid forming nitrogen pentaoxide

(c) Reactivity order of various allotropic forms of phosphorus is white > red > black

(d) Red phosphorus changes to white phosphorus on heating in the atmosphere of CO_2 or coal gas at 573 K

124. The soldiers of Napolean army while at Alps during freezing winter suffered a serious problem as regards to the tin buttons of their uniforms. White Metallic tin buttons get converted to grey powder. This transformation is related to:

(a) An interaction with water vapor contained in humid air

(b) A change in crystalline structure of tin

(c) A change in the partial pressure of O_2 in air

(d) An interaction with N_2 of air at low temperature

125. $NH_4ClO_4 + HNO_{3(dil.)} \longrightarrow HClO_4 + [X]$

$[X] \xrightarrow{\Delta} Y_{(g)}$

[X] and [Y] are respectively:

(a) NH_4NO_3 and N_2O (b) NH_4NO_2 and N_2

(c) HNO_4 and O_2 (d) None

126. S_1: AgCl with liquid ammonia forms a complex $[Ag(NH_3)_2]^+$.

S_2: Ammonium dichromate on heating decomposes to give nitrogen and a green colored compound.

S_3: CaNCN on hydrolysis produces a white precipitate and a gas which turns filter paper moistened with copper sulphate solution deep blue.

(a) T T T (b) T F T
(c) F F T (d) T T F

127. The equivalent weight of H_3PO_4 in the reaction:

$NaOH + H_3PO_4 \rightarrow NaH_2PO_4 + H_2O$ is:

(a) 25 (b) 49
(c) 59 (d) 98

128. Hydrolysis of one mole of peroxodisulphuric produces:

(a) Two moles of sulphuric acid
(b) Two moles of peroxomonosulphuric acid
(c) One mole of sulphuric acid and one mole of peroxomonosulphuric acid
(d) One mole each of sulphuric acid, peroxomonosulphuric acid and hydrogen peroxide

Multiple Correct Answers Type

1. The incorrect statement/s among the following is/are:

(a) NCl_5 does not exist while PCl_5 does
(b) Lead prefers to form tetravalent compounds
(c) The three C—O bonds are not equal in the carbonate ion
(d) Both O_2^+ and NO are paramagnetic

2. Which of the following statements is/are correct?

(a) Silicon is used extensively as a semiconductor
(b) Carborundum is SiC
(c) Silicon occurs in free state in nature
(d) Mica contains the element silicon

3. CO is isostructural with:

(a) $SnCl_2$ (b) $HgCl_2$
(c) SCl_2 (d) ZnI_2

4. Which of the following carbides on treatment with water give methane?

(a) Al_4C_3 (b) Be_2C
(c) Mg_2C_3 (d) CaC_2

5. Which of the following are the ores of lead?

(a) Galena (b) Anglesite
(c) Cerussite (d) Carnallite

6. White phosphorus has:

(a) Six P—P single bonds
(b) Four P—P single bonds
(c) Four lone pairs of electrons
(d) P—P—P angle of 60°

7. Which of the following pairs is/are correctly matched?

(a) A halogen which is liquid at room temperature—Bromine
(b) The most electronegative element—Fluorine
(c) The most reactive halogen—Fluorine
(d) The strongest oxidizing agent—Iodine

8. Which one of the following arrangements does not give the correct picture of the trends indicated against it?

(a) $F_2 > Cl_2 > Br_2 > I_2$: Bond dissociation energy
(b) $F_2 > Cl_2 > Br_2 > I_2$: Electronegativity
(c) $F_2 > Cl_2 > Br_2 > I_2$: Oxidizing nature
(d) $F_2 > Cl_2 > Br_2 > I_2$: Electron gain enthalpy

9. Which one of the following is/are incorrect statement(s)?

(a) The hydroxide of aluminium is more acidic than that of boron
(b) The hydroxide of boron is basic while that of aluminium is amphoteric
(c) The hydroxide of boron is acidic while that of aluminium is amphoteric
(d) The hydroxides of both boron and aluminium are amphoteric

10. Which one of the following statement(s) about H_3BO_3 is/are correct?

(a) It is a strong tribasic acid
(b) It is prepared by acidifying an aqueous solution of borax
(c) It has a layer structure in which planar BO_3 units are joined by hydrogen bonds
(d) It does not act as proton donor as it acts as a Lewis acid by accepting lone pair of hydroxyl ions

11. Which of the following oxides are not neutral?

(a) CO (b) SnO_2
(c) ZnO (d) SiO_2

12. Identify the incorrect statement(s) with respect to CO:

(a) It combines with water to give carbonic acid
(b) It combines with haemoglobin of the blood
(c) It is a powerful oxidizing agent
(d) CO is weak field ligand

13. Which of the following oxides is/are not amphoteric in character?

(a) CaO (b) CO_2
(c) SiO_2 (d) SnO_2

14. Which of the following options are correct for isoelectronic pairs?

(a) H_2, HD (b) CO, N_2

(c) HCl, H_2S (d) D_2O, Ne

15. Which of the following pair(s) represent(s) the isoelectronic species?

(a) S^{-2} and Sc^{+3} (b) SO_2 and NO_3^-

(c) N_2 and CN^- (d) NH_3 and H_3O^+

16. Which one of the following is not hypovalent molecules / species?

(a) AlF_3 (b) $AlCl_3$

(c) HCO_2^- (d) $BeCl_2$

17. Which of the following compound(s) have same hybridization of the central atom?

(a) SeF_2Cl_2 (b) I_3^-

(c) $BeCl_2$ (d) XeF_3^+

18. Which of following species / compounds are planar?

(a) H_2O (b) ICl_2^-

(c) ICl_3 (d) BrF_4^-

19. Which of the molecule / species are not having perfect shape?

(a) CH_2Cl_2 (b) NF_4^+

(c) $SiCl_4$ (d) $BFCl_2$

20. Which of the following statements are correct for HCN molecule?

(a) Two π-bonds are perpendicular to each other

(b) Lone pair lying in the orbital which is perpendicular to both π-bonds

(c) The dipole moment value is non zero

(d) The direction of dipole moment is from N to H-atom

21. The bent-shape of the molecule may develop from which of the following hybridization(s)?

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

(c) sp (d) sp^2

22. Which of the following statement is correct?

(a) xz plane is the nodal plane for p_y orbital

(b) xy and xz planes are nodal planes for d_{xz} orbital

(c) Nodal planes for $d_{x^2-y^2}$ are at 45° inclined with the X-axis and perpendicular to xz-plane

(d) Nodal planes of π-bonds of $B_3N_3H_6$ are at molecular plane

23. Which of the following species are formed by Lewis acid–base interaction?

(a) CH_4 (b) $NaBF_4$

(c) PCl_4^+ (d) $Al(OH)_4^-$

24. Which of the following molecules are polar as well as planar?

(a) BFClBr (b) $B_3N_3H_6$

(c) ClF_3 (d) $CH_2=C=C=CF_2$

25. Which of the following product(s) may be formed by the reaction of diborane with ammonia?

(a) $(BN)_x$ (b) $B_2H_6.2NH_3$

(c) $B_3N_3H_6$ (d) $B_2H_6.NH_3$

26. Which of the following statements are true regarding $(ICl_3)_2$?

(a) All I—Cl bonds are identical in $(ICl_3)_2$

(b) In liquid state it conducts electricity

(c) Its monomer is also planar

(d) It has a planar structure

27. Be and Al show diagonal relationship and thus:

(a) Their oxides are soluble in alkali solution forming $[Be(OH)_4]^{2-}$

(b) They form complex anion BeF_4^{2-} and AlF_6^{3-}

(c) $BeCl_2$ and $AlCl_3$ are Lewis acids

(d) Oxides are basic

28. In the following statements, select the correct statement:

(a) $N(CH_3)_3$ has pyramidal structure

(b) $N(SiH_3)_3$ shows planar arrangement

(c) SiC is highly volatile (d) SiO_2 is called silane

29. Which of the following specie(s) is/are exists?

(a) $[BF_6]^{3-}$ (b) $[AlF_6]^{3-}$

(c) $[GaF_6]^{3-}$ (d) $[InF_6]^{3-}$

30. Which of the following is/are correct?

(a) Hydrolysis of NCl_3 gives NH_3 and HClO

(b) NH_3 is less stable than PH_3

(c) NH_3 is a weak reducing agent compared to PH_3

(d) Nitric oxide is paramagnetic

31. Ammonia on reaction with hypochlorite anion can form:

(a) NO (b) NH_4Cl

(c) N_2H_2 (d) HNO_2

32. The nitrogen oxide(s) that contain(s) N—N bond(s) is(are):

(a) N_2O (b) N_2O_3

(c) N_2O_4 (d) N_2O_5

33. Which statement is/are not correct about halogen?

(a) They are all diatomic and form univalent ions

(b) They are all capable of exhibiting several oxidation states

(c) They are all diatomic and form diatomic ions

(d) They are all reducing agents

34. The shape of O_2F_2 is/are not similar to:

(a) H_2O_2 (b) C_2F_2
(c) H_2F_2 (d) C_2H_2

35. Identify the statement(s) that is/are correct as far as structure of diborane is concerned:
(a) There are two bridging hydrogen atoms in diborane
(b) Each boron atom forms four bonds in diborane
(c) The hydrogen atoms are not in the same plane in diborane
(d) All B—H bonds in diborane are similar

36. Boric acid is a very weak acid but in the presence of certain organic compounds, it acts as a strong acid. Which one of the following organic compound(s) cannot affect such change?
(a) Glycerol (b) Acetic acid
(c) Ethyl alcohol (d) Ethylene

37. Which of the following species are having peroxy linkages?
(a) BrO_4^- (b) $S_2O_8^{2-}$
(c) $P_2O_8^{4-}$ (d) PO_5^{3-}

38. Which of the following statements is/are true?
(a) The strength of H-bond depends upon the polarity of the bond
(b) The extent of H-bond depends upon the number of sites available for H-bond
(c) The extent of H-bond in H_2O_2 is greater than that in H_2O
(d) The strength of H-bond in H_2O_2 is greater than that in H_2O

39. In which of the following option(s) all species contains X—O—X bond(s) in structure (X = central atom)?
(a) $H_2S_2O_5$, S_3O_9, $S_2O_6^{2-}$
(b) P_4O_{10}, P_4O_6, $H_5P_3O_{10}$
(c) N_2O_5, N_2O, N_2O_4
(d) S_3O_9, P_4O_6, $Si_2O_7^{6-}$

40. Which is/are true in case of BF_3?
(a) It is volatile liquid even at room temperature
(b) It is a Lewis acid
(c) It has planar geometry
(d) It forms adduct with NH_3

41. Which of the following order(s) is/are incorrect?
(a) $H_3PO_4 > H_3PO_3 > H_3PO_2$ (reducing character)
(b) $N_2O < NO < N_2O_5$ (oxidation state on nitrogen atom)
(c) $NH_3 > PH_3 > AsH_3 > SbH_3$ (basicity)
(d) $SbH_3 > NH_3 > AsH_3 > PH_3$ (reducing character)

42. The hybridization of Xe-atom in XeO_6^{4-} is same with:
(a) Xe in XeF_6 (b) Te in TeO_6^{6-}
(c) P in PF_6^- (d) Si in SiF_6^{2-}

43. The shape of H_2S_2 is identical to that of:
(a) S_2Cl_2 (b) O_2F_2
(c) C_2F_2 (d) H_2O_2

44. Which pair of compounds is not isostructural but possesses same number of lone pairs on the central atom?
(a) SF_4 and SO_3^{2-} (b) CO_2 and SO_2
(c) XeF_2 and BeH_2 (d) ClF_3 and XeF_4

45. In the reaction

$$2X + B_2H_6 \longrightarrow [BH_2X_2]^+ [BH_4]^-$$

the amine(s) X is (are):
(a) NH_3 (b) CH_3NH_2
(c) $(CH_3)_2NH$ (d) $(CH_3)_3N$

46. 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) $(NH_4)_2SO_4$

47. Select the correct statement(s) about the following:
(a) O_3 is used as germicide for purification of air
(b) In O_3, O—O bond length is identical with that of molecular oxygen
(c) O_3 molecule is angular in shape
(d) O_3 is an oxidizing agent

48. Which of the following statements is/are correct when a mixture of NaCl and $K_2Cr_2O_7$ is gently warmed with conc. H_2SO_4?
(a) A deep red vapor is evolved
(b) The vapor when passed into NaOH solution gives yellow solution of Na_2CrO_4
(c) Chlorine gas is evolved
(d) Chromyl chloride is formed

49. Which of the following is correct about the reaction?

$$3NaClO \xrightarrow{Heat} NaClO_3 + 2NaCl$$

(a) It is a disproportionation reaction
(b) Oxidation number of chlorine decreases as well as increases in this reaction
(c) This reaction is used for the manufacture of halates
(d) It is a non-redox reaction

50. Which one of the following is/are the incorrect statement(s)?

(a) $B_2H_6 \cdot 2NH_3$ is known as "inorganic benzene"

(b) Boric acid is a proton donor acid

(c) Beryllium exhibits coordination number of six

(d) Chlorides of both beryllium and aluminium have bridged chloride structures in solid phase or gas phase

51. Select the correct statement(s) for biogas and producer gas are made up of:

(a) Biogas contains CO_2 but producer gas does not

(b) Producer gas contains CO but not CO_2

(c) Both biogas and producer gas have N_2

(d) Both biogas and producer gas have CO_2

52. Which of the following statements is/are correct regarding graphite and inorganic graphite?

(a) Both are slippery in nature

(b) Both are conducting electricity but graphite is less conducting in nature compared to inorganic graphite

(c) Graphite is not having any charge separation like inorganic graphite

(d) All atoms in graphite as well as inorganic graphite are sp^2 hybridized

53. Which of the following statements is not correct for SiF_6^{2-} and ClF_6^{+}?

(a) They are isoelectronic

(b) They are isostructural

(c) All possible $\angle FSiF$ and $\angle FClF$ angles are identical

(d) d_{Si-F} and d_{Cl-F} (bond lengths) are identical

54. Select the correct statement:

(a) H_2O_2 is used as mild bleaching agent for bleaching delicate articles such as hair, silk, wool, etc.

(b) It restores the color of the old paints blackened by the action of H_2S. The lead sulphide (black) gets oxidized to lead sulphate (white)

$$\underset{\text{Black}}{PbS} + 4\,H_2O_2 \longrightarrow \underset{\text{White}}{PbSO_4} + 4H_2O$$

(c) When $CH_2 = CH_2$ is oxidized by H_2O_2 then ethane-1, 2-diol forms $\begin{array}{l} CH_2-OH \\ | \\ CH_2-OH \end{array}$

(d) H_2O_2 is a polar and non-planar

55. Select the correct reaction for H_2O_2:

(a) $Ag_2O + H_2O_2 \longrightarrow 2Ag + H_2O + O_2$

(b) $Cl_2 + H_2O_2 \longrightarrow 2HCl + O_2$

(c) $O_3 + H_2O_2 \longrightarrow H_2O + 2O_2$

(d) $H_2O_2 + 2KI \longrightarrow 2KOH + I_2$

56. Which of the following statements is / are correct?

(a) Nitrogen (IV) oxide in basic aqueous solution disproportionates

(b) Copper(II) nitrate and lead(II) nitrate each on thermal decomposition liberate both NO_2 and O_2 gases

(c) Some metals (Cr, Al and Fe) do not dissolve in conc. HNO_3 due to the formation of a passive film of oxide on the surface

(d) Hydrogen peroxide is oxidizing agent as well as reducing agent

57. Borax bead test is given by:

(a) An aluminium salt (b) A cobalt salt

(c) A copper salt (d) A nickelate salt

58. $Ca_2B_6O_{11} + Na_2CO_3 \xrightarrow{\Delta} [X] + CaCO_3 + NaBO_2$ (unbalanced equation) Correct choice(s) for $[X]$ is/are:

(a) Structure of anion of crystalline $[X]$ has one boron atom sp^3 hybridized and other three boron atoms sp^2 hybridized

(b) X with $NaOH_{(aq)}$, gives a compound which on reaction with hydrogen peroxide in alkaline medium yields a compound used as brightener in soaps

(c) Hydrolysis of $[X]$ with HCl or H_2SO_4 yields a compound which on reaction with HF gives fluoroboric acid

(d) $[X]$ on heating with chromium slats in oxidizing flame gives green colored bead

Comprehension Type

Comprehension-1: (Q. 1 to Q. 3)

I_2 has less solubility in water and its solubility increases on adding KI solution. When KI and I_2 reacts then a species 'X' is formed by which solubility of I_2 increases.

1. Hybridization of anionic part of 'X' is:

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

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

2. Geometry of anionic part of 'X' is:

(a) Linear (b) T shape

(c) Pyramidal (d) See-saw

3. Which of the following is/are the correct characteristics of anionic part of 'X'?

[Polar and non-polar nature to be considered on the basis of dipole moment]

(I) Planar (II) Non-planar

(III) Polar (IV) Non-polar

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

Comprehension-2: (Q. 4 and Q. 5)

Hybridization is the chemists attempt to explain the observed molecular shape by constructing hybridized atomic orbitals with the appropriate inter orbital angles. The molecule for which deviation from normal bond angle is observed, VSEPR theory suggests electron pair repulsive interaction ($lp - lp > lp - bp > bp - bp$). While from hybridization point of view that is departure from normal hybridization because the angle between any equivalent hybrid orbitals determine the fraction of *s* and *p* characters of the hybrid and *vice-versa*.

4. An element '*A*' has outer shell configuration of $5s^2 5p^6$. If *A* forms covalent compound AF_2 with fluorine. The orbitals used by '*A*' for bonding are:
(a) *d*-orbitals (b) *p*-orbitals
(c) *sp*-hybridized orbital (d) sp^3d hybrid orbital

5. In which species number of lone pair on iodine and number of *d*-orbitals used in hybridization by iodine are same?
(a) ICl_2^+ (b) ICl_2^-
(c) IF_7 (d) ICl_4^-

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

Silicon, Germanium, Tin, and Lead along with carbon constitute the carbon family. The property called catenation facilitates the formation of a very large number of carbon compounds. Carbon also shows CF_3Cl are utilized in refrigeration, they have been blamed for ozone layer depletion.

6. C_{60} (fullerene) has the shape of a soccer ball. Consider the following statements and choose the correct one:
(i) Fullerene is an allotrope of carbon.
(ii) Fullerene has 5 and 6 member rings.
(iii) All carbon in fullerene are sp^2 hybridized.
(a) (i), (ii), and (iii) (b) (i) only
(c) (iii) only (d) (i) and (ii)

7. The carbide Mg_2C_3 upon hydrolysis gives:
(a) C_3H_6 (b) C_3H_4
(c) C_2H_2 (d) None of these

8. Which of the oxides of carbon can act as a reducing agent?
(a) CO_2 (b) CO
(c) CO_3^{2-} (d) None of these

Comprehension-4: (Q. 9 and Q. 10)

In a solution the Tl^+ ion is much more stable than Tl(III). The ionic radius of Tl^+ (1.50Å) is between that of K^+ (1.38Å) and Rb^+ (1.52Å). For this reason Tl^+ resembles group IA ion in number of ways. TlOH and Tl_2O are both soluble in water and are strongly basic. They absorb CO_2 from the air, forming Tl_2CO_3. The solubility of most of the salt is slightly lower than for potassium salts. Tl^+ can replace K^+ in some enzymes. There are some differences. TlOH is yellow and on heating to 100°C it turns into black; Tl_2O TlF is soluble in water, but LiF is insoluble.

9. +1 oxidation state of Tl is most stable due to:
(a) Inert pair effect (b) Small size
(c) Its basic nature (d) None of these

10. Which of the following has lowest melting point?
(a) Boron (b) Al
(c) In (d) Ga

Comprehension-5: (Q. 11 to Q. 14)

Hydrogen peroxide is an important compound of hydrogen and oxygen. It shows various types of properties and chemical reactions.

11. Hydrogen peroxide is not:
(a) A reducing agent (b) An oxidizing agent
(c) A dehydrating agent (d) A bleaching agent

12. The reaction $H_2S + H_2O_2 \longrightarrow S + 2H_2O$ manifests:
(a) Acidic nature of H_2O_2
(b) Alkaline nature of H_2O_2
(c) Oxidizing action of H_2O_2
(d) Reducing nature of H_2O_2

13. The species that do not contain peroxide ion (s) is/are:
(a) PbO_2 (b) SrO_2
(c) Na_2O_2 (d) BaO_2

14. The oxidation state of oxygen in H_2O_2 is:
(a) +1 (b) –1
(c) +2 (d) –2

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

PCl_5 has trigonal pyramidal geometry with sp^3d hybridization in gases and liquid state but in solid state it exist as ionic compound.

15. The hybridization of P and shape of $POCl_3$ are:
(a) sp^3, tetrahedral
(b) sp^3, pyramidal
(c) sp^3d, square planar
(d) sp^3d, distorted tetrahedral

16. In presence of small amount of water, PCl_5 hydrolyzes to form:

(a) PCl_3 (b) POCl
(c) $POCl_3$ (d) H_3PO_3

17. In crystalline state PCl_5 exists as:

(a) $[PCl_4]^+Cl^-$ (b) $[PCl_4]^+[PCl_6]^-$
(c) $[PCl_3]^{2+} + 2Cl^-$ (d) $[PCl_6]^+ [PCl_4]^-$

18. What is the hybridization state of cation part of solid PCl_5?

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

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

H_2SO_4 is the most important acid used in the chemical industry. Concentrated H_2SO_4 has quite strong oxidizing properties.

19. H_2SO_3 acts as:

(a) Reducing agent (b) Oxidizing agent
(c) Only monobasic acid (d) None of these

20. The shape of H_2SO_3 is:

(a) Tetrahedral (b) Pyramidal
(c) Planar (d) t-shaped

21. Oxidation state of S in H_2SO_3 is:

(a) +6 (b) +4
(c) +2 (d) +3

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

NH_3 has got pyramidal structure. By replacement of H atoms it forms $(CH_3)_3N$ and $(SiH_3)_3N$ molecules which are found to have different geometries.

22. Which is the correct relation of bond angles?

(a) $NH_3 > (CH_3)_3N > (SiH_3)_3N$
(b) $(SiH_3)_3N > (CH_3)_3N > NH_3$
(c) $NH_3 > (SiH_3)_3N > (CH_3)_3N$
(d) $(CH_3)_3N > (SiH_3)_3N > NH_3$

23. Shape of $(SiH_3)_3N$ with respect to N is:

(a) Pyramidal (b) Tetrahedral
(c) Trigonal planar (d) T-shaped

24. Which of the following has highest basic character?

(a) NH_3 (b) $(CH_3)_2NH$
(c) $(CH_3)_3N$ (d) $(SiH_3)_3N$

Comprehension-9: (Q. 25 to Q. 27)

Solid N_2O_5 exists as $NO_2^+ NO_3^-$ and hence is called nitronium nitrate .

25. The gas which is acidic in nature is:

(a) NO (b) N_2O
(c) NO_2 (d) Both (a) and (c)

26. Which of the following statement is correct for the oxides of nitrogen?

(a) Dinitrogen trioxide dissolves in potassium hydroxide forming potassium nitrate
(b) Aqueous solution of nitrogen dioxide behaves both as a reducing agent and as an oxidizing agent
(c) Nitrous oxide is fairly soluble in cold water and turns blue litmus red
(d) NO_2 is non-planar

27. Identify the incorrect statement:

(a) In N_2O_4 the N—N bond length is longer than the usual N—N single bond distance
(b) NO_2 molecule is angular with N—O distance equal to intermediate distance between a single and a double bond
(c) N_2O is a linear molecule and has a small dipole moment
(d) None of these

Comprehension-10: (Q. 28 to Q. 30)

A number of molecules and polyatomic ions cannot be described accurately by a single Lewis structure and a number of descriptions based on the same skeletal structure are written and these taken together represent the molecule or ion. These structures have almost similar energies, same arrangement of atoms, and have same number of bonding and non-bonding pair of electrons. These contributing structures or canonical forms taken together constitute the resonance hybrid which represents the molecule or ion.

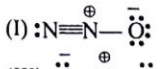
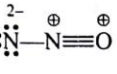
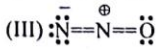
28. Which of the following is not correct about resonance?

(a) It averages the bond features as a whole
(b) It stabilizes the molecule since energy of the resonance hybrid is lower than that of any of the single canonical structure
(c) There is no equilibrium between these canonical structures
(d) These canonical structures have real existence also

29. The value of bond order of C — O bond for CO_3^{2-} ion is:

(a) 1.25 (b) 1.33
(c) 1.5 (d) 1.0

30. The correct order of stability for the resonating structure of nitrous oxide can be given as:

(I) 
(II) 
(III) 

(a) III > II > I (b) I > II > III
(c) I > III > II (d) I > II >> III

Comprehension-11: (Q. 31 to Q. 33)

An inorganic salt '*A*' behaves like a Lewis acid and fumes in moist air. The intensity of fumes increases when NaOH is added dropwise but the precipitate dissolves on adding excess of NaOH. However, on adding NH_4Cl and NH_4OH (in excess) to the salt solution of '*A*', a white precipitate is obtained. '*A*' is $AlCl_3$.

31. Which of the following bond is present in $AlCl_3$?
(a) $3C - 4e^-$ (b) $2C - 2e^-$
(c) Both (a) and (b) (d) None of these

32. The reaction of $AlCl_3$ with NH_4OH (excess) is:
(a) $AlCl_{3(aq)} + 3NH_4OH \longrightarrow Al(OH)_3 + 3NH_4Cl$
(b) $AlCl_{3(aq)} + 6NH_4OH \longrightarrow [Al(NH_3)_6]^{3+} + 3Cl^- + 6H_2O$
(c) $AlCl_{3(aq)} + NH_4OH \longrightarrow [Al(OH)_4Cl_2]^{3-} + 3NH_4^+$
(d) $AlCl_3 + NH_4OH \longrightarrow [Al(OH_3)_4Cl_3] + OH^-$

33. $AlCl_3$ absorbs moisture readily because:
(a) The hydration energy is high
(b) The lattice energy is low
(c) Hydration energy overcomes lattice energy
(d) Lattice energy overcomes hydration energy

Comprehension-12: (Q. 34 to Q. 36)

Orthoboric acid contains triangular BO_3^{3-} units. In solid the $B(OH)_3$ units are hydrogen bonded together into two-dimensional sheets with almost hexagonal symmetry. The layers are quite a large distance apart (3.18 Å) and thus the crystal breaks quite easily into very fine partical. At one time ortho boric acid was used as mildly antiseptic talcum powder for babies, because it forms a fine powder. It is no longer used since it sometimes caused a rash.

34. In which of the following solvent Boric acid acts as strong acid?
(a) Acidic solvent (b) Water
(c) Solvent in which polyhydroxo compounds are present
(d) Boric acid never acts as a strong acid because it is weak acid

35. In solid state, Boric acid has which type of interaction between layers?
(a) Hydrogen bonding (b) van der Walls' force
(c) Covalent bond (d) None of these

36. Aqueous solution of Borax will be:
(a) Acidic (b) Basic
(c) Neutral (d) None of these

Comprehension-13: (Q. 37 to Q. 39)

The term carbide is generally applied to compounds in which carbon is bonded to the elements of lower or approximately same electronegativity. This definition excludes the compounds in which oxygen, sulphur, phosphorus, nitrogen, and halogens are united with carbon. Reactive metals (i.e., of groups 1 and 2) form ionic carbides. They hydrolyze to liberate hydrocarbons. Most of them resembles with NaCl in crystal structure. Transition metals forms interstitial carbides.

37. Consider the following carbides:

CaC_2	Be_2C	MgC_2	SrC_2
I	II	III	IV

Select the carbide which gives different product on hydrolysis than other carbides:
(a) I (b) II (c) III (d) IV

38. Select the methanides from compounds given below:

Al_4C_3	Be_2C	MgC_2	BaC_2
I	II	III	IV

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

39. The conductance of transition metal is not much affected when it forms interstitial carbide because:
(a) The carbide anion helps in conduction
(b) The carbon atoms occupy octahedral holes and so does not affect electrical conductivity
(c) The carbon atoms react with metal and liberate electrons
(d) The conduction is due to holes

Comprehension-14: (Q. 40 to Q. 43)

Oxygen is more electronegative than chlorine. In the series of oxyacids HOCl, $HClO_2$, $HClO_3$, $HClO_4$ an increasing number of oxygen atom are bonded to the chlorine atom.

Chlorine forms a number of oxyacids which differ in their strengths. The conjugate base of these acids also differ in their stability order.

40. The order of acidic strength of HOCl, $HClO_2$, $HClO_3$, and $HClO_4$ are:
(a) $HClO_4 > HClO_3 > HClO_2 > HClO$
(b) $HClO > HClO_2 > HClO_3 > HClO_4$
(c) $HClO_3 > HClO_4 > HClO_2 > HClO$
(d) $HClO_3 > HClO_2 > HClO > HClO_4$

41. Which of the following is strongest conjugate base?

(a) ClO^- (b) ClO_2^-

(c) ClO_3^- (d) ClO_4^-

42. The hybridization of Cl in ClO_2^- and its shape are:

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

(c) sp^3, angular (d) sp^2, trigonal planar

43. The least stable oxo-anion among the following is:

(a) ClO^- (b) ClO_2^-

(c) ClO_3^- (d) ClO_4^-

Comprehension-15: (Q. 44 to Q. 46)

Among the halogens, fluorine differs considerably from the other members. The hydrides of halogens also differ in their properties.

44. Fluorine differs from the other halogens due to:

(a) Small size

(b) Very high electronegativity

(c) Non-availability of *d*-orbitals

(d) All of these

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

(a) F—F (b) Cl—Cl

(c) Br—Br (d) I—I

46. Which of the following halogens do not form polyhalide?

(a) F (b) Cl

(c) Br (d) I

Comprehension-16: (Q. 47 to Q. 49)

All the boron trihalides except BI_3 may be prepared by direct reaction between the elements. Boron trihalides consist of trigonal-planar BX_3 molecules. Unlike the halides of the other elements in the group, they are monomeric in the gas, liquid, and solid states. BF_3 and BCl_3 are gases, BBr_3 is volatile liquid, and BI_3 is a solid. Boron trihalides are Lewis acids because they form simple Lewis complexes with suitable bases, as in the reaction.

$$BF_{3(g)} + :NH_{3(g)} \longrightarrow F_3B \leftarrow NH_{3(s)}$$

However boron chlorides, bromides, and iodides are susceptible (sensitive) to protolysis by mild proton sources such as water, alcohol, and even amines. For example, BCl_3 undergoes rapid hydrolysis

$$BCl_{3(g)} + 3H_2O_{(l)} \longrightarrow B(OH)_{3(aq)} + 3HCl_{(aq)}$$

It is expected that the first step in the above reaction is the formation of the complex Cl_3B —3/4 OH_2 which then eliminates HCl and reacts further with water.

47. Which of the following is the best order of Lewis acid strength of BF_3, BCl_3, and BBr_3?

(a) $BF_3 > BCl_3 > BBr_3$ (b) $BF_3 = BCl_3 = BBr_3$

(c) $BF_3 < BCl_3 < BBr_3$ (d) $BBr_3 > BF_3 > BCl_3$

48. Which of the following is the correct prediction observed B—*X* bond length, in BX_3 molecules?

(a) B—F bond length in BF_3 is found to be less than theoretical value because the electronegativity values of B(2.04) and F(4.0) suggest the bond to be ionic, and hence the attraction between oppositely charged ions must decrease the bond length

(b) BF_3 and $[BF_4]^-$ have equal B—F bond length

(c) The decrease in the B—F bond length in BF_3 is due to delocalized p_π–p_π bonding between vacant '2*p*' orbital of B and filled '2*p*' orbital of F

(d) The correct B—*X* bond length order is B—F > B—Cl > B—Br > B—I

49. Which of the following is correct regarding the hydrolysis of BX_3?

(a) All BX_3 undergo hydrolysis to produce $B(OH)_{3(aq)}$ and $HX_{(aq)}$.

(b) BF_3 does not undergo complete hydrolysis due to formation of HBF_4

(c) BBr_3 does not undergo hydrolysis at all because it cannot form hydrogen bonds with water

(d) All the above are correct

Comprehension-17: (Q. 50 and Q. 51)

Thermodynamically, hydrogen peroxide is unstable as shown by the following equation:

$$H_2O_{2(l)} \longrightarrow H_2O_{(l)} + \frac{1}{2}O_{2(g)}$$

$\Delta_r G^o = -122.6$ kJ/mol

As the reaction from left to right is a accompanied by a decrease in free energy, it is a spontaneous process. However, its decomposition at 25°C in the absence of catalysts is slow. The catalysts which accelerate decomposition are Pt, Ag, cobalt, iron, copper, manganese dioxide and light. Concentrated H_2O_2 solution can result into uncontrolled decompositions leading to explosion. H_2O_2 thus stored in colored wax-lined bottles (as rough glass surfaces) also causes its decomposition. A few stabilizers such as acids acetanilide, pyrophosphates, and stannates are added to slow down the decomposition of H_2O_2.

50. H_2O_2 is a:

(a) Diamagnetic (b) Paramagnetic

(c) Non-polar (d) All are incorrect

51. H_2O_2 stored is in colored wax-lined bottles because:

(a) It is radioactive

(b) It produced uncontrolled decompositions leading to explosion

(c) It is non-polar molecule

(d) None of these

Comprehension-18: (Q. 52 to Q. 54)

Study the given flow-sheet involving reactions of a metal and answer the questions at the end.

A metal M and its compounds can given the following observable changes in a sequence of reactions

$$M \xrightarrow[HNO_3]{dilute} \underset{A}{\begin{bmatrix}\text{Colorless}\\ \text{solution}\end{bmatrix}} \xrightarrow[NaOH]{aqueous} \underset{B}{\begin{bmatrix}\text{White}\\ \text{precipitate}\end{bmatrix}}$$

$$\xrightarrow[NaOH_{(aq.)}]{excess} \underset{C}{\begin{bmatrix}\text{Colorless}\\ \text{solution}\end{bmatrix}} \xrightarrow[NaOH_{(aq.)}]{H_2S} \underset{D}{\begin{bmatrix}\text{White}\\ \text{precipitate}\end{bmatrix}}$$

52. Which of the following metals corresponds to M?

(a) Mg (b) Zn

(c) Al (d) Pb

53. Metal M on reaction with NaOH forms:

(a) H_2 gas (b) O_2 gas

(c) MH_2 (hydride) (d) MH_3 (hydride)

54. Colorless solution C of the metal M has the formula?

(a) $M(OH)_4^-$ (b) $M(OH)_2$

(c) $M(OH)_3$ (d) $M(OH)_4^{2-}$

Comprehension-19: (Q. 55 to Q. 57)

Questions are based on following medical report.

In the first biological application of buckyball, chemists at the University of California at San Francisco and Santa Barbara made a discovery in 1993 that could help in designing drugs to treat AIDS. The human immunodeficiency virus (HIV) that causes AIDS reproduces by synthesizing a long protein chain, which is cut into smaller segments by an enzyme called HIV-protease. One way to stop AIDS then might be to inactivate the enzyme. When the chemists reacted a water-soluble derivative of buckyball with HIV-protease, they found that it binds to the portion of the enzyme that would ordinarily cleave the reproductive protein, thereby preventing the HIV virus from reproducing. Consequently, the virus could no longer infect the human cells they had grown in the laboratory. The buckyball compound itself is not a suitable drug for use against AIDS because of potential side effects and delivery difficulties, but it does provide a model for the development of such drugs.

55. Buckyball is the allotrope of:

(a) Phosphorus (b) Sulphur

(c) Carbon (d) Titanium

56. What is the formula of the buckyball?

(a) P_4 (b) S_8

(c) Ti_3 (d) C_{60}

57. In buckyball, each atom is:

(a) sp^2 hybridized element with extensive delocalized molecular orbital

(b) sp^2 hybridized element with delocalized molecular orbital

(c) sp^3 hybridized element with delocalized molecular orbital

(d) sp^3 hybridized element with localized molecular orbital

Comprehension-20: (Q. 58 to Q. 62)

White crystalline solid (A) reacts with H_2 to form a highly associated liquid (B) and a monoatomic colorless gas (C). The liquid (B) is used for etching glass. Compound (A) undergoes hydrolysis slowly to form (C), (B), and a diatomic gas (D) whose IE is almost similar to that of (C), (B) forms an addition compound with KF to form (E) which is electrolyzed in the molten state to form a most reactive gas (F) which combines with (C) in 1 : 1 ratio to produce (A).

58. The molecular shape and hybridization state of central atom in the molecule (A) are:

(a) Linear, sp (b) Triangular, sp^2

(c) Linear, sp^3d (d) V-shape, sp^3

59. The molecule of compound E contains which of the following types of bonds?

(a) Ionic (b) Ionic and covalent both

(c) Ionic, covalent, and metallic

(d) Ionic, covalent, and H-bonds

60. According to molecular orbital theory, which of the following is correct about the molecule D_2?

(a) Its bond order is 2.0

(b) It has two unpaired electrons in π-bonding molecular orbital

(c) It is paramagnetic (d) All of these

61. The liquid B combines with which of the following to form a magic or superacid?

(a) SbF_5 (b) XeF_2

(c) H_2O (d) BF_3

62. The compound (A) reacts with sulphur to form a compound in which hybridization state of sulphur atom is:

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

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

Comprehension-21: (Q. 63 to Q. 65)

Compound (A) on reduction with $LiAlH_4$ gives a hydride (P) containing 21.72% hydrogen along with other products. The one mole of hydride (P) and 2 moles of

ammonia at higher temperature gives a compound (Q) which is known as inorganic benzene. (A) hydrolysis incompletely and forms a compound (R) and H_3BO_3.

63. In hydride (P) (select correct statement):

(a) The central atom has trigonal planar geometry

(b) All H-atom lie in the same plane

(c) All four terminal B—H bond length are equivalent but that of four bridging B—H bond lengths are not equivalent

(d) A three-centre two-electron bond (3C—2e) is formed by overlap of an sp^3 hybrid orbital from each boron atom with the 1s-orbital of hydrogen atom

64. The hybridization of central atom of compound (R) is:

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

(c) sp (d) sp^3d

65. Which of the following statement is incorrect for the compound (A)?

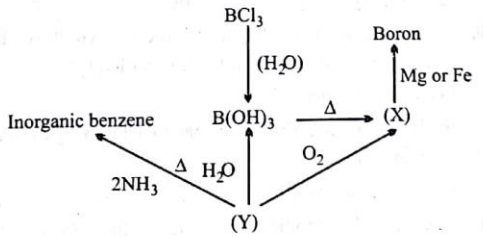
(a) It has trigonal planar geometry

(b) The bond length between the central atom and the substituent atom is shorter than the sum of covalent radii

(c) The coordination geometry around central atom of compound (A) and N atom in 1 : 1 complex of (A) and NH_3 is same

(d) In compound (A), there is p_π–d_π bonding

Comprehension-22: (Q. 66 to Q. 68)



66. The compound Y is:

(a) BF_3 (b) BCl_3

(c) B_2H_6 (d) B_2O_3

67. The compound X is:

(a) B_2H_6 (b) B_2O_3

(c) $[B(OH)_4]^-$ (d) None of these

68. The formula of inorganic benzene:

(a) $(BN)_x$ (b) C_6H_6

(c) $B_3N_3H_6$ (d) $B_3N_3H_9Cl_3$

Assertion-Reasoning Type

1. **Statement-1:** Boron has unusually high melting point.

Statement-2: Boron shows nonmetallic 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.

2. **Statement-1:** Aluminium forms $[AlF_6]^{3-}$ but B does not form $[BF_6]^{3-}$.

Statement-2: BF_3 on hydrolysis gives HBF_4.

(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:** Boron forms only covalent compounds.

Statement-2: Due to small size of boron, the sum of its first three ionization enthalpies is very high.

(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:** Amongst the trihalides of nitrogen, NF_3, NCl_3, NBr_3 and NI_3, NF_3 is least basic.

Statement-2: In NF_3, the fluorine has the highest value of electronegativity and thus the lone pair of electrons on N-atom is strongly bound.

(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:** Dimethyl dichloro silane on hydrolysis followed by condensation gives cross-linked silicones.

Statement-2: Silicones are macromolecules containing repeating —Si—O—Si— linkage.

(a) Statement-1 is true, statement-2 is true and statement-2 is a correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and statement-2 is NOT a correct explanation for statement-1.

(c) Statement-1is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

6. **Statement-1:** In water, orthoboric acid behaves as a weak monobasic acid.

Statement-2: In water, orthoboric acid acts as a proton donor.

(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:** The order of densities of the various allotropes of phosphorus is as follows: black phosphorus > red phosphorus > white phosphorus because.

Statement-2: As tendency of polymerisation increases, the compactness of substance also 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.

8. **Statement-1:** Size of atoms of inert gases are smaller than those of the preceding halogens.

Statement-2: Atomic (covalent or van der Waals' radii generally decreases with increase in atomic number along a period.)

(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:** Both SO_2 and Cl_2 are bleaching agent.

Statement-2: SO_2 bleaches by reduction, whereas Cl_2 bleaches by oxidation.

(a) Statement-1 is true, statement-2 is true and statement-2 is a correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true and 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.

10. **Statement-1:** Boiling solution containing Cl^-, Br^-, I^- with $K_2S_2O_8$, violet and brown vapor appears.

Statement-2: Br^- and I^- are oxidized to Br_2 and I_2 but Cl^- is not oxidized.

(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) Dihydrogen hypophosphate ion	(p) All hydrogens are ionizable
(b) Hydrogen pyrophosphite ion	(q) Number of acidic hydrogen present is two
(c) Pyrosulphurous acid	(r) sp^3 hybridized central atom
(d) Hydrogen peroxymonosulphate ion	(s) Overall non-planar structure
	(t) Ion having peroxy linkage

2. Match the column:

Column-I	Column-II (Molecular consists of what type of bonds)
(a) σ bond	(p) CO
(b) π bond	(q) HCN
(c) Electrovalent bond (or ionic bond)	(r) NH_4Cl
(d) Coordinate	(s) SiH_4
	(t) $LiNO_3$

3. Match the column:

Column-I	Column-II
(a) $H_2C = C = CHF$	(p) Nonpolar and planar

(b) $B_3N_3H_6$	(q) Nodal planes of p-bonds are lying in the molecular plane
(c) XeO_3F_2	(r) Nonpolar and non-planar
	(s) Polar and non-planar

4. Match the molecules/ions (in Column-I) with their shapes (in Column-II).

Column-I	Column-II
(a) ClF_3	(p) Square planar
(b) $[PCl_4]^+$	(q) T-shaped
(c) XeF_4	(r) Tetrahedral
(d) XeO_3	(s) Pyramidal

5. Match the following:

Column-I	Column-II
(a) XeF_5^+	(p) Central atom is having two lone pairs
(b) XeF_5^-	(q) Only five atoms are lying in the one plane
(c) XeF_4	(r) Species is not having any π-bond
(d) XeO_6^{4-}	(s) The central atom is having oxidation state of + 4
	(t) The species is sp^3d^2 hybridized having either zero or one lone pair on the central atom

6. Match the following:

Column-I (Number of electron pair around the central atom)	Column-II (Probable geometry)
(a) 2	(p) Bent
(b) 3	(q) Linear
(c) 4	(r) Sea-saw
(d) 5	(s) Trigonal pyramidal

7. Match the following:

Column-I	Column-II
(a) SiO_2	(p) Reacts with HF
(b) CN^-	(q) Pseudo halide
(c) I^-	(r) Gives compound with Cu^{2+} via redox reaction
(d) N_2	(s) Inert towards reaction

8. Match the following:

Column-I	Column-II
(a) $BBr_3 + H_2 \longrightarrow B$	(p) Borax bead test
(b) $Na_2B_4O_7.10H_2O + CuSO_4 \longrightarrow Cu(BO_2)_2$	(q) Reduction
(c) $AlCl_3 + H_2O \longrightarrow HCl$	(r) White fumes
(d) $Cr_2O_3 + Al \longrightarrow Cr$	(s) Hydrolysis

9. Match the following:

Column-I	Column-II
(a) BF_3	(p) Trigonal planar geometry
(b) $N(SiH_3)_3$ (with respect to N)	(q) $p\pi$–$p\pi$ back bonding
(c) SiF_4	(r) $p\pi$–$d\pi$ back bonding
	(s) Tetrahedral geometry

10. Match the column:

Column-I	Column-II
(a) BF_2Cl	(p) Molecules in the column-I is having maximum number of lying in the same plane
(b) $B_3N_3H_6$	(q) Molecules having maximum number of lone pair
(c) SF_4	(r) Molecule is non-polar
(d) XeO_4	(s) Molecule is planar
	(t) p_x, p_y and p_z orbitals are involved in the hybridization of the central atom

11. Match the following:

Column-I	Column-II
(a) Cl_2 + cold and dilute NaOH $\xrightarrow{0°C}$	(p) Disproportionation takes place
(b) Cl_2 + hot and conc. NaOH $\xrightarrow{> 50°C}$	(q) Chloride (Cl^-) is produced
(c) $KClO_3 \xrightarrow[\text{at low temp.} < 100°C]{\Delta}$	(r) Chlorate (ClO_3^-) is produced
(d) $ClO_2 + NaOH \longrightarrow$	(s) Hypochlorite (OCl^-) is produced
	(t) Chlorite (ClO_2^-) is produced

12. Match the reactions of metals with dilute HNO_3 (in column-I) with the nitrogen compounds (obtained by oxidation/reduction (in column-II).

Column-I	Column-II
(a) Mg + dil. HNO_3	(p) NO
(b) Zn + dil. HNO_3	(q) H_2
(c) Sn + dil. HNO_3	(r) N_2O
(d) Pb + dil. HNO_3	(s) NH_4NO_3

13. Match column-I with column-II and select the correct answer using the codes given below the lists.

Column-I (Allotropic form)	Column-II (Structure)
(a) Engel's sulphur	(p) Rings, Chair conformation, unstable
(b) Sulphur	(q) Fibrous or rubber like

(c) Rhombic sulphur (r) Crystalline form-yellow crystals

(d) Monoclinic sulphur (s) Puckered S_8 rings crown conformation

Integer Answer Type

1. Which of the following oxidation states are the most characteristic for lead and tin, respectively?
   [If answer is 1 and 3, represent as 13]
2. In silica, SiO_2, each silicon atom is bonded to how many oxygen atom?
3. One mole of calcium phosphide on reaction with excess of water gives how many moles of phosphine?
4. PCl_3 reacts with water, then formed acid of phosphorous, what is the basicity of acid of phosphorous?
5. The electronic configuration of an element is $1s^2, 2s^2 2p^6, 3s^2 3p^3$. What is the atomic number of the element which is just below the above element in the periodic table?
6. Hydrolysis of NCl_3 gives NH_3 and X. What is the basicity of X?
7. The number of P—O bonds and lone pairs present in P_4O_6 molecule is/are:
   [If answer is 11 and 22, represent as 1122]
8. Oxygen belongs to which group of the periodic table?
9. In OF_2 molecule, the total number of bond pairs and lone pairs of electrons present is/are:
   [If answer is 3 and 6, represent as 36]
10. How many lone pair(s) is/are present in central atom I of I_3^- ion?
11. How many σ and π-bonds are present in cords?
    [If answer is 2 and 4, represent as 24]
12. H_3PO_3 has ..... non-ionizable P—H bonds.
13. Write the total number of $\angle$FIF angles in IF_7 having the bond angle value of 90°.
14. Calculate the minimum and maximum number of P—O linkages of identical length in P_4O_{10}.
    (If answer is 3 and 18, represent as 318)
15. Find the number of S — S linkage in γ — SO_3 molecule.
16. Al_4C_3 on hydrolysis gives X gas. How many H atoms are present in X?
17. Find the number of P—O—P bonds in cyclic metaphosphoric acid.
18. In NO_3^- ion, find the number of bond pair and lone pair of electrons on nitrogen atoms.
    [If answer is 2 and 4, represent as 24]
19. N_2O is isoelectronic with CO_2 and N_3^-, how many N—O—N linkages is/are present in N_2O?
20. The number of S—O—S bonds in sulphur trioxide trimer S_3O_9 is _____.
21. The number of sigma and pi bonds in peroxydisulphuric acid is/are:
    [If answer is 13 and 6, represent as 136]
22. The angular shape of ozone molecule (O_3) consists of how many σ and π bonds?
    [If answer is 3 and 2, represent as 32]
23. Find the number of compound which are having only acidic nature:
    $Be(OH)_2$, $Mg(OH)_2$, $Al(OH)_3$, $B(OH)_3$
24. The numbers of $F\hat{I}F$ angles equal to 90° and less than 90° in IF_7 are _____ and _____ respectively.
    [If answer is 15 and 9, represent as 159]
25. Find the number of P—O bonds of identical length in hypophosphate ion.
26. $SiCl_4 \xrightarrow{H_2O} X \xrightarrow{1000} Y$
    In the above reaction, how many oxygen atom(s) is/are present in X and Y?
    [If answer is 6 and 4, represent as 64]
27. Find the number of nitrate which gives NO_2 gas on heating from the following:
    Nitrogen dioxide is released on heating:
    NH_4NO_3, KNO_3, $NaNO_2$, $Pb(NO_3)_2$, $AgNO_3$
28. The atomicity of phosphorus is X and the P—P—P bond angle is Y. What are X and Y?
    [If answer is 2 and 90°, represent as 290]
29. $SO_2 + H_2S \longrightarrow X + H_2O$, X belongs to which group of the periodic table?
30. Find the number of ions having S—S bond from following:
    $S_2O_4^{2-}$, $S_2O_6^{2-}$, $S_2O_2^{2-}$, $S_2O_3^{2-}$, $S_2O_7^{2-}$
31. When thiosulphate ion is oxidized by iodine, the new product formed is how many S—S linkage is/are present in X?
32. Find the sum of the number of P==O, P—O—P linkages in $P_5O_{16}^{-7}$ ion.

NCERT Exemplar Exercises

Single Correct Answer Type

1. The element which exists in liquid state for a wide range of temperature and can be used for measuring high temperature is:
   (a) B (b) Al
   (c) Ga (d) In

2. Which of the following is a Lewis acid?
   (a) $AlCl_3$ (b) $MgCl_2$
   (c) $CaCl_2$ (d) $BaCl_2$

3. The geometry of a complex species can be understood from the knowledge of type of hybridization of orbitals of central atom. The hybridization of orbitals of central atom in $[Be(OH)_4]^{-2}$ and the geometry of the complex are respectively:
   (a) sp^3, tetrahedral (b) sp^3, square planar
   (c) $sp\,3d^2$, octahedral (d) dsp^2, square planar

4. Which of the following oxide is acidic in nature?
   (a) B_2O_3 (b) Al_2O_3
   (c) Ga_2O_3 (d) In_2O_3

5. The exhibition of highest coordination number depends on the availability of vacant orbitals in the central atom. Which of the following elements is **not** likely to act as central atom in MF_6^{3-}?
   (a) B (b) Al
   (c) Ga (d) In

6. Boric acid is an acid because its molecule:
   (a) Contains replaceable H^+ ion
   (b) Gives up a proton
   (c) Accepts OH^- from water releasing proton
   (d) Combines with proton from water molecule

7. Catenation i.e., linking of similar atoms depends on size and electronic configuration of atoms. The tendency of catenation in Group 14 elements follows the order:
   (a) C > Si > Ge > Sn (b) C >> Si > Ge > Sn
   (c) Si > C > Sn > Ge (d) Ge > Sn > Si > C

8. Silicon has a strong tendency to form polymers like silicones. The chain length of silicone polymer can be controlled by adding:
   (a) $MeSiCl_3$ (b) Me_2SiCl
   (c) Me_3SiCl (d) Me_4Si

9. Ionization enthalpy ($\Delta_i H_1$ kJ mol^{-1}) for the elements of Group 13 follows the order.
   (a) B > Al > Ga > In > Tl
   (b) B < Al < Ga < In < Tl
   (c) B < Al > Ga < In > Tl
   (d) B > Al < Ga > In < Tl

10. In the structure of diborane:
   (a) All hydrogen atoms lie in one plane and boron atoms lie in a plane perpendicular to this plane
   (b) 2 boron atoms and 4 terminal hydrogen atoms lie in the same plane and 2 bridging hydrogen atoms lie in the perpendicular plane
   (c) 4 bridging hydrogen atoms and boron atoms lie in one plane and two terminal hydrogen atoms lie in a plane perpendicular to this plane
   (d) All the atoms are in the same plane

11. A compound X of boron reacts with NH_3 on heating to give another compound Y which is called inorganic benzene. The compound X can be prepared by treating BF_3 with lithium aluminium hydride. The compounds X and Y are represented by the formulas.
   (a) B_2H_6, $B_3N_3H_6$ (b) B_2O_3, $B_3N_3H_6$
   (c) BF_3, $B_3N_3H_6$ (d) $B_3N_3H_6$, B_2H_6

12. Quartz is extensively used as a piezoelectric material, it contains _____.
   (a) Pb (b) Si
   (c) Ti (d) Sn

13. The most commonly used reducing agent is:
   (a) $AlCl_3$ (b) $PbCl_2$
   (c) $SnCl_4$ (d) $SnCl_2$

14. Dry ice is:
   (a) Solid NH_3 (b) Solid SO_2
   (c) Solid CO_2 (d) Solid N_2

15. Cement, the important building material is a mixture of oxides of several elements. Besides calcium, iron and sulphur, oxides of elements of which of the group (s) are present in the mixture?
   (a) Group 2
   (b) Groups 2, 13 and 14
   (c) Groups 2 and 13
   (d) Groups 2 and 14

16. On addition of conc. H_2SO_4 to a chloride salt, colorless fumes are evolved but in case of iodide salt, violet fumes come out. This is because:
(a) H_2SO_4 reduces HI to I_2
(b) HI is of violet color
(c) HI gets oxidised to I_2
(d) HI changes to HIO_3

17. In qualitative analysis when H_2S is passed through an aqueous solution of salt acidified with dil. HCl, a black precipitate is obtained. On boiling the precipitate with dil. HNO_3, it forms a solution of blue color. Addition of excess of aqueous solution of ammonia to this solution gives _____.
(a) Deep blue precipitate of $Cu(OH)_2$
(b) Deep blue solution of $[Cu(NH_3)_4]^{2+}$
(c) Deep blue solution of $Cu(NO_3)_2$
(d) Deep blue solution of $Cu(OH)_2 \cdot Cu(NO_3)_2$

18. In a cyclotrimetaphosphoric acid molecule, how many single and double bonds are present?
(a) 3 double bonds; 9 single bonds
(b) 6 double bonds; 6 single bonds
(c) 3 double bonds; 12 single bonds
(d) Zero double bonds; 12 single bonds

19. Which of the following elements can be involved in $p\pi$–$d\pi$ bonding?
(a) Carbon (b) Nitrogen
(c) Phosphorus (d) Boron

20. Which of the following pairs of ions are isoelectronic and isostructural?
(a) CO_3^{2-}, NO_3^- (b) ClO_3^-, CO_3^{2-}
(c) SO_3^{2-}, NO_3^- (d) ClO_3^-, SO_3^{2-}

21. Affinity for hydrogen decreases in the group from fluorine to iodine. Which of the halogen acids should have highest bond dissociation enthalpy?
(a) HF (b) HCl
(c) HBr (d) HI

22. Bond dissociation enthalpy of E—H (E = element) bonds is given below. Which of the compounds will act as strongest reducing agent?

Compound	NH_3	PH_3	AsH_3	SbH_3
Δ_{diss} (E–H)/kJ mol^{-1}	389	322	297	255

(a) NH_3 (b) PH_3
(c) AsH_3 (d) SbH_3

23. On heating with concentrated NaOH solution in an inert atmosphere of CO_2, white phosphorus gives a gas. Which of the following statement is incorrect about the gas?
(a) It is highly poisonous and has smell like rotten fish
(b) Its solution in water decomposes in the presence of light
(c) It is more basic than NH_3
(d) It is less basic than NH_3

24. Which of the following acids forms three series of salts?
(a) H_3PO_2 (b) H_3BO_3
(c) H_3PO_4 (d) H_3PO_3

25. Strong reducing behavior of H_3PO_2 is due to
(a) Low oxidation state of phosphorus
(b) Presence of two –OH groups and one P–H bond
(c) Presence of one –OH group and two P–H bonds
(d) High electron gain enthalpy of phosphorus

26. On heating lead nitrate forms oxides of nitrogen and lead. The oxides formed are _____.
(a) N_2O, PbO (b) NO_2, PbO
(c) NO, PbO (d) NO, PbO_2

27. Which of the following elements does not show allotropy?
(a) Nitrogen (b) Bismuth
(c) Antimony (d) Arsenic

28. Maximum covalency of nitrogen is _____.
(a) 3 (b) 5
(c) 4 (d) 6

29. Which of the following statements is wrong?
(a) Single N–N bond is stronger than the single P–P bond
(b) PH_3 can act as a ligand in the formation of coordination compound with transition elements
(c) NO_2 is paramagnetic in nature
(d) Covalency of nitrogen in N_2O_5 is four

30. A brown ring is formed in the ring test for NO_3^- ion. It is due to the formation of:
(a) $[Fe(H_2O)_5(NO)]^{2+}$ (b) $FeSO_4 \cdot NO_2$
(c) $[Fe(H_2O)_4(NO)_2]^2$ (d) $FeSO_4 \cdot HNO_3$

31. Elements of group-15 form compounds in +5 oxidation state. However, bismuth forms only one well characterized compound in +5 oxidation state.

The compound is:
(a) Bi_2O_5 (b) BiF_5
(c) $BiCl_5$ (d) Bi_2S_5

32. On heating ammonium dichromate and barium azide separately we get:
(a) N_2 in both cases
(b) N_2 with ammonium dichromate and NO with barium azide
(c) N_2O with ammonium dichromate and N_2 with barium azide
(d) N_2O with ammonium dichromate and NO_2 with barium azide

33. In the preparation of HNO_3, we get NO gas by catalytic oxidation of ammonia.
The moles of NO produced by the oxidation of two moles of NH_3 will be _____.
(a) 2 (b) 3
(c) 4 (d) 6

34. The oxidation state of central atom in the anion of compound NaH_2PO_2 will be _____.
(a) +3 (b) +5
(c) +1 (d) –3

35. Which of the following is not tetrahedral in shape?
(a) NH_4^+ (b) $SiCl_4$
(c) SF_4 (d) SO_4^{2-}

36. Which of the following are peroxoacids of sulphur?
(a) H_2SO_5 and $H_2S_2O_8$
(b) H_2SO_5 and $H_2S_2O_7$
(c) $H_2S_2O_7$ and $H_2S_2O_8$
(d) $H_2S_2O_6$ and $H_2S_2O_7$

37. Hot conc. H_2SO_4 acts as moderately strong oxidizing agent. It oxidises both metals and nonmetals. Which of the following element is oxidised by conc. H_2SO_4 into two gaseous products?
(a) Cu (b) S
(c) C (d) Zn

38. A black compound of manganese reacts with a halogen acid to give greenish yellow gas. When excess of this gas reacts with NH_3 an unstable trihalide is formed. In this process the oxidation state of nitrogen changes from _____.
(a) – 3 to +3 (b) – 3 to 0
(c) – 3 to +5 (d) 0 to – 3

39. In the preparation of compounds of Xe, Bartlett had taken O_2^+ Pt F_6^- as a base compound. This is because:
(a) Both O_2 and Xe have same size.
(b) Both O_2 and Xe have same electron gain enthalpy.
(c) Both O_2 and Xe have almost same ionisation enthalpy.
(d) Both Xe and O_2 are gases.

40. In solid state PCl_5 is a _____.
(a) Covalent solid
(b) Octahedral structure
(c) Ionic solid with $[PCl_6]^+$ octahedral and $[PCl_4]^-$ tetrahedral
(d) Ionic solid with $[PCl_4]^+$ tetrahedral and $[PCl_6]^-$ octahedra

41. Reduction potentials of some ions are given below. Arrange them in decreasing order of oxidizing power.

Ion	ClO_4^-	IO_4^-	BrO_4^-
Reduction potential $E^\ominus$/V	$E^\ominus$=1.19V	$E^\ominus$=1.65V	$E^\ominus$=1.74V

(a) $ClO_4^- > IO_4^- > BrO_4^-$
(b) $IO_4^- > BrO_4^- > ClO_4^-$
(c) $BrO_4^- > IO_4^- > ClO_4^-$
(d) $BrO_4^- > ClO_4^- > IO_4^-$

42. Which of the following is isoelectronic pair?
(a) ICl_2, ClO_2 (b) BrO_2^-, BrF_2^+
(c) ClO_2, BrF (d) CN^-, O_3

Multiple Correct Answers Type

In the following questions two or more options may be correct.

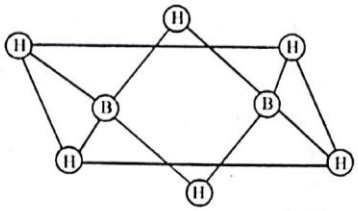
1. The reason for small radius of Ga compared to Al is _____.
(a) Poor screening effect of d orbitals
(b) Increase in effective nuclear charge
(c) Presence of higher orbitals
(d) Higher atomic number

2. The linear shape of CO_2 is due to _____.
(a) sp^3 hybridisation of carbon
(b) sp hybridisation of carbon
(c) $p\pi$–$p\pi$ bonding between carbon and oxygen
(d) sp^2 hybridisation of carbon

3. Me_3SiCl is used during polymerisation of organo silicones because:
(a) The chain length of organo silicone polymers can be controlled by adding Me_3SiCl
(b) Me_3SiCl blocks the end terminal of silicone polymer
(c) Me_3SiCl improves the quality and yield of the polymer
(d) Me_3SiCl acts as a catalyst during polymerisation

4. Which of the following statements are correct?
   (a) Fullerenes have dangling bonds
   (b) Fullerenes are cage-like molecules
   (c) Graphite is thermodynamically most stable allotrope of carbon
   (d) Graphite is slippery and hard and therefore used as a dry lubricant in machines

5. Which of the following statements are correct. Answer on the basis of the given figure.



   (a) The two bridged hydrogen atoms and the two boron atoms lie in one plane
   (b) Out of six B–H bonds, two bonds can be described in terms of 3 center 2-electron bonds
   (c) Out of six B–H bonds four B–H bonds can be described in terms of 3 center 2 electron bonds
   (d) The four terminal B–H bonds are two center two electron regular bonds

6. Identify the correct resonance structures of carbon dioxide from the ones given below:
   (a) $O-C=O$ (b) $O=C=O$
   (c) $^{-}O=C-O^{+}$ (d) $^{-}O-C\equiv O^{+}$

7. If chlorine gas is passed through hot NaOH solution, two changes are observed in the oxidation number of chlorine during the reaction. These are _____ and _____.
   (a) 0 to +5 (b) 0 to +3
   (c) 0 to –1 (d) 0 to +1

8. Which of the following options are not in accordance with the property mentioned against them?
   (a) $F_2 > Cl_2 > Br_2 > I_2$ Oxidizing power
   (b) MI > MBr > MCl > MF Ionic character of metal halide
   (c) $F_2 > Cl_2 > Br_2 > I_2$ Bond dissociation enthalpy
   (d) HI < HBr < HCl < HF Hydrogen–halogen bond strength

9. Which of the following is correct for P_4 molecule of white phosphorus?
   (a) It has 6 lone pairs of electrons
   (b) It has six P–P single bonds
   (c) It has three P–P single bonds
   (d) It has four lone pairs of electrons

10. Which of the following statements are correct?
   (a) Among halogens, radius ratio between iodine and fluorine is maximum
   (b) Leaving F—F bond, all halogens have weaker X—X bond than X—X′ bond in interhalogens
   (c) Among interhalogen compounds maximum number of atoms are present in iodine fluoride
   (d) Interhalogen compounds are more reactive than halogen compounds

11. Which of the following statements are correct for SO_2 gas?
   (a) It acts as bleaching agent in moist conditions
   (b) Its molecule has linear geometry
   (c) Its dilute solution is used as disinfectant
   (d) It can be prepared by the reaction of dilute H_2SO_4 with metal sulphide

12. Which of the following statements are correct?
   (a) All the three N—O bond lengths in HNO_3 are equal
   (b) All P—Cl bond lengths in PCl_5 molecule in gaseous state are equal
   (c) P_4 molecule in white phohsphorus have angular strain therefore white phosphorus is very reactive
   (d) PCl is ionic in solid state in which cation is tetrahedral and anion is octahedral

13. Which of the following orders are correct as per the properties mentioned against each?
   (a) $As_2O_3 < SiO_2 < P_2O_3 < SO_2$ Acid strength
   (b) $AsH_3 < PH_3 < NH_3$ Enthalpy of vaporization
   (c) S < O < Cl < F More negative electron gain enthalpy
   (d) $H_2O > H_2S > H_2Se > H_2Te$ Thermal stability

14. Which of the following statements are correct?
   (a) S–S bond is present in $H_2S_2O_6$
   (b) In peroxosulphuric acid (H_2SO_5) sulphur is in +6 oxidation state
   (c) Iron powder along with Al_2O_3 and K_2O is used as a catalyst in the preparation of NH_3 by Haber's process
   (d) Change in enthalpy is positive for the preparation of SO_3 by catalytic oxidation of SO_2

15. In which of the following reactions conc. H_2SO_4 is used as an oxidizing reagent?
    (a) $CaF_2 + H_2SO_4 \rightarrow CaSO_4 + 2HF$
    (b) $2HI + H_2SO_4 \rightarrow I2 + SO_2 + 2H_2O$
    (c) $Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$
    (d) $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$
16. Which of the following statements are true?
    (a) Only type of interactions between particles of noble gases are due to weak dispersion forces
    (b) Ionization enthalpy of molecular oxygen is very close to that of xenon
    (c) Hydrolysis of XeF_6 is a redox reaction
    (d) Xenon fluorides are not reactive

Short Answer Type

1. Draw the structures of $BCl_3{\cdot}NH_3$ and $AlCl_3$ (dimer).
2. Explain the nature of boric acid as a Lewis acid in water.
3. Draw the structure of boric acid showing hydrogen bonding. Which species is present in water? What is the hybridization of boron in this species?
4. Explain why the following compounds behave as Lewis acids?
   (a) BCl_3 (b) $AlCl_3$
5. Give reasons for the following:
   (a) CCl_4 is immiscible in water, whereas $SiCl_4$ is easily hydrolyzed.
   (b) Carbon has a strong tendency for catenation compared to silicon.
6. Explain the following:
   (a) CO_2 is a gas whereas SiO_2 is a solid.
   (b) Silicon forms SiF_6^{2-} ion whereas corresponding fluoro compound of carbon is not known.
7. The + 1 oxidation state in group 13 and +2 oxidation state in group 14 becomes more and more stable with increasing atomic number. Explain.
8. Carbon and silicon both belong to the group 14, but inspite of the stoichiometric similarity, the dioxides, (i.e., carbon dioxide and silicon dioxide), differ in their structures. Comment.
9. If a trivalent atom replaces a few silicon atoms in three dimensional network of silicon dioxide, what would be the type of charge on overall structure?
10. When BCl_3 is treated with water, it hydrolyzes and forms $[B(OH)_4]^-$ only, whereas $AlCl_3$ in acidified aqueous solution forms $[Al(H_2O)_6]^{3+}$ ion. Explain what is the hybridization of boron and aluminium in these species?
11. Aluminium dissolves in mineral acids and aqueous alkalies and thus shows amphoteric character. A piece of aluminium foil is treated with dilute hydrochloric acid or dilute sodium hydroxide solution in a test tube and on bringing a burning matchstick near the mouth of the test tube, a pop sound indicates the evolution of hydrogen gas. The same activity when performed with concentrated nitric acid, reaction does not proceed. Explain the reason.
12. Explain the following:
    (a) Gallium has higher ionization enthalpy than aluminium.
    (b) Boron does not exist as B^{3+} ion.
    (c) Aluminium forms $[AlF_6]^{3-}$ ion but boron does not form $[BF_6]^{3-}$ ion.
    (d) PbX_2 is more stable than PbX_4.
    (e) Pb^{4+} acts as an oxidizing agent but Sn^{2+} acts as a reducing agent.
    (f) Electron gain enthalpy of chlorine is more negative as compared to fluorine.
    (g) $T\ell(NO_3)_3$ acts as an oxidizing agent.
    (h) Carbon shows catenation property but lead does not.
    (i) Why does the element silicon, not form a graphite like structure whereas carbon does.
13. Identify the compounds A, X, and Z in the following reactions:
    (a) $A + 2HCl + 5H_2O \rightarrow 2NaCl + X$
    $$X \xrightarrow[370K]{\Delta} HBO_2 \xrightarrow[>370K]{\Delta} Z$$
14. Complete the following chemical equations:
    $Z + 3\ LiAlH_4 \rightarrow X + 3\ LiF + 3AlF_3$
    $X + 6H_2O \rightarrow Y + 6H_2$
    $3X + 3O_2 \xrightarrow{\Delta} B_2O_3 + 3H_2O$
15. In the preparation of H_2SO_4 by Contact process, why is SO_3 not absorbed directly in water to form H_2SO_4?
16. Write a balanced chemical equation for the reaction showing catalytic oxidation of NH_3 by atmospheric oxygen.
17. Write the structure of pyrophosphoric acid.
18. PH_3 forms bubbles when passed slowly in water but NH_3 dissolves. Explain why?

19. In PCl_5, phosphorus is in sp^3d hybridized state but all its five bonds are not equivalent. Justify your answer with reason.

20. Why is nitric oxide paramagnetic in gaseous state but the solid obtained on cooling it is diamagnetic?

21. Give reason to explain why ClF_3 exists but FCl_3 does not exist.

22. Out of H_2O and H_2S, which one has higher bond angle and why?

23. SF_6 is known but SCl_6 is not. Why?

24. On reaction with Cl_2, phosphorus forms two types of halides 'A' and 'B'. Halide A is yellowish-white powder but halide 'B' is colorless oily liquid. Identify A and B and write the formulas of their hydrolysis products.

25. In the ring test of NO_3^- ion, Fe^{2+} ion reduces nitrate ion to nitric oxide, which combines with Fe^{2+} (aq) ion to form brown complex. Write the reactions involved in the formation of brown ring.

26. Explain why the stability of oxoacids of chlorine increases in the order given below: $HClO < HClO_2 < HClO_3 < HClO_4$

27. Explain why ozone is thermodynamically less stable than oxygen.

28. P_4O_6 reacts with water according to equation $P_4O_6 + 6H_2O \rightarrow 4H_3PO_3$.

    Calculate the volume of 0.1 M NaOH solution required to neutralize the acid formed by dissolving 1.1 g of P_4O_6 in H_2O.

29. White phosphorus reacts with chlorine and the product hydrolyzes in the presence of water. Calculate the mass of HCl obtained by the hydrolysis of the product formed by the reaction of 62 g of white phosphorus with chlorine in the presence of water.

30. Name three oxoacids of nitrogen. Write the disproportionation reaction of that oxoacid of nitrogen in which nitrogen is in +3 oxidation state.

31. Nitric acid forms an oxide of nitrogen on reaction with P_4O_{10}. Write the reaction involved. Also write the resonating structures of the oxide of nitrogen formed.

32. Phosphorus has three allotropic forms — (A) white phosphorus, (B) red phosphorus, and (C) black phosphorus. Write the difference between white and red phosphorus on the basis of their structure and reactivity.

33. Give an example to show the effect of concentration of nitric acid on the formation of oxidation product.

34. PCl_5 reacts with finely divided silver on heating and a white silver salt is obtained, which dissolves on adding excess aqueous NH_3 solution. Write the reactions involved to explain what happens.

35. Phosphorus forms a number of oxoacids. Out of these oxoacids phosphinic acid has strong reducing property. Write its structure and also write a reaction showing its reducing behavior.

Matching Column Type

In the following questions more than one correlation is possible between options of Column-I and Column-II.

1. Match the species given in Column-I with the properties mentioned in Column-II.

Column-I	Column-II
(a) BF_4^-	(p) Oxidation state of central atom is +4
(b) $AlCl_3$	(q) Strong oxidizing agent
(c) SnO	(r) Lewis acid
(d) PbO_2	(s) Can be further oxidized
	(t) Tetrahedral shape

2. Match the species given in Column-I with properties given in Column-II.

Column-I	Column-II
(a) Diborane	(p) Used as a flux for soldering metals
(b) Gallium	(q) Crystalline form of silica
(c) Borax	(r) Banana bonds
(d) Aluminosilicate	(s) Low melting, high boiling, useful for measuring high temperatures
(e) Quartz	(s) Used as catalyst in petrochemical industries

3. Match the species given in Column-I with the hybridisation given in Column-II.

Column-I	Column-II
(a) Boron in $[B(OH)_4]^-$	(i) sp^2
(b) Aluminium in $[Al(H_2O)_6]^{3+}$	(ii) sp^3
(c) Boron in B_2H_6	(iii) sp^3d^2
(d) Carbon in Buckminsterfullerene	
(e) Silicon in SiO_4^{4-}	
(f) Germanium in $[GeCl_6]^{2-}$	

4. Match the compounds given in Column-I with the hybridization and shape given in Column-II and mark the correct option.

Column-I	Column-II
(a) XeF_6	(p) sp^3d^3-distorted octahedral
(b) XeO_3	(q) sp^3d^2-square planar
(c) $XeOF_4$	(r) sp^3-pyramidal
(d) XeF_4	(s) sp^3d^2-square pyramidal

Code:

(a) a → (p); b → (r); c → (s); d → (q)
(b) a → (p); b → (q); c → (s) d → (r)
(c) a → (s); b → (r) c → (p) d → (q)
(d) a → (s); b → (p) c; → (q) d → (r)

5. Match the formulas of oxides given in Column-I with the type of oxide given in Column-II and mark the correct option.

Column-I	Column-II
(a) Pb_3O_4	(p) Neutral oxide
(b) N_2O	(q) Acidic oxide
(c) Mn_2O_7	(r) Basic oxide
(d) $Bi2O_3$	(s) Mixed oxide

Code:

(a) a → (p); b →(q); c → (r); d → (s)
(b) a → (s); b → (p); c → (q); d → (r)
(c) a → (r); b → (q); c → (s); d → (p)
(d) a → (s); b → (r); c → (p) d → (q)

6. Match the items of Columns I and II and mark the correct option.

Column-I	Column-II
(a) H_2SO_4	(p) Highest electron gain enthalpy
(b) CCl_3NO_2	(q) Chalcogen
(c) Cl_2	(r) Tear gas
(d) Sulphur	(s) Storage batteries

Code:

(a) a → (s); b → (r); c → (p); d → (q)
(b) a → (r); b → (s); c → (p); d → (q)
(c) a → (s); b → (p); c → (q); d → (r)
(d) a → (q); b → (p); c → (r); d → (s)

7. Match the species given in Column-I with the shape given in Column-II and mark the correct option.

Column-I	Column-II
(a) SF_4	(p) Tetrahedral
(b) BrF_3	(q) Pyramidal
(c) BrO_3^-	(r) Sea-saw shaped
(d) NH_4^+	(s) Bent T-shaped

Code:

(a) a → (r); b → (q); c → (p); d → (s)
(b) a → (r); b → (s); c → (q); d → (p)
(c) a → (p); b (q); c → (r); d → (s)
(d) a → (p); b → (s); c → (r); d → (q)

8. Match the items of Columns I and II and mark the correct option.

Column-I	Column-II
(a) Its partial hydrolysis does not	(p) He change oxidation state of central atom
(b) It is used in modern diving apparatus	(q) XeF_6
(c) It is used to provide inert atmosphere	(r) XeF_4 for filling electrical bulbs
(d) Its central atom is in sp^3d^2 hybridisation	(s) Ar

Code:

(a) a → (p); b → (s); c → (q); d → (r)
(b) a → (p); b → (q); c → (r); d → (s)
(c) a → (q); b → (p); c → (s); d → (r)
(d) a → (p); b → (r); c → (q); d → (s)

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):** If aluminium atoms replace a few silicon atoms in three-dimensional network of silicon dioxide, the overall structure acquires a negative charge.

   Reason (R): Aluminium is trivalent while silicon is tetravalent.

   (a) Both A and R are correct and R is the correct explanation of A.
   (b) Both A and R are correct but R is not the correct explanation of A.
   (c) Both A and R are not correct
   (d) A is not correct but R is correct.

2. **Assertion (A):** Silicones are water repelling in nature.

   Reason (R): Silicones are organosilicon polymers, which have $(-R_2SiO-)$ as repeating unit.

(a) A and R both are correct and R is the correct explanation of A.

(b) Both A and R are correct but R is not the correct explanation of A.

(c) A and R both are not true.

(d) A is not true but R is true.

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 correct statements, and reason is the correct explanation of the assertion.

(b) Both assertion and reason are correct statements, but reason is not the correct explanation of the assertion.

(c) Assertion is correct, but reason is wrong statement.

(d) Assertion is wrong but reason is correct statement.

(e) Both assertion and reason are wrong statements.

3. **Assertion:** N_2 is less reactive than P_4.

   Reason: Nitrogen has more electron gain enthalpy than phosphorus.

4. **Assertion:** HNO_3 makes iron passive.

   Reason: HNO_3 forms a protective layer of ferric nitrate on the surface of iron.

5. **Assertion:** HI cannot be prepared by the reaction of KI with concentrated H_2SO_4

   Reason: HI has lowest H–X bond strength among halogen acids.

6. **Assertion:** Both rhombic and monoclinic sulphur exist as S_8 but oxygen exists as O_2.

   Reason: Oxygen forms $p\pi$–$p\pi$ multiple bond due to small size and small bond length but $p\pi$–$p\pi$ bonding is not possible in sulphur.

7. **Assertion:** NaCl reacts with concentrated H_2SO_4 to give colorless fumes with pungent smell. But on adding MnO_2 the fumes become greenish yellow.

   Reason: MnO_2 oxidizes HCl to chlorine gas which is greenish yellow.

8. **Assertion:** SF_6 cannot be hydrolyzed but SF_4 can be.

   Reason: Six F atoms in SF_6 prevent the attack of H_2O on sulphur atom of SF_6.

Long Answer Type

1. Describe the general trends in the following properties of the elements in Groups 13 and 14.
   (a) Atomic size
   (b) Ionization enthalpy
   (c) Metallic character
   (d) Oxidation states
   (e) Nature of halides

2. Account for the following observations:
   (a) $AlCl_3$ is a Lewis acid
   (b) Though fluorine is more electronegative than chlorine yet BF_3 is a weaker Lewis acid than BCl_3
   (c) PbO_2 is a stronger oxidizing agent than SnO_2
   (d) The +1 oxidation state of thallium is more stable than its +3 state

3. When aqueous solution of borax is acidified with hydrochloric acid, a white crystalline solid is formed which is soapy to touch. Is this solid acidic or basic in nature? Explain.

4. Three pairs of compounds are given below. Identify that compound in each of the pairs which has group 13 element in more stable oxidation state. Give reason for your choice. State the nature of bonding also.
   (a) $TlCl_3$, TlCl
   (b) $AlCl_3$, AlCl
   (c) $InCl_3$, InCl

5. BCl_3 exists as monomer whereas $AlCl_3$ is dimerized through halogen bridging. Give reason. Explain the structure of the dimer of $AlCl_3$ also.

6. Boron fluoride exists as BF_3 but boron hydride does not exist as BH_3. Give reason. In which form does it exist? Explain its structure.

7. (a) What are silicones? State the uses of silicones.
   (b) What are boranes? Give chemical equation for the preparation of diborane.

8. A compound (A) of boron reacts with NMe_3 to give an adduct (B) which on hydrolysis gives a compound (C) and hydrogen gas. Compound (C) is an acid. Identify the compounds A, B, and C. Give the reactions involved.

9. A nonmetallic element of group 13, used in making bullet proof vests is extremely hard solid of black color. It can exist in many allotropic forms and has unusually high melting point. Its trifluoride acts as Lewis acid towards ammonia. The element

exhibits maximum covalency of four. Identify the element and write the reaction of its trifluoride with ammonia. Explain why does the trifluoride act as a Lewis acid.

10. A tetravalent element forms monoxide and dioxide with oxygen. When air is passed over heated element (1273 K), producer gas is obtained. Monoxide of the element is a powerful reducing agent and reduces ferric oxide to iron. Identify the element and write formulae of its monoxide and dioxide. Write chemical equations for the formation of producer gas and reduction of ferric oxide with the monoxide.

11. An amorphous solid "A" burns in air to form a gas "B" which turns lime water milky. The gas is also produced as a by-product during roasting of sulphide ore. This gas decolorizes acidified aqueous $KMnO_4$ solution and reduces Fe^{3+} to Fe^{2+}. Identify the solid "A" and the gas "B" and write the reactions involved.

12. On heating lead(II) nitrate gives a brown gas "A". The gas "A" on cooling changes to colorless solid "B". Solid "B" on heating with NO changes to a blue solid 'C'. Identify 'A', 'B', and 'C' and also write reactions involved and draw the structures of 'B' and 'C'.

13. On heating compound (A) gives a gas (B) which is a constituent of air. This gas when treated with 3 mol of hydrogen (H_2) in the presence of a catalyst gives another gas (C) which is basic in nature. Gas C on further oxidation in moist condition gives a compound (D) which is a part of acid rain. Identify compounds (A) to (D) and also give necessary equations of all the steps involved.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. Alum helps in purifying water by:
   (a) Forming Si complex with clay particles
   (b) Sulphate part which combines with the dirt and removes it
   (c) Coagulating the mud particles
   (d) Making mud water soluble **(AIEEE, 2002)**

2. In XeF_2, XeF_4, and XeF_6, the number of lone pairs on Xe are, respectively:
   (a) 2, 3, and 1 (b) 1, 2, and 3
   (c) 4, 1, and 2 (d) 3, 2, and 1
   (AIEEE, 2002)

3. In case of nitrogen, NCl_3 is possible but not NCl_5, whereas in case of phosphorous, PCl_3 as well as PCl_5 are possible. It is due to: **(AIEEE, 2002)**
   (a) Availability of vacant *d*-orbitals in P but not in N
   (b) Lower electronegativity of P than N
   (c) Lower tendency of H-bond formation in P than N
   (d) Occurrence of P in solid whereas N is in gaseous state at room temperature

4. Which of the following statements is true?
   (a) HF is less polar than HBr
   (b) Absolutely pure water does not contain any ions
   (c) Chemical bond formation takes place when forces of attraction overcome the forces of repulsion
   (d) In covalency, transfer of electron takes place
   (AIEEE, 2002)

5. Number of sigma bonds in P_4O_{10} is:
   (a) 6 (b) 7
   (c) 17 (d) 16
   (AIEEE, 2002)

6. Oxidation number of Cl in $CaOCl_2$ (bleaching powder) is:
   (a) Zero, since it contains Cl_2
   (b) –1, since it contains Cl^-
   (c) +1, since it contains ClO^-
   (d) +1 and –1, since it contains ClO^- and Cl^-
   (AIEEE, 2002)

7. What may be expected to happen when phosphine gas is mixed with chlorine gas?
   (a) PCl_3 and HCl are formed and the mixture warms up
   (b) PCl_3 and HCl are formed and the mixture cools down
   (c) $PH_3 \cdot Cl_2$ is formed with warming up
   (d) The mixture only cools down
   (AIEEE, 2003)

8. Concentrated hydrochloric acid when kept in open air sometimes produces a cloud of white fumes. The explanation for it is that:
   (a) Oxygen in air reacts with the emitted HCl gas to form a cloud of chlorine gas
   (b) Strong affinity of HCl gas for moisture in air results in forming of droplets of liquid solution that appears like a cloudy smoke
   (c) Due to strong affinity for water, concentrated hydrochloric acid pulls moisture of air towards itself. This moisture forms droplets of water and hence the cloud
   (d) Concentrated hydrochloric acid emits strongly smelling HCl gas all the time
   (AIEEE, 2003)

9. Graphite is a soft solid lubricant extremely difficult to melt. The reason for this anomalous behavior is that graphite:
   (a) Is an allotropic form of diamond
   (b) Has molecules of variable molecular masses like polymers
   (c) Has carbon atoms arranged in large plates of rings of strongly bound carbon atoms with weak interpolate bonds
   (d) Is a non-crystalline substance **(AIEEE, 2003)**

10. Glass is a
   (a) Super-cooled liquid
   (b) Gel
   (c) Polymeric mixture
   (d) Micro-crystalline solid **(AIEEE, 2003)**

11. Which one of the following substances has the highest proton affinity?
   (a) H_2S (b) NH_3
   (c) PH_3 (d) H_2O
   (AIEEE, 2003)

12. For making good quality mirrors, plates of float glass are used. These are obtained by floating molten glass over a liquid metal which does not solidify before glass. The metal used can be:
   (a) Tin (b) Sodium
   (c) Magnesium (d) Mercury
   (AIEEE, 2003)

13. Which among the following factors is the most important in making fluorine the strongest oxidizing halogen?
   (a) Hydration enthalpy
   (b) Ionization enthalpy
   (c) Electron affinity
   (d) Bond dissociation energy **(AIEEE, 2004)**

14. Which one of the following statement regarding helium is incorrect?
   (a) It is used to produce and sustain powerful superconducting magnets
   (b) It is used as a cryogenic agent for carrying out experiments at low temperatures
   (c) It is used to fill gas balloons instead of hydrogen because it is lighter and non-inflammable
   (d) It is used in gas-cooled nuclear reactors
   (AIEEE, 2004)

15. Beryllium and aluminium exhibit many properties that are similar. But the two elements differ in:
   (a) Forming covalent halides
   (b) Forming polymeric hydrides
   (c) Exhibiting maximum covalency in compounds
   (d) Exhibiting amphoteric nature in their oxides
   (AIEEE, 2004)

16. Aluminium chloride, Al_2Cl_6, exists as dimer in solid state as well as in solution of non-polar solvents such as benzene. When dissolved in water, it gives:
   (a) $[Al(OH)_6]^{3-} + 3HCl$
   (b) $[Al(H_2O)_6]^{3+} + 3Cl^-$
   (c) $Al^{3+} + 3Cl^-$
   (d) $Al_2O_3 + 6HCl$ **(AIEEE, 2004)**

17. Excess of KI reacts with $CuSO_4$ solution and then $Na_2S_2O_3$ solution is added to it. Which of the statements is incorrect for this reaction?
   (a) $Na_2S_2O_3$ is oxidized
   (b) CuI_2 is formed
   (c) Cu_2I_2 is formed
   (d) Evolved I_2 is reduced
   (AIEEE, 2004)

18. The soldiers of napoleon army while at Alps, during freezing winter, suffered a serious problem as regards to the tin buttons of their uniforms. White metallic tin buttons got converted to grey powder. This transformation is related to:
   (a) A change in the partial pressure of oxygen in the air
   (b) A change in the crystalline structure of tin
   (c) An interaction with nitrogen of the air at very low temperature
   (d) An interaction with water vapor contained in the humid air **(AIEEE, 2004)**

19. The number of hydrogen atoms attached to phosphorus atom in hypophosphorous acid is:
   (a) Three (b) One
   (c) Two (d) Zero
   (AIEEE, 2005)

20. The correct order of the thermal stability of hydrogen halides (H – X) is:
   (a) HI > HCI < HF > HBr
   (b) HCI < HF > HBr < HI
   (c) HF > HCI > HBr > HI
   (d) HI < HBr > HCI < HF **(AIEEE, 2005)**

21. Heating an aqueous solution of aluminium chloride to dryness will give:
   (a) $Al(OH)Cl_2$ (b) Al_2O_3
   (c) $Al2Cl_6$ (d) $AlCl_3$
   (AIEEE, 2005)

22. In silicon dioxide:
(a) There are double bonds between silicon and oxygen atoms
(b) Silicon atom is bonded to two oxygen atoms
(c) Each silicon atom is surrounded by two oxygen atoms, and each oxygen atom is bonded to two silicon atoms
(d) Each silicon atom is surrounded by four oxygen atoms, and each oxygen atom is bonded to two silicon atoms
(AIEEE, 2005)

23. The structure of diborane (B_2H_6) contains
(a) Four 2c–2e bonds and four 3c-2e bonds
(b) Two 2c–2e bonds and two 3c–3e bonds
(c) Two 2c–2e bonds and four 2c–2e bonds
(d) Four 2c–2e bonds and two 3c–2e bonds
(AIEEE, 2005)

24. Which of the following statements is true?
(a) $HClO_4$ is a weaker acid than $HClO_3$
(b) HNO_3 is a stronger acid than HNO_2
(c) H_3PO_3 is a stronger acid than H_2SO_3
(d) In aqueous medium, HF is a stronger acid than HCl **(AIEEE, 2006)**

25. The increasing order of the first ionization enthalpies of the elements B, P, S, and F (lowest first) is:
(a) B < P < S < F (b) B < S < P < F
(c) F < S < P < B (d) P < S < B < F
(AIEEE, 2006)

26. What products are expected from the disproportionation reaction of hypochlorous acid?
(a) HCl and Cl_2O (b) HCl and $HClO_3$
(c) $HClO_3$ and Cl_2O (d) $HClO_2$ and $HClO_4$
(AIEEE, 2006)

27. Identify the incorrect statement among the following: **(AIEEE, 2007)**
(a) Br_2 reacts with hot and strong NaOH solution to give NaBr and H_2O
(b) Ozone reacts with SO_2 to give SO_3
(c) Silicon reacts with NaOH(aq) in the presence of air to give Na_2SiO_3 and H_2O
(d) Cl_2 reacts with excess of NH_3 to give N_2 and HCl

28. Regular use of the following fertilizers increases the acidity of soil?
(a) Ammonium sulphate
(b) Potassium nitrate
(c) Urea
(d) Superphosphate of lime **(AIEEE, 2007)**

29. The stability of dihalides of Si, Ge, Sn, and Pb increases steadily in the sequence **(AIEEE, 2007)**
(a) $PbX_2 << SnX_2 << GeX_2 << SiX_2$
(b) $GeX_2 << SiX_2 << SnX_2 << PbX_2$
(c) $SiX_2 << GeX_2 << PbX_2 << SnX_2$
(d) $SiX_2 << GeX_2 << SnX_2 << PbX_2$

30. Which one of the following is the correct statement?
(a) Boric acid is a protonic acid
(b) Beryllium exhibits coordination number of six
(c) Chlorides of both beryllium and aluminium have bridged chloride structures in solid phase
(d) $B_2H_6 \cdot 2NH_3$ is known as 'inorganic benzene'
(AIEEE, 2008)

31. Which one of the following reactions of xenon compounds is not feasible?
(a) $3XeF_4 + 6H_2O \rightarrow 2Xe + XeO_3 + 12HF + 1.5O_2$
(b) $2XeF_2 + 2H_2O \rightarrow 2Xe + 4HF + O_2$
(c) $XeF_6 + RbF \rightarrow Rb[XeF_7]$
(d) $XeO_3 + 6HF \rightarrow XeF_6 + 3H_2O$
(AIEEE, 2009)

32. Which of the following statement is wrong?
(a) The stability of hydride increases from NH_3 to BiH_3 in group 15 of the periodic table
(b) Nitrogen cannot form dp–pp bond
(c) Single N–N bond is weaker than the single P–P bond
(d) N_2O_4 has two resonance structures
(AIEEE, 2011)

33. Which of the following statements regarding sulphur is incorrect?
(a) S_2 molecule is paramagnetic
(b) The vapor at 200°C consists mostly of S_8 rings
(c) At 600°C, the gas mainly consists of S_2 molecules
(d) The oxidation state of sulphur is never less than +4 in its compounds **(AIEEE, 2011)**

34. Boron cannot form which one of the following anions?
(a) BF_6^{-3} (b) BH_4^-
(c) $B(OH)_4^-$ (d) BO_2^-
(AIEEE, 2011)

35. Identify the incorrect statement from the following:
(a) Ozone absorbs the intense ultraviolet radiation of the sun
(b) Depletion of ozone layer is because of its chemical reactions with chlorofluoroalkanes
(c) Ozone absorbs infrared radiation
(d) Oxides of nitrogen in the atmosphere can cause the depletion of ozone layer
(AIEEE, 2011)

36. The correct order of electron gain enthalpy with negative sign of F, Cl, Br, and I having atomic number 9, 17, 35, and 53 respectively, is:
(a) F > Cl > Br > I (b) Cl > F > Br > I
(c) Br > Cl > I > F (d) I > Br > Cl > F
(AIEEE, 2011)

37. In view of the signs of $\Delta_r G°$ for the following reactions:
$PbO_2 + Pb \rightarrow 2PbO$, $\Delta_r G° < 0$
$SnO_2 + Sn \rightarrow 2SnO$, $\Delta_r G° > 0$
which oxidation states are more characteristics for lead and tin?
(a) For lead +2, for tin +2
(b) For lead +4, for tin +4
(c) For lead +2, for tin +4
(d) For lead +4, for tin +2 **(AIEEE, 2011)**

38. Which of the following has maximum number of lone pairs associated with Xe?
(a) XeF_4 (b) XeF_6
(c) XeF_2 (d) XeO_3
(AIEEE, 2011)

39. The molecule having the smallest bond angle is:
(a) NCl_3 (b) $AsCl_3$
(c) $SbCl_3$ (d) PCl_3
(AIEEE, 2012)

40. In the following sets of reactants which two sets best exhibit the amphoteric character of $Al_2O_3.xH_2O$? **(JEE Main, 2014)**
Set-1: $Al_2O_3.xH_2O(s)$ and OH^- (aq)
Set-2: $Al_2O_3.xH_2O(s)$ and H_2O (l)
Set-3: $Al_2O_3.xH_2O(s)$ and H^+ (aq)
Set-4: $Al_2O_3.xH_2O(s)$ and NH_3 (aq)
(a) 1 and 2 (b) 2 and 4
(c) 1 and 3 (d) 3 and 4

41. The gas evolved on heating CaF_2 and SiO_2 with concentrated H_2SO_4, on hydrolysis gives a white gelatinous precipitate. The precipitate is:
(a) Silica gel
(b) Silicic acid
(c) Hydrofluosilicic acid
(d) Calciumfluorosilicate
(JEE Main, 2014)

JEE (Advanced) Exercises

Fill in the Blanks Type

1. Iodine reacts with hot NaOH solution. The products are NaI and _____.
(IIT-JEE, 1980)

2. _____ phosphorus is reactive because of its highly strained tetrahedral structure.
(IIT-JEE, 1987)

3. The basicity of phosphorus acid (H_3PO_3) is _____.
(IIT-JEE, 1990)

4. The hydrolysis of alkyl-substituted chlorosilanes gives _____.
(IIT-JEE, 1991)

5. In P_4O_{10}, the number of oxygen atoms bonded to each phosphorus atom is _____.
(IIT-JEE, 1992)

6. The lead chamber process involves oxidation of SO_2 by atomic oxygen under the influence of _____ as catalyst.
(IIT-JEE, 1992)

7. The hydrolysis of trialkylchlorosilane, R_3SiCl, yields _____.
(IIT-JEE, 1994)

8. The two types of bonds present in B_2H_6 are covalent and _____. **(IIT-JEE, 1994)**

9. One recently discovered allotrope of carbon (e.g., C_{60}) is commonly known as _____.
(IIT-JEE, 1994)

10. A liquid which is permanently supercooled is frequently called a _____.
(IIT-JEE, 1998)

True/False Type

1. When PbO_2 reacts with a dilute acid, it gives hydrogen peroxide. **(IIT-JEE, 1982)**

2. Carbon tetrachloride burns in air when lighted to give phosgene.
(IIT-JEE, 1983)

3. Dilute HCl oxidizes metallic Fe to Fe^{2+}.

(IIT-JEE, 1983)

4. In aqueous solution, chlorine is a stronger oxidizing agent than fluorine.

(IIT-JEE, 1984)

5. The H—N—H bond angle in NH_3 is greater than the H—As—H bond angle in AsH_3.

(IIT-JEE, 1984)

6. Graphite is a better lubricant on the moon than on the earth.

(IIT-JEE, 1987)

7. All the Al—Cl bonds in Al_2Cl_6 are equivalent.

(IIT-JEE, 1989)

8. Nitric oxide, though an odd electron molecule, is diamagnetic in liquid state.

(IIT-JEE, 1991)

9. Diamond is harder than graphite.

(IIT-JEE, 1993)

10. The basic nature of the hydroxides of group 13 [Gr III (b)] decreases progressively down the group.

(IIT-JEE, 1993)

11. The tendency for catenation is much higher for C than for Si.

(IIT-JEE, 1993)

12. HBr is a stronger acid than HI because of hydrogen bonding.

(IIT-JEE, 1993)

Single Correct Answer Type

1. Which of the following statement is incorrect?
   (a) NO is heavier than O_2
   (b) The formula of heavy water is D_2O
   (c) Nitrogen diffuses faster than oxygen through an orifice
   (d) NH_3 can be used as a refrigerant

(IIT-JEE, 1978)

2. Ammonia gas can be dried by:
   (a) Conc. H_2SO_4 (b) P_2O_5
   (c) $CaCl_2$ (d) Quick lime

(IIT-JEE, 1978)

3. HBr and HI reduce sulphuric acid, HCl can reduce $KMnO_4$, and HF can reduce:
   (a) H_2SO_4 (b) $KMnO_4$
   (c) $K_2Cr_2O_7$ (d) None of these

(IIT-JEE, 1981)

4. Moderate electrical conductivity is shown by:
   (a) Silica (b) Graphite
   (c) Diamond (d) Carborundum

(IIT-JEE, 1982)

5. Chlorine acts as a bleaching agent only in the presence of:
   (a) Dry air (b) Moisture
   (c) Sunlight (d) Pure oxygen

6. The oxide that gives H_2O_2 on treatment with a dilute acid is:
   (a) PbO_2 (b) Na_2O_2
   (c) MnO_2 (d) TiO_2

(IIT-JEE, 1985)

7. A gas that cannot be collected over water is:
   (a) N_2 (b) O_2
   (c) SO_2 (d) PH_3

(IIT-JEE, 1985)

8. The bonds present in N_2O_5 are:
   (a) Only ionic
   (b) Covalent and coordinate
   (c) Only covalent
   (d) Covalent and ionic **(IIT-JEE, 1986)**

9. Which of the following oxides of nitrogen is a colored gas?
   (a) N_2O (b) NO
   (c) N_2O_4 (d) NO_2

(IIT-JEE, 1987)

10. Among the trihalides of nitrogen, which is the least basic?
   (a) NF_3 (b) NCl_3
   (c) NBr_3 (d) NI_3

(IIT-JEE, 1987)

11. Bromine can be liberated from potassium bromide solution by the action of:
   (a) Iodine solution (b) Chlorine water
   (c) Sodium chloride (d) Potassium iodide

(IIT-JEE, 1987)

12. Which of the following is the strongest base?
   (a) AsH_3 (b) NH_3
   (c) PH_3 (d) SbH_3

(IIT-JEE, 1989)

13. There is no S—S bond in:
   (a) $S_2O_4^{2-}$ (b) $S_2O_5^{2-}$
   (c) $S_2O_3^{2-}$ (d) $S_2O_7^{2-}$

(IIT-JEE, 1991)

14. The oxidation states of the most electronegative element in the products of the reaction, BaO_2 with dil. H_2SO_4, are:
(a) 0 and –1 (b) –1 and –2
(c) –2 and 0 (d) –2 and –1
(IIT-JEE, 1991)

15. The species that do not contain peroxide ions is:
(a) PbO_2 (b) H_2O_2
(c) SrO_2 (d) BaO_2
(IIT-JEE, 1992)

16. Hydrolysis of 1 mol of peroxodisulphuric acid produces:
(a) 2 mol of sulphuric acid
(b) 2 mol of peroxomono sulphuric acid
(c) 1 mol of sulphuric acid and 1 mol of peroxomono sulphuric acid
(d) 1 mol of sulphuric acid, 1 mol of peroxomono sulphuric acid, and 1 mol of hydrogen peroxide
(IIT-JEE, 1996)

17. Which of the following halides is least stable and has a doubtful existence?
(a) CCl_4 (b) GeI_4
(c) SnI_4 (d) PbI_4
(IIT-JEE, 1996)

18. Which of the following oxides is neutral?
(a) CO (b) SNO_2
(c) ZnO (d) SiO_2
(IIT-JEE, 1996)

19. The following acids have been arranged in the order of decreasing acid strength. Identify the correct order:
ClOH (I), BROH (II), IOH (III)
(a) I > II > III (b) II > I > III
(c) III > II > I (d) I > III > II
(IIT-JEE, 1996)

20. Which of the following species is not a pseudo halide?
(a) CNO^- (b) $RCOO^-$
(c) OCN^- (d) NNN^-
(IIT-JEE, 1997)

21. In compounds of the type ECl_3, where E = *B*, *P*, As, or Bi, the angles Cl—E—Cl for different *E* are in the order:
(a) B > P = As = Bi (b) B > P > As > Bi
(c) B < P = As = Bi (d) B < P < As < Bi
(IIT-JEE, 1999)

22. The number of P—O—P bonds in cyclic metaphosphoric acid is:
(a) Zero (b) Two
(c) Three (d) Four
(IIT-JEE, 2000)

23. The correct order of acidic strength is:
(a) $Cl_2O_7 > SO_2 > P_4O_{10}$
(b) $CO_2 > N_2O_5 > SO_3$
(c) $Na_2O > MgO > Al_2O_3$
(d) $K_2O > CaO > MgO$ **(IIT-JEE, 2000)**

24. Among H_2O, H_2S, H_2Se, and H_2Te, the one with the highest boiling point is:
(a) H_2O because of hydrogen bonding
(b) H_2Te because of higher molecular weight
(c) H_2S because of hydrogen bonding
(d) H_2Se because of lower molecular weight
(IIT-JEE, 2000)

25. Ammonia can be dried by:
(a) Conc. H_2SO_4 (b) P_4O_{10}
(c) CaO (d) Anhydrous $CaCl_2$

26. The set with the correct order of acidity is:
(a) $HClO < HClO_2 < HClO_3 < HClO_4$
(b) $HClO_4 < HClO_3 < HClO_2 < HClO$
(c) $HClO < HClO_4 < HClO_3 < HClO_2$
(d) $HClO_4 < HClO_2 < HClO_3 < HClO$
(IIT-JEE, 2001)

27. The number of S—S bonds in sulphur trioxide trimer (S_3O_9) is:
(a) Three (b) Two
(c) One (d) Zero
(IIT-JEE, 2001)

28. Identify the correct order of acidic strength of CO_2, CuO, CaO, and H_2O:
(a) $CaO < CuO < H_2O < CO_2$
(b) $H_2O < CuO < CaO < CO_2$
(c) $CaO < H_2O < CuO < CO_2$
(d) $H_2O < CO_2 < CaO < CuO$ **(IIT-JEE, 2002)**

29. H_3BO_3 is:
(a) A monobasic acid and weak Lewis acid
(b) A monobasic and weak Bronsted acid
(c) A monobasic and strong Lewis acid
(d) A tribasic and weak Bronsted acid
(IIT-JEE, 2003)

30. $(Me)_2SiCl_2$ on hydrolysis will produce:
(a) $(Me)_2Si(OH)_2$ (b) $(Me)_2Si{=}O$
(c) $[-O-Si(Me)_2-O-]_n$ (d) $Me_2SiCl(OH)$
(IIT-JEE, 2003)

31. When I^- is oxidized by MnO_4^- in an alkaline medium, I^- converts into:

(a) IO_3^- (b) I_2
(c) IO_4^- (d) IO^-

(IIT-JEE, 2004)

32. Which is the most thermodynamically stable allotropic form of phosphorus?

(a) Red (b) White
(c) Black (d) Yellow

(IIT-JEE, 2005)

33. Which of the following is not oxidized by O_3?

(a) KI (b) $FeSO_4$
(c) $KMnO_4$ (d) K_2MnO_4

(IIT-JEE, 2005)

34. Which blue liquid is obtained on reacting equimolar amounts of two gases at –30°C?

(a) N_2O (b) N_2O_3
(c) N_2O_4 (d) N_2O_5

35. The name of the structure of silicates in which three oxygen atoms of $[SiO_4]^{4-}$ are shared is:

(a) Pyrosilicate
(b) Sheet silicate
(c) Linear-chain silicate
(d) Three-dimensional silicate

(IIT-JEE, 2005)

36. $B(OH)_3 + NaOH \rightleftharpoons NaBO_2 + Na[B(OH)_4] + H_2O$
How can this reaction be made to proceed in the forward direction?

(a) By the addition of *cis*-1,2-diol.
(b) By the addition of borax.
(c) By the addition of *trans*-1,2-diol.
(d) By the addition of Na_2HPO_4.

(IIT-JEE, 2006)

37. The reaction of P_4 with *X* leads selectively to P_4O_6. *X* is:

(a) Dry O_2
(b) A mixture of O_2 and N_2
(c) Moist O_2
(d) O_2 in the presence of aqueous NaOH

(IIT-JEE, 2009)

38. The species having pyramidal shape is:

(a) SO_3 (b) BrF_3
(c) SiO_3^{2-} (d) OSF_2

(IIT-JEE, 2010)

39. Extra pure N_2 can be obtained by heating:

(a) NH_3 with CuO (b) NH_4NO_3
(c) $(NH_4)_2Cr_2O_7$ (d) $Ba(N_3)_2$

(IIT-JEE, 2011)

40. Concentrated nitric acid, upon long standing, turns yellow-brown due to the formation of:

(a) NO (b) NO_2
(c) N_2O (d) N_2O_4

(JEE Advanced, 2013)

41. Under ambient conditions, the total number of gases released as products in the final step of the reaction scheme shown below is:

$$XeF_6 \xrightarrow{\text{Complete Hydrolysis}} P + \text{other product}$$
$$\downarrow OH^-/H_2O$$
$$Q$$
$$\downarrow \text{slow disproportionation in } OH^-/H_2O$$
$$\text{products}$$

(a) 0 (b) 1
(c) 2 (d) 3

(JEE Advanced, 2014)

42. The product formed in the reaction of $SOCl_2$ with white phosphorous is

(a) PCl_3 (b) SO_2Cl_2
(c) SCl_2 (d) $POCl_3$

(JEE Advanced, 2014)

43. Hydrogen peroxide in its reaction with KIO_4 and NH_2OH respectively, is acting as a:

(a) Reducing agent, oxidizing agent
(b) Reducing agent, reducing agent
(c) Oxidizing agent, oxidizing agent
(d) Oxidizing agent, reducing agent

(JEE Advanced, 2014)

Multiple Correct Answers Type

1. Nitrogen(I) oxide is produced by:

(a) Thermal decomposition of ammonium nitrate
(b) Disproportionation of N_2O_4
(c) Thermal decomposition of ammonium nitrite
(d) Interaction of hydroxylamine and nitrous acid

(IIT-JEE, 1989)

2. White phosphorus (P_4) has:
   (a) Six P—P single bonds
   (b) Four P—P single bonds
   (c) Four lone pairs of electrons
   (d) PPP angle of 60°

(IIT-JEE, 1998)

3. Ammonia, on reaction with hypochlorite anion, can form:
   (a) NO (b) NH_4Cl
   (c) N_2H_4 (d) HNO_2

(IIT-JEE, 1999)

4. When PbO_2 reacts with concentrated HNO_3, the gas(es) evolved is/are:
   (a) NO_2 (b) O_2
   (c) N_2 (d) N_2O

(IIT-JEE, 2005)

5. In the following reaction,
   $2X + B_2H_6 \rightarrow [BH_2(X)_2]^+ [BH_4]^-$
   The amine(s) X is/are:
   (a) NH_3 (b) CH_3NH_2
   (c) $(CH_3)_2NH$ (d) $(CH_3)N$

(IIT-JEE, 2009)

6. The nitrogen oxide(s) that contains N—N bond is/are:
   (a) N_2O (b) N_2O_3
   (c) N_2O_4 (d) N_2O_5

(IIT-JEE, 2010)

7. The correct statement(s) about O_3 is(are)
   (a) O–O bond lengths are equal
   (b) Thermal decomposition of O_3 is endothermic
   (c) O_3 is diamagnetic in nature
   (d) O_3 has a bent structure

(JEE Advanced, 2013)

8. The correct statements(s) for orthoboric acid is/are:
   (a) It behaves as a weak acid in water due to self-ionization
   (b) Acidity of its aqueous solution increases upon addition of ethylene glycol
   (c) It has a three-dimensional structure due to hydrogen bonding
   (d) It is a weak electrolyte in water

(JEE Advanced, 2014)

Comprehension Type

For Problems 1–3

The noble gases have closed-shell electronic configuration and are monatomic gases under normal conditions. The low boiling points of the lighter noble gases are due to the weak dispersion forces between the atoms and the absence of other interatomic interactions.

The direct reaction of xenon with fluorine leads to a series of compounds with oxidation numbers +2, +4, and +6. XeF_4 reacts violently with water to give XeO_3. The compounds of xenon exhibit rich stereochemistry and their geometries can be deduced considering the total number of electron pairs in the valence shell.

1. Argon is used in arc welding because of its:
   (a) Low reactivity with metals
   (b) Ability to lower the melting point of metals
   (c) Flammability
   (d) High calorific value
2. The structure of XeO_3 is:
   (a) Linear (b) Planar
   (c) Pyramidal (d) T-shaped
3. XeF_4 and XeF_6 are expected to be:
   (a) Oxidizing (b) Reducing
   (c) Unreactive (d) Strongly basic

(IIT-JEE, 2007)

For Problems 4–6

There are some deposits of nitrates and phosphates in the earth's crust. Nitrates are more soluble in water. Nitrates are difficult to reduce under laboratory conditions but microbes do it easily. Ammonia forms a large number of complexes with transition metal ions. Hybridization easily explains the ease of sigma donation capability of NH_3 and PH_3. Phosphine is a flammable gas and is prepared from white phosphorus.

4. Which of the following statemets is correct?
   (a) Phosphates have no biological significance in humans
   (b) Between nitrates and phosphates, phosphates are less abundant in earth's crust
   (c) Between nitrates and phosphates, nitrates are less abundant in earth's crust
   (d) Oxidation of nitrates is possible in soil
5. Which of the following statements is correct?
   (a) Between NH_3 and PH_3, NH_3 is a better electron donor because the lone pair of electrons occupies spherical s-orbital and is less directional

(b) Between NH_3 and PH_3, PH_3 is a better electron donor because the lone pair of electrons occupies sp^3-orbital and is more directional

(c) Between NH_3 and PH_3, NH_3 is a better electron donor because the lone pair of electrons occupies sp^3-orbital and is more directional

(d) Between NH_3 and PH_3, PH_3 is a better electron donor because the lone pair of electrons occupies spherical *s*-orbital and is less directional

6. White phosphorus on reaction with NaOH gives PH_3 as one of the products. This is a:
   (a) Dimerization reaction
   (b) Disproportionation reaction
   (c) Condensation reaction
   (d) Precipitation reaction **(IIT-JEE, 2008)**

Paragraph for Question 7 and 8

The reaction of Cl_2 gas with cold dilute and hot concentrated NaOH in water give sodium salt of two (different) oxoacids of chlorine P and Q respectively. The Cl_2 gas reacts with SO_2 gas , in presence of charcoal to give a product R. R reacts with white phosphorous to give a compound S. On hydrolysis, S gives as oxoacid of phosphorous T.

7. R, S, and T, respectively are:
   (a) SO_2Cl_2, PCl_5, and H_3PO_4
   (b) SO_2Cl_2, PCl_3, and H_3PO_3
   (c) $SOCl_2$, PCl_3, and H_3PO_2
   (d) SO_2Cl_2, PCl_5, and H_3PO_4
   (JEE Advanced, 2013)

8. P and Q, respectively, are the sodium salts of:
   (a) Hypochlorus and chloric acid
   (b) Hypochlorus and chlorus acid
   (c) Chloric and perchloric acids
   (d) Chloric and hypochlorus acids
   (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 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:** Although PF_5, PCl_5, and PBr_5 are known, the pentahalides of nitrogen have not been observed.
   Statement-II: Phosphorous has lower electronegativity than nitrogen.
   (IIT-JEE, 1994)

2. **Statement-I:** $Al(OH)_3$ is amphoteric in nature.
   Statement-II: Al—O and O—H bonds can be broken with equal ease in $Al(OH)_3$.
   (IIT-JEE, 1998)

3. **Statement-I:** HNO_3 is a stronger acid than HNO_2.
   Statement-II: In HNO_3, there are two nitrogen to oxygen bonds, whereas in HNO_2 there is only one.
   (IIT-JEE, 1998)

4. **Statement-I:** Between $SiCl_4$ and CCl_4, only $SiCl_4$ reacts with water.
   Statement-II: $SiCl_4$ is ionic and CCl_4 is covalent.
   (IIT-JEE, 2001)

5. **Statement-I:** In water, orthoboric acid behaves as a weak monobasic acid.
   Statement-II: In water, orthoboric acid acts as a proton donor.
   (IIT-JEE, 2007)

6. **Statement-I:** Boron always forms covalent bonds.
   Statement-II: The small size of B^{3+} favors formation of covalent bond.
   (IIT-JEE, 2007)

7. **Statement-I:** Pb^{4+} compounds are stronger oxidizing agents than Sn^{4+} compounds.
   Statement-II: The higher oxidation states for group 14 elements are more stable for the heavier members of the group due to 'inert pair effect'. **(IIT-JEE, 2008)**

Matching Column Type

1. Match the following:

Column-I	Column-II
(a) $Bi^{3+} \rightarrow (BiO)^+$	(p) Heat
(b) $[AlO_2]^- \rightarrow Al(OH)_3$	(q) Hydrolysis
(c) $SiO_4^{4-} \rightarrow Si_2O_7^{6-}$	(r) Acidification
(d) $(B_4O_7^{2-}) \rightarrow [B(OH)_3]$	(s) Dilution by water

(IIT-JEE, 2006)

2. Match each of the reactions given in Column-I with the corresponding product(s) given in Column-II.

Column-I	Column-II
(a) Cu + dil. HNO_3	(p) NO
(b) Cu + conc. HNO_3	(q) NO_2

(c) Zn + dil. HNO_3	(r) N_2O
(d) Zn + conc. HNO_3	(s) $Cu(NO_3)_2$
	(t) $Zn(NO_3)_2$

(IIT-JEE, 2009)

3. All the compounds listed in Column-I react with water. Match the result of the respective reactions with the appropriate options listed in Column-II.

Column-I	Column-II
(a) $(CH_3)_2SiCl_2$	(p) Hydrogen halide formation
(b) XeF_4	(q) Redox reaction
(c) Cl_2	(r) Reacts with glass
(d) VCl_5	(s) Polymerisation
	(t) O_2 formation

(IIT-JEE, 2010)

4. The unbalanced chemical reactions given in List-I show missing reagent or condition (?) which are provided in List-II. Match List-I with List-II and select the correct answer using the code given below the lists:

List-I	List-II
(P) $PbO_2 + H_2SO_4 \longrightarrow PbSO_4 + O_2$ + other product	(a) NO
(Q) $Na_2S_2O_3 + H_2O \xrightarrow{?} NaHSO_4$ + other product	(b) I_2
(R) $N_2H_4 \xrightarrow{?} \overset{\circ}{N}_2$ + other product	(c) Warm
(S) $XeF_2 \xrightarrow{?} Xe$ + other product	(d) Cl_2

Codes:

	P	Q	R	S
(a)	4	2	3	1
(b)	3	2	1	4
(c)	1	4	2	3
(d)	3	4	2	1

(JEE Advanced, 2013)

Integer Answer Type

1. The coordination number of Al in the crystalline state of $AlCl_3$ is_____.

(IIT-JEE, 2009)

2. Among the following, how many elements show only one non-zero oxidation state?
O, Cl, F, N, P, Sn, Tl, Na, Ti

(IIT-JEE, 2010)

3. What is the total number of diprotic acids among the following?
H_3PO_4, H_2SO_4, H_3PO_3, H_2CO_3, $H_2S_2O_7$, H_3BO_3, H_3PO_2, H_2CrO_4, H_2SO_3

(IIT-JEE, 2010)

4. The value of n in the molecular formula $Be_nAl_2Si_6O_{18}$ is _____.

(IIT-JEE, 2010)

Subjective Type

1. Water is a liquid, while H_2S is a gas at ordinary temperature. Explain.

(IIT-JEE, 1978)

2. Write the chemical equations involved in the extraction of lead from galena by self-reduction process.

(IIT-JEE, 1979)

3. State with balanced equations, what happens when:
   (a) Aluminium is reacted with hot concentrated caustic soda solution.
   (b) Ammonium dichromate is heated.
   (c) Silver is treated with hot concentrated sulphuric acid.
   (d) H_2S is passed through a solution of potassium permanganate acidified with dilute sulphuric acid.
   (e) Tin is treated with moderately concentrated nitric acid.

(IIT-JEE, 1979)

4. 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. Explain.

(IIT-JEE, 1979)

5. Write the balanced equations involved in the preparation of:
   (a) Bleaching powder from slaked lime.
   (b) Nitric oxide from nitric acid.
   (c) Chlorine from sodium chloride.
   (d) Anhydrous aluminium chloride from alumina.
   (e) Tin metal from cassiterite.

(IIT-JEE, 1979)

6. Give reasons for the following within two sentences:
   (i) Hydrogen bromide cannot be prepared by the action of concentrated sulphuric acid on sodium bromide.

(ii) When a blue litmus paper is dipped in a solution of hypochlorous acid, it first turns red and then gets decolorized.

(IIT-JEE, 1979)

7. Explain the following in not more than two sentences:

(i) Concentrated HNO_3 turns yellow in sunlight.

(ii) Bleaching powder loses its bleaching property when it is kept in an open bottle for a long time.

(IIT-JEE, 1980)

8. Give reasons for the following:

(i) Sulphur melts to a clear mobile liquid at 119°C, but on further heating above 160°C, it again becomes viscous.

(ii) Sodium carbonate is prepared by the Solvay process but the same process is not extended for the manufacture of potassium carbonate.

(IIT-JEE, 1981)

9. Give the structural formula for the following:

(i) Phosphorous acid, H_3PO_3

(ii) Pyrophosphoric acid, $H_4P_2O_7$

(IIT-JEE, 1981)

10. Explain why 'orthophosphoric acid, H_3PO_4, is tribasic but phosphorus acid, H_3PO_3, is dibasic'.

(IIT-JEE, 1982)

11. 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)

12. Give reason for the following in one or two sentences: "Solid carbon dioxide is known as dry ice".

(IIT-JEE, 1983)

13. Complete and balance the following reactions:

(i) $HNO_3 + HCl \rightarrow NO + Cl_2$

(ii) $Ce^{3+} + S_2O_8^{2-} \rightarrow SO_4^{2-} + Ce^{4+}$

(iii) $Cl_2 + OH^- \rightarrow Cl^- + ClO^-$

(IIT-JEE, 1983)

14. When 16.8 g of white solid of *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)

15. Show with balanced equations what happens when the following are mixed:
Aqueous solution of ferric sulphate and potassium iodide.

(IIT-JEE, 1984)

16. Give reasons in one or two sentences for each of the following:

(i) Graphite is used as a solid lubricant.

(ii) Fluorine cannot be prepared from fluorides by chemical oxidation.

(IIT-JEE, 1985)

17. 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)

18. Write the balanced equations for the reactions when a mixture of potassium chlorate, oxalic acid, and sulphuric acid, is heated.

(IIT-JEE, 1985)

19. Write the resonance structure of nitrous oxide.

(IIT-JEE, 1985)

20. Write the balanced equations for the reactions when ammonium sulphate is heated with a mixture of nitric oxide and nitrogen dioxide.

(IIT-JEE, 1985)

21. Arrange the following in the order of:

(i) Increasing bond strength: HCl, HBr, HF, HI

(ii) Increasing oxidation number of iodine:
I_2, HI, HIO_4, ICl

(IIT-JEE, 1986)

22. Complete and balance the following reactions.

(i) $S + OH^- \rightarrow S_2O_3^{2-} + \cdots$

(ii) $ClO_3^- + I^- + H_2SO_4 \rightarrow Cl^- + HSO_4^- + \cdots$

(IIT-JEE, 1986)

23. Mention the products formed in the following:
"Chlorine gas is bubbled through a solution of ferrous bromide".

(IIT-JEE, 1986)

24. Write balanced chemical equations for the following:
"Gold is dissolved in aquaregia".

(IIT-JEE, 1987)

25. Write balanced equations for the following:
(i) Phosphorus is reacted with boiling aqueous solution of sodium hydroxide in an inert atmosphere.
(ii) Dilute nitric acid is slowly reacted with metallic tin.

(IIT-JEE, 1987)

26. Explain the following in one or two sentences only:
"Orthophosphrous acid is not a tribasic acid".

(IIT-JEE, 1987)

27. "The valency of oxygen is generally two, whereas sulphur shows valency of two, four, and six". Explain.

(IIT-JEE, 1988)

28. Give balanced equations for the following:
(i) Iodate ion reacts with bisulphite ion to liberate iodine.
(ii) Phosphrous reacts with nitric acid to give equimolar ratio of nitric oxide and nitrogen dioxide.

(IIT-JEE, 1988)

29. Arrange the following in each sub-question as indicated.
(i) HOCl, $HOClO_2$, and HOClO in increasing order of thermal stability
(ii) CO_2, N_2O_5, SiO_2, and SO_3 in the order of increasing acidic character

(IIT-JEE, 1988)

30. Write the balanced chemical equations for the following:
(i) Hypophosphorus acid is heated.
(ii) Sodium bromate reacts with fluorine in the presence of an alkali.
(iii) Sodium chlorate reacts with sulphur dioxide in dilute sulphuric acid medium.

(IIT-JEE, 1989)

31. Explain the following:
(i) H_3PO_3 is a dibasic acid.
(ii) Phosphine has lower boiling point than ammonia.

(IIT-JEE, 1989)

32. Each entry in column X is in some way related to the entries in columns Y and Z. Match the appropriate entries.

X	Y	Z
Yeast	Fermentation	Ethanol
Mica	Graphite	Abrasive
Superphosphate	Crystallite cubic	Insulator
Carbon fibers	Layer structure	Fertilizer
Rock salt	Diamond structure	Reinforced plastics
Carborundum	Bone ash	Preservative

(IIT-JEE, 1989)

33. Write balanced equations for:
(i) The preparation of crystalline silicon from $SiCl_4$.
(ii) The preparation of phosphine from CaO and white phosphorus.
(iii) The preparation of ammonium sulphate from gypsum, ammonia, and carbon dioxide.

(IIT-JEE, 1990)

34. Write two resonance structures of N_2O that satisfy the octet rule.

(IIT-JEE, 1990)

35. Write balanced chemical equations for the following:
(i) Sodium nitrite is produced by absorbing the oxides of nitrogen in aqueous solution of washing soda.
(ii) Nitrogen is obtained in the reaction of aqueous ammonia with potassium permanganate.
(iii) Elemental phosphorus reacts with conc. HNO_3 to give phosphoric acid.
(iv) Sulphur is precipitated in the reaction of hydrogen sulphide with sodium bisulphite solution.

(v) Carbon dioxide is passed through a suspension of limestone in water.

(IIT-JEE, 1991)

36. Arrange the following as stated:
Increasing order of the extent of hydrolysis: CCl_4, $MgCl_2$, $AlCl_3$, PCl_3, PCl_5, $SiCl_4$

(IIT-JEE, 1991)

37. Give reasons in one or two sentences.
"Ammonium chloride is acidic in liquid ammonia solvent".

(IIT-JEE, 1991)

38. Write two resonance structures of ozone which satisfy the octet rule.

(IIT-JEE, 1991)

39. Give reasons in only two or three sentences for the following:

(i) Bond dissociation energy of F_2 is less than that of Cl_2.

(ii) Sulphur dioxide is a more powerful reducing agent in the alkaline medium than in the acidic medium. **(IIT-JEE, 1992)**

40. Complete and balance the following chemical reactions:
Red phosphorus is reacted with iodine in the presence of water to form H_3PO_3 and HI.
$2P + 3I_2 + 6H_2O \rightarrow$

(IIT-JEE, 1992)

41. Identify the compounds *A* and *B*.
$PCl_5 + SO_2 \rightarrow A + B$

(IIT-JEE, 1994)

42. Complete and balance the following reactions.

(i) $Ca_5(PO_4)_3F + H_2SO_4 + H_2O \xrightarrow{\text{Heat}}$

(ii) $Sn + 2KOH + 4H_2O \rightarrow$ **(IIT-JEE, 1994)**

43. Account for the following:

(i) The experimentally determined N—F bond length in NF_3 is greater than the sum of the single bond covalent radii of N and F.

(ii) Mg_3N_2 when reacted with water gives NH_3 but HCl is not obtained from $MgCl_2$ on reaction with water at room temperature.

(iii) $(SiH_3)_3N$ is a weaker base than $(CH_3)_3N$.

(IIT-JEE, 1995)

44. Draw the structure of P_4O_{10} and identify the number of single and double P—O bonds.

(IIT-JEE, 1996)

45. Complete the following chemical equations:
$KI + Cl_2 \rightarrow$
$KClO_3 + I_2 \rightarrow$

(IIT-JEE, 1996)

46. A soluble compound of a poisonous element *M*, when heated with Zn/H_2SO_4, gives a colorless and extremely poisonous gaseous compound *N*, which on passing through a heated tube gives a silvery mirror of element *M*. Identify *M* and *N*.

(IIT-JEE, 1997)

47. Anhydrous $AlCl_3$ is covalent. From the data given below, predict whether it would remain covalent or become ionic in aqueous solution. (Ionization energy for Al is 5137 kJ mol^{-1}.)
$\Delta H_{hydration}$ for $Al^{3+} = -4665$ kJ mol^{-1}
$\Delta H_{hydration}$ for $Cl^- = -381$ kJ mol^{-1}

(IIT-JEE, 1997)

48. Aluminium sulphide gives a foul odor when it becomes damp. Write a balanced chemical equation for the reaction.

(IIT-JEE, 1997)

49. Draw the structure of a cyclic silicate $(Si_3O_9)^{6-}$ with proper labelling.

(IIT-JEE, 1998)

50. Reaction of phosphoric acid with $Ca_5(PO_4)_3F$ yields a fertilizer 'triple superphosphate'. Represent the same through balanced chemical equations.

(IIT-JEE, 1998)

51. Complete and balance the following chemical equations:

(i) $P_4O_{10} + PCl_5 \rightarrow$

(ii) $SnCl_4 + C_2H_5Cl + Na \rightarrow$ **(IIT-JEE, 1998)**

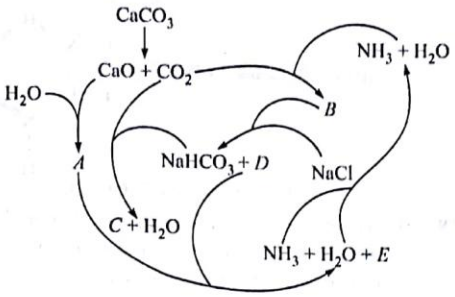
52. In the following equation
$A + 2B + H_2O \rightarrow C + 2D$
$A = HNO_2$, $B = H_2SO_3$, $C = NH_2OH$
Identify *D*. Draw the structures of *A*, *B*, *C*, and *D*.

(IIT-JEE, 1999)

53. In the contact process for industrial manufacture of sulphuric acid, some amount of sulphuric acid is used as a starting material. Explain briefly. What is the catalyst used in the oxidation of SO_2?

(IIT-JEE, 1999)

54. The Solvay process can be represented by the following scheme



Identify *A*, *B*, *C*, *D*, and *E*. **(IIT-JEE, 1999)**

55. Give an example of oxidation of one halide by another halogen. Explain the feasibility of the reaction.

(IIT-JEE, 2000)

56. Write the chemical reactions associated with the 'borax beat test' of cobalt(II) oxide.

(IIT-JEE, 2000)

57. Draw the molecular structure of XeF_2, XeF_4, and XeO_2F_2, indicating the location of lone pairs of electrons.

(IIT-JEE, 2000)

58. Give reason, why elemental nitrogen exists as a diatomic molecule, whereas elemental phosphorus is a tetra-atomic molecule.

(IIT-JEE, 2000)

59. Compound *X* on reduction with 21.72% gives a hydride *Y* containing 21.72% hydrogen along with other products. Compound *Y* reacts with air explosively resulting in boron trioxide. Identify *X* and *Y*. Give balanced reactions involved in the formation of *Y* and its reaction with air. Draw the structure of *Y*.

(IIT-JEE, 2001)

60. Starting from $SiCl_4$, prepare the following in steps not exceeding the number given in parenthesis (give reactions only).

(i) Silicon (1)

(ii) Linear silicone containing methyl group only (4)

(iii) Na_2SiO_3(3)

(IIT-JEE, 2001)

61. 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)

62. Write the balanced equations for the reactions of the following compounds with water:

(i) Al_4C_3

(ii) CaNCN

(iii) BF_3

(iv) NCl_3

(v) XeF_4

(IIT-JEE, 2002)

63. 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)

64. How many grams of CaO are required to neutralize 852 g of P_4O_{10}? Draw the structure of P_4O_{10}.

(IIT-JEE, 2005)

Hints & Solutions

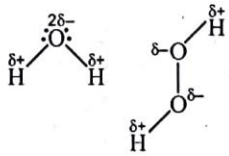
JEE (Main) Exercises

Single Correct Answer Type

83. (b) Acidic character increases with increase in electronegativity of central atom.

Ionic radius decreases with increase in positive charge on cation.

84. (b) The more is the partial charges generated, the more is the strength of H-bonding.



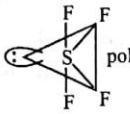
The strength of H-bonding is more in H_2O.

85. (c) Cl forms one bond in its ground state but three bonds in its first excited state.

Therefore, in ClF_3, Cl is having 10 electrons.

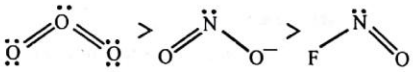
86. (a) H_3O^+ will have three bond pairs and one lone pair and shape same as $\ddot{N}H_3$, therefore is pyramidal.

87. (c) NH_3 has more dipole moment than NF_3 but bond moment (bond dipole) of NF_3, i.e. N—F, is more than N—H



polar molecule.

88. (a)



(I) (II) (III)

B.A. ∝ E.N. of central atom (F is more E.N., therefore bond pair towards F, bond angle decreases).

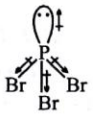
JEE (Advanced) Exercises

Single Correct Answer Type

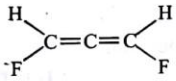
14. (d) Values of dipole moment cannot be predicted as we do not know about the electronegativities of the atoms.

15. (c) $SiF_4 \rightarrow$ Si have vacant *d*-orbital so can act as Lewis acid.

→ In benzyne all C-atoms are sp^2-hybridized.

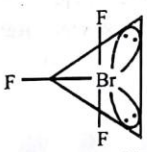


→ This is polar molecule.

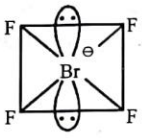


→ The nodal planes of π-bonds are perpendicular to each other.

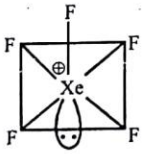
16. (c)



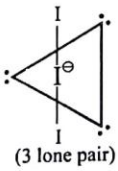
(2 lone pair)



(2 lone pair)



(1 lone pair)



(3 lone pair)

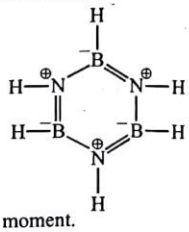
17. (d) (a) Phosphorous acid is $H_3PO_3 \rightarrow$ Basicity: 2

(b) Perbromic acid is $HBrO_4 \rightarrow O = \overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{Br}} - OH$

No peroxy linkage

(c) γ-SO_3 is cyclic, β is helical chain.

(d) Borazine $\rightarrow B_3N_3H_6$



is having zero dipole moment.

19. (a) As we move from left to right in a period, electronegativity increases and acidic nature also increases (non-metals form acidic oxides)

64. (b) Ga is a soft silvery white metal and is liquid at room temperature. When it solidifies, it expands by 3.1 percent. Therefore, it should not be stored in glass or metal containers.

68. (d) $2BCl_3 + 3H_2 \xrightarrow[\text{discharge}]{\text{electric}} \underset{(A)}{B_2H_6} + 6HCl$

$B_2H_6 + 2NH_3 \longrightarrow B_2H_6 . 2NH_3$

$\downarrow 200°C$

$B_3N_3H_6$

79. (a) $NO + NO_2 \xrightarrow{-30°C} N_2O_3$ (Pale blue)

86. (b) N_2 prevents the further reaction of P_4O_6 into P_4O_{10}.

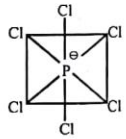
93. (b) $Na_2S_2O_3 + 4Cl_2 + 5H_2O \longrightarrow 2NaHSO_4 + 8HCl$

94. (c) $PBr_5(s) \rightarrow [PBr_4]^+ + Br^-$

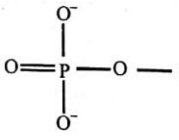
$N_2O_5(s) \rightarrow NO_2^+ + NO_3^-$ $(sp)^2$

$PCl_5(s) \rightarrow PCl_4^+ + PCl_6^-$ (sp^3d^2)

$Cl_2O_6(s) \rightarrow ClO_2^+ + ClO_4^-$ (sp^3)

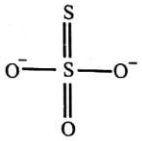


95. (c) (a)



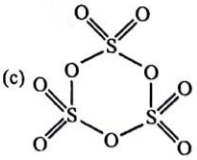
$(P_2O_8^{4-})$

(b)



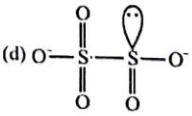
$(S_2O_3^{2-})$

(c)

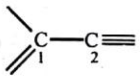


(γ-SO_3 is cyclic)

(d)



$(S_2O_5^{2-})$

96. (d)  $\rightarrow sp^2$ hybridized

Therefore, more % *s*-character and least bond distance

$C_2 \rightarrow sp$ hybridized

115. (d) $Mg_3B_2 + HCl_{(aq)} \longrightarrow B_2H_6 + MgCl_2$

(*X*)

$B_2H_6 + 3H_2O \longrightarrow H_3BO_3 + 3H_2$

(*X*)

$B_2H_6 + O_2 \longrightarrow B_2O_3$

$H_3BO_3 \xrightarrow{\Delta} B_2O_3$

(*Y*)

In *Y*, B completes it octet by removing H^+ from water molecule.

116. (b) Solution

$B(OH)_3 + 2NH_4HF_2 \longrightarrow NH_4[BF_4] + NH_3\uparrow + 3H_2O$

126. (a) $AgCl + NH_3 \longrightarrow [Ag(NH_3)_2]^+ + Cl^-$

$(NH_4)Cr_2O_7 \xrightarrow{\Delta} N_2 + Cr_2O_3 + 4H_2O$

$CaNCN + 3H_2O \longrightarrow CaCO_3 + 2NH_3$

(white ppt.)

Multiple Correct Answers Type

1. (b), (d)

Hint: Lead prefers to form divalent compounds due to inert pair effect. In carbonate ion, all the three C—O bonds are equal due to resonance.

8. (a), (d)

$Cl_2 > Br_2 > F_2 > I_2$: Bond dissociation energy

$Cl_2 > F_2 > Br_2 > I_2$: Electron gain enthalpy

} correct trends

14. (a), (b), (c), (d)

(a) H_2, HD $\rightarrow$ 2 electron

(b) CO, $N_2 \rightarrow$ 14 electron

(c) HCl, $H_2S \rightarrow$ 18 electron

(d) D_2O, Ne $\rightarrow$ 10 electron

15. (a), (b), (c), (d)

S^{-2} and Sc^{+3} = 18 electrons

Species having same number of electrons are isoelectronic.

SO_2 and NO_3^- = 32 electrons

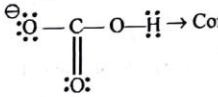
N_2 and CN = 14 electrons

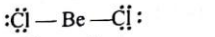
NH_3 and H_3O^+ = 10 electrons

16. (a), (c)

$AlF_3 \rightarrow$ it is ionic. Therefore, Al^{3+} and $3F^-$ thus not hypovalent

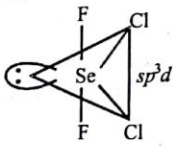
$AlCl_3 \rightarrow$ Covalent. Therefore, hypovalent

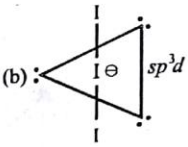
 $\rightarrow$ Complete octet



Hypovalent

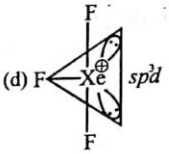
17. (a), (b), (d)

(a) 

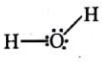
(b) 

(c) Cl—Be—Cl

sp

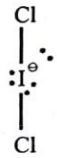
(d) 

18. (a), (b), (c), (d)

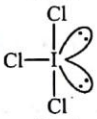


Bent

Planar



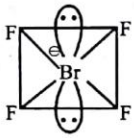
Linear planar



Bent

T-Shaped

Planar



Square Planar

19. (a), (d)

If surrounding atoms are not same and lone pairs are present then shape is not perfect.

20. (a), (b), (c)

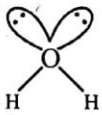
H—C≡N

↓

sp

Dipole moment is directed from less electronegative to more electronegative and its dipole moment is non-zero.

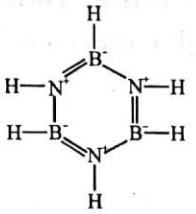
21. (b), (d)

(b) 

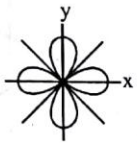
sp^3 bent shaped

(d) sp^2–hybridization with one lone pair is bent shaped.

22. (a), (d)



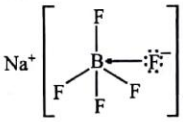
Molecular plane is nodal plane for π-bonds.



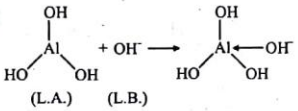
Nodal plane are at 45° with *x* and *y*-axis and perpendicular *xy* plane.

23. (b), (d)

(i) BF_3 + NaF ⟶ $Na^+[BF_4]^-$
(L.A.) (L.B.)



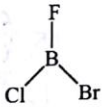
(ii)



(L.A.) (L.B.)

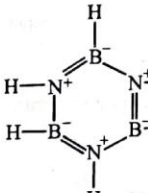
24. (a), (c), (d)

(i)



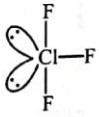
sp^2, Trigonal Planar
Polar
All atoms are sp^2 hybridized.

(ii)



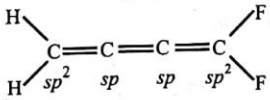
Overall molecule is planar. Non-polar.

(iii) ClF_3



Planar, Polar

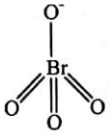
(iv)



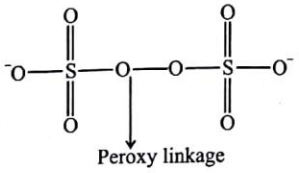
Planar, Polar

37. (b), (c), (d)

(a)

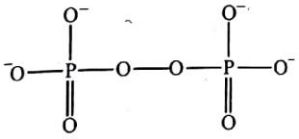


(b)

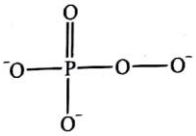


Peroxy linkage

(c)



(d)

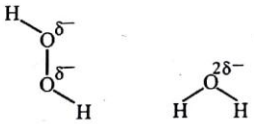


38. (a), (b), (c)

(a) The more polar a bond is, the more stronger is H-bonding H—F > H—O > H—N [Order of strength]

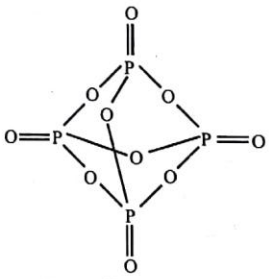
(b) True statement

(c)

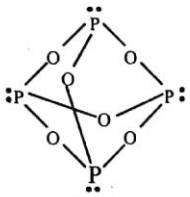


Strength is more in H_2O as it has $2s^-$ charge, but extent is more in H_2O_2 as it forms 6H bonds and H_2O forms 4 hydrogen bonds.

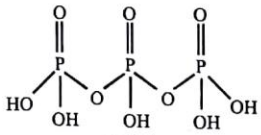
39. (b), (d)



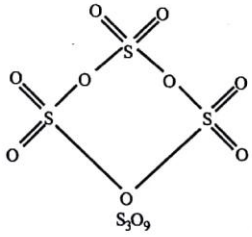
P_4O_{10}



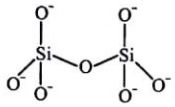
P_4O_{10}



$H_5P_3O_{10}$



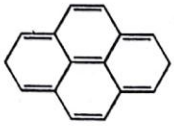
S_3O_9



45. (b), (c)

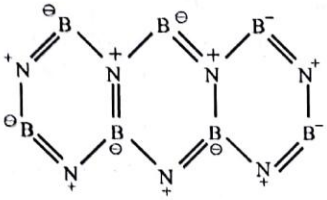
With $(CH_3)_3N$, B_2H_6 forms an adduct, $(CH_3)_3N \rightarrow BH_3$

52. (a), (c), (d)



Graphite have a layered structure and each C-atom is sp^2 hybridized

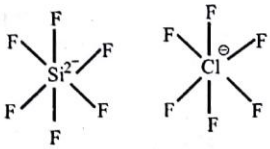
(No charge separation as all atoms are carbon.)



Inorganic graphite $(BN)_x$.

Non-conducting, slippery in nature and 2-D layered structure. All atoms are sp^2-hybridized.

53. (c), (d)

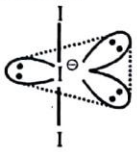


All the bond lengths are not equal as size of central atom is different.

Comprehension Type

1. (c) $I_2 + KI \rightarrow K^+[I_3^-]$

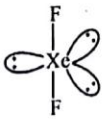
Anion I_3^-



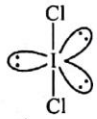
Hybridization $\rightarrow sp^3d$

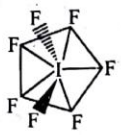
Geometry $\rightarrow$ Linear, and it is planar and non-polar.

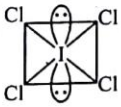
4. (d) $A = Xe$

Compound = XeF_2 Geometry $\Rightarrow$  sp^3d, Linear

5. (d) ICl_2^+ sp^3

ICl_2^-  sp^3d

IF_7  sp^3d^3

ICl_4^-  sp^3d^2

12. (c) $\overset{2-}{H_2S} + \overset{1-}{H_2O_2} \xrightarrow{\text{oxid}} \overset{0}{S} + 2H_2O$ (red: $S^{2-} \rightarrow S^0$)

65. (d) $4BF_4 + 3LiAlH_4 \longrightarrow 2B_2H_6 + 3LiF + 3AlF_3$

$3B_2H_6 + 6NH_3 \longrightarrow 3[B_2H_6 . 2NH_3] \xrightarrow{\text{heating}} 2B_3N_3H_6$

$BF_3 + 3H_2O \longrightarrow B(OH)_3 + 3HF$

$3BF_3 + 3HF \longrightarrow 3H[BF_4]$

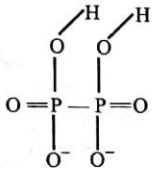
$4BF_3 + 3H_2O \longrightarrow 3H[BF_4] + B(OH)_3$

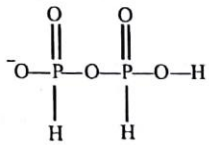
Assertion-Reasoning Type

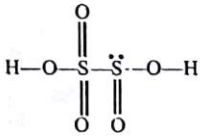
1. (d) Size of inert gases is larger than halogen because van der Waals' radius is considered for inert gas.

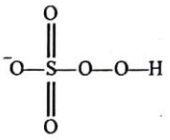
Matching Column Type

1. (a) p, q, r, s; (b) r, s; (c) p, q, r, s; (d) p, r, s, t

(a) $H_2P_2O_6^{2-}$ $\rightarrow$ 

(b) $H_3PO_5^-$ (Basicity = 2) $\rightarrow$ 

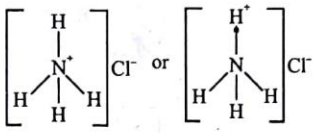
(c) $H_2S_2O_5$ $\rightarrow$ 

(d) HSO_5^- → 

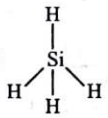
2. (a) p, q, r, s, t; (b) p, q, t; (c) r, t; (d) p, r, t

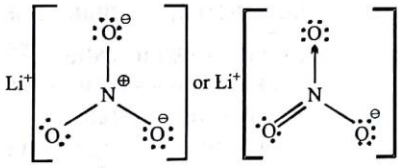
(p) $:C \equiv O:$ or $:\overset{\ominus}{C} \equiv \overset{\oplus}{O}:$ ⟶ A,B,D

(q) H–C≡N ⟶ A,B

(r) 

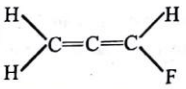
⟶ A,C,D

(s)  ⟶ A

(t) 

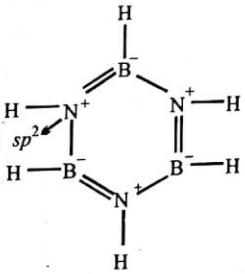
⟶ A,B,C,D

3. (a) s; (b) p, q; (c) r

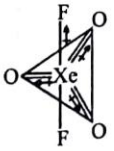
(a)  (s) Odd number of carbon atoms

Therefore, non-planar, surrounding atoms are not same.

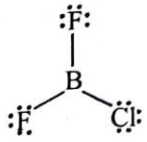
∴ Polar

(b) sp^2  (p,q) Non-polar and planar

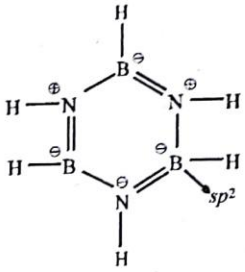
p_π-bond will be formed perpendicular to the σ-bond Therefore, nodal plane of the π-bond will be the molecular plane.

(c)  (r) Non-planar and non-polar

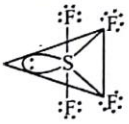
10. (a) s; (b) p, r, s; (c) q, t; (d) r, t

(a) 

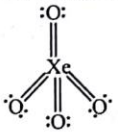
sp^2 hybridization, $\mu \neq 0$ (Polar). Total lone pairs = 9 and is planar; 4 atoms in same plane.

(b) 

sp^2 hybridized, Therefore planar, non-polar. 12 atoms in same plane.

(c) 

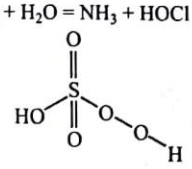
sp^3d hybridized. Total lone pairs = 13 molecule non-planar and polar.

(d) 

sp^3 Total *l.p.* = 8 non-planar and non-polar.

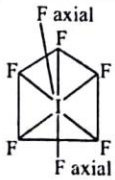
Integer Answer Type

6. (1) $NCl_3 + H_2O = NH_3 + HOCl$

11. (72) 

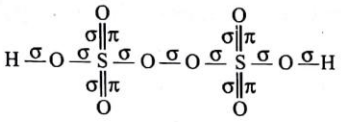
13. (10) $IF_7 \rightarrow sp^3d^3$ Pentagonal bipyronidal

Five 90° angle of each axial fluorine atom.



16. (4) CH_4

21. (114) Structure of peroxydisulphuric acid

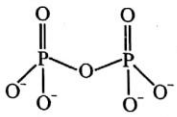


23. (1) $Mg(OH)_2$ is a weak base and $Be(OH)_2$ and $Al(OH)_3$ are amphoteric in nature. $B(OH)_3$ can accept one hydroxyl ion from water and proton is released. Thus, it acts as a Lewis acid.

25. (6) Hypophosphate ion is →

$$2H_3PO_4 \xrightarrow{-H_2O} H_4P_2O_7 \xrightarrow{-[O]} H_4P_2O_6$$

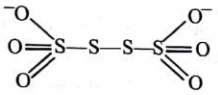
Hypophosphoric acid



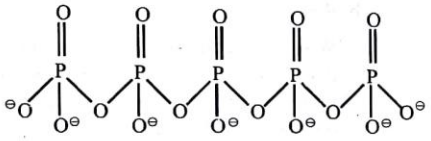
6 identical P—O bonds.

Hypophosphate ion

31. (3) $S_2O_3^{2-} + I_2 \longrightarrow S_4O_6^{2-} + I^-$



32. (9)



No. of P = O bonds 5

No. of P – O – P bonds = 4

Total = 5 + 4 = 9

NCERT Exemplar Exercises

Short Answer Type

2. Boric acid acts as Lewis acid in water by accepting a pair of electrons from water: $B(OH)_3 + 2HOH \rightarrow [B(OH)_4]^- + H_3O^+$

3. Species present in water is $[B(OH)_4]^-$. Boron is sp^3 hybridized.

4. BCl_3 and $AlCl_3$ being electron deficient due to incomplete octet of central metal atom behave as Lewis acids.

5. CCl_4 is a non polar covalent compound. Hence, insoluble in water whereas $SiCl_4$ is soluble because Si atom in $SiCl_4$ can accomodate the lone pair of electrons obtained from oxygen atom of water molecule in *d*-orbitals.

6. (a) Very high Si-O bond enthalpy and ionic character of Si-O bond.

(b) Vacant 3*d* orbitals are available on Si atom to accommodate electrons and expand its coordination number up to 6.

8. [**Hint:** In CO_2, carbon is *sp* hybridized and it is a linear molecule. In SiO_2, Si is tetrahedrally bonded to four oxygen atoms.]

9. Negative

11. [**Hint:** Conc. HNO_3 renders aluminium passive by forming a protective oxide layer on the surface.]

13. A : $Na_2B_4O_7$ (Borax)

X : H_3BO_3

Z : B_2O_3

14. Z : BF_3

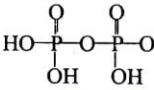
X : B_2H_6

Y ; H_3BO_3

15. Acid fog is formed, which is difficult to condense.

16. $4NH_3 + 5O_2 \xrightarrow[500K, 9bar]{Pt/Rauge\ catalyst} 4NO + 6H_2O$

(From air)

17.  Pyrophosphoric acid

18. NH_3 forms hydrogen bonds with water therefore it is soluble in it but PH_3 cannot form hydrogen bond with water so it escapes as gas.

19. [**Hint:** It has trigonal bipyramidal geometry]

20. In gaseous state NO_2 exists as monomer which has one unpaired electron but in solid state it dimerizes to N_2O_4 so no unpaired electron is left hence solid form is diamagnetic.

21. Because fluorine is more electronegative as compared to chlorine.

22. Bond angle of H_2O is larger, because oxygen is more electronegative than sulphur therefore bond pair electron of O–H bond will be closer to oxygen and there will be more bond–pair bond–pair repulsion between bond pairs of two O–H bonds.

23. Due to small size of fluorine six F atom can be accomodated around sulphur whereas chloride ion is comparatively larger in size, therefore, there will be interatomic repulsion.

24. A is PCl_5 (It is yellowish white powder)

$P_4 + 10Cl_2 \rightarrow 4PCl_5$

B is PCl_3 (It is a colorless oily liquid)

$P_4 + 6Cl_2 \rightarrow 4PCl_3$

Hydrolysis products are formed as follows:

$PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$

$PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$

25. $NO_3^- + 3Fe^{2+} + 4H^+ \rightarrow NO + 3Fe^{3+} + 2H_2O$

$[Fe(H_2O)_6]^{2+} + NO \rightarrow [Fe(H_2O)_5(NO)]^{2+} + H_2O$
(brown complex)

26. Oxygen is more electronegative than chlorine, therefore dispersal of negative charge present on chlorine increases from ClO^- to ClO_4^- ion because number of oxygen atoms attached to chlorine is increasing. Therefore, stability of ions will increase in the order given below:

$ClO^- < ClO_2^- < ClO_3^- < ClO_4^-$

Thus due to increase in stability of conjugate base, acidic strength of corresponding acid increases in the following order

$HClO < HClO_2 < HClO_3 < HClO_4$

28. $P_4O_6 + 6H_2O \rightarrow 4H_3PO_3$

$H_3PO_3 + 2NaOH \rightarrow Na_2HPO_3 + 2H_2O] \times 4$
(Neutralization reaction)

$P_4O_6 + 8NaOH \rightarrow 4Na_2HPO_4 + 2H_2O$

1 mol 8 mol

Product formed by 1 mol of P_4O_6 is neutralized by 8 mols of NaOH

$\therefore$ Product formed by $\frac{1.1}{220}$ mol of P_4O_6 will be neutralized by $\frac{1.1}{220} \times 8$ mols of NaOH

Molarity of NaOH solution is 0.1M

$\Rightarrow$ 0.1 mol NaOH is present in 1 L solution

$\therefore \frac{1.1}{220} \times 8$ mols of NaoH is present in $\frac{1.1 \times 8}{220 \times 0.1}$ L

$= \frac{88}{220} L = \frac{4}{10} L = 0.4$ L

= 400 mL of NaOH solution

29. $P_4 + 6Cl_2 \rightarrow 4PCl_3$

$PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl] \times 4$

$P_4 + 6Cl_2 + 12H_2O \rightarrow 4H_3PO_3 + 12HCl$

1 mol of white phosphorus produces 12 mols of HCl

62 g of white phosphorus has been taken which is equivalent to $\frac{64}{124} = \frac{1}{2}$ mol.

Therefore 6 mols HCl will be formed.

Mass of 6 mols HCl = 6 × 36.5 = 219.0 g HCl

30. Three oxoacids of nitrogen are

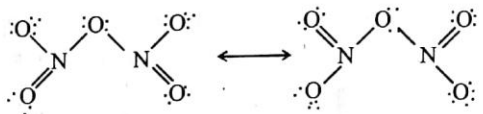
(a) HNO_2, Nitrous acid

(b) HNO_3, Nitric acid

(c) Hyponitrous acid, $H_2N_2O_2$

$3HNO_2 \xrightarrow{\text{Disproportionation}} HNO_3 + H_2O + 2NO$

31. $4HNO_3 + P_4O_{10} \rightarrow 4HPO_3 + 2N_2O_5$



32. (a) Structures

White phosphorus is discrete tetrahedral molecule. Thus it has tetrahedral structure with six P–P bonds.

Red phosphorus has polymeric structure in which P_4 tetrahedra are linked together through P—P bonds to form chain.

(b) Reactivity

White phosphorus is much more reactive than red phosphorus. This is because in white phosphorus there is angular strain in P_4 molecules because the bond angles are only of 60°.

33. Dilute and concentrated nitric acid give different oxidation products on reaction with copper metal.

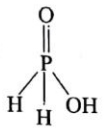
$3Cu + 8HNO_3$ (dil.) $\rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

$Cu + 4HNO_3$ (Conc.) $\rightarrow 3Cu(NO_3)_2 + 2NO_2 + 2H_2O$

34. $PCl_5 + 2Ag \rightarrow 2AgCl + PCl_3$

$AgCl + 2NH_3(aq) \rightarrow [Ag(NH_3)_2]^+ CL^-$
(soluble compled)

35. Structure of phosphinic acid (Hypophosphorous acid) is as follows:



Reducing behavior of phosphinic acid is observable in the reaction with silver nitrate given below:

$4AgNO_3 + 2H_2O + H_3PO_2 \rightarrow 4Ag + 4HNO_3 + H_3PO_4$

Long Answer Type

5. [**Hint:** Absence of *d*-orbitals in boron.]

8. $A = B_2H_6$, $B = BH_3 \cdot NMe_3$, $C = B(OH)_3$ i.e. H_3BO_3.

11. 'A' is S_8 'B' is SO_2 gas

$$S_8 + 8O_2 \xrightarrow{\Delta} 8SO_2$$

$$2MnO_4^- + 5SO_2 + 2H_2O \rightarrow 5SO_4^{2-} + 4H^+ + 2Mn^{2+}$$

(violet) (colorless)

$$2Fe^{3+} + SO_2 + 2H_2O \rightarrow 2Fe^{2+} + SO_4^{2-} + 4H^+$$

12. $Pb(NO_3)_2 \xrightarrow[673\,K]{\Delta} PbO + 2NO_2$

(A)

(Brown color)

$$2NO_2 \xrightarrow[\text{Heating}]{\text{On cooling}} N_2O_4$$

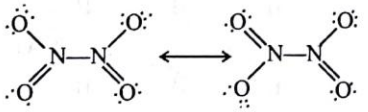
(B)

(Colorless solid)

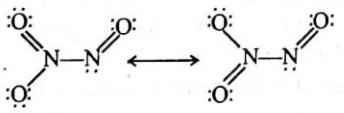
$$2NO + N_2O_4 \xrightarrow{\Delta 250\,K} 2\,N_2O_3$$

(C)

(Blue solid)



(Structure of N_2O_4)



(Structure of N_2O_3)

13. $A = NH_4NO_2$ $B = N_2$ $C = NH_3$ $D = HNO_3$

(a) $NH_4NO_2 \rightarrow N_2 + 2H_2O$

(b) $N_2 + 3H_2 \rightarrow 2NH_3$

(c) $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

$2NO + O_2 \rightarrow 2NO_2$

$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (c) The water obtained from natural sources often contains suspended impurities. Alum is added to such water to coagulate the suspended impurities and make water fit for drinking purposes.

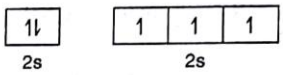
2. (d)

XeF_2	XeF_4	XeF_6
No. of σ bond = 2	No. of σ bond = 4	No. of σ bond = 6
No. of lp = 3	No. of lp = 2	No. of lp = 1

There are eight electrons in the outermost orbit of Xe and F is always monovalent.

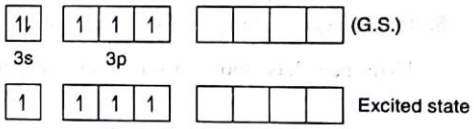
3. (a) No. of bonds = No. of unpaired electrons in the outermost orbit of central atom in ground or excited state

$N - 1s^2 2s^2 2p^3$



N can form 3 normal bonds in ground state, but it cannot form bond in excited state because there is no vacant orbitals in the outermost orbit, that is, 2nd orbit.

$P - 1s^2 2s^2 2p^6 3s^2 3p^3$ Ground state



Phosphorous can form 3 bonds in ground state and 5 bonds in excited state because it has vacant 3d-orbitals in the outermost orbit.

(b) N has more electronegativity than P but P has more negative electron gain enthalpy than N.

(c) Due to more electronegativity, N, O, and F can form hydrogen bond.

(d) P exist at P_4 molecule and N as N_2 molecule due to strong catanation property of P than N, it exist in solid state.

4. (c)

(a) HF is more polar than HBr. Dipole moment of HF is 1.78 D and of HBr is 079 D.

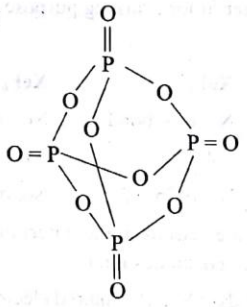
(b) N has more electronegativity than P, but P has more negative electron gain enthalpy than N.

(c) Due to more electronegativity, N, O, and F can form hydrogen bond.

(d) P exist as P_4 molecule and N as N_2 molecule due to strong catenation property of P than N

it in solid state.

5. (d)



Number of σ bonds = 12

Number of π bonds = 4

6. (d) $CaOCl_2$ is actually $Ca(OH)_2 \cdot CaCl_2 \cdot Ca(OCl)_2 \cdot 2H_2O$

It contains Ca^{2+}, Cl^-, and OCl^-.

The oxidation number of Cl is –1 and +1.

7. (a) PH_3 is highly poisonous; it explodes with traces of oxidizing agent like HNO_3Cl_2 and Br_2 vapors.

$PH_3 + BCl_2 \rightarrow PCl_3 + 3HCl\ \Delta H = -ve$

8. (a) $2HCl(g) + \frac{1}{2}O_2(g) \rightarrow H_2O + Cl_2(g)$

Hydrogen has more affinity to oxygen than chlorine.

9. (c) Graphite is a covalent solid in which each carbon is attached with three other carbon atoms. In order to melt graphite, the strong covalent bond has to be broken; hence, the melting point of graphite is high.

10. (a) Glass is an example of amorphous solid. Glass shows the tendency to flow like liquid; hence, it is also known as supercooled liquid.

11. (b)

(a) H_2S is acidic in nature.

(b) NH_3 and PH_3 is basic but the basicity of NH_3 is more than PH_3 due to high charge density of *l*p in sp^3 hybridized orbital of NH_3, whereas in case of PH_3, *l*p is present in pure 35 orbital.

(c) H_2O is neutral.

12. (d) Among the given metals, mercury has lowest MP, which means lowest freezing point.

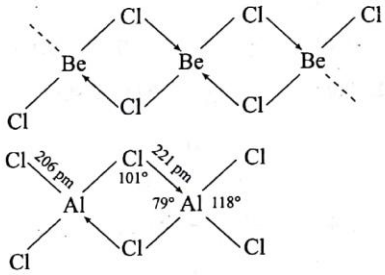
13. (d) The anomalous behavior of fluorine is due to small size, highest electronegativity, low F–F bond dissociation enthalpy and non-availability of *d*-orbitals in valence shell.

14. (c) He gas is heavier gas than H_2 gas. It is used instead of H_2 gas because H_2 is inflammable gas, whereas He is non-inflammable gas.

15. (c)

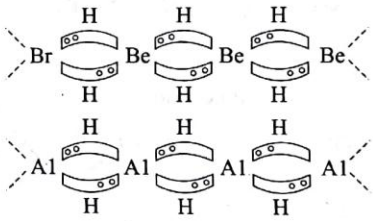
(a) $BeCl_2(s)$ and $AlCl_3(s)$ are dimers.

Anhydrous $BeCl_2$ is polymeric.



(b) $BeH_2(s)$ and $AlH_3(s)$ are polymers.

It exists in polymeric form.



(c) Be is second period element; Its maximum covalency is 4. Al is third period element; its maximum covalency is 6 due to vacant 3*d*-orbitals.

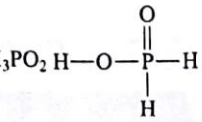
(d) $Be(OH_2)$, $Al(OH)_3$ both are amphotaric means they can react with acid as well as base.

16. (b) When $AlCl_3(s)$ is dissolved in water, the high enthalpy of hydration is sufficient to break the covalent dimmer into $[Al(H_2O)_6]^{3+}$ and $3Cl^-$.

17. (b) $4KI(aq) + 2CuSO_4(aq) \rightarrow Cu_2I_2(s) + 2K_2SO_4(aq) + I_2$

$I_2 + 2Na_2S_2O_3(aq) \rightarrow Na_2S_4O_6(aq) + 2NaI(aq)$

18. (b) $\underset{\text{grey (diamond)}}{Sn(s)} \xrightleftharpoons{13.2°C} \underset{\text{white (metalic)}}{Sn(s)}$

19. (c) Hypophosphorous acid H_3PO_2 

Shortcut method to remember only applicable to H_3PO_4, H_3PO_3, and H_3PO_2. No. of replaceable H atom = No. of O atom in a molecule-1.

20. (c) The thermal stability of these halides decreases down the group due to decrease in bond (H–X) dissociation enthalpy, which 574 kJ/mol, 432 kJ/mol, 363 kJ/mol, and 295 kJ/mol for HF, HCl, HB and HI, respectively.

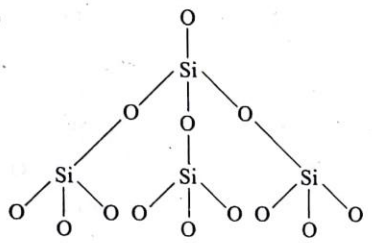
21. (b) $[Al(H_2O)_6]Cl_3 \xrightarrow{\Delta} Al(OH)_3 + 3HCl + 3H_2O$

$2[Al(H_2O)_6]Cl_3 \xrightarrow{\Delta} Al_2O_3 + 6HCl + 9H_2O$

$2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$

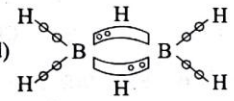
Note: We cannot obtain anhydrous $AlCl_3$ on heating hydrated $AlCl_3$.

22. (d)



SiO_2 is a 3D network solid in which each silicon atom is surrounded by 4 oxygen atoms, and each oxygen atom is surrounded by two silicon atoms.

23. (d)



B_2H_6: Four two-centered 2 electron bonds and two three-centered two electron bonds.

24. (b)

(a) $HClO_4$ is a stronger acid than $HClO_3$.

(b) HNO_3 is a stronger acid than HNO_2.

(c) H_2SO_3 is a stronger acid than H_3PO_3.

(d) HCl is stronger acid than HF.

25. (b) In general, the ionization energy increases from left to right in a period and decreases from top to bottom. The ionization energy of N is greater than O and P is greater than S due to half-filled P sub-orbit.

26. (b) $HClO \rightarrow HCl + HClO_3$

27. (d)

(a) $Br_2 + NaOH \rightarrow NaBr + NaBrO_3 + H_2O$

(b) $SO_2 + O_3 \rightarrow SO_3$

(c) $Si + 2NaOH(aq) + O_2 \rightarrow Na_2SiO_3 + H_2O$

(d) $Cl_2 + \underset{\text{excess}}{NH_3} \rightarrow NH_4Cl + N_2$

$\underset{\text{excess}}{Cl_2} + NH_3 \rightarrow \underset{\text{(explosive)}}{NCl_3} + HCl$

28. (a)

(a) Ammonium sulphate is a salt of weak base and strong acid. Its solution is acidic due to hydrolysis of atom.

(b) Potassium nitrate is a salt of strong base and strong acid. Its solution is neutral.

(c) Urea is basic in nature.

(d) Super phosphate of lime is $Ca(H_2PO_4)_2 + 7CaSO_4$.

29. (d) Stability of dihalides increases steadily down the group.

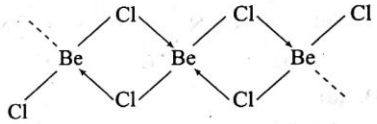
30. (c)

(a) Boric acid is Lewis acid. It accepts OH^- from base. It is not protonic acid.

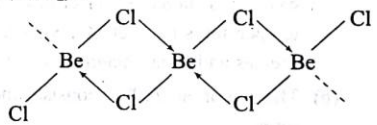
$B(OH)_3 + NaOH \rightarrow Na[B(OH)_4]$

(b) The maximum coordination number of beryllium is 4 because it is 2nd period element. It cannot form 6 bonds because it has no vacant *d*-orbitals in the outermost orbit.

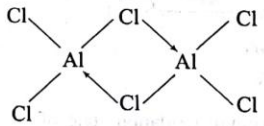
$BeCl_2(s)$



(c) $(BeCl_2)n$

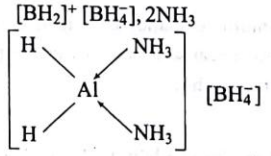


Al_2Cl_2

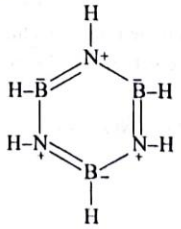


(d) $B_2H_6 \cdot 2NH_3$ is

$[BH_2]^+ [BH_4^-], 2NH_3$



Inorganic benzene is $B_3N_3H_6$.



31. (d)

(a) XeF_4 is hydrolyzed to give Xe, XeO_3, HF, and O_2.

(b) XeF_2 is hydrolyzed to give Xe, HF, O_2.

(c) $XeF_6 + RbF \rightarrow Rb^+[XeF_7]^-$

(d) $XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$

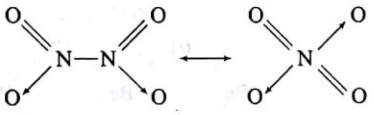
XeF_6 is hydrolyzed to give XeO_3 reaction, which is spontaneous in forward direction not in backward direction.

32. (a)

(a) Stability of NH_3 to BiH_3 decreases down the group due to increase in M–H bond length.

(a) Nitrogen has no vacant d-orbital in the outermost orbit, and hence, cannot form $d\pi$–$p\pi$ bond.

(c) N–N bond is weaker than P–P bond; hence, Nitrogen exist as N_2 and phosphorous as P_4.

(d) 

33. (d)

(a) S_2 molecule is paramagnetic like O_2 and both have two unpaired electrons. At elevated temperatures (~ 1000 K), S_2 is the dominant species and is paramagnetic lie O_2.

(b) The vapor at 200°C consists mostly of S_8 rings.

$$S_8(g) \xrightarrow{600°C} S_2(g)$$

(c) $\uparrow_{200°C}$

$S_8(S)$

(d) Maximum oxidation state of 'S' is +6, e.g., SF_6.

34. (a) Maximum covalancy of B is 4; it cannot from 6 bonds because it has no vacant orbital in the outermost orbit.

35. (c)

(a) Chloro floro carbon (CFC) depletes ozone.

(b) Ozone absorbs ultraviolet radiation.

(c) Oxides of nitrogen in the atmosphere can cause the depletion of ozone layer like nitrogen oxides.

$$O_3 + NO \rightarrow NO_2 + O_2$$

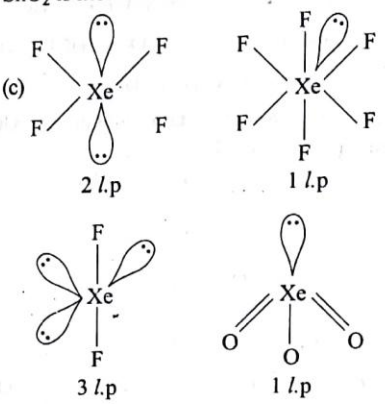
36. (b) The electron affinity of F is less than Cl due to small size of 2P orbital of F atom than 3P-orbital of Cl atom. The negative value of electron gain enthalpy is the highest.

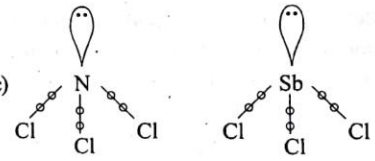
37. (c) $PbO_2 + Pb \rightarrow 2PBO, \quad \Delta_rG° < 0$

PbO is more stable than PbO_2.

$SnO_2 + Sn \rightarrow 2SnO, \Delta_rG° > 0$

SnO_2 is more stable SnO.

38. (c) 

39. (c) 

The electronegativity (EN) difference between Sb and Cl is more; hence, shared electrons are shifted more towards Cl atom. Therefore, b.p.–b.p. repulsion will be less.

40. (c) In set 1: $Al(OH)_4^-$ is formed

In set 2: Al^{+3} and H_2O is formed

41. (c) $CaF_2 + H2SO_4 \rightarrow H_2F_2 + Ca(HSO_4)_2$

$SiO_2 + 2H_2F_2 \rightarrow SiF_4 + 2H_2O$

$SiF_4 + H_2O \rightarrow H_2[SiF_6]$

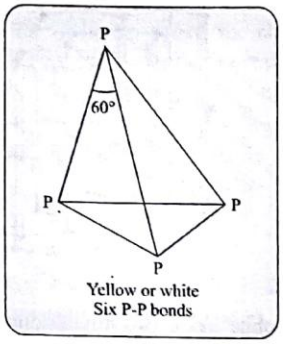
JEE (Advanced) Exercises

Fill in the Blanks Type

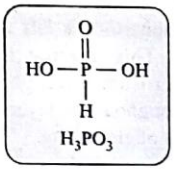
1. Iodine reacts with hot NaOH solution. The products are NaI and **$NaIO_3$**.

$$\underset{\text{(Hot concentrated)}}{6NaOH} + 3I_2 \rightarrow 5NaI + NaIO_3 + 3H_2O$$

2. **White/yellow** phosphorus is reactive because of its highly strained tetrahedral structure.

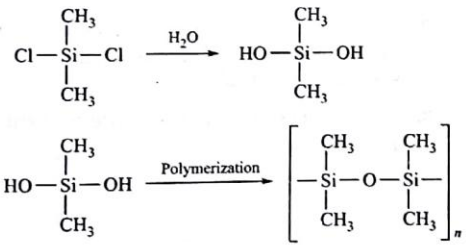


3. The basicity of phosphorus acid (H_3PO_3) is **2**.

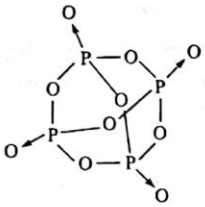


Only those hydrogens are replacable that are attached to oxygen and contribute to basicity. From the structure, it is clear that phosphorus acid (H_3PO_3) is dibasic.

4. The hydrolysis of alkyl substituted chlorosilanes gives **silicones**.



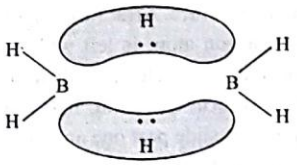
5. In P_4O_{10}, the number of oxygen atoms bonded to each phosphorus atom is **4**.



6. The lead chamber process involves oxidation of SO_2 by atomic oxygen under the influence of **nitrogen dioxide** as catalyst.

7. The hydrolysis of trialkylchlorosilane, R_3SiCl, yields **$R_3Si(OH)$** which may further form silicone.

8. The two types of bonds present in B_2H_6 are covalent and **banana bonds** (three-center two-electron bonds)



9. One recently discovered allotrope of carbon (e.g., C_{60}) is commonly known as **Buckeminsterfullerene.**

10. A liquid which is permanently supercooled is frequently called a **glass.**

True/False Type

1. **False.**
PbO_2 with dilute acid does not give hydrogen peroxide, because it does not have a peroxide bond in it.

2. **False.**
CCl_4 gives phosgene gas with superheated steam only.
$CCl_4 + H_2O \rightarrow COCl_2 + 2HCl$

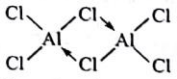
3. **True.**
Dilute HCl oxidizes metallic Fe to Fe^{2+}.
$Fe + 2HCl \rightarrow FeCl_2 + H_2$

4. **False.**
The oxidizing power decreases from fluorine to iodine.

5. **True.**
In hydrides of group 15, bond angle decreases down the group.

6. **True.**
Graphite is a better lubricant on the moon than on earth because less gravitational attraction on moon as compared to earth.

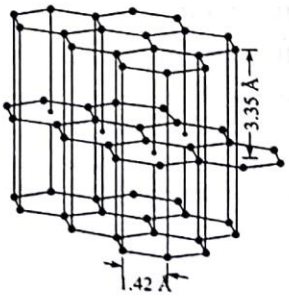
7. **False.**



Bridging chlorine bonds are different than terminal chlorine bonds.

8. **False.**
Nitric oxide (NO) is paramagnetic.

9. **True.**



Graphite has a two-dimensional sheet structure. Each carbon atom is in sp^2-hybridized state and is linked to three other carbon atoms in a hexagonal planar structure. After forming three C—C bonds, each carbon atom is left with one electron in its p-orbital. This electron then overlaps with the other to form a π-bond. It is a soft structure and layers can slide past one another.

In diamond, each carbon atom is in sp^3-hybridized state and linked to four other carbon atoms tetrahedrally by covalent bonds. This gives a giant three-dimensional polymeric structure.

As the atoms are held firmly by strong covalent bonds, diamond is a very hard substance,

10. False.

The basic nature of the hydroxides of group 13 [Gr. III (b)] increases progressively down the group because the electropositive character of elements increases.

11. True.

The tendency for catenation is much higher for C than for Si. Due to smaller size of carbon, bonds are stronger.

12. False.

The strength of acidic character in halogen acids increases from HF to HI down the group.

Single Correct Answer Type

1. (a) Molecular weight of NO = 14 + 16 = 30

Vapor density $= \frac{M}{2} = \frac{30}{2} = 15$

Molecular weight of O_2 = 16 + 16 = 32

Vapor density $= \frac{M}{2} = \frac{32}{2} = 16$

Therefore, NO is lighter than O_2.

2. (d) $NH_3 \xrightarrow{H_2SO_4} (NH_4)_2SO_4$

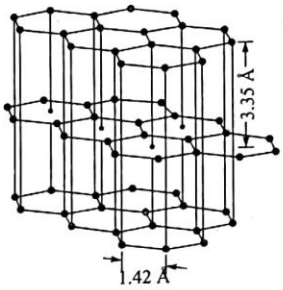
$NH_3 \xrightarrow{CaCl_2} CaCl_2 \cdot 8NH_3$

$NH_3 \xrightarrow{P_2O_5} (NH_4)_3PO_4$

Only CaO can be used for drying of ammonia as it does not react with ammonia.

3. (d) HF does not behave as a reducing agent. Therefore, it cannot be oxidized by any of these.

4. (b)



Graphite has a two-dimensional sheet structure. Each carbon atom is in sp^2-hybridized state and is linked to other three carbon atoms in a hexagonal planar structure. After forming three C—C bonds, each carbon atom is left with one electron in its p-orbital. This electron then overlaps with the other to form a π-bond. The π-electrons are free to move throughout the layers, so graphite is a good conductor of electricity.

5. (b) $Cl_2 + H_2O \rightarrow HCl + HClO$

$HOCl \rightarrow HCl + [O]$

Colored material + [O] → Colorless material

Therefore, chlorine acts as a bleaching agent only when moisture is present.

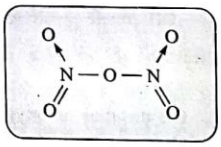
6. (b) Only true peroxides which have —O—O— bond give hydrogen peroxide with dilute acids.

$Na_2O_2 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O_2$

7. (c) SO_2 reacts with water to form sulphurous acid, so it cannot be collected over water.

$SO_2 + H_2O \rightarrow H_2SO_3$

8. (b) The bonds present in N_2O_5 are covalent as well as coordinate.



9. (d) NO_2 is a brown-colored gas.

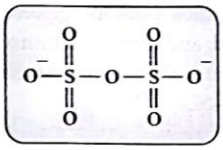
10. (a) Fluorine has the highest electronegativity, therefore in NF_3, the lone pair of electrons on nitrogen is the most difficult to donate. So it is least basic.

11. (b) Potassium bromide is oxidized by chlorine water and bromine is evolved.

12. (b) In the hydrides of group 15, the basic character decreases down the group. NH_3 is the strongest electron pair donor due to its small size as the electron density of the electron pair is concentrated over a small region. As the size increases, the

electron density gets diffused over a large region and hence the ability to donate the electron pair decreases. Therefore, the basic nature decreases.

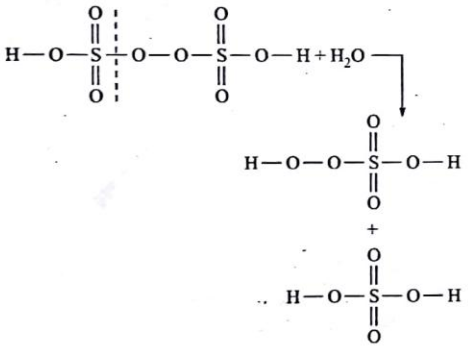
13. (d)



14. (d) $BaO_2 + H_2SO_4 \rightarrow BaSO_4 + H_2O_2$
The oxidation state of O in $BaSO_4$ is –2.
The oxidation state of O in H_2O_2 is –1.

15. (a) Only true peroxides which have —O—O— bond give hydrogen peroxide with dilute acids.
PbO_2 does not give hydrogen peroxide with dilute acids. So it is not a true peroxide.

16. (c) Peroxodisulphuric acid ($H_2S_2O_8$) on partial hydrolysis gives 1 mol of peroxomonosulphuric acid and 1 mol of H_2SO_4.



17. (d) Due to strong inert pair effect, Pb^{2+} is more stable than Pb^{4+}. Non-existence of PbI_4 can be explained on the basis of strong oxidizing nature of Pb^{4+}. The iodide ions are reducing agents. In the presence of these ions, Pb^{4+} ions are reduced to Pb^{2+} ions.

$Pb^{4+} + 2I^- \rightarrow Pb^{2+} + I_2$

18. (a) CO, NO, N_2O, and H_2O are neutral oxides.

19. (a) For the same oxidation state, when the electronegativity of the halogen increases, the strength of the oxy acid increases.

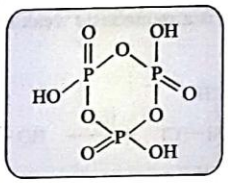
HOCl > HOBr > HOI

20. (b) There are some ions consisting of two or more electronegative atoms of which at least one is nitrogen that has properties similar to those of halide ions. These ions are called pseudohalide ions.
$RCOO^-$ is not a pseudohlide ion.

21. (b) BCl_3 is trigonal planar in structure and bond angles are 120° each. PCl_3, $AsCl_3$, and $BiCl_3$ are pyramidal in shape with sp^3-hybridization. In all of them, the bond angles are less than the normal tetrahedral angle of 109°28', and also these bond angles decrease down the group. Therefore, the correct order of bond angles is as follows:

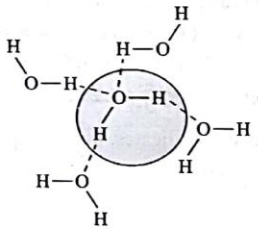
$BCl_3 > PCl_3 > AsCl_3 > BiCl_3$

22. (c)



23. (a) $Cl_2O_7 > SO_2 > P_4O_{10}$
Going from left to right in the periodic table along a group, the acidic character of oxides goes on decreasing.

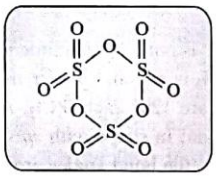
24. (a) In general, the boiling point of group 16 hydrides increases down the group because of increase in molecular mass, but in case of water, there is intramolecular hydrogen bonding, and so it has the highest boiling point.



25. (c) $NH_3 \xrightarrow{H_2SO_4} (NH_4)_2SO_4$
$NH_3 \xrightarrow{CaCl_2} CaCl_2 \cdot 8NH_3$
$NH_3 \xrightarrow{P_2O_5} (NH_4)_3PO_4$
Only CaO can be used for drying of ammonia as it does not react with ammonia.

26. (a) $HClO < HClO_2 < HClO_3 < HClO_4$
For the same halogen, the strength of the oxy-acids increases with increase in the oxidation state of the halogen.

27. (d)



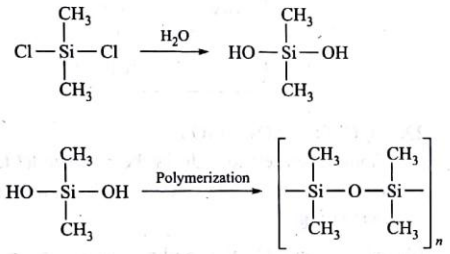
28. (a) $CaO < CuO < H_2O < CO_2$

Going from left to right in the periodic table along a group, the acidic character of oxides goes on decreasing.

29. (a) $B(OH)_3 + H_2O \rightarrow [B(OH)_4]^- + H^+$

H_3BO_3 is a monobasic weak Lewis acid.

30. (c)



31. (a) In alkaline medium, potassium permanganate oxidizes iodide salts to give iodate salts.

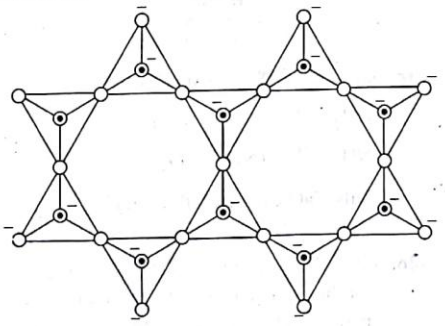
$2KMnO_4 + KI + H_2O \rightarrow 2KOH + 2MnO_2 + KIO_3$

32. (c) Black phosphorus is the most thermodynamically stable form of phosphorous.

33. (c) In $KMnO_4$, manganese is in its highest oxidation state of +7, and it cannot be oxidized any further.

34. (b) $NO_{(g)} + NO_{2(g)} \xrightarrow{-30°C} N_2O_3$ (Blue liquid)

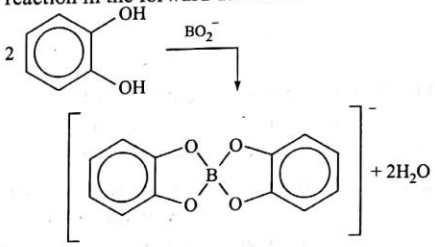
35. (b) In sheet silicates, three oxygen atoms of silicate are shared.



36. (a) $B(OH)_3 + NaOH \rightleftharpoons NaBO_2 + Na^+[B(OH)_4]^- + H_2O$

This reaction is reversible due to the hydrolysis of sodium metaborate, $NaBO_2$.

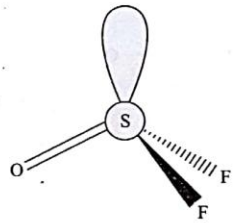
In the presence of complexing agents such as *cis*-1,2-diol, catechol, glycerol, etc., a complex is formed, and it prevents hydrolysis from taking the reaction in the forward direction.



37. (b) $P_4 + 3O_2 \xrightarrow{N_2} P_4O_6$

Nitrogen retards further oxidation of P_4O_6.

38. (d)



OSF_2

sp^3-Hybridization

Three bond pairs, one lone pair

Pyramidal shape

38. (d)

$NH_3 + CuO \xrightarrow{\Delta} N_{2(g)} + Cu_{(S)} + H_2O$

$NH_4NO_3 \xrightarrow{\Delta} N_2O_{(g)} + H_2O_{(g)}$

$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_{2(g)} + H_2O_{(g)} + Cr_2O_{3(s)}$

$Ba(N_3)_2 \xrightarrow{\Delta} Ba_3N_2 + N_{2(g)}$

Note: In the last reaction, we will get pure N_2 as no other gas is evolved.

40. (b) Conc. HNO_3 decomposes partly on long standing in light as follows:

$$2HNO_3 \rightarrow H_2O + 2NO_2 + \frac{1}{2}O_2$$

This NO_2 gets dissolved in remaining HNO_3 and turns its color yellow-brown which is due to the paramagnetic behavior of NO_2.

41. (c) $XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$

(P)

$XeO_3 + OH^-/H_2O \rightarrow HXeO_4^-$
(P) (Q)
$2HXeO_4^- \rightarrow Xe\uparrow + XeO_6^{4-} + O_2\uparrow + H_2O$
(Q)
Hence, there are two gaseous products Xe and O_2.

42. (a) $P_4 + 8SOCl_2 \rightarrow 4PCl_3 + 4SO_2 + 2S_2Cl_2$

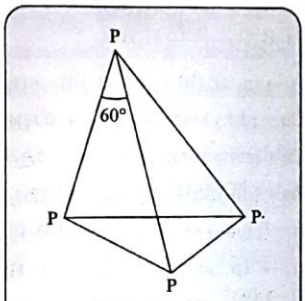
43. (a) $\underset{\text{Reducing agent}}{H_2O_2} + \overset{+7}{KIO_4} \rightarrow O_2 + I$ (with oxidation state lower than 7)

$40\overset{-1}{N}H_2OH + 10H_2O_2 \rightarrow 7H_2O + 20\overset{+3}{N_2O_3}$
Oxidizing agent

Multiple Correct Answers Type

1. (a), (d) Following two methods are used for the preparation of nitrous oxide:
$NH_4NO_3 \rightarrow N_2O + 2H_2O$
$NH_2OH{\cdot}HCl + NaNO_2 \rightarrow NaCl + 2N_2O + 2H_2O$

2. (a), (c), (d)



Yellow or white
Six P-P bonds

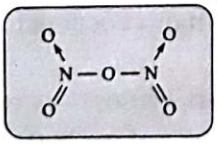
Every phosphorus atom has a lone pair of electrons.

3. (c) $2NH_3 + OCl^- \rightarrow H_2N{-}NH_2 + Cl^- + H_2O$

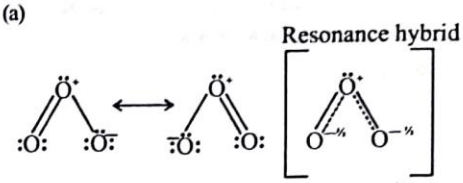
4. (b) When PbO_2 reacts with concentrated HNO_3, the gas evolved is oxygen.

5. (a), (b), (c) Tertiary amines do not react in this reaction due to bulky methyl groups.

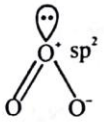
6. (a), (b), (c) N_2O_5 does not have an N—N bond.



7. (a, c, d)
(a)



(b) $2O_3 \rightarrow 3O_2$ $\Delta H = -ve$
(c) All the e^- are paired in O_3 (diamagnetic)
(d) sp^2 hybridized "O" and bent shape molecule



30. (b, d)
(a) It does not self-ionized in water and ionized in water as follows
$H_3BO_3 + H_2O \rightleftharpoons B(OH)_4^- + H^+$
(b) Acidity of the aq.solution of boric acid not affected by ethylene glycol
(c) In boric acid due to hydrogen bonding two-dimensional sheet structure is formed.
(d) In water the pKa value of H_3BO_3 is 9.25
$H_3BO_3 + H_2O \rightleftharpoons B(OH)_4^- + H^+$

Comprehension Type

1. (a) Argon is used in arc welding because of its low reactivity with metals. It causes an inert atmosphere without interaction with the metal.

2. (c)

XeO_3
sp^3-Hybridization
Three bond pairs, one lone pair
Pyramidal shape

3. (a) XeF_4 and XeF_6 are expected to be oxidizing. In such reactions, the oxidation state of xenon is decreased.

4. (c) Between nitrates and phosphates, nitrates are less abundant in the earth's crust because most of them are soluble in water.

5. (c)

NH_3 is a better electron donor than phosphine because the lone pair of electrons occupies the sp^3-orbital and is more directional. It is easily donatable.

6. (b) Oxidation number increases as well as decreases, so this is called disproportionation reaction.
$P_4 + 3NaOH + 3H_2O \rightarrow 3NaH_2PO_2 + PH_3$
From $P_4 \rightarrow NaH_2PO_2$: 0 to +1
From $P_4 \rightarrow PH_3$: 0 to –3

7. (a) $Cl_2 + SO_2 \xrightarrow[\text{charcoal}]{\text{in presence of}} \underset{(R)}{SO_2Cl_2}$

$\underset{(R)}{10\ SO_2Cl_2} + P_4 \rightarrow \underset{(S)}{4PCl_5} + 10\ SO_2$

$\underset{(S)}{PCl_5} + 4H_2O \rightarrow \underset{(T)}{H_3PO_4} + 5\ HCl$

8. (a) $Cl_2 + 2NaOH$ (dil. and cold) $\rightarrow NaCl + NaOCl + H_2O$

$5Cl_2 + 6NaOH$ (conc. and hot) $\rightarrow 5NaCl + NaClO_3 + 3H_2O$

Assertion-Reasoning Type

1. (b) Statement-I and Statement-II are both correct but Statement-II is not the correct explanation for Statement-I. Nitrogen does not form pentahalides because it does not have *d*-orbitals. The electronegativity of N is greater than that of phosphorus.

2. (c) Statement-I is true; Statement-II is false.
The O—H bond is stronger than the Al—O bond in aluminium hydroxide.

3. (a) Statement-I is true; Statement-II is true; Statement-II is the correct explanation for Statement-I. HNO_3 is a stronger acid than HNO_2.

4. (c) Statement-I is correct but Statement-II is incorrect. $SiCl_4$ also has covalent bonds. CCl_4 does not get hydrolyzed because carbon does not have vacant *d*-orbitals, so water cannot donate lone pair of electrons to start the reaction.

5. (c) Statement-I is true; Statement-II is false
$B(OH)_3 + H_2O \rightarrow [B(OH)_4]^- + H^+$
H_3BO_3 is a monobasic weak Lewis acid.

6. (a) Boron always forms covalent bond because boron requires very high energy to form a tripositive ion. Due to its very small size, B^{3+} has high polarizing power, so it forms covalent linkages according to Fajan rule.

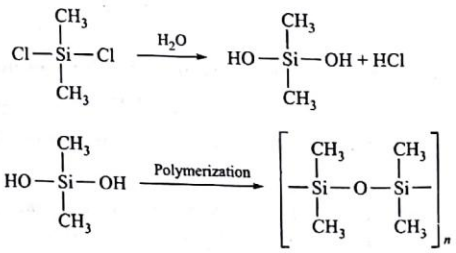
7. (c) Statement-I is true; Statement-II is false.
Down the group, the inert pair effect increases, therefore the higher oxidation state becomes less stable, and the lower oxidation state becomes more stable down the group. Pb^{4+} has a higher tendency to pass into Pb^{2+}, and is therefore a good oxidizing agent compared to Sn^{4+}.

Matching Column Type

1. (a) → (q, s); (b) → (s); (c) → (r); (d) → (q, r)
$Bi^{3+} + H_2O \rightarrow [BiO]^+ + 2H^+$
$NaAlO_2 + 2H_2O \rightarrow Al(OH)_3 + NaOH$
$2SiO_4^{4-} + 2H^+ \rightarrow Si_2O_7^{6-} + H_2O$
$Na_2B_4O_7 \xrightarrow{\text{Acid}} H_3BO_3$
$Na_2B_4O_7 \xrightarrow{H_2O} H_3BO_3$

2. (a) → (p, s); (b) → (q, s); (c) → (r, t); (d) → (q, t)
$3Cu + (\text{dil.})\ 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$
$3Cu + (\text{conc.})\ 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$
$4Zn + (\text{dil.})\ 10HNO_3 \rightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$
$Zn + (\text{conc.})\ 4HNO_3 \rightarrow Zn(NO_3)_2 + NO_2 + 2H_2O$

3. (a) → (p, s); (b) → (p, q, r, t); (c) → (p, q); (d) → (p)



$2XeF_4 + 3H_2O \rightarrow Xe + XeO_3 + 3H_2F_2 + F_2$
$Cl_2 + H_2O \rightarrow HCl + HClO$
$VCl_5 + H_2O \rightarrow VOCl + HCl$

4. (d)

(P) $PbO_2 + H_2SO_4 \xrightarrow{\Delta} PbSO_4 + O_2 + 2H_2O$
Other product = $2H_2O$
? = Δ

(Q) $Na_2S_2O_3 + 5H_2O \xrightarrow{4Cl_2} 2NaHSO_4 + 8\ HCl$

Other product = 8 HCl

? = Cl_2

(R) $N_2H_4 + 2I_2 \rightarrow N_2 + 4HI$

? = I_2

Other product = 4HI

(S) $XeF_2 + NO \rightarrow Xe + NOF$

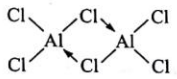
Other product = NOF

? = NO

Hence answer is (D)

Integer Answer Type

1. (6) The coordination number of Al in the crystalline state of $AlCl_3$ is 6.



2. (2) Among the following, the number of elements showing only one non-zero oxidation state is 2.
O, Cl, F, N, P, Sn, Tl, Na, Ti
Fluorine shows only –1 and sodium shows only +1.

3. (6) The total number of diprotic acids among the following is 6.

H_3PO_4, H_2SO_4, H_2CO_3, $H_2S_2O_7$, H_2CrO_4, H_2SO_3

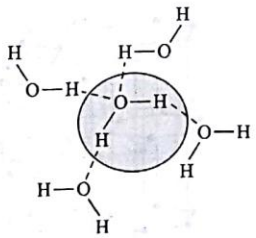
4. (3) The value of n in the molecular formula $Be_nAl_2Si_6O_{18}$ is 3.

$2n + (2 \times 3) + (4 \times 6) + (18 \times -2) = 0$

or $n = 3$

Subjective Type

1. In water, there is intermolecular hydrogen bonding, and the molecules are associated. So it has a higher boiling point and occurs in liquid state.



Sulphur is less electronegative and cannot participate in hydrogen bonding, so in hydrogen sulphide there is no hydrogen bonding, and therefore it occurs in gaseous state with low boiling point.

2. Lead is mainly extracted from sulphide ore called galena. Roasting is done followed by reduction with carbon. Self-reduction finally takes place.
$2PbS + 3O_2 \rightarrow 2PbO + SO_2$
$PbS + 2O_2 \rightarrow PbSO_4$
$PbSO_4 + PbO \rightarrow 2Pb + 2SO_2$
$PbS + 2PbO \rightarrow 3Pb + SO_2$

3. (a) Hydrogen gas is evolved.

$$2Al + 2H_2O + 2NaOH \xrightarrow{\Delta} 2NaAlO_2 + 3H_2\uparrow$$

(b) Nitrogen gas is evolved.

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} Cr_2O_3 + N_2\uparrow + 4H_2O$$

(c) Sulphur dioxide gas is evolved.

$$2Ag + 2H_2SO_4 \xrightarrow{\Delta} Ag_2SO_4 + SO_2\uparrow + 2H_2O$$

(d) Pink color of acidified potassium permanganate is discharged.

$$5H_2S + 2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 5S + 8H_2O$$

(e) Metastannic acid is formed.

$Sn + 4HNO_3 \rightarrow H_2SnO_3 + 4NO_2 + H_2O$

4. The precipitation of second group sulphides in the 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.

5. (a) $Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$

(b) $3Cu + (\text{dil.})\ 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

(c) $2NaCl + 2H_2SO_4 + MnO_2 \rightarrow Na_2SO_4 + MnSO_4 + Cl_2\uparrow + 2H_2O$

(d) $Al_2O_3 + 3C + 3Cl_2 \xrightarrow{\Delta} 2AlCl_3 + 3CO$

(c) $SnO_2 + 2C \xrightarrow{\Delta} Sn + 2CO$

6. (i) $H_2SO_4 + 2HBr \rightarrow SO_2 + Br_2 + 2H_2O$
HBr is a stronger reducing agent, thus it reduces concentrated H_2SO_4 into SO_2 and itself gets oxidized to bromine.

(ii) Hypochlorous acid is acidic in nature, so it turns blue litmus red.
$HClO \rightarrow HCl + [O]$
It gives nascent oxygen, so it is also a bleaching agent, and the litmus gets decolorized.

7. (i) $2HNO_3 \rightarrow H_2O + 2NO_2 + \frac{1}{2}O_2$

In sunlight, slight decomposition of nitric acid produces nitrogen dioxide which is brown in color. It dissolves in nitric acid to give pale yellow color.

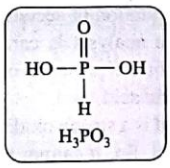
(ii) $CaOCl_2 + H_2O \rightarrow Ca(OH)_2 + Cl_2$

In the presence of moisture, bleaching powder loses chlorine, so its bleaching action decreases.

8. (i) Sulphur consists of octa-atomic cyclic molecules. At its melting point, it becomes a clear liquid, and the rings slip over each other easily. On further heating to a higher temperature, the rings break and long chains are formed. Their network gives rise to a viscous substance.

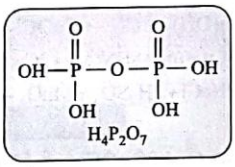
(ii) Potassium bicarbonate is more soluble than sodium bicarbonate. It cannot be filtered out and separated. Therefore, sodium carbonate is prepared by the Solvay process but the same process is not extended to the manufacture of potassium carbonate.

9. (i)



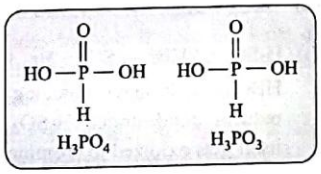
H_3PO_3

(ii)



$H_4P_2O_7$

10.



H_3PO_4 H_3PO_3

Only those hydrogens are replaceable that are attached to oxygen and contribute to basicity. From the structures it is clear that orthophosphoric acid, H_2PO_4, is tribasic but phosphorus acid, H_3PO_3, is dibasic.

11. $Al + NaOH \xrightarrow{\text{Aqueous}} NaAlO_2 + H_2O$

$NaAlO_2 \xrightarrow{CO_2} Al(OH)_3 + Na_2CO_3$

$Al(OH)_3 \xrightarrow{\Delta} \underset{\text{Alumina}}{Al_2O_3} + H_2O$

12. If CO_2 under pressure is allowed to escape through a nozzle, a white solid, dry ice is obtained. Solid CO_2 is a soft, white, snow-like substance. It sublimes and leaves no residue. So it is known as dry ice.

13. (i) $2HNO_3 + 6HCl \rightarrow 2NO + 3Cl_2 + 4H_2O$

(ii) $2Ce^{3+} + S_2O_8^{2-} \rightarrow 2SO_4^{2-} + 2Ce^{4+}$

(iii) $Cl_2 + 2OH^- \rightarrow Cl^- + ClO^- + H_2O$

14. *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

$\frac{16.8}{4.4} \times 44 = 168$ g of salt

So, the molecular mass of the salt is 168/2 = 84

Accordingly, M should be sodium.

$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$

$CO_2 + Ca(OH)_2 \rightarrow \underset{\text{Milkiness}}{CaCO_3\downarrow} + H_2O$

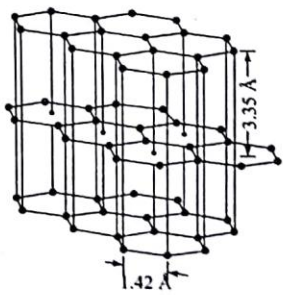
$Na_2CO_3 + BaCl_2 \rightarrow \underset{\text{White}}{BaCO_3\downarrow} + NaCl$

$BaCO_3 + 2HCl \rightarrow BaCl_2 + H_2O + CO_2$

15. Ferric sulphate is reduced to give ferrous sulphate.

$Fe_2(SO_4)_3 + 2KI \rightarrow 2FeSO_4 + K_2SO_4 + I_2$

16. (i)



Graphite has a two-dimensional sheet structure. Each carbon atom is in sp^2-hybridized state and is linked to three other carbon atoms in a hexagonal planar structure. After forming three C—C bonds, each carbon atom is left with one electron in its *p*-orbital. This electron then overlaps with the other to form a π-bond. Hexagonal planes are held by weak van der Waals forces. These planes can slide over one another. Therefore, graphite is a good lubricant.

(ii) Fluorine has the maximum value of standard reduction potential, so it is the best oxidizing agent. That is why it cannot be produced by the oxidation of fluorides with other oxidizing agents.

17. (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.

$$H_2O_2 \rightarrow H_2O + O$$
$$2CrCl_3 + 10NaOH + 3[O] \rightarrow 2Na_2CrO_4 + 6NaCl + 3H_2O$$

(v) Lead dioxide is precipitated.

$$Pb_3O_4 + 4HNO_3 \rightarrow 2Pb(NO_3)_2 + 2H_2O + PbO_2\downarrow$$

18. $3KClO_3 + 3H_2SO_4$ (conc.)

$$\xrightarrow{\Delta} 3KHSO_4 + HClO_4 + 2ClO_2 + H_2O$$

$$(COOH)_2 \xrightarrow{\text{Conc. } H_2SO_4} CO + CO_2 + H_2O$$

19. $:N\equiv\overset{+}{N}-\ddot{\underset{..}{O}}: \longleftrightarrow :\ddot{N}=\overset{+}{N}=\ddot{O}:$

20.

$$(NH_4)_2SO_4 + NO + NO_2 \xrightarrow{\Delta} 2N_2 + 3H_2O + H_2SO_4$$

21. (i) HI < HBr < HCl < HF (Increasing bond strength)

(ii) HI < I_2 < ICl < HIO_4 (Increasing oxidation number of iodine)

22. (i) Thiosulphate is formed.

$$4S + 6OH^- \rightarrow 2S^{2-} + S_2O_3^{2-} + 3H_2O$$

(ii) Iodine is evolved.

$$ClO_3^- + 6I^- + 6H_2SO_4 \rightarrow Cl^- + 6HSO_4^- + 3I_2 + 3H_2O$$

23. Ferrous is oxidized to ferric with chlorine, and bromine is evolved.

$$3Cl_2 + 2FeBr_2 \rightarrow 2FeCl_3 + 2Br_2$$

24. Aquaregia is three parts concentrated HCl and one part concentrated HNO_3. Aquaregia forms nascent chlorine which attacks gold.

$$HNO_3 + 3HCl \rightarrow NOCl + 2H_2O + 2Cl$$
$$Au + 3Cl \rightarrow AuCl_3$$
$$AuCl_3 + HCl \rightarrow HAuCl_4$$

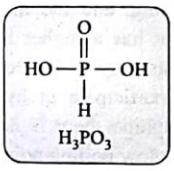
25. (i) Phosphine gas is formed.

$$P_4 + 3NaOH + 3H_2O \xrightarrow[\text{atm.}]{\text{Inert}} 3NaH_2PO_2 + PH_3\uparrow$$

(ii) Nitrous oxide is evolved.

$$4Sn + (\text{dil.})\,10HNO_3 \rightarrow 4Sn(NO_3)_2 + N_2O\uparrow + 5H_2O$$

26.



Only those hydrogens are replaceable that are attached to oxygen and contribute to basicity. From the structure it is clear that phosphorus acid H_3PO_3 is dibasic.

27. Oxygen does not have vacant *d*-orbitals, so it cannot extend its valency beyond 2, but in case of sulphur, vacant *d*-orbitals participate in bonding, so it can also show valencies of 4 and 6.

28. (i) Iodine is formed.

$$2IO_3^- + 5HSO_3^- \rightarrow I_2 + 3HSO_4^- + 2SO_4^{2-}$$

(ii) Phosphoric acid is obtained.

$$4P + 10HNO_3 + H_2O \rightarrow 5NO + 5NO_2 + 4H_3PO_4$$

29. (i) $HOCl < HOClO < HOClO_2 < HOClO_3$

As the oxidation number of the central halogen increases, thermal stability of the oxy-acid increases.

(ii) $SiO_2 < CO_2 < N_2O_5 < SO_3$

Going from left to right in the periodic table along a group, the acidic character of oxides

goes on decreasing. Also, down the group, acidic character decreases.

30. (i) Phosphine is formed.

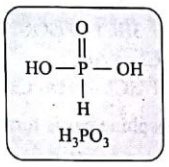
$$2H_3PO_2 \xrightarrow{\Delta} PH_3 + H_3PO_4$$

(ii) Oxygen difluoride is formed.

$$NaBrO_3 + 3F_2 \rightarrow NaBr + 3OF_2$$

(iii) Sulphur is precipitated.

31. (i)



Only those hydrogens are replaceable that are attached to oxygen and contribute to basicity. From the structure it is clear that phosphorus acid, H_3PO_3, is dibasic.

(ii) In ammonia, there is intermolecular hydrogen bonding, and the molecules are associated. So, it has a higher boiling point. However, phosphorus is less electronegative and can not participate in hydrogen bonding, so in phosphine there is no hydrogen bonding, it has a low boiling point.

32.

X	Y	Z
Yeast	Fermentation	Ethanol
Mica	Layer structure	Insulator
Superphosphate	Bone ash	Fertilizer
Carbon fibers	Graphite	Reinforced plastics
Rock salt	Cubic	Preservative
Carborundum SiC	Diamond structure	Abrasive

33. (i) By passing vapors of $SiCl_4$ through molten aluminium.

$$3SiCl_4 + 4Al \xrightarrow{\Delta} 4AlCl_3 + 3Si$$

(ii) White phosphorus is heated with CaO to get calcium phosphide, which is then hydrolyzed to get phosphine gas.

$$15CaO + 4P_4 \xrightarrow{\Delta} 5Ca_3P_2 + 3P_2O_5\uparrow$$

$$Ca_3P_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2PH_3\uparrow$$

(iii)

$$2NH_3 + CO_2 + H_2O \rightarrow (NH_4)_2CO_3$$

$$CaSO_4 + (NH_4)_2CO_3 \rightarrow CaCO_3\downarrow + (NH_4)_2SO_4$$

$$CaSO_4 + 2NH_3 + CO_2 + H_2O \rightarrow CaCO_3\downarrow + (NH_4)_2SO_4$$

34. $:N\equiv\overset{+}{N}-\ddot{\underset{..}{O}}: \longleftrightarrow :\ddot{\underset{..}{N}}=\overset{+}{N}=\ddot{O}:$

35. (i) $NaCO_3 + NO + NO_2 \rightarrow 2NaNO_2 + CO_2$

(ii) $2KMnO_4 + 2NH_3 \rightarrow 2MnO_3 + 2KOH + N_2 + 2H_2O$

(iii) $P_4 + 20HNO_3 \rightarrow 4H_3PO_4 + 20NO_2 + 4H_2O$

(iv) $2H_2S + NaHSO_3 + H^+ \rightarrow 3S + 3H_2O + Na^+$

(v) $CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$

36. $CCl_4 < MgCl_2 < AlCl_3 < PCl_5 < SiCl_4$

Increasing order of the extent of hydrolysis.

CCl_4 does not get hydrolyzed because carbon does not have vacant *d*-orbitals, so water cannot donate lone pair of electrons to start the reaction.

37. $2NH_3 \rightleftharpoons NH_4^+ + NH_2^-$

A substance which increases the concentration of ammonium ions in liquid ammonia is an ammono acid. When NH_4Cl is added, the concentration of ammonium increases.

38.

Resonating structures of ozone

39. (i) With the increase of size, the bond length increases from fluorine to iodine. Since the bond length of fluorine is minimum, its bond dissociation energy should be highest. But the bond dissociation energy of fluorine is less than Cl—Cl and Br—Br. The lower value of bond dissociation energy of fluorine is due to the high interelectronic repulsions between the non-bonding electrons in the 2*p*-orbitals of fluorine.

(ii) $SO_2 + 2OH^- \rightarrow SO_4^{2-} + 2H^+ + 2e^-$

In alkaline medium, the above reaction is shifted in forward reaction due to the removal of the hydrogen ions, therefore sulphur dioxide is a more powerful reducing agent in the alkaline medium than in acidic medium.

40. $2P + 3I_2 + 6H_2O \rightarrow 2H_3PO_3 + 6HI$

41. $PCl_5 + SO_2 \rightarrow POCl_3 + SOCl_2$

42. (i) $Ca_5(PO_4)_3F + 5H_2SO_4 + 10H_2O \xrightarrow{\Delta} 3H_3PO_4 + 5CaSO_4 \cdot 2H_2O + HF$

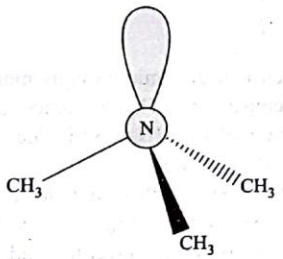
(ii) $Sn + 2KOH + H_2O \rightarrow K_2SnO_3 + 2H_2$

43. (i) Nitrogen and fluorine are small atoms, and electron density is high. When the bond is formed, the bond pairs suffer repulsions, therefore the bond length slightly increases. Therefore, the experimentally determined N–F bond length in NF_3 is greater than the sum of the single bond covalent radii of N and F.

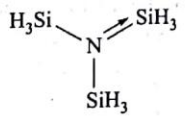
(ii) $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$

Magnesium chloride does not hydrolyze, being a stronger electrolyte. So, Mg_3N_2 when reacted with water gives NH_3 but HCl is not obtained from $MgCl_2$ on reaction with water at room temperature.

(iii)

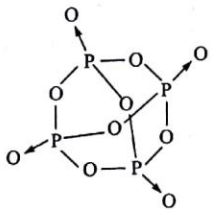


$N(Me)_3$ is pyramidal in shape due to sp^3-hybridization.



$N(SiMe_3)_3$ 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. Therefore, lone pair is not available for donation and hence it is less basic than $(CH_3)_3N$.

44.



There are 12 single P—O bonds, and there are four double or coordinate P—O bonds.

45. $2KI + Cl_2 \rightarrow 2KCl + I_2$

$2KClO_3 + I_2 \rightarrow 2KIO_3 + Cl_2$

46. The poisonous element must be arsenic.

$AsCl_3 + 6H \xrightarrow{Zn/HCl} AsH_3 + 3HCl$

$2AsH_3 \xrightarrow{\Delta} 2As + 3H_2\uparrow$

47. $(\Delta H_{hydration})$ for $AlCl_3 = -4665 + 3(-381)$
$= -5808 \text{ kJ mol}^{-1}$

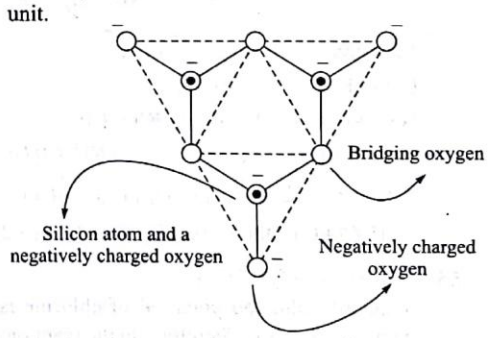
Hydration energy is more than ionization energy of aluminium; so in aqueous solution, it exists in ionic form.

$AlCl_3 + 6H_2O \rightarrow [Al(H_2O)_6]^{3+} + 3Cl^-$

48. Aluminium sulphide gives a foul odor when it becomes damp because upon hydrolysis, hydrogen sulphide is produced which has a rotten egg-like smell.

$Al_2S_3 + 6H_2O \rightarrow 2Al(OH)_3\downarrow + 3H_2S$

49. There is sharing of two oxygen atoms per silicate unit.



$(Si_3O_9)^{6-}$

50. The reaction of phosphoric acid with $Ca_5(PO_4)_3$ yields a fertilizer "triple superphosphate."

$7H_3PO_4 + Ca_5(PO_4)_3F \rightarrow 5Ca(H_2PO_4)_2 + HF$

51. (i) $POCl_3$ is formed.

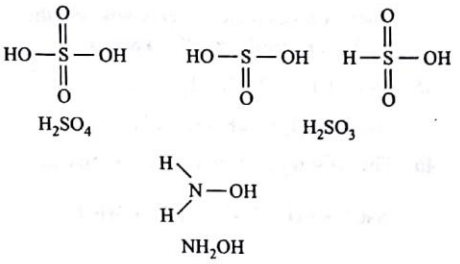
$P_4O_{10} + 6PCl_5 \rightarrow 10POCl_3$

(ii) Butane is formed.

$SnCl_4 + 2C_2H_3Cl + 2Na \rightarrow Na_2SnCl_6 + C_4H_{10}$

52. $\underset{A}{HNO_2} + \underset{B}{2H_2SO_3} + H_2O \rightarrow \underset{C}{NH_2OH} + \underset{D}{2H_2SO_4}$

HNO_2: H—O—N=O

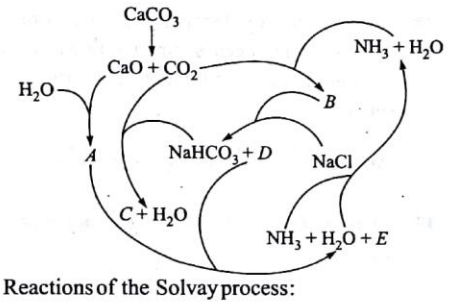


53. If sulphur trioxide is directly added to water to get sulphuric acid, fumes are formed and it is highly exothermic. Therefore, first oleum is prepared by dissolving sulphur trioxide in sulphuric acid. Then oleum is treated with water to get sulphuric acid.

$H_2SO_4 + SO_3 \rightarrow H_2S_2O_7$ (Oleum)

$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

54.



Reactions of the Solvay process:

$CaO + H_2O \rightarrow Ca(OH)_2 \{A\}$

$NH_3 + H_2O + CO_2 \rightarrow NH_4HCO_3 \{B\}$

$NH_4HCO_3 + NaCl \rightarrow NaHCO_3 + NH_4Cl\{D\}$

$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3\{C\} + CO_2 + H_2O$

$2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2\{E\} + 2NH_3 + 2H_2O$

55. $2KI + Cl_2 \rightarrow I_2 + 2KCl$

Standard reduction potential of chlorine is more than that of iodine; therefore, in the reaction iodide gets oxidized to iodine, and chlorine gets reduced to chloride.

56. When borax is heated, a colorless glassy bead is formed of the following composition:

$Na_2B_4O_7 \cdot 10H_2O \xrightarrow{\Delta} Na_2B_4O_7 + 10H_2O$

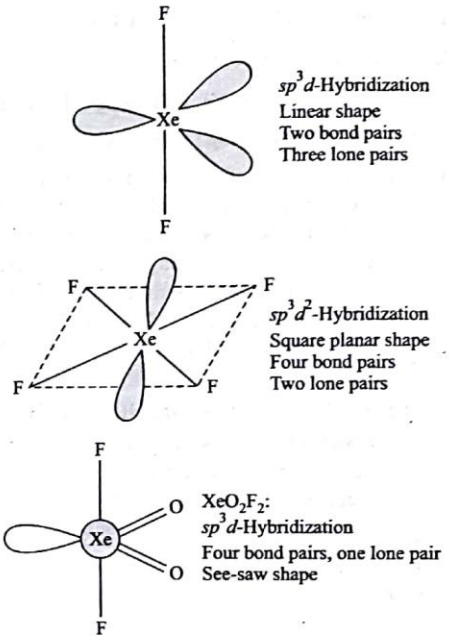
$Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$

$Co(II)\,salt \xrightarrow{\Delta} CoO + Some\,gas$

$CoO + B_2O_3 \xrightarrow{\Delta} Co(BO_2)_2$

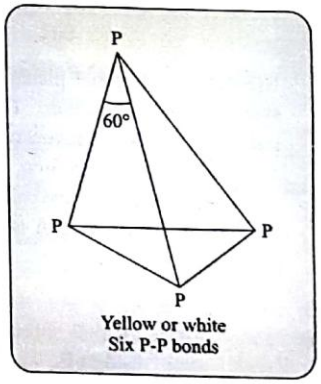
Blue-colored bead of cobalt metaborate is formed.

57.



58. Nitrogen is a diatomic gaseous molecule at ordinary temperature. The existence of nitrogen as diatomic molecule (N≡N) is due to its ability to form multiple bonds.

The triple bond in nitrogen molecule is very stable as the dissociation energy is very high (225 kcal mol^{-1}). Phosphorus, arsenic, and antimony all exist as discrete tetratomic tetrahedral molecules, as these are not capable of forming multiple bonds due to the repulsion between the non-bonded electrons of the inner core.



59. Compound X on reduction with $LiAlH_4$ gives a hydride Y containing 21.72% hydrogen along with other products. Compound Y reacts with air explosively resulting in boron trioxide. Y seems to be a hydride of boron, may be B_2H_6.

$$\text{Percentage of H in } B_2H_6 = \frac{\text{Mass of H}}{\text{Mass of } B_2H_6} \times 100$$

$$= \frac{6}{27.6} \times 100$$

$$\approx 21.73\%$$

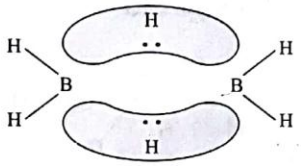
This matches the given data, so the hydride is B_2H_6.

X is some halide of boron which is reduced to B_2H_6 with lithium aluminium hydride.

$4BX_3 + 3LiAlH_4 \rightarrow 2B_2H_6 + 3AlX_3 + 3LiX$

$B_2H_6 + 3O_2 \rightarrow B_2O_3 + 3H_2O$

Structure of B_2H_6:



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 type of bonds in diborane. The boron atom undergoes sp^3-hybridization. Two hybrid orbitals of each B atom overlap with 1s 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 1s orbital of an H atom to form B—H—B bridge bond, this B—H—B bond is called three-center electron pair bond. It is also called banana bond.

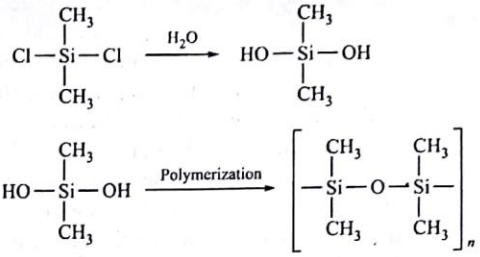
60. (i) With aluminium, it can be reduced to silicon.

$3SiCl_4 + 4Al \rightarrow 3Si + 4AlCl_3$

(ii) $3SiCl_4 + 4Al \rightarrow 3Si + 4AlCl_3$

$Si + Cu \xrightarrow{\Delta} Cu - Si$

$Cu - Si + 2CH_3Cl \rightarrow (CH_3)_2SiCl_2 + Cu$



(iii) $SiCl_4 + 4H_2O \rightarrow Si(OH)_4 + HCl$

$Si(OH)_4 \rightarrow SiO_2 + 2H_2O$

$SiO_2 + Na_2CO_3 \xrightarrow{1400°C} Na_2SiO_3 + CO_2$

61. The 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.

$2H_3BO_3 \rightarrow B_2O_3 + 3H_2O$

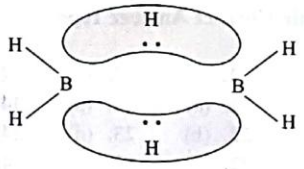
The reduction of boric anhydride (B_2O_3) can be done with sodium, potassium, or magnesium.

$B_2O_3 + 6K \rightarrow 2B + 3K_2O$

$B_2O_3 + 3Mg \rightarrow 2B + 3MgO$

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 as follows:



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 type of bonds in diborane. The boron atom undergoes sp^3-hybridization. Two hybrid orbitals of each B atom overlap 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 bond. It is also called banana bond.

$$B_2H_6 + HCl \rightarrow \underset{\text{Chlorodiborane}}{B_2H_5Cl} + H_2$$

62. (i) With aluminium carbide, methane is formed.

$$Al_4C_3 + 12H_2O \rightarrow 4Al(OH)_3 + 3CH_4\uparrow$$

(ii) With calcium cynamide, calcium carbonate is precipitated.

$$CaNCN + 5H_2O \rightarrow CaCO_3\downarrow + 2NH_4OH$$

(iii) With boron trifluoride, boric acid is formed.

$$4BF_3 + 3H_2O \rightarrow H_3BO_3 + 3HBF_4$$

(iv) With nitrogen trichloride, ammonia and hypochlorous acid are formed.

$$NCl_3 + 3H_2O \rightarrow NH_3 + 3HOCl$$

(v) With xenon tetrafluoride, xenon trioxide is formed.

$$2XeF_4 + 3H_2O \rightarrow Xe + XeO_3 + F_2 + 3H_2F_2$$

63. 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 F^- from $[AlF_6]^{3-}$ because it is more acidic than AlF_3.

$$K_3[AlF_6] + BF_3 \rightarrow AlF_3\downarrow + 3KBF_4$$

64. $P_4O_{10} + 6CaO \rightarrow 2Ca_3(PO_4)_2$

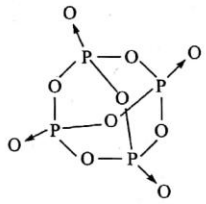
$6CaO \equiv P_4O_{10}$

$6 \times 56 \equiv 284$

$m \equiv 852$

$$\therefore \frac{6 \times 56}{m} = \frac{284}{852}$$

or $m = 336$ g of CaO



Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (c)	**2.** (d)	**3.** (b)	**4.** (b)	**5.** (d)	**6.** (d)	**7.** (b)	**8.** (b)	**9.** (a)	**10.** (d)
11. (d)	**12.** (a)	**13.** (d)	**14.** (b)	**15.** (a)	**16.** (c)	**17.** (d)	**18.** (a)	**19.** (d)	**20.** (a)
21. (d)	**22.** (b)	**23.** (d)	**24.** (b)	**25.** (a)	**26.** (d)	**27.** (d)	**28.** (a)	**29.** (c)	**30.** (a)
31. (c)	**32.** (b)	**33.** (a)	**34.** (d)	**35.** (d)	**36.** (a)	**37.** (b)	**38.** (b)	**39.** (a)	**40.** (c)
41. (b)	**42.** (d)	**43.** (c)	**44.** (d)	**45.** (b)	**46.** (d)	**47.** (b)	**48.** (b)	**49.** (a)	**50.** (a)
51. (b)	**52.** (c)	**53.** (c)	**54.** (b)	**55.** (a)	**56.** (d)	**57.** (a)	**58.** (a)	**59.** (b)	**60.** (b)
61. (d)	**62.** (d)	**63.** (c)	**64.** (c)	**65.** (c)	**66.** (a)	**67.** (c)	**68.** (b)	**69.** (a)	**70.** (b)
71. (a)	**72.** (c)	**73.** (b)	**74.** (b)	**75.** (a)	**76.** (c)	**77.** (c)	**78.** (c)	**79.** (c)	**80.** (c)
81. (b)	**82.** (b)	**83.** (b)	**84.** (b)	**85.** (c)	**86.** (a)	**87.** (c)	**88.** (a)	**89.** (a)	**90.** (c)
91. (c)	**92.** (a)	**93.** (a)	**94.** (c)	**95.** (b)	**96.** (a)	**97.** (b)	**98.** (b)	**99.** (a)	**100.** (d)
101. (d)	**102.** (a)	**103.** (a)	**104.** (c)	**105.** (b)	**106.** (c)	**107.** (a)	**108.** (d)	**109.** (a)	**110.** (a)
111. (b)	**112.** (d)	**113.** (d)	**114.** (c)	**115.** (c)	**116.** (d)	**117.** (c)	**118.** (a)	**119.** (b)	**120.** (a)
121. (b)	**122.** (a)	**123.** (c)	**124.** (a)	**125.** (b)	**126.** (c)	**127.** (c)	**128.** (a)		

JEE (Advanced) Exercises

Single Correct Answer Type

1. (b)	2. (a)	3. (a)	4. (a)	5. (d)	6. (a)	7. (c)	8. (a)	9. (a)	10. (a)
11. (d)	12. (d)	13. (d)	14. (d)	15. (c)	16. (c)	17. (d)	18. (a)	19. (a)	20. (c)
21. (c)	22. (d)	23. (b)	24. (c)	25. (a)	26. (c)	27. (a)	28. (a)	29. (c)	30. (b)
31. (d)	32. (c)	33. (b)	34. (c)	35. (d)	36. (b)	37. (b)	38. (b)	39. (a)	40. (b)
41. (c)	42. (b)	43. (d)	44. (d)	45. (d)	46. (c)	47. (a)	48. (c)	49. (a)	50. (a)
51. (d)	52. (a)	53. (d)	54. (a)	55. (a)	56. (b)	57. (c)	58. (c)	59. (d)	60. (d)
61. (d)	62. (b)	63. (b)	64. (b)	65. (d)	66. (c)	67. (a)	68. (d)	69. (c)	70. (b)
71. (d)	72. (d)	73. (c)	74. (a)	75. (c)	76. (c)	77. (b)	78. (d)	79. (a)	80. (a)
81. (d)	82. (b)	83. (d)	84. (c)	85. (c)	86. (b)	87. (c)	88. (d)	89. (c)	90. (a)
91. (b)	92. (d)	93. (b)	94. (c)	95. (a)	96. (d)	97. (c)	98. (b)	99. (b)	100. (c)
101. (d)	102. (d)	103. (a)	104. (c)	105. (b)	106. (a)	107. (a)	108. (b)	109. (a)	110. (c)
111. (d)	112. (a)	113. (d)	114. (d)	115. (d)	116. (b)	117. (d)	118. (a)	119. (a)	120. (b)
121. (a)	122. (d)	123. (d)	124. (b)	125. (a)	126. (a)	127. (d)	128. (c)		

Multiple Correct Answers Type

1. (b), (c)	2. (a), (b), (d)	3. (b), (d)	4. (a), (b)	5. (a), (b), (c)
6. (a), (c), (d)	7. (a), (b), (c)	8. (a), (d)	9. (a), (b), (d)	10. (b), (c), (d)
11. (b), (c), (d)	12. (a), (c), (d)	13. (a), (b), (c)	14. (a), (b), (c), (d)	15. (a), (b), (c), (d)
16. (a), (c)	17. (a), (b), (d)	18. (a), (b), (c), (d)	19. (a), (d)	20. (a), (b), (c)
21. (b), (d)	22. (a), (d)	23. (b), (d)	24. (a), (c), (d)	25. (a), (b), (c)
26. (b), (c), (d)	27. (a), (b), (c)	28. (a), (b)	29. (b), (c), (d)	30. (a), (c), (d)
31. (b), (c)	32. (a), (b), (c)	33. (b), (c), (d)	34. (b), (c), (d)	35. (a), (b), (c)
36. (b), (c), (d)	37. (b), (c), (d)	38. (a), (b), (c)	39. (b), (d)	40. (b), (c), (d)
41. (a), (d)	42. (b), (c), (d)	43. (a), (b), (d)	44. (a), (d)	45. (b), (c)
46. (a), (b)	47. (a), (c), (d)	48. (a), (b), (d)	49. (a), (b), (c)	50. (a), (b), (c)
51. (a), (b), (c)	52. (a), (c), (d)	53. (c), (d)	54. (a), (b), (c), (d)	55. (a), (b), (c), (d)
56. (a), (b), (c), (d)	57. (b), (c), (d)	58. (b), (c), (d)		

Comprehension Type

Comprehension-1	1. (c)	2. (a)	3. (b)	
Comprehension-2	4. (d)	5. (d)		
Comprehension-3	6. (a)	7. (b)	8. (b)	
Comprehension-4	9. (a)	10. (d)		
Comprehension-5	11. (c)	12. (c)	13. (a)	14. (b)
Comprehension-6	15. (a)	16. (c)	17. (b)	18. (c)
Comprehension-7	19. (a)	20. (b)	21. (b)	
Comprehension-8	22. (b)	23. (c)	24. (b)	
Comprehension-9	25. (c)	26. (b)	27. (d)	
Comprehension-10	28. (d)	29. (b)	30. (c)	
Comprehension-11	31. (b)	32. (a)	33. (a)	
Comprehension-12	34. (c)	35. (b)	36. (b)	
Comprehension-13	37. (b)	38. (c)	39. (b)	
Comprehension-14	40. (a)	41. (a)	42. (c)	43. (a)
Comprehension-15	44. (d)	45. (b)	46. (a)	

Comprehension-16	**47.** (c)	**48.** (c)	**49.** (b)		
Comprehension-17	**50.** (a)	**51.** (b)			
Comprehension-18	**52.** (b)	**53.** (a)	**54.** (d)		
Comprehension-19	**55.** (c)	**56.** (d)	**57.** (a)		
Comprehension-20	**58.** (c)	**59.** (d)	**60.** (d)	**61.** (a)	**62.** (b)
Comprehension-21	**63.** (d)	**64.** (b)	**65.** (d)		
Comprehension-22	**66.** (c)	**67.** (b)	**68.** (c)		

Assertion-Reasoning Type

1. (d) **2.** (b) **3.** (a) **4.** (a) **5.** (d) **6.** (c) **7.** (a) **8.** (d) **9.** (b) **10.** (a)

Matching Column Type

1. (a) p, q, r, s; (b) r, s; (c) p, q, r, s; (d) p, r, s, t
2. (a) p, q, r, s, t; (b) p, q, t; (c) r, t; (d) p, r, t
3. (a) s; (b) p, q; (c) r
4. (a) q; (b) r; (c) p; (d) s
5. (a) r, t; (b) p, r, s; (c) p, q, r, s; (d) q, t
6. (a) q; (b) p, q; (c) p, q, s; (d) p, q, r
7. (a) p; (b) q, r; (c) r; (d) s
8. (a) q; (b) p; (c) r, s; (d) q
9. (a) q, p; (b) r, p; (c) r, s
10. (a) s; (b) p, r, s; (c) q, t; (d) r, t
11. (a) p, q, s; (b) p, q, r; (c) p, q; (d) p, r, t
12. (a) s; (b) s; (c) p
13. (a) p; (b) s; (c) r; (d) q

Integer Answer Type

1. (24) **2.** (4) **3.** (2) **4.** (2) **5.** (33) **6.** (1) **7.** (1216) **8.** (6) **9.** (28) **10.** (3)
11. (72) **12.** (1) **13.** (10) **14.** (412) **15.** (0) **16.** (4) **17.** (3) **18.** (40) **19.** (0) **20.** (3)
21. (114) **22.** (21) **23.** (1) **24.** (105) **25.** (6) **26.** (42) **27.** (2) **28.** (460) **29.** (6) **30.** (4)
31. (3) **32.** (9)

NCERT Exemplar Exercises

Single Correct Answers Type

1. (c) **2.** (a) **3.** (a) **4.** (a) **5.** (a) **6.** (c) **7.** (b) **8.** (c) **9.** (d) **10.** (b)
11. (a) **12.** (b) **13.** (d) **14.** (c) **15.** (b) **16.** (c) **17.** (b) **18.** (c) **19.** (c) **20.** (a)
21. (a) **22.** (d) **23.** (c) **24.** (c) **25.** (c) **26.** (b) **27.** (a) **28.** (c) **29.** (a) **30.** (a)
31. (b) **32.** (a) **33.** (a) **34.** (c) **35.** (c) **36.** (a) **37.** (c) **38.** (a) **39.** (c) **40.** (d)
41. (c) **42.** (b)

Multiple Correct Answers Type

1. (a), (b) **2.** (b), (c) **3.** (a), (b) **4.** (b), (c) **5.** (a), (b), (d)
6. (b), (d) **7.** (a), (c) **8.** (b), (c) **9.** (b), (d) **10.** (a), (c), (d)
11. (a), (c) **12.** (c), (d) **13.** (a), (d) **14.** (a), (b) **15.** (b), (c)
16. (a), (b)

Matching Column Type

1. (a) → (t); (b) → (r); (c) → (s); (d) → (p), (q)
2. (a) → (r); (b) → (s); (c) → (p); (d) → (t); (e) → (q)
3. (a) → (q); (b) → (r); (c) → (q); (d) → (p); (e) → (q); (f) → (r)

4. (a) **5.** (b) **6.** (a) **7.** (b) **8.** (c)

Assertion-Reasoning Type

1. (a) **2.** (b) **3.** (c) **4.** (c) **5.** (b) **6.** (a) **7.** (a) **8.** (a)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (c)	**2.** (d)	**3.** (a)	**4.** (c)	**5.** (d)	**6.** (d)	**7.** (a)	**8.** (a)	**9.** (c)	**10.** (a)
11. (b)	**12.** (d)	**13.** (d)	**14.** (c)	**15.** (c)	**16.** (b)	**17.** (b)	**18.** (b)	**19.** (c)	**20.** (c)
21. (b)	**22.** (d)	**23.** (d)	**24.** (b)	**25.** (b)	**26.** (b)	**27.** (d)	**28.** (a)	**29.** (d)	**30.** (c)
31. (d)	**32.** (a)	**33.** (d)	**34.** (a)	**35.** (c)	**36.** (b)	**37.** (c)	**38.** (c)	**39.** (c)	**40.** (c)
41. (c)									

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a)	**2.** (d)	**3.** (d)	**4.** (b)	**5.** (b)	**6.** (b)	**7.** (c)	**8.** (b)	**9.** (d)	**10.** (a)
11. (b)	**12.** (b)	**13.** (?)	**14.** (d)	**15.** (a)	**16.** (c)	**17.** (d)	**18.** (a)	**19.** (a)	**20.** (b)
21. (b)	**22.** (c)	**23.** (a)	**24.** (a)	**25.** (c)	**26.** (a)	**27.** (d)	**28.** (a)	**29.** (a)	**30.** (c)
31. (a)	**32.** (c)	**33.** (c)	**34.** (b)	**35.** (b)	**36.** (a)	**37.** (b)	**38.** (d)	**39.** (d)	**40.** (b)
41. (c)	**42.** (a)	**43.** (a)							

Multiple Correct Answers Type

1. (a), (d) **2.** (a), (c), (d) **3.** (c) **4.** (b) **5.** (a), (b), (c)
6. (a), (b), (c) **7.** (a), (c), (d) **8.** (b), (d)

Comprehension Type

1. (a) **2.** (c) **3.** (a) **4.** (c) **5.** (c) **6.** (b) **7.** (a) **8.** (a)

Assertion-Reasoning Type

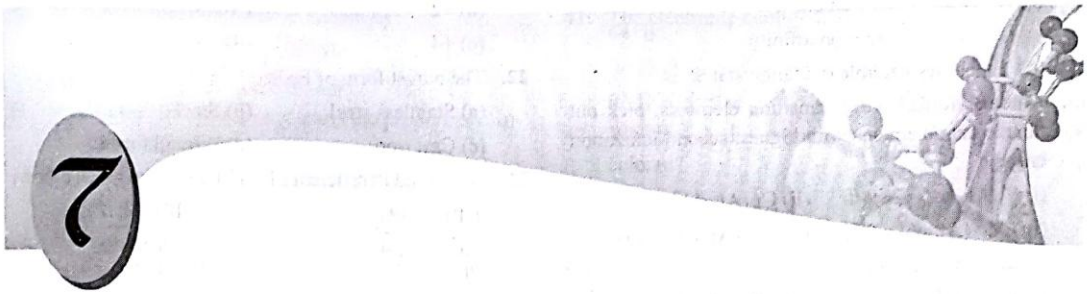
1. (b) **2.** (c) **3.** (a) **4.** (c) **5.** (c) **6.** (a) **7.** (c)

Matching Column Type

1. (a) → (q, s); (b) → (s); (c) → (r); (d) → (q, r)
2. (a) → (p, s); (b) → (q, s); (c) → (r, t); (d) → (q, t)
3. (a) → (p, s); (b) → (p, q, r, t); (c) → (p, q); (d) → (p)
4. (d)

Integer Answer Type

1. (6) **2.** (2) **3.** (6) **4.** (3)



7 *d*-Block Elements

JEE (Main) Exercises

Single Correct Answer Type

1. A transition element containing only one electron in 4*s*-orbital is:
   (a) $_{21}Sc$ (b) $_{23}Mn$
   (c) $_{26}Fe$ (d) $_{29}Cu$

2. The magnetic moment of a transition metal of 3*d*-series is 6.92 μ_B. Its electronic configuration will be:
   (a) $(3d)^4(4s)^2$ (b) $(3d)^5(4s)^1$
   (c) $(3d)^{10}$ (d) $(3d)^5(4s)^0$

3. Which of the following electronic configuration will be associated with the lowest magnetic moment?
   (a) d^2 (b) d^3
   (c) d^4 (d) d^9

4. Find the species/elemental atom has minimum number of unpaired electrons:
   (a) Kr^+ (b) Mn^{2+}
   (c) Fe^{3+} (d) O^+

5. In which of the following pairs do the two species resemble each other most closely in chemical properties?
   (a) ^1_1H and ^2_1H (b) $^{16}_8O$ and $^{16}_8O^{2-}$
   (c) $^{24}_{12}Mg$ and $^{24}_{12}Mg^{2+}$ (d) $^{14}_7N$ and $^{14}_7N^{3-}$

6. Which forms interstitial compounds?
   (a) Fe (b) Co
   (c) Ni (d) All

7. The highest magnetic moment is shown by the transition metal with the configuration:
   (a) $3d^2$ (b) $3d^5$
   (c) $3d^7$ (d) $3d^9$

8. Arrange the following ions in order of their magnetic moment:
   (i) V^{4+} (ii) Mn^{4+}
   (iii) Fe^{3+} (iv) Ni^{2+}
   (Atomic number of V = 23, Mn = 25, Fe = 26, Ni = 28)
   (a) (ii) > (iii) > (i) > (iv) (b) (iii) > (ii) > (iv) > (i)
   (c) (i) > (iv) > (iii) > (ii) (d) (iv) > (iii) > (i) > (ii)

9. Which of the ions will give colorless aqueous solution?
   (a) Ni^{2+} (b) Fe^{2+}
   (c) Cu^{2+} (d) Cu^+

10. Which of the following form an alloy?
    (a) Zn + Pb (b) Fe + Hg
    (c) Pt + Hg (d) Fe + C

11. In which of the following pairs are both the ion colored in aqueous solution?
    (a) Sc^{3+}, Co^{2+} (b) Ni^{2+}, Cu^+
    (c) Ni^{2+}, Ti^{3+} (d) Sc^{3+}, Ti^{3+}

12. The electronic configuration of four elements are:
    (i) [Xe] $6s^1$ (ii) [Xe] $4f^{14}$, $5d^1$ $6s^2$
    (iii) [Ar] $4s^2$ $4p^3$ (iv) [Ar] $3d^7$, $4s^2$
    Which one of the following statements about these elements is not correct?
    (a) (i) is a strong reducing agent

(b) (ii) is a *d*-block element
(c) (iii) has high electron affinity
(d) (iv) shows variable oxidation states

13. Among the following transition elements, pick out the element/elements with highest second ionization energy:
(i) V (At. no. = 23) (ii) Cr (At. no. = 24)
(iii) Mn (At. no. = 25) (iv) Cu (At. no. = 29)
(v) Zn (At. no. = 30)
(a) (i) and (iii) (b) (ii) and (v)
(c) Only (iii) (d) Only (iv)

14. Lanthanoids contraction is caused due to:
(a) The same effective nuclear charge from Ce to Lu
(b) The imperfect shielding on outer electrons by 4*f* electrons from the nuclear charge
(c) The appreciable shielding on outer electrons by 4*f*-electrons from the nuclear charge
(d) The appreciable shielding on outer electrons by 5*d*-electrons from the nuclear charge

15. Which of the following has the maximum number of unpaired electrons?
(a) Mg^{2+} (b) Ti^{3+}
(c) V^{3+} (d) Fe^{2+}

16. Which of the following halides is least stable and has doubtful existence?
(a) CI_4 (b) GeI_4
(c) SnI_4 (d) PbI_4

17. The lanthanoids contraction is responsible for the fact that:
(a) Zr and Y have about the same radius
(b) Zr and Nb have similar oxidation state
(c) Zr and Hf have about the same radius
(d) Zr and Zn have the same oxidation state

18. $K_2[HgI_4]$ detects the ion/group:
(a) NH_2^- (b) NO
(c) NH_4^+ (d) $AlCl_3$

19. Which of the following belongs to the actinoids series of elements?
(a) Y (b) Ta
(c) U (d) Y

20. Which oxides will not give metal on heating?
(a) HgO (b) ZnO
(c) Ag_2O (d) All of these

21. Most common oxidation state of lanthanoids is:
(a) +2 (b) +3
(c) +4 (d) +5

22. The purest form of Fe is:
(a) Stainless steel (b) Steel
(c) Cast iron (d) Wrought iron

23. For Ni and Pt different I.P. in kJ mol^{-1} are given below:

	$(IP)_1 + (IP)_2$	$(IP)_3 + (IP)_4$
Ni	2.49	8.80
Pt	2.60	6.70

Hence:
(a) Nickel(II) compounds tend to be thermodynamically more stable than platinum(II)
(b) Platinum(IV) compounds tend to be more stable than nickel(IV)
(c) Both are correct
(d) None is correct

24. An acidic solution contains Cu^{2+}, Pb^{2+}, and Zn^{2+}. If hydrogen sulphide gas is passed through this solution, the precipitate will contain:
(a) CuS and ZnS (b) PbS and ZnS
(c) CuS and PbS (d) CuS, PbS, and ZnS

25. Ti^{2+} is purple while Ti^{4+} is colorless, because:
(a) There is no crystal field effect in Ti^{4+}
(b) Ti^{4+} has $3d^2$ configuration
(c) Ti^{4+} has $3d^0$ configuration
(d) Ti^{4+} is a very small cation when compared to Ti^{2+}, and hence does not absorb any radiation

26. In dilute alkaline solution MnO_4^- changes to:
(a) MnO_4^{2-} (b) MnO_2
(c) Mn_2O_3 (d) MnO

27. Pyrolusite in MnO_2 is used to prepare $KMnO_4$. Steps are:

$$MnO_2 \xrightarrow{I} MnO_4^{2-} \xrightarrow{II} MnO_4^-$$

I and II are:
(a) Fused with KOH/air, electrolytic oxidation
(b) Fused with KOH/air, electrolytic reduction
(c) Fused with conc. HNO_3/air, electrolytic reduction
(d) All are correct

28. Maximum magnetic moment is shown by:
(a) d^5 (b) d^6
(c) d^7 (d) d^8

29. Magnetic moments of Cr ($Z = 24$), Mn^+ ($Z = 25$), and Fe^{2+} ($Z = 26$), are x, y, z. They are in order:
(a) $x < y < z$ (b) $x = y < z$
(c) $z < x = y$ (d) $x = y = z$

30. Maximum oxidation state is shown by:
(a) Os (b) Mn
(c) Cr (d) Co

31. Following elements do not show the properties characteristic of *d*-block elements:
(a) Cu, Ag, Au (b) Zn, Hg, Cd
(c) Sc, Ti, V (d) Fe, Co, Ni

32. AgCl and NaCl are colorless. NaBr and NaI are also colorless but AgBr and AgI are colored. This is due to:
(a) Ag^+ polarizes Br^- and I^-
(b) Ag^+ has unpaired *d*-orbital
(c) Ag^+ depolarizes Br^- and I^-
(d) None is correct

33. In 3*d* transition series, if nuclear charge increases, the screening effect:
(a) Increases (b) Decreases
(c) First decreases and then increases
(d) First increases and then decreases

34. Least paramagnetic property is shown by:
(a) Fe (b) Mn
(c) Ni (d) Cu

35. Which shows maximum magnetic moment among the bivalent ions of the first transition series?
(a) Fe^{2+} (b) Co^{2+}
(c) Ni^{2+} (d) Mn^{2+}

36. Which of the following compounds is amphoteric?
(a) $Cr(OH)_2$ (b) $Fe(OH)_2$
(c) $Cr(OH)_3$ (d) $Fe(OH)_3$

37. $(NH_4)_2Cr_2O_7$ on heating gives a gas which is also given by:
(a) Heating NH_4NO_2 (b) Heating NH_4NO_3
(c) $Mg_3N_2 + H_2O$ (d) $Na + H_2O_2$

38. The pair of compounds having metals in their highest oxidation state is:
(a) MnO_2, $FeCl_3$ (b) $[MnO_4]^-$, CrO_2Cl_2
(c) $[Fe(CN)_6]^{3-}$, $[Co(CN)_3]$
(d) $[NiCl_4]^{2-}$, $[CoCl_4]^-$

39. The compound having tetrahedral geometry is:
(a) $[Ni(CN)_4]^{2-}$ (b) $[Pd(CN)_4]^{2-}$
(c) $[PdCl_4]^{2-}$ (d) $[NiCl_4]^{2-}$

40. CrO_3 dissolves in aqueous NaOH to give:
(a) CrO_4^{2-} (b) $Cr(OH)_3$
(c) $Cr_2O_7^{2-}$ (d) $Cr(OH)_2$

41. The electronic configuration of gadolinium (At. no.= 64) is:
(a) [Xe] $4f^8, 5d^0, 6s^2$ (b) [Xe] $4f^7, 5d^1, 6s^2$
(c) [Xe] $4f^3, 5d^5, 6s^2$ (d) [Xe] $4f^6, 5d^2, 6s^2$

42. Which of the following compounds is expected to be colored?
(a) Ag_2SO_4 (b) CuF_2
(c) MgF_2 (d) CuCl

43. Ammonium dichromate is used in fire works. The green colored powder blow in the air is:
(a) CrO_3 (b) Cr_2O_3
(c) Cr (d) $CrO(O_2)$

44. In acidic medium, one mole of MnO_4^- accepts how many moles of electrons in a redox process?
(a) 1 (b) 3
(c) 5 (d) 6

45. The correct formula for permanganic acid is:
(a) $HMnO_4$ (b) $HMnO_5$
(c) H_2MnO_4 (d) MnO_2

46. On heating ammonium dichromate, the gas evolved is:
(a) Oxygen (b) Ammonia
(c) Nitrous oxide (d) Nitrogen

47. Arrange the following in order of their increasing thermal conductivity.
(a) Al, Ag, Cu (b) Cu, Ag, Al
(c) Ag, Cu, Al (d) Al, Cu, Ag

48. Which one of the following forms a colorless solution in aqueous medium?
(a) Cr^{3+} (b) Ti^{3+}
(c) Sc^{3+} (d) V^{3+}

49. $KMnO_4$ acts as an oxidizing agent in:
(a) Acidic medium only
(b) Neutral and acidic media
(c) Neutral and alkaline media
(d) Neutral, acidic, and alkaline media

50. The transition metals are mostly:
(a) Diamagnetic (b) Paramagnetic
(c) Neither diamagnetic nor paramagnetic
(d) Both diamagnetic and paramagnetic

51. Titanium shows magnetic moment of 1.73 BM; then find out its oxidation state:
(a) + 1 (b) + 4
(c) + 3 (d) + 2

52. The colorless species is:

(a) VCl_3 (b) $VOSO_4$

(c) Na_3VO_4 (d) $[V(H_2O)_6\ SO_4].H_2O$

53. MnO_4^{2-} (1 mole) in neutral aqueous medium disproportionate to:

(a) 2/3 mole of MnO_4^- and 1/3 mole of MnO_2

(b) 1/3 mole of MnO_4^- and 2/3 mole of MnO_2

(c) 1/3 mole of Mn_2O_7 and 1/3 mole of MnO_2

(d) 2/3 mole of Mn_2O_7 and 1/3 mole of MnO_2

54. Lanthanoids contraction is observed in:

(a) Hf (b) At

(c) Xe (d) Ac

55. Lanthanoids are:

(a) 14 elements in the sixth period (atomic number 90 to 103) that are filling 4*f*-sublevel

(b) 14 elements in the seventh period (atomic number 90 to 103) that are filling 5*f*-subshell

(c) 14 elements in the sixth period (atomic number 58 to 71) that are filling the 4*f*-subshell

(d) 14 elements in the seventh period (atomic number 58 to 71) that are filling the 4*f*-subshell

56. For delocalization of 1 mole of $KMnO_4$, the moles of H_2O_2 required is:

(a) 1/2 (b) 3/2

(c) 5/2 (d) 7/2

57. Among the following pairs of ions, the lower oxidation state in aqueous solution is more stable than the other, in:

(a) Tl^+, Tl^{3+} (b) Fe^{+1}, Fe^{3+}

(c) Cr^{2+}, Cr^{3+} (d) V^{2+}, VO^{2+}

JEE (Advanced) Exercises

Single Correct Answer Type

1. The oxidation states of Mn in K_2MnO_4 and $KMnO_4$ respectively are:

(a) +6, +7 (b) +6, +6

(c) +7, +7 (d) +7, +6

2. The basic character of the transition metal monoxides follows the order:

(a) CrO > VO > FeO > TiO

(b) TiO > FeO > VO > CrO

(c) TiO > VO > CrO > FeO

(d) VO > CrO > TiO > FeO

3. Which is not a transition element?

(a) Cu (b) Ac

(c) Zn (d) Pd

4. One element (A) is having four valence shell electron. Which of following values will be maximum.

(a) EA of A (b) $IE_4 - IE_3$

(c) $IE_5 - IE_3$ (d) $IE_2 - IE_1$

5. The maximum oxidation state of osmium is:

(a) +6 (b) +7

(c) +8 (d) +5

6. Which of the following elements involves gradual filling of 5*f*-level?

(a) Lanthanoids (b) Actinoids

(c) Transition metals (d) Coinage metals

7. Which chromium compound in widely used in tanning of leather?

(a) Cr_2O_3 (b) CrO_2Cl_2

(c) $CrCl_3$

(d) $K_2SO_4.Cr_2(SO_4)_3.24H_2O$

Chrome alum $K_2SO_4{\cdot}Cr_2(SO_4)_3{\cdot}24H_2O$ is widely used in tanning of leather.

8. $K_2Cr_2O_7$ reacts with NH_4Cl in the presence of H_2SO_4. The product formed is:

(a) Chromyl chlorate with green vapor

(b) Chromous chloride with white vapor

(c) Chromous chloride with blue vapor

(d) Chromyl chloride with deep red color

9. The "Spin-only" magnetic moment [in units of Bohr magneton, (μ_B)] of Ni^{2+} in aqueous solution would be (At. no. Ni = 28):

(a) 0 (b) 1.73

(c) 2.84 (d) 4.90

10. Which of the following compounds is not colored?

(a) Na_2CuCl_4 (b) Na_2CdCl_4

(c) $K_4[Fe(CN)_6]$ (d) $K_3[Fe(CN)_6]$

11. When KI (excess) is added to:

(i) $CuSO_4$ (ii) $HgCl_2$ (iii) $Pb(NO_3)_2$

(a) A white ppt. of CuI in (i), an orange ppt. of HgI_2 in (ii), and a yellow ppt. of PbI_2 in (iii)

(b) A white ppt. of Cu_2I_2 in (i), a red ppt. dissolving to HgI_4^{2-} in (ii), and a yellow ppt. of PbI_2 in (iii)

(c) A white ppt. of CuI, HgI_2, and PbI_2 in each case

(d) None is correct

12. Due to lanthanoids contraction:

(a) Fe, Co, Ni have equal size

(b) Zr and Hf have equal size

(c) All *f*-block ions have equal size

(d) All isoelectronic ions have equal size

13. Silver ornaments turn black in atmosphere:
(a) O_2 (b) N_2
(c) Cl_2 (d) H_2S

14. What are the species A and B in the following:
$$CrO_3 + H_2O \longrightarrow A \xrightarrow{OH^-} B$$
(a) H_2CrO_4, $H_2Cr_2O_7$ (b) $H_2Cr_2O_7$, Cr_2O_3
(c) CrO_4^{2-}, $Cr_2O_7^{2-}$ (d) $H_2Cr_2O_7$, CrO_4^{2-}

15. In August 2003, IUPAC approved the name of the element of atomic number 110. Name of the elements is:
(a) Darmstadtium (b) Mountanium
(c) Rhenium (d) Bhorium

16. Which one of the following characteristics of the transition metals is associated with their catalytic activity?
(a) Color of hydrated ions
(b) Variable oxidation states
(c) Diamagnetic behavior
(d) Paramagnetic behavior

17. Which of the following factor may be regarded as the main cause of lanthanoids contraction?
(a) Poor shielding of one of the 4 *f*-electrons by another in the subshell.
(b) Effective shielding of one of the 4*f*-electrons by another in the subshell.
(c) Poorer shielding of 5*d*-electrons by 4*f*-electrons.
(d) Greater shielding of 5*d*-electrons by 4*f*-electrons.

18. An extremely hot copper wire reacts with steam to produce:
(a) Cu_2O (b) CuO_2
(c) Cu_2O_2 (d) CuO

19. Spin only magnetic moment of the compound $Hg[Co(SCN)_4]$ is:
(a) $\sqrt{3}$ (b) $\sqrt{15}$
(c) $\sqrt{24}$ (d) $\sqrt{8}$

20. Consider a titration of potassium dichromate solution with acidified Mohr's salt solution using diphenylamine as indicator. The number of moles of Mohr's salt required per mole of dichromate is:
(a) 3 (b) 4
(c) 5 (d) 6

21. $FeCr_2O_4 + Na_2CO_3 + O_2 \xrightarrow{\text{Fusion}} [X] \xrightarrow[H_2O]{H^+} [Y] \xrightarrow[H_2O_2]{H^+} [Z]$
Which of the following statements is true for the compounds [*X*], [*Y*], and [*Z*]?
(a) In all three compounds, the chromium is in +6 oxidation state
(b) [*Z*] is a deep blue-violet colored compound which decomposes rapidly in aqueous solution into Cr^{3+} and dioxygen
(c) Saturated solution of [*Y*] given bright orange compound, chromic anhydride, with concentrated H_2SO_4
(d) All of these

22. The number of moles of $KMnO_4$ that will be needed to react with one mole of sulphite in an acidic solution is:
(a) 2/5 (b) 3/5
(c) 4/5 (d) 1

23. Which of the following metals will not form an amalgam?
(a) Gold (b) Silver
(c) Zinc (d) Iron

24. The equivalent weight of $K_2Cr_2O_7$ in acid medium is equal to:
(a) Molecular weight (b) 1/2 Molecular weight
(c) 1/6 Molecular weight (d) 1/5 Molecular weight

25. Number of electrons transfer in each case when $KMnO_4$ acts as an oxidizing agent to give MnO_2, Mn^{2+}, $Mn(OH)_3$, and MnO_4^{2-} are respectively:
(a) 3, 5, 4, and 1 (b) 4, 3, 1, and 5
(c) 1, 3, 4, and 5 (d) 5, 4, 3, and 1

26. The atomic numbers of V, Cr, Mn, and Fe are respectively 23, 24, 25, and 26. Which one of these may be expected to have the highest second ionization enthalpy?
(a) Cr (b) Mn
(c) Fe (d) V

27. In the reaction,
$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2 + H_2O + Cr_2O_3$$
The coefficient of H_2O is:
(a) 1 (b) 2
(c) 3 (d) 4

28. Lanthanoids contraction is due to increase in:
(a) Shielding by 4*f*-electrons
(b) Atomic number
(c) Effective nuclear charge
(d) Size of 4*f*-orbital

29. A certain metal will liberate hydrogen from dilute acids. It will react with water to form hydrogen only

when the metal is heated and the water is in the form of steam. The metal is probably:

(a) Iron (b) Potassium
(c) Copper (d) Mercury

30. The product of oxidation of I^- with MnO_4^- in alkaline medium is:

(a) IO_3^- (b) I_2
(c) IO^- (d) IO_4^-

31. The non-metallic cation is present in:

(a) CrO_2Cl_2 (b) VOCl
(c) NH_4Cl (d) PCl_3

32. The compound of vanadium has magnetic moment of 1.73 BM. The vanadium chloride has the formula:

(a) VCl_2 (b) VCl_3
(c) VCl_4 (d) VCl_5

33. Which of the following species will be the strongest Lewis acid?

(a) Fe^0 (b) Fe^{3+}
(c) Fe^{2+} (d) Fe^{1+}

34. $Cr_2O_7^{2-} \xrightarrow{H^+} Cr^{3+}$. Eq.wt. of $Cr_2O_7^{2-}$ is:

(a) mol. wt./6 (b) mol. wt./3
(c) mol. wt./4 (d) mol. wt./1

35. More number of oxidation states are exhibited by the actinoids than by the lanthanoids. The main reason for this is:

(a) Greater metallic character of the lanthanoids than that of the corresponding actinoids.
(b) More active nature of the actinoids
(c) More energy difference between 5*f* and 6*d*-orbitals than that between 4*f* and 5*d*-orbitals
(d) Lesser energy difference between 5*f* and 6*d*-orbitals than that between 4*f* and 5*d*-orbitals

36. The reduction potential values of *M, N* and *O* are +2.46, –1.13 and –3.13 V respectively. Which of the following order is correct regarding their reducing property?

(a) $O > N > M$ (b) $O > M > N$
(c) $M > N > O$ (d) $M > O > N$

37. Which of the following compounds will not give positive chromyl chloride test?

(a) $CuCl_2$ (b) $HgCl_2$
(c) $ZnCl_2$ (d) $C_6H_5\overset{+}{N}H_3Cl^-$

38. The equivalent weight of $KMnO_4$ (formula weight: *M*) when it is used as an oxidant in neutral medium is:

(a) *M* (b) *M*/2
(c) *M*/3 (d) *M*/5

39. Hemoglobin and chlorophyll contain respectively:

(a) Fe, Co (b) Fe, Mn
(c) Mg, Fe (d) Fe, Mg

40. In $Cr_2O_7^{2-}$ every Cr is linked to:

(a) Two O-atoms (b) Three O-atoms
(c) Four O-atoms (d) Five O-atoms

41. Fe is made passive by:

(a) Dil. H_2SO_4 (b) Dil. HCl
(c) Aqua regia (d) Conc. H_2SO_4

42. $FeCr_2O_4$ (chromite) is converted to Cr by following steps:

$$\text{Chromite} \xrightarrow{I} Na_2CrO_4 \xrightarrow{II} Cr_2O_3 \xrightarrow{III} Cr$$

I, II, and III are:

	I	II	III
(a)	Na_2CO_3/air, Δ	C	C
(b)	Na_2CO_3/air, Δ	C, Δ	Al, Δ
(c)	NaOH/air, Δ	C, Δ	Mg, Δ
(d)	conc. H_2SO_4, Δ	NH_4Cl, Δ	C, Δ

43. When H_2O_2 is added to an acidified solution of $K_2Cr_2O_7$:

(a) Solution turns green due to formation of Cr_2O_3
(b) Solution turns yellow due to formation of K_2CrO_4
(c) A deep blue-violet colored compound $CrO(O_2)_2$ is formed
(d) Solution gives green ppt. of $Cr(OH)_3$

44. Four successive members of the first row transition elements are listed below with their atomic numbers. Which one of them is expected to have the highest third ionization enthalpy?

(a) Vanadium ($Z = 23$) (b) Manganese ($Z = 25$)
(c) Chromium ($Z = 24$) (d) Iron ($Z = 26$)

45. Select incorrect statement(s):

(a) Ionization energies of 5*d*-elements are greater than those of 3*d* and 4*d*-elements
(b) Cu(I) is diamagnetic while Cu(II) is paramagnetic
(c) $[Ti(H_2O)_6]^{3+}$ is colored while $[Sc(H_2O_6)]^{3+}$ is colorless
(d) Transition elements cannot form complexes

46. Increasing basic properties of TiO_2, ZrO_2, and HfO_2 are in order:

(a) $TiO_2 < ZrO_2 < HfO_2$ (b) $HfO_2 < ZrO_2 < TiO_2$
(c) $HfO_2 < TiO_2 < ZrO_2$ (d) $ZrO_2 < TiO_2 < HfO_2$

47. Which is called chromic anhydrided?
(a) CrO (b) Cr_2O_3
(c) CrO_3 (d) CrO_2

48. Philosopher's wool on treatment with cobalt nitrate produces:
(a) $CoBaO_2$ (b) $CoZnO_2$
(c) $CoSrO_2$ (d) $CoMgO_2$

49. Fulminating gold is:
(a) $AuCl_3$ (b) Au_2S
(c) $Au(NH_2) = NH$ (d) $H[Au(Cl)_4]$

50. Anhydrous ferric chloride is prepared by:
(a) Heating hydrated ferric chloride at a high temperature in a stream of air
(b) Heating metallic iron in a stream of dry chlorine gas
(c) Reaction of ferric oxide with HCl
(d) Reaction of metallic iron with HCl

51. When MnO_2 is fused with KOH and $KClO_3$, a colored compound is formed, the product and its color is:
(a) K_2MnO_4, green (b) $KMnO_4$, purple
(c) Mn_2O_3, brown (d) Mn_3O_4, black

52. Which pair of compounds is expected to show similar color in aqueous medium?
(a) $FeCl_3$ and $CuCl_2$ (b) $VOCl_2$ and $CuCl_2$
(c) $VOCl_2$ and $FeCl_2$ (d) $FeCl_2$ and $MnCl_2$

53. 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+}

54. In the standardization of $Na_2S_2O_3$ using $K_2Cr_2O_7$ by iodometry, the equivalent weight of $K_2Cr_2O_7$ is:
(a) (Molecular weight)/2 (b) (Molecular weight)/6
(c) (Molecular weight)/3
(d) Same as molecular weight

55. 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 the cooler parts of the test tube. The red solid is
(a) HgI_2 (b) HgO
(c) Pb_3O_4 (d) $(NH_4)_2Cr_2O_7$

56. The value of 'spin only' magnetic moment for one of the following configurations is 2.84 BM. The correct one is:
(a) d^4 (in strong ligand field)
(b) d^4 (in weak ligand field)
(c) d^3 (in weak as well as strong fields)
(d) d^5 (in strong ligand field)

57. When MnO_2 is fused with KOH, a colored compound is formed. The product and its color is:
(a) K_2MnO_4, purple green
(b) $KMnO_4$, purple
(c) Mn_2O_3, brown
(d) Mn_2O_4, black

Multiple Correct Answers Type

1. $d_{x^2-y^2}$ orbital is involved in which of the following hybridization:
(a) sp^3d (TBP) (b) sp^3d^2
(c) sp^3d^3 (d) None of these

2. Which of following is/are correctly matched?
(a) *d*-block element : electronic configuration is $ns^{0-2}(n-1)d^{1-10}$
(b) *p*-block element : electronic configuration is $ns^{1-2}np^{1-6}$
(c) *s*-block element : electronic configuration is ns^{1-2}
(d) Ce : *f*-block's first member

3. Which is true statement about $KMnO_4$?
(a) Its solution is unstable in acidic medium
(b) It has purple color
(c) MnO_4^- changes to Mn^{2+} in basic solution
(d) It is self-indicator in Fe^{2+} or $C_2O_4^{2-}$ titration

4. The ability of *d*-block elements to form complexes is due to:
(a) Small and highly charged ions
(b) Vacant low energy orbitals to accept lone pair of electrons from ligands
(c) Low polarizing power of cation
(d) None is correct

5. Out of $[Fe(CN)_6]^{4-}$, $[Ni(CN)_4]^{2-}$, and $[Ni(CO)_4]$: select the incorrect statement(s):
(a) All have identical geometry
(b) All are paramagnetic
(c) All are diamagnetic

(d) $[Fe(CN)_6]^{4-}$ is diamagnetic but $[Ni(CN)_4]^{2-}$ and $[Ni(CO)_4]$ are paramagnetic

6. A transition element X has a configuration $[Ar]3d^4$ in its +3 oxidation state. Its atomic number is not
(a) 25 (b) 26
(c) 22 (d) 19

7. Which one of the following ionic species will not impart color to an aqueous solution?
(a) Ti^{4+} (b) Cu^{+}
(c) Zn^{2+} (d) Cr^{3+}

8. Which out of the following halogen to 3*d*-series?
(a) Copper (b) Cobalt
(c) Gold (d) Silver

9. Transition elements have greater tendency to form complexes because:
(a) They have vacant *d*-orbitals
(b) They have large size
(c) They show variable oxidation state
(d) They have two electrons in their outermost shells.

10. The color of the transition metal ions is due to:
(a) *d-d* transition (b) Charge transfer
(c) Change in the geometry
(d) None of these

11. The transition metals which do not form amalgams are:
(a) Zn (b) Fe
(c) Cd (d) Pt

12. The elements which exist in the liquid state at room temperature are:
(a) Na (b) Br
(c) Hg (d) Ga

13. Which of the following statements 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

14. Which of the following is false?
(a) Cr^{2+} (g) ion has greater magnetic moment compared to Co^{3+}(g)
(b) The magnitude of ionization potential of iron anion (monoanion) would be equal to electron gain enthalpy of iron
(c) Lanthanoids contraction is cause of lower I.P. of Pb than Sn
(d) If successive ionization energy are 332, 738, 849, 4080, 4958 (in kJ/mol). Then this element can be of 15th group

15. Which of the following represents the correct order of the properties indicated?
(a) $Ni^{2+} > Cr^{2+} > Fe^{2+} > Mn^{2+}$ (size)
(b) Sc > Ti > Cr > Mn (size)
(c) $Ni^{2+} < Co^{2+} < Fe^{2+} < Mn^{2+}$ (unpaired electron)
(d) $Cr^{3+} > Cr^{2+}$ (magnetic moment)

16. Which of the following represents the incorrect order of the properties indicated?
(a) $Ni^{2+} > Cr^{2+} > Fe^{2+} > Mn^{2+}$ (size)
(b) Sc > Ti > Cr > Mn (size)
(c) $Ni^{2+} < Co^{2+} < Fe^{2+} < Mn^{2+}$ (unpaired electron)
(d) $H_3AsO_4 > H_3PO_4$ (acidic strength order)

17. For CrO_3, following is/are true statement:
(a) It is called chromic anhydride
(b) It is colorless due to $3d^{10}$ configuration
(c) It is bright orange solid and color arises due to charge transfer
(d) It is toxic and corrosive

18. Coagulation of blood takes place by:
(a) Ferric alum (b) Potash alum
(c) Chrom alum (d) None of these

19. The correct statement for *d*-block element is:
(a) It shows magnetic property
(b) It has variable valency
(c) It has tendency of formation of colored ions
(d) It has complete *d*-orbitals

20. The aqueous solution of the salt will be colored in the case of:
(a) $Zn(NO_3)_2$ (b) $LiNO_3$
(c) $Co(NO_3)_2$ (d) $CrCl_3$

21. Complex forming tendency of an element depends upon:
(a) High charge (b) Small size of its cation
(c) Availability of vacant *d*-orbitals
(d) None of these

22. Potassium manganate (K_2MnO_4) is formed when:
(a) Chlorine is passed through aqueous $KMnO_4$ solution
(b) Manganese dioxide is fused with potassium hydroxide in air

(c) Formaldehyde reacts with potassium

(d) Potassium permanganate reacts with H_2SO_4

23. What will be the correct representation of quantum numbers for the last electron entered into Ce?

	n	l	m	s
(a)	4	3	–3	$-\frac{1}{2}$
(b)	4	3	0	$-\frac{1}{2}$
(c)	4	2	–3	$+\frac{1}{2}$
(d)	4	3	+2	$-\frac{1}{2}$

24. Cl_2 gas is obtained by various reactions select the reactions from the following(s):

(a) $KMnO_4 + \text{conc. HCl} \xrightarrow{\Delta}$

(b) $KCl + K_2Cr_2O_7 + \text{conc. } H_2SO_4 \xrightarrow{\Delta}$

(c) $MnO_2 + \text{conc. HCl} \xrightarrow{\Delta}$

(d) $KCl + F_2 \longrightarrow$

25. Which is/are true statement?

(a) Ions of *d*-block elements are colored due to *d-d* transition

(b) Ions of *f*-block elements are colored due to *f-f* transition

(c) $[Sc(H_2O)_6]^{3+}$, $[Ti(H_2O)_6]^{4+}$ are colored complexes

(d) Cu^+ is colorless ion

26. $In[Fe(CN)_5(NO)]^{2-}$, Fe has +2 state. It cannot be decided by:

(a) Magnetic measurement

(b) Colligative property

(c) Color (d) Hybridization

27. Which one of the following statements is/are correct?

(a) Zinc dissolves in sodium hydroxide solution

(b) Carbon monoxide reduces iron(III) oxide to iron

(c) Mercury(II) iodide dissolves in excess of potassium iodide solution

(d) Tin(IV) chloride is made by dissolving tin solution in concentrated hydrochloric acid

28. In $Na_2[Fe(CN)_5NO]$, sodium nitroprusside:

(a) Oxidation state of Fe is +2

(b) This has NO^+ as ligand

(c) d^2sp^3-hybridization

(d) None of the above is correct

29. In the iodometric estimation in the laboratory which process is involved?

(a) $Cr_2O_7^{2-} + H^+ + I^- \longrightarrow 2Cr^{3+} + I_2$
$I_2 + S_2O_3^{2-} \longrightarrow S_4O_6^{4-} + I^-$

(b) $MnO_4^- + H^+ + I^- \longrightarrow Mn^{2+} + I_2$
$I_2 + S_2O_3^- \longrightarrow S_4O_6^{2-} + I^-$

(c) $MnO_4^- + OH^- + I^- \longrightarrow MnO_2 + I_2$
$I_2 + S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + I^-$

(d) $Cr_2O_7^{2-} + OH^- + I^- \longrightarrow 2Cr^{3+} + I_2$
$I_2 + S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + I^-$

30. $K_4[Fe(CN)_6]$ is used in detecting:

(a) Cu^{2+} ions (b) Fe^{2+} ions

(c) Fe^{3+} ions (d) Cu^{2+} ions

31. Which of the following statements are correct when a mixture of NaCl and $K_2Cr_2O_7$ is gently warmed with conc. H_2SO_4?

(a) A deep red vapor is evolved

(b) The vapor when passed into NaOH solution gives yellow solution of Na_2CrO_4

(c) Chlorine gas is evolved

(d) Chromyl chloride is formed

32. Pyrolusite is MnO_2 used to prepare $KMnO_4$. Steps are:

$$MnO_2 \xrightarrow{I} MnO_4^{2-} \xrightarrow{II} MnO_4^-$$

Steps I and II are respectively:

(a) Fuse with KOH / air, electrolytic oxidation

(b) Fuse with KOH / KNO_3, electrolytic oxidation

(c) Fuse with concentrated HNO_3 / air, electrolytic reduction

(d) Dissolve in H_2O oxidation.

Comprehension Type

Comprehension-1: (Q.1 to Q.4)

The elements of the three transition series of the *d*-block are given below:

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Y	Zr	Nb	Mo	Tc	Ru	Rh	Rd	Ag	Cd
La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg

In any transition series, as we move form left to right, the *d*-orbitals are progressively filled and their properties vary accordingly.

1. Which element do you expect to have the smallest atomic radius?

(a) Sc (b) Zn
(c) La (d) Hg

2. Which element do you expect to have the highest melting point?
(a) La (b) W
(c) Os (d) Pt

3. Which element out of the following do you expect to have the lowest melting point?
(a) Cr (b) Mn
(c) Fe (d) Co

4. Which of the following is the correct order of second ionization energy?
(a) V > Cr > Mn (b) V < Cr < Mn
(c) V < Cr > Mn (d) V > Cr < Mn

Comprehension-2: (Q. 5 to Q. 7)

Potassium permanganate is prepared from the mineral pyrolusite, MnO_2. Its crystals have deep purple color. It acts as an oxidizing agent in the neutral, alkaline as well as acidic medium. In acidic medium, it is used in volumetric analysis for the estimation of ferrous salts, oxalates, etc. The titrations are carried out in the presence of H_2SO_4. However, before using it as a titrant, it is first standardized with standard oxalic acid solution or Mohr salt solution. In one of the experiments on titration, 13.4 g of dry pure sodium oxalate (molar mass = 134 g mol^{-1}) was dissolved in 100 mL of distilled water and then 100 mL of distilled water and then 100 mL of $2M$ H_2SO_4 were added. The solution was cooled to 25.30°C. Now to this solution, $0.1M$ $KMnO_4$ solution was added till a very faint pink color persisted.

5. When pyrolusite is fused with KOH and $KClO_3$, we get:
(a) $KMnO_4$ (b) K_2MnO_4
(c) Both $KMnO_4$ and K_2MnO_4
(d) None of these

6. The purple color of $KMnO_4$ is due to:
(a) Incomplete *d*-subshell
(b) Ionic nature of $KMnO_4$
(c) Charge transfer
(d) Resonance in MnO_4^- ion

7. Mohr salt, $FeSO_4.(NH_4)_2SO_4{\cdot}6H_2O$, is preferred over $FeSO_4{\cdot}7H_2O$ for standardization of $KMnO_4$ solution because:
(a) Mohr salt is a double salt while ferrous sulphate is a single salt
(b) Mohr salt is not hygroscopic but $FeSO_4{\cdot}7H_2O$ is hygroscopic
(c) Mohr salt contains only ferrous ions whereas ferrous sulphate contains some ferric ions
(d) Mohr salt solution can be titrated even in the absence of H_2SO_4

Assertion-Reasoning Type

1. **Statement-1:** 'La' should be the *f*-block element according to Aufbau principle.

Statement-2: 57th electron exceptionally enters into the 5*d*-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.

2. **Statement-1:** The compounds of copper in +1 state are colorless.

Statement-2: Due to $3d^{10}$ electronic configuration of Cu^+ ion no *d-d* transition takes place.
(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:** Mercurous compounds are diamagnetic.

Statement-2: Two Hg^+ species which have $6s^1$ configuration are bonded together using *s*-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.

Matching Column Type

1. Match the column:

Column-I	Column-II
(a) Ni	(p) Elements having same number of unpaired electron in their dipositive in column-I.
(b) K	(q) At least 13 electrons are having magnetic quantum number 'zero'.
(c) Mn	(r) Atom is paramagnetic.
(d) Pd	(s) Element is not transition element
	(t) Element having pseudo inert gas configuration in its dipositive cation.

2. Match the column:

Column-I	Column-II
(a) Cr^{3+}	(p) Zero B.M.
(b) Cu^{+}	(q) 5.92 B.M.
(c) Mn^{2+}	(r) 3.87 B.M.
(d) Fe^{2+}	(s) 4.90 B.M.

3. Match the column:

Column-I	Column-II
(a) Pt	(p) Used in X-ray tube
(b) Fe	(q) Do not form alloy with Hg
(c) Mo	(r) Element of VIII group
(d) Mn	(s) Native metal
	(t) highest unpaired e^- in *d*-orbital

4. Match coloum-I with coloum-II and select the correct answer using the codes given below the coloums.

Column-I (Metal ion)	Column-II (Magnetic moment (BM))
(a) Cr^{3+}	(p) $\sqrt{35}$
(b) Fe^{2+}	(q) $\sqrt{30}$
(c) Ni^{2+}	(r) $\sqrt{24}$
(d) Mn^{2+}	(s) $\sqrt{15}$
	(t) $\sqrt{8}$

5. Match the column:

Column-I (Property)	Column-II (Transition elements)
(a) Highest oxidation state	(p) Cr
(b) Highest density	(q) Os
(c) Element with maximum unpaired electrons	(r) Tc
(d) Radioactive transition element	(s) Ru

6. Match the following:

Column-I	Column-II
(a) K_2MnO_4	(p) Transition element in +6 oxidation state
(b) $KMnO_4$	(q) Paramagnetic
(c) $K_2Cr_2O_7$	(r) Manufactured from pyrolusite ore
(d) K_2CrO_4	(s) Manufactured from chromite ore

7. Match the column:

Column-I	Column-II
(a) CrO_2Cl_2	(p) d^3s-hybridization
(b) CrO_4^{2-}	(q) Diamagnetic
(c) VO_4^{3-}	(r) Colorless
(d) MnO_4^{-2}	(s) Paramagnetic
	(t) Colorful due to charge transfer

8. Match the alloys (in Column-I) with the constituents metal (in Column-II).

Column-I	Column-II
(a) Gun metal	(p) Pb, Sn
(b) German silver	(q) Cu, Sn, Zn
(c) Brass	(r) Cu, Zn
(d) Solder	(s) Cu, Zn, Ni

9. Match the column:

Column-I	Column-II
(a) Cu^{2+}	(p) Form amphoteric oxide
(b) Zn^{2+}	(q) Diamagnetic and colorless compounds
(c) Cr^{3+}	(r) Form complex with NH_3
(d) Ag^{+}	(s) White oxide but on heating become yellow

10. Match coloum-I with coloum-II and select the correct answer using the codes give below the coloums:

Column-I (Alloys)	Column-II (Constituents)
(a) Gun metal	(p) Lead + tin
(b) German silver	(q) Copper + tin + zinc
(c) Brass	(r) Copper + zinc
(d) Solder	(s) Copper + zinc + nickel

11. Match the compounds in column-I with their properties in column-II:

Column-I	Column-II
(a) K_2MnO_4	(p) Transition element in +6 state
(b) $KMnO_4$	(q) Oxidizing agent in acid medium

(c) $K_2Cr_2O_7$ (r) Manufactured from pyrolusite ore
(d) K_2CrO_4 (s) Manufactured from chromite ore

12. Match the column:

Column-I	Column-II
(a) Baeyer's reagent	(p) $CuSO_4 + Ca(OH)_2$
	(q) 1% alkaline $KMnO_4$
(b) Bordeaux mixture	(r) Detection of unsaturation in organic compounds
(c) Nessler's reagent	(s) Complex of mercury

13. Match the compounds of column *X* with oxidation state of column-II.

Column-I	Column-II
(a) $[Cr(H_2O)_6]Cl_3$	(p) 5
(b) CrO_5	(q) 4
(c) K_3CrO_8	(r) 6
	(s) 3

14. Match the reactions in Column-I with nature of the reactions/type of the products in Column-II.

Column-I	Column-II
(a) $O_2^- \longrightarrow O_2 + O_2^{2-}$	(p) Redox reaction
(b) $CrO_4^{2-} + H^+ \longrightarrow$	(q) One of the products has trigonal planar structure
(c) $MnO_4^- + NO_2^- + H^+ \longrightarrow$	(r) Dimeric bridged tetrahedral metal ion
(d) $NO_3^- + H_2SO_4 + Fe^{2+} \longrightarrow$	(s) Disproportionation

Integer Answer Type

1. Calculate the Z_{eff} (approx.) for 4*s*-electron of Ni-atom according to Slater's rule.
2. Calculate the value of Z_{eff} on 3*d*-electron of Sc.

NCERT Exemplar Exercises

Single Correct Answer Type

1. Electronic configuration of a transition element X in +3 oxidation state is $[Ar]3d^5$. What is its atomic number?
   (a) 25 (b) 26
   (c) 27 (d) 24

2. The electronic configuration of Cu(II) is $3d^9$ whereas that of Cu(I) is $3d^{10}$. Which of the following is correct?
   (a) Cu(II) is more stable
   (b) Cu(II) is less stable
   (c) Cu(I) and Cu(II) are equally stable
   (d) Stability of Cu(I) and Cu(II) depends on nature of copper salts

3. Metallic radii of some transition elements are given below. Which of these elements will have highest density?

Element	Fe	Co	Ni	Cu
Metallic radii/pm	126	125	125	128

   (a) Fe (b) Ni
   (c) Co (d) Cu

4. Generally transition elements form colored salts due to the presence of unpaired electrons. Which of the following compounds will be colored in solid state?
   (a) Ag_2SO_4 (b) CuF_2
   (c) ZnF_2 (d) Cu_2Cl_2

5. On addition of small amount of $KMnO_4$ to concentrated H_2SO_4, a green oily compound is obtained which is highly explosive in nature. Identify the compound from the following.
   (a) Mn_2O_7 (b) MnO_2
   (c) $MnSO_4$ (d) Mn_2O_3

6. The magnetic nature of elements depends on the presence of unpaired electrons. Identify the configuration of transition element, which shows highest magnetic moment.
   (a) $3d^7$ (b) $3d^5$
   (c) $3d^8$ (d) $3d^2$

7. Which of the following reactions are disproportionation reactions?
   (a) $2Cu^+ \rightarrow Cu^{2+} + Cu$
   (b) $3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$
   (c) $2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$
   (d) $2MnO_4^- + 3Mn^{2+} + 2H_2O \rightarrow 5MnO_2 + 4H^+$
   (a) a, b (b) a, b, c
   (c) b, c, d (d) a, d

8. When $KMnO_4$ solution is added to oxalic acid solution, the decolorization is slow in the beginning but becomes instantaneous after some time because
   (a) CO_2 is formed as the product
   (b) Reaction is exothermic

(c) MnO_4^- catalyzes the reaction
(d) Mn^{2+} acts as autocatalyst

9. $KMnO_4$ acts as an oxidizing agent in acidic medium. The number of moles of $KMnO_4$ that will be needed to react with one mole of sulphide ions in acidic solution is
(a) $\frac{2}{5}$ (b) $\frac{3}{5}$
(c) $\frac{4}{5}$ (d) $\frac{1}{5}$

10. Which of the following is amphoteric oxide? Mn_2O_7, CrO_3, Cr_2O_3, CrO, V_2O_5, V_2O_4
(a) V_2O_5, Cr_2O_3 (b) Mn_2O_7, CrO_3
(c) CrO, V_2O_5 (d) V_2O_5, V_2O_4

11. Interstitial compounds are formed when small atoms are trapped inside the crystal lattice of metals. Which of the following is not the characteristic property of interstitial compounds?
(a) They have high melting points in comparison to pure metals
(b) They are very hard
(c) They retain metallic conductivity
(d) They are chemically very reactive

12. The magnetic moment is associated with its spin angular momentum and orbital angular momentum. Spin only magnetic moment value of Cr^{3+} ion is _____.
(a) 2.87 B.M. (b) 3.87 B.M.
(c) 3.47 B.M. (d) 3.57 B.M.

13. $KMnO_4$ acts as an oxidizing agent in alkaline medium. When alkaline $KMnO_4$ is treated with KI, iodide ion is oxidized to _____.
(a) I_2 (b) IO^-
(c) IO_3^- (d) IOO_4^-

14. Which of the following statements is not correct?
(a) Copper liberates hydrogen from acids
(b) In its higher oxidation states, manganese forms stable compounds with oxygen and fluorine
(c) Mn^{3+} and Co^{3+} are oxidizing agents in aqueous solution
(d) Ti^{2+} and Cr^{2+} are reducing agents in aqueous solution

15. When acidified $K_2Cr_2O_7$ solution is added to Sn^{2+} salts then Sn^{2+} changes to
(a) Sn (b) Sn^{3+}
(c) Sn^{4+} (d) Sn^+

16. Highest oxidation state of manganese in fluoride is +4 (MnF_4) but highest oxidation state in oxides is +7 (Mn_2O_7) because _____.
(a) Fluorine is more electronegative than oxygen
(b) Fluorine does not possess d-orbitals
(c) Fluorine stabilizes lower oxidation state
(d) In covalent compounds fluorine can form single bond only while oxygen forms double bond

17. Why is HCl not used to make the medium acidic in oxidation reactions of $KMnO_4$ in acidic medium?
(a) Both HCl and $KMnO_4$ act as oxidizing agents
(b) $KMnO_4$ oxidizes HCl into Cl_2 which is also an oxidizing agent
(c) $KMnO_4$ is a weaker oxidizing agent than HCl
(d) $KMnO_4$ acts as a reducing agent in the presence of HCl

Multiple Correct Answers Type

Note: In the following questions two or more options may be correct.

1. Transition elements show magnetic moment due to spin and orbital motion of electrons. Which of the following metallic ions have almost same spin only magnetic moment?
(a) Co^{2+} (b) Cr^{2+}
(c) Mn^{2+} (d) Cr^{3+}

2. In the form of dichromate, Cr(VI) is a strong oxidizing agent in acidic medium but Mo(VI) in MoO_3 and W(VI) in WO_3 are not because _____.
(a) Cr(VI) is more stable than Mo(VI) and W(VI)
(b) Mo(VI) and W(VI) are more stable than Cr(VI)
(c) Higher oxidation states of heavier members of group-6 of transition series are more stable
(d) Lower oxidation states of heavier members of group-6 of transition series are more stable

3. Which of the following ions show higher spin only magnetic moment value?
(a) Ti^{3+} (b) Mn^{2+}
(c) Fe^{3+} (d) Co^{3+}

4. Transition elements form binary compounds with halogens. Which of the following elements will form MF_3 type compounds?
(a) Cr (b) Co
(c) Cu (d) Ni

5. Which of the following will not act as oxidizing agents?
   (a) CrO_3 (b) MoO_3
   (c) WO_3 (d) CrO_4^{2-}

Short Answer Type

1. Why does copper not replace hydrogen from acids?
2. Why E^0 values for Mn, Ni, and Zn are more negative than expected?
3. Why first ionization enthalpy of Cr is lower than that of Zn?
4. Transition elements show high melting points. Why?
5. When Cu^{2+} ion is treated with KI, a white precipitate is formed. Explain the reaction with the help of chemical equation.
6. Out of Cu_2Cl_2 and $CuCl_2$, which is more stable and why?
7. When a brown compound of manganese (A) is treated with HCl it gives a gas (B). The gas taken in excess, reacts with NH_3 to give an explosive compound (C). Identify compounds A, B, and C.
8. Although fluorine is more electronegative than oxygen, but the ability of oxygen to stabilize higher oxidation states exceeds that of fluorine. Why?
9. Although Cr^{3+} and Co^{2+} ions have same number of unpaired electrons but the magnetic moment of Cr^{3+} is 3.87 B.M. and that of Co^{2+} is 4.87 B.M. Why?
10. Explain why does color of $KMnO_4$ disappear when oxalic acid is added to its solution in acidic medium.
11. When orange solution containing $Cr_2O_7^{2-}$ ion is treated with an alkali, a yellow solution is formed and when H^+ ions are added to yellow solution, an orange solution is obtained. Explain why does this happen?
12. A solution of $KMnO_4$ on reduction yields either a colorless solution or a brown precipitate or a green solution depending on pH of the solution. What different stages of the reduction do these represent and how are they carried out?
13. E^0 of Cu is +0.34 V while that of Zn is −0.76 V. Explain.
14. The halides of transition elements become more covalent with increasing oxidation state of the metal. Why?
15. While filling up of electrons in the atomic orbitals, the 4s orbital is filled before the 3d orbital but reverse happens during the ionization of the atom. Explain why?
16. Reactivity of transition elements decreases almost regularly from Sc to Cu. Explain.

Matching Column Type

Note: Match the items of Column-I and Column-II in the following questions.

1. Match the catalysts given in Column-I with the processes given in Column-II.

Column-I (Catalyst)	Column-II (Process)
(a) Ni in the presence of hydrogen	(p) Zieglar Natta catalyst
(b) Cu_2Cl_2	(q) Contact process
(c) V_2O_5	(r) Vegetable oil to ghee
(d) Finely divided iron	(s) Sandmeyer reaction
(e) $TiCl_4 + Al(CH_3)_3$	(t) Haber's process
(f) Decomposition of $KClO_3$	

2. Match the properties given in Column-I with the metals given in Column-II.

Column-I (Property)	Column-II (Metal)
(a) An element which can show +8 oxidation state	(p) Mn
(b) 3*d* series element that can show up to +7 oxidation state	(q) Cr
(c) 3*d* series element with highest melting point	(r) Os
	(s) Fe

3. Match the solutions given in Column-I and the colors given in Column-II.

Column-I (Aqueous solution of salt)	Column-II (Color)
(a) $FeSO_4 \cdot 7H_2O$	(p) Green
(b) $NiCl_2 \cdot 4H_2O$	(q) Light pink
(c) $MnCl_2 \cdot 4H_2O$	(r) Blue
(d) $CoCl_2 \cdot 6H_2O$	(s) Pale green
(v) Cu_2Cl_2	(t) Pink
	(u) Colorless

4. Match the properties given in Column-I with the metals given in Column-II.

Column-I (Property)	Column-II (Metal)
(a) Element with highest second ionization enthalpy	(p) Co
(b) Element with highest third ionization enthalpy	(q) Cr
(c) M in $M(CO)_6$ is	(r) Cu
(d) Element with highest heat of atomization	(s) Zn
	(t) Ni

Assertion-Reasoning Type

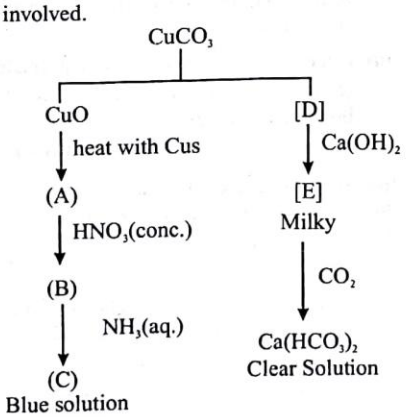
Note: In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Both assertion and reason are true, and reason is the correct explanation of the assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Assertion is not true but reason is true.
(d) Both assertion and reason are false.

1. **Assertion:** Cu^{2+} iodide is not known.
   Reason: Cu^{2+} oxidizes I^- to iodine.
2. **Assertion:** Cu cannot liberate hydrogen from acids.
   Reason: Because it has positive electrode potential.
3. **Assertion:** The highest oxidation state of osmium is +8.
   Reason: Osmium is a 5d-block element.

Long Answer Type

1. Identify A to E and also explain the reactions involved.



2. When a chromite ore (A) is fused with sodium carbonate in free excess of air and the product is dissolved in water, a yellow solution of compound (B) is obtained. After treatment of this yellow solution with sulphuric acid, compound (C) can be crystallized from the solution. When compound (C) is treated with KCl, orange crystals of compound (D) crystallize out. Identify A to D and also explain the reactions.
3. When an oxide of manganese (A) is fused with KOH in the presence of an oxidizing agent and dissolved in water, it gives a dark green solution of compound (B). Compound (B) disproportionates in neutral or acidic solution to give purple compound (C). An alkaline solution of compound (C) oxidises potassium iodide solution to a compound (D) and compound (A) is also formed. Identify compounds A to D and also explain the reactions involved.
4. (I) Answer the following questions:
   (a) Which element of the first transition series has highest second ionization enthalpy?
   (b) Which element of the first transition series has highest third ionization enthalpy?
   (c) Which element of the first transition series has lowest enthalpy of atomization?

   (II) Identify the metal and justify your answer.
   (a) Carbonyl $M(CO)_5$
   (b) MO_3F
5. Mention the type of compounds formed when small atoms like H, C, and N get trapped inside the crystal lattice of transition metals. Also give physical and chemical characteristics of these compounds.
6. (a) Transition metals can act as catalysts because these can change their oxidation state. How does Fe(III) catalyze the reaction between iodide and persulphate ions?
   (b) Mention any three processes where transition metals act as catalysts.
7. A violet compound of manganese (A) decomposes on heating to liberate oxygen and compounds (B) and (C) of manganese are formed. Compound (C) reacts with KOH in the presence of potassium nitrate to give compound (B). On heating compound (C) with conc. H_2SO_4 and NaCl, chlorine gas is liberated and a compound (D) of manganese along with other products is formed. Identify compounds A to D and also explain the reactions involved.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. Which of the following ions has the maximum magnetic moment?
   (a) Mn^{+2} (b) Fe^{+2}
   (c) Ti^{+2} (d) Cr^{+2}
   (AIEEE, 2002)

2. When $KMnO_4$ acts as an oxidizing agent and ultimately forms $[MnO_4]^{-2}$, MnO_2, Mn_2O_3, and Mn^{+2}, then the number of electrons transferred in each case, respectively, is:
   (a) 4, 3, 1, and 5 (b) 1, 5, 3, and 7
   (c) 1, 3, 4, and 5 (d) 3, 5, 7, and 1
   (AIEEE, 2002)

3. 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 the cooler parts of the test tube. The red solid is:
   (a) HgI_2 (b) HgO
   (c) Pb_3O_4 (d) $(NH_4)_2Cr_2O_7$
   (AIEEE, 2003)

4. What would happen when a solution of potassium chromate is treated with an excess of dilute nitric acid?
   (a) $Cr_2O_7^{2-}$ and H_2O are formed
   (b) CrO_4^{2-} is reduced to +3 state of Cr
   (c) CrO_4^{2-} is oxidized to +7 state of Cr
   (d) Cr^{3+} and $Cr_2O_7^{2-}$ are formed
   (AIEEE, 2003)

5. Which one of the following nitrates will leave behind a metal on strong heating?
   (a) Copper nitrate (b) Manganese nitrate
   (c) Silver nitrate (d) Ferric nitrate
   (AIEEE, 2003)

6. Of the following outer electronic configuration of atoms, the highest oxidation state is achieved by which one of them?
   (a) $(n-1)d^3 ns^2$ (b) $(n-1)d^5 ns^1$
   (c) $(n-1)d^8 ns^2$ (d) $(n-1)d^5 ns^2$
   (AIEEE, 2004)

7. Heating Cu_2O and Cu_2S will give:
   (a) Cu_2SO_3 (b) CuO + CuS
   (c) Cu + SO_3 (d) Cu + SO_2
   (AIEEE, 2005)

8. The oxidation state of chromium in the final product formed by the reaction between KI and acidified potassium dichromate solution is:
   (a) +3 (b) +2
   (c) +6 (d) +4
   (AIEEE, 2005)

9. Calomel (Hg_2Cl_2) on reaction with ammonium hydroxide gives:
   (a) HgO (b) Hg_2O
   (c) NH_2–Hg–Hg–Cl (d) Hg NH_2Cl
   (AIEEE, 2005)

10. Amount of oxalic acid present in a solution can be determined by its titration with $KMnO_4$ solution in the presence of H_2SO_4. The titration gives unsatisfactory result when carried out in the presence of HCl, because HCl:
    (a) Gets oxidized by oxalic acid to chlorine
    (b) Furnishes H^+ ions in addition to those from oxalic acid
    (c) Reduces permanganate to Mn^{2+}
    (d) Oxidizes oxalic acid to carbon dioxide and water
    (AIEEE, 2008)

11. In context with the transition elements, which of the following statements is incorrect?
    (a) In the highest oxidation states, the transition metals show basic character and form cationic complexes
    (b) In the highest oxidation states of the first five transition elements (Sc to Mn), all the 4s- and 3d-electrons are used for bonding
    (c) In addition to the normal oxidation state, the zero oxidation state is also shown by these elements in complexes
    (d) Once the d^5 configuration is exceeded, the tendency to involve all the 3d-electrons in bonding decreases
    (AIEEE, 2009)

12. Iron exhibits +2 and +3 oxidation states. Which of the following statements about iron is incorrect?
    (a) Ferrous oxide is more basic in nature than the ferric oxide
    (b) Ferrous compounds are relatively more ionic than the corresponding ferric compounds
    (c) Ferrous compounds are less volatile than the corresponding ferric compounds

(d) Ferrous compounds are more easily hydrolyzed than the corresponding ferric compounds

(AIEEE, 2012)

13. Which of the following arrangements does not represent the correct order of the property stated against it?

(a) $V^{2+} < Cr^{2+} < Mn^{2} < Fe^{2+}$: paramagnetic behavior

(b) $Ni^{2+} < Co^{2+} < Fe^{2+} < Mn^{2+}$: ionic size

(c) $Co^{3+} < Fe^{3+} < Cr^{3+} < Sc^{3+}$: stability in aqueous solution

(d) Sc < Ti < Cr < Mn: number of oxidation states

(JEE Main, 2013)

14. Four successive members of the first row transition elements are listed below with atomic numbers. Which one of them is expected to have the highest $E^{0}_{M^{3+}/M^{2+}}$ value?

(a) Cr(Z = 24) (b) Mn(Z = 25)

(c) Fe (Z = 26) (d) Co(Z = 27)

(JEE Main, 2013)

15. Which series of reactions correctly represents chemical relations related to iron and its compound?

(a) $Fe \xrightarrow{Cl_2, heat} Cl_2 \xrightarrow{heat, air} FeCl_2 \xrightarrow{Zn} Fe$

(b) $Fe \xrightarrow{O_2, heat} Fe_3O_4 \xrightarrow{CO, 600°C} FeO \xrightarrow{CO, 700°C} Fe$

(c) $Fe \xrightarrow{dil\ H_2SO_4} FeSO_4 \xrightarrow{H_2SO_4, O_2} Fe_2(SO_4)_2 \xrightarrow{Heat} Fe$

(d) $Fe \xrightarrow{O_2, heat} FeO \xrightarrow{dil\ H_2SO_4} FeSO_4 \xrightarrow{Heat} Fe$

(JEE Main, 2014)

16. Among the following oxoacids, the correct decreasing order of acid strength is:

(a) $HClO_4 > HClO_3 > HClO_2 > HOCl$

(b) $HClO_2 > HClO_4 > HClO_3 > HOCl$

(c) $HOCl > HClO_2 > HClO_3 > HClO_4$

(d) $HClO_4 > HOCl > HClO_2 > HClO_3$

(JEE Main, 2014)

17. Chloro compound of Vanadium has only spin magnetic moment of 1.73 BM. This Vanadium chloride has the formula: (at. no. of V = 23)

(a) VCl_4 (b) VCl_3

(c) VCl_2 (d) VCl_5

(JEE Main, 2014)

18. Which of the following is **not** formed when H_2S reacts with acidic $K_2Cr_2O_7$ solution?

(a) K_2SO_4 (b) $Cr_2(SO_4)_3$

(c) S (d) $CrSO_4$

(JEE Main, 2014)

JEE (Advanced) Exercises

Fill in the Blanks Type

1. Mn^{2+} can be oxidized to MnO_4^- by _____ (SnO_2, PbO_2, BaO_2).

(IIT-JEE, 1981)

2. Galvanization of iron denotes coating with _____.

(IIT-JEE, 1983)

3. Silver chloride is sparingly soluble in water because its lattice energy is greater than _____ energy.

(IIT-JEE, 1987)

4. The salts _____ and _____ are isostructural. ($FeSO_4 \cdot 7H_2O$, $CuSO_4 \cdot 5H_2O$, $MnSO_4 \cdot 4H_2O$, $ZnSO_4 \cdot 7H_2O$)

(IIT-JEE, 1990)

5. Fehling solution A consists of an aqueous solution of copper sulphate, while Fehling solution B consists of an alkaline solution of _____.

(IIT-JEE, 1990)

6. The outermost electronic configuration of Cr is _____.

(IIT-JEE, 1994)

7. The compound $YBa_2Cu_3O_7$ which shows super conductivity has copper in oxidation state _____. Assume that the rare earth element yttrium is in its usual +3 oxidation state.

(IIT-JEE, 1994)

8. Silver jewellery items tarnish slowly in air due to their reaction with _____.

(IIT-JEE, 1997)

True/False Type

1. Copper metal reduces Fe^{2+} in an acid medium.

(IIT-JEE, 1982)

2. Silver fluoride is fairly soluble in water.

(IIT-JEE, 1982)

3. The electron density in the *xy*-plane in $3d_{x^2-y^2}$ orbital is zero.

(IIT-JEE, 1986)

4. Dipositive zinc exhibits paramagnetism due to loss of two electrons from 3*d*-orbitals of neutral atom. **(IIT-JEE, 1987)**

Single Correct Answer Type

1. One of the constituents of German silver is:
   (a) Ag (b) Cu
   (c) Mg (d) Al
   (IIT-JEE, 1980)

2. Which of the following dissolves in hot concentrated NaOH solution?
   (a) Fe (b) Zn
   (c) Cu (d) Ag
   (IIT-JEE, 1980)

3. How many unpaired electrons are present in Ni^{2+}?
   (a) 0 (b) 2
   (c) 4 (d) 4
   (IIT-JEE, 1981)

4. In the metallurgy of iron, when limestone is added to the blast furnace, the calcium ions end up in:
   (a) Slag (b) Gangue
   (c) Metallic calcium (d) Calcium carbonate
   (IIT-JEE, 1982)

5. Iron is rendered passive by treatment with concentrated:
   (a) H_2SO_4 (b) H_3PO_4
   (c) HCl (d) HNO_3
   (IIT-JEE, 1982)

6. The types of bonds present in $CuSO_4 \cdot 5H_2O$ are only:
   (a) Electrovalent and covalent
   (b) Electrovalent and coordinate covalent
   (c) Electrovalent, covalent, and coordinate covalent
   (d) Covalent and coordinate covalent
   (IIT-JEE, 1983)

7. Zinc–copper couple that can be used as a reducing agent is obtained by:
   (a) Mixing zinc dust and copper gauze
   (b) Zinc coated with copper
   (c) Copper coated with zinc
   (d) Zinc and copper wires welded together
   (IIT-JEE, 1984)

8. The reaction which proceeds in the forward direction is:
   (a) $Fe_2O_3 + 6HCl = 2FeCl_3 + 3H_2O$
   (b) $NH_3 + H_2O + NaCl = NH_4Cl + NaOH$
   (c) $SnCl_4 + Hg_2Cl_2 = SnCl_2 + 2HgCl_2$
   (d) $2CuI + I_2 + 4H^+ = 2Cu^{2+} + 4KI$
   (IIT-JEE, 1991)

9. 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)

10. 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)

11. Which compound does not dissolve in hot, diluted HNO_3?
    (a) HgS (b) PbS
    (c) CuS (d) CdS
    (IIT-JEE, 1996)

12. Ammonium dichromate is used in some fireworks. The green-colored powder blown in the air is:
    (a) CrO_3 (b) Cr_2O_3
    (c) Cr (d) $CrO(O_2)$
    (IIT-JEE, 1997)

13. Which of the following compounds is expected to be colored?
    (a) Ag_2SO_4 (b) CuF_2
    (c) MgF_2 (d) CuCl
    (IIT-JEE, 1997)

14. Which of the following is an organometallic compound?
    (a) Lithium methoxide
    (b) Lithium acetate
    (c) Lithium dimethylamide
    (d) Methyl lithium
    (IIT-JEE, 1997)

15. In the dichromate dianion:
    (a) Four Cr — O bonds are equivalent
    (b) Six Cr — O bonds are equivalent
    (c) All Cr — O bonds are equivalent
    (d) All Cr — O bonds are non-equivalent
    (IIT-JEE, 1999)

16. On heating ammonium dichromate, the gas evolved is:
    (a) Oxygen (b) Ammonia
    (c) Nitrous oxide (d) Nitrogen
    (IIT-JEE, 1999)

17. 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)

18. Anhydrous ferric chloride is prepared by:
(a) Heating hydrated ferric chloride at a high temperature in a stream of air
(b) Heating metallic iron in a stream of dry chlorine gas
(c) Reaction of ferric oxide with HCl
(d) Reaction of metallic iron with HCl
(IIT-JEE, 2002)

19. When MnO_2 is fused with KOH, a colored compound is formed, the product and its color are:
(a) K_2MnO_4, purple (b) $KMnO_4$, purple
(c) Mn_2O_3, brown (d) Mn_3O_4, black
(IIT-JEE, 2003)

20. $(NH_4)_2Cr_2O_7$ on heating gives a gas which is also given by:
(a) Heating NH_4NO_2 (b) Heating NH_4NO_3
(c) $Mg_3N_2 + H_2O$ (d) Na(comp) + H_2O_2
(IIT-JEE, 2004)

21. Which pair of compounds is expected to show similar color in aqueous medium?
(a) $FeCl_3$ and $CuCl_2$ (b) $VOCl_2$ and $CuCl_2$
(c) $VOCl_2$ and $FeCl_2$ (d) $FeCl_2$ and $MnCl_2$
(IIT-JEE, 2005)

22. 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)

Multiple Correct Answers Type

1. Potassium manganate (K_2MnO_4) is formed when:
(a) Chlorine is passed into aqueous $KMnO_4$ solution
(b) Manganese dioxide is fused with potassium hydroxide in air
(c) Formaldehyde reacts with potassium permanganate in the presence of a strong alkali
(d) Potassium permanganate reacts with concentrated sulphuric acid
(IIT-JEE, 1988)

2. The aqueous solutions 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) $CrCl_3$
(e) Potash alum
(IIT-JEE, 1990)

3. Which of the following alloys contain(s) Cu and Zn?
(a) Bronze (b) Brass
(c) Gun metal (d) Type metal
(IIT-JEE, 1993)

4. Which of the following statements is/are correct, when a mixture of NaCl and $K_2Cr_2O_7$ is gently warmed with concentrated H_2SO_4?
(a) Deep red vapors are evolved
(b) The vapors when passed into NaOH solution give a yellow solution of Na_2CrO_4
(c) Chlorine gas is evolved
(d) Chromyl chloride is formed
(IIT-JEE, 1998)

5. The addition of high proportions of manganese makes steel useful in making rails or railroads because manganese:
(a) Gives hardness to steel
(b) Helps in the formation of oxides of iron
(c) Can remove oxygen and sulphur
(d) Can show the highest oxidation state of +7
(IIT-JEE, 1998)

Comprehension Type

For Problems 1–3

p-Amino-*N*,*N*-dimethyl is added to a strongly acidic solution of *X*. The resulting solution is treated with a few drops of aqueous solution of *Y* to yield blue coloration due to the formation of methylene blue. Treatment of aqueous solution of *Y* with reagent potassium hexacyanoferrate(II) leads to the formation of an intense blue precipitate. The precipitate dissolves on excess addition of the reagent. Similarly, the treatment of the solution of *Y* with the solution of potassium hexacyanoferrate(III) leads to a brown coloration due to the formation of *Z*.

1. Compound *X* is:
(a) $NaNO_3$ (b) NaCl
(c) Na_2SO_4 (d) Na_2S

2. Compound *Y* is:
(a) $MgCl_2$ (b) $FeCl_2$
(c) $FeCl_3$ (d) $ZnCl_2$

3. Compound Z is:
   (a) $Mg_2[Fe(CN)_6]$ (b) $Fe[Fe(CN)_6]$
   (c) $Fe_4[Fe(CN)_6]_3$ (d) $K_2Zn_3[Fe(CN)_6]_2$

(IIT-JEE, 2009)

For Problems 4–6

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.

4. 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
5. Iron is removed from chalcopyrite as:
   (a) FeO (b) FeS
   (c) Fe_2O_3 (d) $FeSiO_3$
6. In self-reduction, the reducing species is:
   (a) S (b) O^{2-}
   (c) S^{2-} (d) SO_2

(IIT-JEE, 2010)

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:** To a solution of potassium chromate, if a strong acid is added, it changes its color from yellow to orange.

   Statement-II: The color change is due to the change in oxidation state of potassium chromate.

   (IIT-JEE, 1998)
2. **Statement-I:** Zn^{2+} is diamagnetic.

   Statement-II: The electrons are lost from 4*s*-orbital to form Zn^{2+}.

   (IIT-JEE, 1998)
3. **Statement-I:** $[Fe(H_2O)_5NO]SO_4$ is para-magnetic.

   Statement-II: The Fe in $[Fe(H_2O)_5\ NO]\ SO_4$ has three unpaired electrons.

   (IIT-JEE, 2008)

Matching Column Type

1. Match each of the reactions given in Column-I with the corresponding product(s) given in Column-II:

Column-I	Column-II
(a) Cu + dil. HNO_3	(p) NO
(b) Cu + conc. HNO_3	(q) NO_2
(c) Zn + dil. HNO_3	(r) N_2O
(d) Zn + conc. HNO_3	(s) $Cu(NO_3)_2$
	(t) $Zn(NO_3)_2$

(IIT-JEE, 2009)

Integer Answer Type

1. The oxidation number of Mn in the product of alkaline oxidative fusion of MnO_2 is _____.

   (IIT-JEE, 2009)
2. The number of water molecule(s) directly bonded to the metal center in $CuSO_4 \cdot 5H_2O$ is _____.

   (IIT-JEE, 2009)

Subjective Type

1. What happens when sulphurdioxide gas is bubbled through an aqueous solution of copper sulphate in the presence of potassium thiocyanate?

   (IIT-JEE, 1983)
2. Given reasons for the following in one or two sentences: "Silver bromide is used in photography".

   (IIT-JEE, 1983)
3. Complete and balance the following reactions:
   (i) $Zn + NO_3^- \rightarrow Zn^{2+} + NH_4^+$
   (ii) $Cr_2O_7^{2-} + C_2H_4O \rightarrow C_2H_4O_2 + Cr^{3+}$

   (IIT-JEE, 1983)
4. State the conditions under which the following preparations are carried out. Give the necessary equations which need not be balanced.
   "Potassium permanganate from manganese dioxide".

   (IIT-JEE, 1983)
5. Show with balanced equations what happens when the following are mixed:
   (i) Aqueous solution of potassium manganate and acid
   (ii) Aqueous solution of potassium chromate and acid

   (IIT-JEE, 1984)

6. Write the balanced equations for the reactions when
   (i) Potassium permanganate interacts with manganese dioxide in the presence of potassium hydroxide.
   (ii) Potassium ferrocyanide is heated with concentrated sulphuric acid.

(IIT-JEE, 1985)

7. 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.

(IIT-JEE, 1986)

8. Write the balanced equations for the reaction occurring when gold is dissolved in aquaregia.

(IIT-JEE, 1987)

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. Complete and balance the following reactions:
   (i) $Mn^{2+} + PbO_2 \rightarrow MnO_4^- + H_2O$
   (ii) $Ag^+ + AsH_3 \rightarrow H_3AsO_3 + H^+$

(IIT-JEE, 1987)

11. Answer the following questions briefly:
   (i) What is the actual reducing agent of hematite in blast furnace?
   (ii) Zinc, not copper, is used for the recovery of metallic silver from the complex $[Ag(CN)_2]^-$, explain.
   (iii) Why is chalcocite roasted and not calcinated during the recovery of copper?

(IIT-JEE, 1987)

12. Write the balanced equations for extraction of silver from glance cyanide process.

(IIT-JEE, 1988)

13. 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)

14. Write the balanced equation for 'the extraction of copper from copper pyrites by self-reduction'.

(IIT-JEE, 1990)

15. Write the balanced chemical equations for the following reactions:
   (i) A mixture of potassium dichromate and sodium chloride is heated with concentrated H_2SO_4.
   (ii) Potassium permanganate is added to a hot solution of manganous sulphate.

(IIT-JEE, 1990)

16. A light bluish-green crystalline compound responds to the following tests:
   (i) Its aqueous solution gives a brown precipitate on 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)

17. Complete and balance the following chemical reactions:
   (i) Na_2CO_3 is added to a solution of copper sulphate.
   $CuSO_4 + Na_2CO_3 + H_2O \rightarrow \cdots + Na_2SO_4 + \cdots$
   (ii) Potassium dichromate and concentrated HCl are heated together.
   $K_2Cr_2O_7 + HCl \rightarrow KCl + \cdots + \cdots + H_2O$
   (iii) Copper reacts with HNO_3 to give NO and NO_2 in molar ratio of 2 : 1.
   $Cu + HNO_3 \rightarrow \cdots + NO + NO_2 + \cdots$

(IIT-JEE, 1993)

18. Complete and balance the following:
   $(NH_4)_2S_2O_8 + H_2O + MnSO_4 \rightarrow$

(IIT-JEE, 1993)

19. The composition of a sample of wustite is $Fe_{0.93}O_{100}$. What percentage of iron is present in the form of Fe(III)?

(IIT-JEE, 1994)

20. Complete and balance the following reactions:
   (i) $[MnO_4]^{2-} + H^+ \rightarrow \cdots + [MnO_4]^- + H_2O$
   (ii) $SO_2(aq.) + Cr_2O_7^{2-} + 2H^+ \rightarrow \cdots$

(IIT-JEE, 1994)

21. Write a balanced equation for the reaction of argentite with KCN and name the products in solution.

(IIT-JEE, 1996)

22. Write a balanced equation for the following: "Reaction of zinc with dilute nitric acid".

(IIT-JEE, 1997)

23. Thionyl chloride can be synthesized by chlorinating SO_2 using PCl_5. Thionyl chloride is used to prepare anhydrous ferric chloride starting from its hexahydrated salt. Alternatively, the anhydrous ferric chloride can also be prepared from its hexahydrated salt by treating with 2,2-dimethoxypropane. Discuss all this using balanced chemical equations.

(IIT-JEE, 1998)

24. When the ore hematite 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)

25. Work out the following using chemical equation: "In moist air, copper corrodes to produce a green layer on the surface".

(IIT-JEE, 1998)

26. Give reasons for following in one or two sentences: "CrO_3 is an acid anhydride".

(IIT-JEE, 1999)

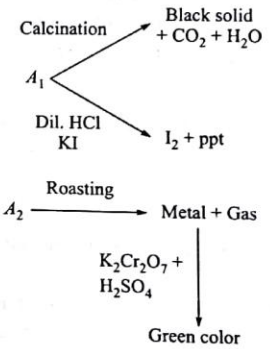
27. An aqueous blue-colored solution of a transition metal sulphate reacts with H_2S in acidic medium to give a black precipitate A which is insoluble in warm aqueous solution of KOH. The blue solution on treatment with KI in weakly acidic medium turns yellow and produces a white precipitate B. Identify the transition metal ion. Write the chemical reactions involved in the formation of A and B.

(IIT-JEE, 2000)

28. 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)

29. A_1 and A_2 are two ores of metal M. A_1 on calcination gives black precipitate, CO_2, and water. Identify A_1 and A_2.



(IIT-JEE, 2004)

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

4. (a) $Kr^+ \rightarrow 4s^2\,4p^5$ ∴ 1 unpaired electron
$Mn^{2+} \rightarrow 3d^5\,4s^0$ ∴ 5 unpaired electrons
$Fe^{3+} \rightarrow 3d^5\,4s^0$ ∴ 5 unpaired electrons
$O^+ \rightarrow 2s^2\,2p^3$ ∴ 3 unpaired electrons

5. (a) Both are having the same number of electrons on the basis of which chemical properties depend and both are neutral.

10. (d) Iron and carbon form alloy which is called cementite (Fe_3C).

JEE (Advanced) Exercises

Single Correct Answer Type

2. (c) The size of given metals decreases whereas ionization energy increases from Ti to V to Cr to Fe. Hence, the metallic character of the metals decreases so is their basicity of oxides from Ti to V to Cr to Fe.

3. (c) Zn ⟶ as both are in ground state and have most stable oxidation state $3d$ is completely filled.

4. (c) A → $ns^2\ np^2$

⇅ [1][1][ ]

Maximum difference would be

$IE_5 - IE_3$

7. (d) Chrom alum $K_2SO_4 \cdot Cr_2(SO_4)_3 \cdot 24H_2O$ is widely used in tanning of leather.

31. (c) $NH_4^+ Cl^-$ → Cation is non-metallic (PCl_3 is covalent)

32. (c) $\sqrt{n(n+2)} = 1.73$ V → [Ar] $3d^3\ 4s^2$

For $n = 1$, $\mu = 1.73$ and n is number of unpaired electron. Therefore, V^{4+} must be formed; thus VCl_4.

33. (b) Strongest Lewis Acid is one with maximum oxidation state.

Multiple Correct Answers Type

1. (b), (c)

$sp^3d^2 = d_{z^2}, d_{x^2-y^2}$ and sp^3d^3 uses → $d_{x^2-y^2}, d_{z^2}, d_{xy}$

2. (a), (c), (d)

For p-block, configuration is ns^2np^{1-6}

14. (a), (b), (d)

(a) Cr^{2+} → [Ar] $3d^4\ 4s^0$

[↑][↑][↑][↑][ ] 4 unpaired electrons

Magnetic moment = $\sqrt{n(n+2)} = \sqrt{4(4+2)} = \sqrt{24}$

Co^{3+} → [Ar] $3d^6\ 4s^0$

[↑↓][↑][↑][↑][↑] 4 unpaired electrons

$= \sqrt{4(4+2)} = \sqrt{24}$

(b) $Fe^- \xrightarrow{I.E.} Fe$ (+electron) So ionization energy of Fe^- is equal to ΔH_{eg} of Fe

(c) Pb has more ionization potential than Sn due to poor shielding of $4f$-orbitals.

(d) Number of valence electrons in given element is 3. Thus, from data of ionization potential thus element corresponds to 13 group.

16. (a), (d)

Sc Ti V Cr Mn → (size ↓); Fe Co Ni ↔ (same); Cu Zn →

Same order for neutral atom and ion having same charge.

$H_3AsO_4 < H_3PO_4$ as P is more electronegative than As.

23. (a), (b), (d)

$_{58}Ce$ → f-block element: Last electron enters in f-orbital and highest value of $n = 6$ but the last electron will enter in $4f$-orbitals filled would be [Xe] $6s^2 4f^1 5d^1$.

Comprehension Type

Comprehension-1: (Q. 1 to Q. 4)

1. (b)

	Sc	Zn	La	Hg
Covalent radii (Å)	1.44	1.25	1.69	1.44

2. (b)

3. (b)

4. (c)

Assertion-Reasoning Type

1. (b) La → [Xe] $6s^2\ 5d^1$; La → Exception of Aufbau's rule.

Matching Column Type

1. (a) p, q, s; (b) r, s; (c) q, r; (d) p, q

(a) $Ni_{(28)}$ — $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ 4s^2$

[⇅][⇅][⇅][1][1]

Ni^{2+} — $3d^8\ 4s^0$ [⇅][⇅][⇅][1][1]

Number of unpaired electron in $Ni^{2+} = 2$

$m = 0$ present in all orbitals

$2 + 2 + 2 + 2 + 2 + 2 + 1 = 13$ (min)

Atom is paramagnetic.

It is transition element.

(b) $K_{(19)}$ — $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$ [1]

K^{2+} — $3p^5$ [⇅]

$m = 0$

Number of unpaired electron in $K^{2+} = 1$

$m = 0$ present in all orbitals

$2 + 2 + 2 + 2 + 2 + 1 = 11$ (min)

Atom is paramagnetic.

It is not transition element.

(c) $Mn_{(25)}$ – $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$

Mn^{2+} $3d^5$

$m = 2 + 2 + 2 + 2 + 2 + 2 + 1 = 13$

(Transition element)

Number of unpaired electron in $Mn^{2+} = 5$

$m = 0$ present in all orbitals

$2 + 2 + 2 + 2 + 2 + 2 + 1 = 13$ (min)

Atom is paramagnetic.

It is transition element.

(d) Pd – $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}$

Pd^{2+} $4d^6\ 5s^2\ 4d^8$

Number of unpaired electron in $Pd^{2+} = 2$

$m = 0$ present in all orbitals

$m = 2+2+2+2+2+2+2+2+2+1 = 19$

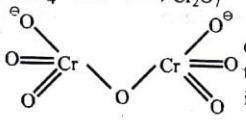
Atom is diamagnetic.

It is transition element.

14. (a) p, s; (b) r; (c) p, q; (d) p

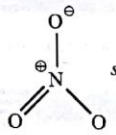
(a) $O_2^- \longrightarrow O_2 + O_2^{2-}$ (disproportionation reaction)

(b) $CrO_4^{2-} + H^+ \longrightarrow Cr_2O_7^{2-}$



dimeric bridged tetrahedral metal ion

(c) $MnO_4^- + NO_2^- + H^+ \longrightarrow Mn^{2+} + NO_3^-$



sp^2 Trigonal planar

(d) $NO_3^- + H_2SO_4 + Fe^{2+} \longrightarrow Fe_2(SO_3)_3 + NO]$

(redox reaction)

Integer Answer Type

1. (4) $Ni \rightarrow 1s^2\, 2s^2 2p^6\, 3s^2 3p^6\, 3d^8 4s^2$

Grouping $\rightarrow \underbrace{(1s)^2}_{(n-3)}\, \underbrace{(2s2p)^8}_{(n-2)}\, \underbrace{(3s3p)^8 (3d)^8}_{(n-1)}\, \underset{n}{(4s)^2}$

$\sigma = 10 \times 1 + 16 \times 0.85 + 1 \times 0.35 = 23.95$

$Z_{eff} = Z - \sigma$

$= 28 - 23.95 = 4.05 \simeq 4$

2. (3) $\underbrace{(1s)^2 (2s\,2p)^8 (3s\,3p)^8}_{0^{8\times1} \times 0.35}\, \underbrace{(3d)^1}_{nd}\, \underbrace{(4s)^2}_{0.00}$

$S = 18 + 0.00 = 18.00$

$Z_{eff} = Z - S$

$= 21 - 18 \Rightarrow 3$

NCERT Exemplar Exercises

Short Answer Type

1. Cu shows positive $E^\ominus$ value.

2. **Hint:** Negative $E^\ominus$ values for Mn^{2+} and Zn^{2+} are related to stabilities of half filled and fully filled configuration respectively. But for Ni^{2+}, $E^\ominus$ value is related to the highest negative enthalpy of hydration.

3. Ionization enthalpy of Cr is lower due to stability of d 5 and the value for Zn is higher because its electron comes out from 4*s* orbital.

4. The high melting points of transition metals are attributed to the involvement of greater number of electrons in the interatomic metallic bonding from $(n-1)$ *d*-orbitals in addition to *ns* electrons

5. **Hint:** Cu^{2+} gets reduced to Cu^+

$2Cu^{2+} + 4I^- \rightarrow Cu_2I_2 + I_2$

(white precipitate)

6. **Hint:** $CuCl_2$ is more stable than Cu_2Cl_2. The stability of Cu^{2+} (aq.) rather than Cu^+(aq.) is due to the much more negative hyd$H^\ominus$ of Cu^{2+} (aq.) than Cu^+(aq.).

7. $A = MnO_2$ $B = Cl_2$ $C = NCl_3$

$MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$

(A) (B)

$NH_3 + 3Cl_2 \rightarrow NCl_3 + 3HCl$

(excess) (C)

8. **Hint:** It is due to the ability of oxygen to form multiple bonds to metals.

9. **Hint:** Due to symmetrical electronic configuration there is no orbital contribution in Cr^{3+} ion. However appreciable orbital contribution takes place in Co^{2+} ion.

10. $KMnO_4$ acts as oxidizing agent. It oxidizes oxalic acid to CO_2 and itself changes to Mn_{2+} ion which is colorless.

$5C_2O_4^{2-} + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$

(Colored) (Colorless)

11. $Cr_2O_7^{2-}$ $\underset{H^+}{OH^-}$ $CrO2_4^-$

Dichromate Chromate

(Orange) (Yellow)

12. Oxidizing behavior of $KMnO_4$ depends on pH of the solution. In acidic medium (pH < 7)

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

(Colorless)

In alkaline medium (pH > 7)

$MnO_4^- + e \rightarrow MnO_4^{2-}$

(Green)

In neutral medium (pH = 7)

$MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$

(Brown precipitate)

13. **Hint:** High ionization enthalpy to transform Cu(s) to Cu^{2+} (aq.) is not balanced by its hydration enthalpy. However, in case of Zn after removal of electrons from 4*s*-orbital, stable $3d^{10}$ configuration is acquired.

14. As the oxidation state increases, size of the ion of transition element decreases. As per Fajan's rule, as the size of metal ion decreases, covalent character of the bond formed increases.

15. $n + l$ rule: For $3d = n + l = 5$ $4s = n + l = 4$

So electron will enter in $4s$ orbital.

Ionization enthalpy is responsible for the ionization of atom. $4s$ electrons are loosely held by the nucleus. So electrons are removed from $4s$ orbital prior to $3d$.

16. **Hint:** It is due to regular increase in ionization enthalpy.

Long Answer Type

1. A = Cu B = $Cu(NO_3)_2$ C = $[Cu(NH_3)_4]$

D = CO_2

E = $CaCO_3$ F = $Cu_2[Fe(CN)_6]$ G = $Ca(HCO_3)_2$

$CuCO_3 \rightarrow CuO + CO_2$

$CuO + CuS \rightarrow Cu + SO_2$

(A)

$Cu + 4HNO_3$ (Conc) $\rightarrow Cu(NO_3)_2 + 2NO + 2H_2O$

(B)

$Cu^{2+} + NH^3 \rightarrow [Cu(NH_3)_4]$

(B) (C)

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

(D) (E)

$CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$

2. A = $FeCr_2O_4$ B = Na_2CrO_4

C = $Na_2Cr_2O_7 \cdot 2H_2O$ D = $K_2Cr_2O_7$

$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$

(A) (B)

$2NaCrO_4 + 2H^+ \rightarrow Na_2Cr_2O_7 + 2Na^+ + H_2O$

$Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$

(C) (D)

3. A = MnO_2 (B) K_2MnO_4 (C) $KMnO_4$ (D) KIO_3

$2\,MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$

(A) (B)

$3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

(C)

$2MnO_4^- + H_2O + KI \rightarrow 2MnO_2 + 2OH^- + KIO_3$

(A) (D)

4. (a) (A) Cu, because the electronic configuration of Cu is $3d^{10}4s^1$. So second electron needs to be removed from completely filled d-orbital.

(b) Zn [**Hint:** As above]

(c) Zn [**Hint:** No unpaired electron for metallic bonding]

(b) (A) $Fe(CO)_5$ [**Hint:** EAN rule]

(b) MnO_3F [**Hint:** Mn shows +7 oxidation state; d-electrons are not involved in bonding.]

5. Interstitial compounds.

Characteristic properties:

(a) High melting points, higher than those of pure metals.

(b) Very hard.

(c) Retain metallic conductivity.

(d) Chemically inert.

6. (a) Reaction between iodide and persulphate ions is:

$$2I^- + S_2O_8^{2-} \xrightarrow{Fe(III)} I_2 + 2SO_4^{2-}$$

Role of Fe(III) ions:

$2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$

$2Fe^{2+} + S_2O_8^{2-} \rightarrow 2Fe^{3+} + 2SO_4^{2-}$

(b) (A) Vanadium (V) oxide in contact process for oxidation of SO_2 to SO_3.

(B) Finely divided iron in Haber's process in conversion of N_2 and H_2 to NH_3.

(C) MnO_2 in preparation of oxygen from $KClO_3$.

7. A = $KMnO_4$ B = K_2MnO_4

C = MnO_2 D = $MnCl_2$

$KMnO_4 \xrightarrow{\Delta} K_2MnO_4 + MnO_2 + O_2$

(A) (B) (C)

$MnO_2 + KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$

$MnO_2 + 4NaCl + 4H_2SO_4 \rightarrow MnCl_2 + 2NaHSO_4 + 2H_2O + Cl_2$

(D)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (a) Magnetic moment $\mu = \sqrt{n(n+2)}$

where n = no. of unpaired e^-.

Thus, more the no. of unpaired e^-, higher will be the value of magnetic moment. Mn^{2+} has 5 unpaired e^-s.

2. (c) $KMnO_4 \xrightarrow{+1e^-} MnO_4^{2-}$

$KMnO_4 \xrightarrow{+3e^-} MnO_2$

$KMnO_4 \xrightarrow{+4e^-} Mn_2O_3$

$KMnO_4 \xrightarrow{+5e^-} Mn^{2+}$

3. (a) HgI_2 is a red solid insoluble in water. On addition of some KI, it forms a soluble complex K_2HgI_4. On heating HgI_2 in the test tube, I_2 vapors, violet fumes are liberated and droplets of mercury appears on the cooler parts of the test tube.

4. (a) $2K_2CrO_4 + \text{dil. } 2HNO_3 \rightleftharpoons K_2Cr_2O_7 + H_2O + 2KNO_3$ CrO_4^{2-} and $Cr_2O_7^{2-}$ ions are in the state of dynamic equilibrium with each other. Under acidic pH, dichromate ions are formed, and under alkaline pH, chromate ions are formed mainly.

5. (c) Mercury and silver oxysalts on strong heating leaves behind metals.

$AgNO_3 \xrightarrow{\Delta} Ag\downarrow + NO_2\uparrow + \frac{1}{2}O_2\uparrow$

6. (d) The highest oxidation state in case of d-block elements is equal to the total number of s and unpaired *d*-electrons. Hence, the answer is (d) having the highest oxidation state of +7.

7. (d) $Cu_2O + Cu_2S \rightarrow Cu + SO_2\uparrow$

This reaction is an example of self-reduction reaction, which is a characteristic of Cu.

8. (a) $K_2Cr_2O_7 + 6KI + 7H_2SO_4$

$\downarrow$

$Cr_2(SO_4)_3 + 3I_2 + 4K_2SO_4 + 7H_2O$

Cr is in +3 oxidation state in $Cr_2(SO_4)_3$.

9. (d) $Hg_2Cl + 2NH_4OH \rightarrow \underset{\text{white}}{[Hg(NH_2)]Cl\downarrow} + \underset{\text{black}}{Hg\downarrow}$

It is disproportionation reaction.

10. (c) If titration is carried out in presence of HCl, then $KMnO_4$ will also be consumed by HCl as HCl will be oxidized to Cl_2.

$HCl + KMnO_4 \rightarrow Cl_2 + MnCl_2 + KCl$

11. (a) In the highest oxidation state, the transition metals show acidic character and form anionic complexes.

Example: Mn in +7 form MnO_4^{2-}.

Cr in +6 form $Cr_2O_7^{2-}$ and CrO_4^{2-}.

12. (d)

(a) With increase in oxidation state of the metal ion, its basic nature decreases.

(b) With increase in oxidation state of the metal ion, its covalent nature.

(c) Covalent compounds are more volatile than ionic compounds.

(d) With increase in oxidation state of the metal ion, hydration tendency of the compound increases.

13. (a) V^{2+} = [Ar] 3d: ⇅ ⇅ ⇅ 1 1

Cr^{2+} = [Ar] 3d: ⇅ ⇅ ⇅ 1 1

Mn^{2+} = [Ar] 3d: ⇅ ⇅ ⇅ 1 1

Fe^{2+} = [Ar] 3d: ⇅ ⇅ ⇅ 1 1

Correct order of Paramagnetic behaviour $Mn^{2+} > Fe^{+2} = Cr^{2+} > V^{2+}$

15. (b) Answer is (2) because all steps are correct as per information.

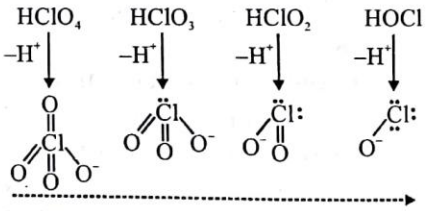
(a) is wrong because

$$\overset{III}{FeCl_3} \xrightarrow[\substack{1/2\,O_2 \\ \text{(in presence of air)}}]{\Delta} \overset{III}{FeOCl} + Cl_2\uparrow$$

(c) is wrong because $Fe_2(SO_4)_3 \xrightarrow{\Delta} Fe_2O_{3(s)} + 3SO_3\uparrow$

(d) is wrong because $2FeSO_4 \xrightarrow{\Delta} Fe_2O_{3(s)} + SO_2\uparrow + SO_3\uparrow$

16. (a)



Stability of conjugate base is decreasing due to decreasing no. of resonating structures.

$HClO_4 > HClO_3 > HClO_2 > HOCl$

17. (a) If the magnetic moment is 1.73 BM then the number of unpaired e^- V^{4+} having our unpaired electron

18. (d) $K_2Cr_2O_7 + H_2S \rightarrow Cr_2(SO_4)_3 + S + K_2SO_4 + H_2O$

JEE (Advanced) Exercises

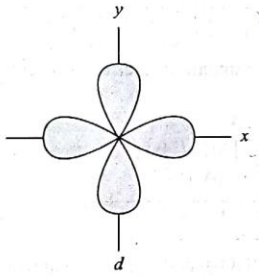
Fill in the Blanks Type

1. Mn^{2+} can be oxidized to MnO_4^- by **PbO_2**.
2. Galvanization of iron denotes coating with **zinc**.
3. Silver chloride is sparingly soluble in water because its lattice energy is greater than **its hydration** energy.

4. The salts **$FeSO_4 \cdot 7H_2O$** and **$ZnSO_4 \cdot 7H_2O$** are isostructural.
5. Fehling solution A consists of an aqueous solution of copper sulphate while Fehling solution B consists of an alkaline solution of **sodium potassium tartarate**.
6. The outermost electronic configuration of Cr is **$3d^5\ 4s^1$**. It is a half-filled stable configuration.
7. The compound $YBa_2Cu_3O_7$, which shows super conductivity, has copper in the oxidation state $+\frac{7}{3}$.
8. Silver jewellery items tarnish slowly in air due to their reaction with **H_2S**. Black-colored silver sulphide is formed.

True/False Type

1. **False.**
   Fe^{2+} cannot be further reduced by copper metal.
2. **True.**
   Hydration energy of AgF is higher than its lattice energy. It is soluble in water, but chloride, bromide, and iodide of silver are not soluble in water.
3. **False.**



d
$x^2 - y^2$

4. **False.**
   Zn^{2+}:
   The oxidation numner of Zn is +2.
   $z = 30$
   $Zn = [Ar]3d^{10}\ 4s^2$
   $Zn^{2+} = [Ar]3d^{10}$

3d				
↑↓	↑↓	↑↓	↑↓	↑↓

No unpaired electron present; hence diamagnetic.

Single Correct Answer Type

1. (b) German silver is an alloy which contains copper, zinc, and nickel.
2. (b) Only zinc dissolves due to the formation of sodium zincate.

$$Zn + 2NaOH \xrightarrow{\Delta} Na_2ZnO_2 + H_2\uparrow$$

3. (b) Atomic number of Ni is 28.
   $Ni:[Ar]3d^8\ 4s^2$
   $Ni^{2}:[Ar]3d^8$

3d				
↑↓	↑↓	↑↓	↑	↑

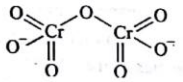
   There are two unpaired electrons.
4. (a) In the metallurgy of iron, when limestone is added to the blast furnace, the calcium ions end up in slag.
   $CaCO_3 \rightarrow CaO + CO_2$
   $CaO + SiO_2 \rightarrow CaSiO_3$ (slag)
5. (d) The inertness exhibited by metals under conditions in which chemical activity is expected is known as passivity. The phenomenon of passivity is explained by assuming the formation of a thin film of oxide on the surface of the metal which prevents the action of the reagent. The concentrated nitric acid makes metals such as iron, cobalt, nickel, chromium, aluminium, etc., passive.
6. (c) $[Cu(H_2O)_4]SO_4 \cdot H_2O$
   There are electrovalent, covalent, and coordinate bonds.
7. (b) Zinc–copper couple, which can be used as a reducing agent, is obtained by coating zinc with copper. Zinc is dipped in a solution of copper salt. It displaces copper and copper gets deposited over the surface of zinc.
8. (a) $Fe_2O_3 + 6HCl \rightarrow 2FeCl_3 + 3H_2O$
   Backward reaction will not take place due to the lack of hydrolysis of $FeCl_3$.
9. (d) When excess of KCN is added to an aqueous solution of copper sulphate, $K_3[Cu(CN)_4]$ is formed.
   $CuSO_4 + 2KCN \rightarrow Cu(CN)_2 + K_2SO_4$
   $2Cu(CN)_2 \rightarrow Cu_2(CN)_2 + (CN)_2$
   $Cu_2(CN)_2 + 6KCN \rightarrow 2K_3\ [Cu(CN)_4]$
10. (c) In the presence of peroxide, chromium ions are oxidized to chromate ions which give a yellow filtrate. Ferric ions form brown precipitate of $Fe(OH)_3$.
11. (a) HgS is not dissolved in hot dilute HNO_3. It dissolves only in aquaregia.
12. (b) Ammonium dichromate is used in some fireworks. The green-colored powder which blows in air is Cr_2O_3.

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} Cr_2O_3 + N_2 + 4H_2O$$

13. (b) CuF_2 is blue colored.
In CuF_2, Cu^{2+} ions are present.
$Cu = [Ar]3d^{10}\,4s^1$
$Cu^{2+} = [Ar]3d^9$
Unpaired electron present.
Colored
$Cu+ = [Ar]3d^{10}$
No unpaired electron
Colorless

14. (d) Organometallic compounds are those compounds in which metal atom is directly bonded with C atom.
Methyl lithium is one such compound.

15. (b)



Due to resonance, six Cr—O bonds are equivalent in dichromate ion.

16. (d) $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2\uparrow + Cr_2O_3 + 4H_2O$

17. (d) MnO_4^-: Mn (+ 7)
$Cr(CN)_6^{3-}$: Cr (+ 3)
NiF_6^{2-}: Ni (+ 4)
CrO_2Cl_2: Cr (+ 6)

18. (b) By heating metallic iron in a stream of dry chlorine gas.
$2Fe + 3Cl_2 \rightarrow 2FeCl_3$

19. (a) Potassium manganate is formed which has purple color.
$2\,MnO_2 + 4KOH + O_2 \rightarrow 2K_2MNO_4 + 2H_2O$

20. (a) $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} Cr_2O_3 + 4H_2O + N_2\uparrow$

$NH_4NO_2 \xrightarrow{\Delta} 2H_2O + N_2\uparrow$

21. (b) $VOCl_2$:
The oxidation number of V is +4.
$z = 23$
$V = [Ar]3d^3\,4s^2$
$V^{4+} = [Ar]3d^1$

↑				

One unpaired electron present
$CuCl_2$:
The oxidation number of Cu is +2.
$z = 29$
$Cu = [Ar]\,3d^{10}\,4s^1$
$Cu^+ = [Ar]3d^9$

↑↓	↑↓	↑↓	↑↓	↑

One unpaired electron present.
The metal ion salts having similar number of unpaired electrons in *d*-orbitals show similar color in aqueous medium.

22. (b) $Hg^{2+} + 2I^- \rightarrow HgI_2\downarrow$(Scarlet red precipitate)
$HgI_2 + 2I^- \rightarrow [HgI_4]^{2-}$
$Hg^{2+} + Co(SCN)_2 \rightarrow \underset{\text{Deep-blue crystalline}}{Hg(SCN)_2}\downarrow + Co^{2+}$

Multiple Correct Answers Type

1. (b), (c) Potassium manganate (K_2MnO_4) is formed when manganese dioxide is fused with potassium hydroxide in air or formaldehyde reacts with potassium permanganate in the presence of a strong alkali.
$4KOH + 2MnO_2 + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$
$HCHO + 2KMnO_4 + 2KOH$
$\rightarrow K_2MnO_4 + H_2O + HCOOH$

2. (c), (d) Co^{2+}:
$z = 27$
$Co = [Ar]3d^7\,4s^2$
$Co^{2+} = [Ar]3d^7$

↑↓	↑↓	↑	↑	↑

Two unpaired electrons present.
Cr^{3+}:
$z = 24$
$Cr = [Ar]3d^5 4s^1$
$Cr^{3+} = [Ar]3d^3$

↑	↑	↑		

$Co(NO_3)_2$ and $CrCl_3$ have unpaired electron; hence, they are colored.

3. (a), (b), (c) Brass (Cu, Zn)
Bronze (Cu, Sn)
Gun metal (Cu, Sn, Zn)
Type metal (Pb, Sn, and Sb).

4. (a), (b), (d)

$K_2Cr_2O_7 + 6H_2SO_4 + 4NaCl \rightarrow 2KHSO_4$
$+ 4NaHSO_4 + 2CrO_2Cl_2 + 3H_2O$

Orange-red vapors of CrO_2Cl_2 are produced.
When these vapors are passed through NaOH, a yellow solution of Na_2CrO_4 is produced.

$CrO_2Cl_2 + 4NaOH \rightarrow \underset{\text{Yellow}}{Na_2CrO_4} + 2H_2O + 2NaCl$

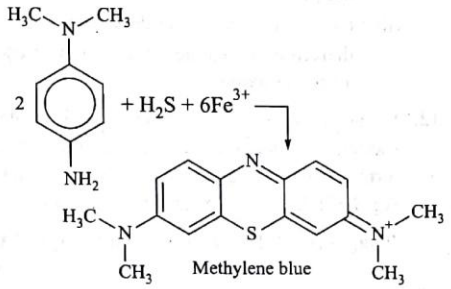
5. (a), (c) Manganese gives hardness to steel.
It also removes oxygen and sulphur from steel by forming slag.

$Fe_2O_3 + 3Mn \rightarrow 3MnO + 2Fe$
$MnO + SiO_2 \rightarrow MnSiO_3$

Comprehension Type

1. (d) X is Na_2S.
$Na_2S + 2H^+ \rightarrow H_2S + Na^+$

2. (b) Y is $FeCl_3$.



$+ 6Fe^{2+} + NH_4^+ + 4H^+$

3. (b) $4FeCl_3 + 3K_4[Fe(CN)_6] \rightarrow Fe_4[Fe(CN)_6]_3 + 2KCl$
$FeCl_3 + K_3[Fe(CN)_6] \rightarrow Fe[Fe(CN)_6] + 3KCl$
$Fe[Fe(CN)_6]$ is brown in color.

4. (a) Partial roasting:
$2CuFeS_2 + O_2 \xrightarrow{\Delta} Cu_2S + 2FeS + SO_2$
$2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$

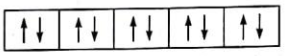
5. (d) Removal of iron:
$FeO + SiO_2 \rightarrow FeSiO_3$ (Slag)

6. (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.

Assertion-Reasoning Type

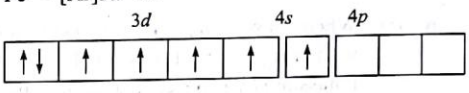
1. (c) To a solution of potassium chromate if a strong acid is added, it changes its color from yellow to orange. The color change is due to the change in the oxidation state of potassium chromate, there is no change in the oxidation state of chromium which is +6 in both cases.
$\underset{\text{(Yellow)}}{2CrO_4^{2-}} + SO_4^{2-} + 2H^+ \rightarrow \underset{\text{(Orange)}}{Cr_2O_7^{2-}} + SO_4^{2-} + H_2O$

2. (a) Both statements are correct and Statement-II is the correct explanation for Statement-I.
Zn^{2+}:
The oxidation number of Zn is + 2.
$z = 30$
$Zn = [Ar]3d^{10}\,4s^2$
$Zn^{2+} = [Ar]3d^{10}$

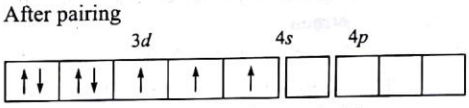


No unpaired electron present.

3. (a) $[Fe(H_2O)_5\,NO]\,SO_4$
NO has charge equal to +1 in this complex. Therefore, the oxidation number of Fe in the complex becomes +1.
$Fe = [Ar]3d^6\,4s^2$
$Fe^+ = [Ar]3d^6\,4s^1$



After pairing



NO^+ causes pairing of $4s$ electron inside.
Thus, the configuration is $3d^7$ and the number of unpaired electrons is 3.

Matching Column Type

1. (a) → (p, s); (b) → (q, s); (c) → (r, t); (d) → (q, t)
$3Cu + (dil.)\ 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$
$3Cu + (conc.)\ 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$
$4Zn + (dil.)\ 10HNO_3 \rightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$
$Zn + (conc.)\ 4HNO_3 \rightarrow Zn(NO_3)_2 + NO_2 + 2H_2O$

Integer Answer Type

1. (6) The oxidation number of Mn in the product of alkaline oxidative fusion of MnO_2 is 6.
$2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$
In K_2MnO_4, the oxidation state of Mn is +6.

2. (4) The number of water molecules directly bonded to the metal center in $CuSO_4{\cdot}5H_2O$ is 4.
$[Cu(H_2O)_4]\,SO_4{\cdot}H_2O$

Subjective Type

1. $2CuSO_4 + SO_2 + 2KCNS + 2H_2O \rightarrow 2CuCNS\downarrow + K_2SO_4 + 2H_2SO_4$

2. Silver bromide is used in photography because silver bromide is photosensitive. It decomposes and is converted into metallic silver grains when light is incident on it.

3. (i) $4Zn + NO_3^- + 10H^+ \rightarrow 4Zn^{2+} + NH_4^+ + 3H_2O$
(ii) $CrO_7^{2-} + 3C_2H_4O + 8H^+ \rightarrow 3C_2H_4O_2 + 2Cr^{3+} + 4H_2O$

4. Potassium permanganate can be prepared from manganese dioxide as follows:
$2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$

$2K_2MnO_4 + Cl_2 \rightarrow 2KMnO_4 + 2KCl$

The above reaction can also be carried out with ozone or carbon dioxide or electrolytically.

5. (i) Permanganate is formed.

$2MnO_4^{2-} + 4H^+ \rightarrow MnO_2 + MnO_4^- + 2H_2O$

(ii) Yellow-colored chromate changes to orange-colored dichromate.

$2CrO_4^{2-} + 2H^+ \rightleftharpoons Cr_2O_7^{2-} + H_2O$

6. (i) When potassium permanganate interacts with manganese dioxide in the presence of potassium hydroxide, potassium manganate is formed

$2KMnO_4 + 4KOH + MnO_2 \rightarrow 3K_2MnO_4 + 2H_2O$

(ii) When potassium ferrocyanide is heated with concentrated sulphuric acid, CO is evolved.

$K_4Fe(CN)_6 + 6H_2SO_4 + 6H_2O$

$\rightarrow 2K_2SO_4 + FeSO_4 + 3(NH_4)_2SO_4 + 6CO\uparrow$

When potassium ferrocyanide is heated with dilute sulphuric acid, HCN is evolved, which is a poisonous gas.

7. (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.

$SnCl_2 + 2HCl + I_2 \rightarrow SnCl_4 + 2HI$

8. Gold dissolves in aquaregia due to the reaction with nascent chlorine.

$[HNO_3 + 3HCl \rightarrow NOCl + 2H_2O + 2Cl] \times 3$

$[Au + 3Cl \rightarrow AuCl_3] \times 2$

$[AuCl_3 + HCl \rightarrow HAuCl_4] \times 2$

$2Au + 3HNO_3 + 11HCl \rightarrow 2HAuCl_4 + 3NOCl + 6H_2O$

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. (i) $2Mn^{2+} + 5PbO_2 + 4H^+ \rightarrow 2MnO_4^- + 5Pb^{2+} + 2H_2O$

(ii) $6Ag^+ + AsH_3 + 3H_2O \rightarrow 6Ag\downarrow + 6H^+ + H_3AsO_3$

11. (i) 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 blast furnace.

(ii) Zinc is more reducing and cheaper than copper.

(iii) Chalcocite is a sulphide ore of copper; therefore, it must be roasted in the presence of air to get oxide.

12. In case of silver metal, sulphide ore is treated with sodium cyanide. Sodium argentocyanide complex is formed which on treating with zinc metal gives silver.

$Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2] + Na_2S$

$2Na[Ag(CN)_2] + Zn \rightarrow \underset{\text{Soluble}}{Na_2[Zn(CN)_4]} + \underset{\text{ppt.}}{2Ag\downarrow}$

13. (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) Yellow precipitate is formed.

$KNO_2 + CH_3COOH \rightarrow CH_3COOK + HNO_2$

$CoCl_2 + 2KNO_2 \rightarrow Co(NO_2)_2 + 2KCl$

$Co(NO_2)_2 + 2HNO_2 \rightarrow Co(NO_2)_3 + NO + H_2O$

$Co(NO_2)_3 + 3KNO_2 + K_3[Co(NO_2)_6]$

14. Roasting:

$2CuFeS_2 + O_2 \xrightarrow{\Delta} Cu_2S + 2FeS + SO_2$

$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 3SO_2$

$2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$

Smelting:

$FeO + SiO_2 \rightarrow FeSiO_3$ (Slag)

$Cu_2O + FeS \rightarrow Cu_2S + FeO$

Bessemerization:

Self-reduction

$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$

15. (i) Orange-red vapors of chromyl chloride are formed.

$K_2Cr_2O_7 + 4NaCl + 6H_2SO_4 \rightarrow 2CrO_2Cl_2$

$+ 4NaHSO_4 + 3H_2O + 2KHSO_4$

(ii) Manganese dioxide is formed.

$2KMnO_4 + 3MnSO_4 + 2H_2O \rightarrow 5MnO_2$

$+ K_2SO_4 + 2H_2SO_4$

16. 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 $FeSO_4(NH_4)_2SO_4 \cdot 6H_2O$ (Mohr's salt).

17. (i) $CuSO_4 + Na_2CO_3 + H_2O \rightarrow \underset{\text{Blue}}{Cu(OH)_2\downarrow} + Na_2SO_4 + CO_2\uparrow$

(ii) Chlorine is evolved.

$K_2Cr_2O_7 + 14HCl \rightarrow 2KCl + 2CrCl_3 + 7H_2O + 3Cl_2\uparrow$

(iii) $Cu + \text{(conc.)}\ 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

$3Cu + \text{(dil.)}\ 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$

Multiplying the second equation by 2 and adding both the equations, we get

$7Cu + 20HNO_3 \rightarrow 7Cu(NO_3)_2 + 4NO + 2NO_2 + 10H_2O$

Molar ratio of NO and NO_2 is 2 : 1.

18. $(NH_4)_2S_2O_8 + 2H_2O + MnSO_4 \rightarrow MnO_2 + 2H_2SO_4 + (NH_4)_2SO_4$

19. $Fe_{0.93}O_{100}$

Let Fe occurring as +3 state be a.

Fe occurring as +2 state = $(0.93 - a)$

$\therefore 3a + 2(0.93 - a) = 2$

or $3a + 1.86 - 2a = 2$

or $a = 0.14$

Percentage of Fe(III) = $\frac{0.14}{0.93} \times 100 \approx 15$

20. (i) $3MnO_4^{2-} + 4H^+ \rightarrow MnO_2 + 2MnO_4^- + 2H_2O$

(ii) $2SO_2 + Cr_2O_7^{2-} + 2H^+ \rightarrow 3SO_4^{2-} + 2Cr^{3+} + H_2O$

21. Potassium argentocyanide is formed.

$Ag_2S + 4KCN \rightarrow 2K[Ag(CN)_2] + K_2S$

22. Zinc gives nitrous oxide with dilute nitric acid.

$4Zn + 10HNO_3 \rightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$

23. Thionyl chloride is $SOCl_2$

$SO_2 + PCl_5 \rightarrow SOCl_2 + POCl_3$

$FeCl_3 \cdot 6H_2O + 6SOCl_2 \rightarrow FeCl_3 + 12HCl + 6SO_2$

$FeCl_3 \cdot 6H_2O + 6CH_3C(OCH_3)_2CH_3 \rightarrow FeCl_3 + 12CH_3OH + 6CH_3COCH_3$

24. 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.

$P_4 + 5O_2 \rightarrow P_4O_{10}$

$6CaO + P_4O_{10} \rightarrow \underset{\text{(Thomas slag)}}{2Ca_3(PO_4)_2}$

25. In moist air, copper corrodes to produce a green layer on the surface due to the following slow reaction. Basic copper carbonate is formed.

$Cu + H_2O + CO_2 + O_2 \rightarrow CuCO_3 \cdot Cu(OH)_2$

26. CrO_3 is an acid anhydride. When it is added to water, it forms chromic acid. So it is the anhydride of chromic acid.

$CrO_3 + H_2O \rightarrow H_2CrO_4$

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 the black precipitate of CuS because copper sulphate is also blue colored. The blue solution on treatment with KI in a weak acidic medium turns yellow and produces a white precipitate B. In this reaction, cupric iodide is first formed 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. 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 a brown-colored iodide of Millon's base.

29. 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. (d)	**2.** (b)	**3.** (d)	**4.** (a)	**5.** (a)	**6.** (d)	**7.** (b)	**8.** (b)	**9.** (d)	**10.** (d)
11. (c)	**12.** (b)	**13.** (d)	**14.** (b)	**15.** (d)	**16.** (d)	**17.** (c)	**18.** (c)	**19.** (c)	**20.** (b)
21. (b)	**22.** (d)	**23.** (c)	**24.** (c)	**25.** (b)	**26.** (b)	**27.** (a)	**28.** (a)	**29.** (c)	**30.** (a)
31. (b)	**32.** (a)	**33.** (a)	**34.** (d)	**35.** (d)	**36.** (c)	**37.** (a)	**38.** (b)	**39.** (d)	**40.** (a)
41. (b)	**42.** (b)	**43.** (b)	**44.** (c)	**45.** (a)	**46.** (d)	**47.** (c)	**48.** (c)	**49.** (d)	**50.** (b)
51. (c)	**52.** (c)	**53.** (a)	**54.** (a)	**55.** (c)	**56.** (c)	**57.** (a)			

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a)	**2.** (c)	**3.** (c)	**4.** (c)	**5.** (c)	**6.** (b)	**7.** (d)	**8.** (d)	**9.** (c)	**10.** (b)
11. (b)	**12.** (b)	**13.** (d)	**14.** (d)	**15.** (a)	**16.** (b)	**17.** (a)	**18.** (d)	**19.** (b)	**20.** (d)
21. (d)	**22.** (a)	**23.** (d)	**24.** (c)	**25.** (c)	**26.** (a)	**27.** (d)	**28.** (c)	**29.** (a)	**30.** (a)
31. (c)	**32.** (c)	**33.** (b)	**34.** (a)	**35.** (d)	**36.** (a)	**37.** (b)	**38.** (c)	**39.** (d)	**40.** (c)
41. (c)	**42.** (b)	**43.** (c)	**44.** (b)	**45.** (d)	**46.** (a)	**47.** (c)	**48.** (b)	**49.** (c)	**50.** (b)
51. (a)	**52.** (b)	**53.** (b)	**54.** (b)	**55.** (a)	**56.** (d)	**57.** (a)			

Multiple Correct Answers Type

1. (b), (c)	**2.** (a), (c), (d)	**3.** (a), (b), (d)	**4.** (a), (b)	**5.** (a), (b), (d)
6. (b), (c), (d)	**7.** (a), (b), (c)	**8.** (a), (b)	**9.** (a), (c)	**10.** (a), (b)
11. (b), (c)	**12.** (b), (c), (d)	**13.** (a), (b), (c)	**14.** (a), (b), (d)	**15.** (b), (c)
16. (a), (d)	**17.** (a), (c), (d)	**18.** (a), (b), (c)	**19.** (a), (b), (c)	**20.** (c), (d)

21. (a), (b), (c) 22. (b), (c) 23. (a), (b), (d) 24. (a), (c), (d) 25. (a), (b), (d)
26. (b), (c), (d) 27. (a), (b), (c) 28. (a), (b), (c) 29. (a), (b) 30. (c), (d)
31. (a), (b), (d) 32. (a), (b)

Comprehension Type

Comprehension-1 1. (b) 2. (b) 3. (b) 4. (c)
Comprehension-2 5. (b) 6. (c) 7. (c)

Assertion-Reasoning Type

1. (b) 3. (a) 4. (a)

Matching Column Type

1. (a) p, q, s; (b) r, s; (c) q, r; (d) p, q
2. (a) r; (b) p; (c) q; (d) s
3. (a) q, r, s; (b) q, r; (c) p; (d) t
4. (a) s; (b) r; (c) t; (d) p
5. (a) q, s; (b) q; (c) p; (d) r
6. (a) p, q, r; (b) r; (c) p, s; (d) p, s
7. (a) p, q, t; (b) p, q, t; (c) p, q, r; (d) p, s, t
8. (a) q; (b) s; (c) r; (d) p
9. (a) r; (b) p, q, r, s; (c) p, r; (d) q, r
10. (a) q; (b) s; (c) r; d) p
11. (a) p, r; (b) q, r; (c) p, q, s; (d) p, s
12. (a) q, r; (b) p; (c) s
13. (a) s; (b) r; (c) p
14. (a) p, s; (b) r; (c) p, q; (d) p

Integer Answer Type

1. (4) 2. (3)

NCERT Exemplar Exercises

Single Correct Answer Type

1. (b) 2. (a) 3. (d) 4. (b) 5. (a) 6. (b) 7. (a) 8. (d) 9. (a) 10. (a)
11. (d) 12. (b) 13. (c) 14. (a) 15. (c) 16. (d) 17. (b)

Multiple Correct Answers Type

1. (a), (d) 2. (b), (c) 3. (b), (c) 4. (a), (b) 5. (b), (c)

Matching Column Type

1. (a) → (r); (b) → (s); (c) → (q); (d) → (t); (e) → (p)
2. (a) → (r); (b) → (p); (c) → (q)
3. (a) → (s); (b) → (p); (c) → (q); (d) → (t); (e) → (u)
4. (a) → (r); (b) → (s); (c) → (q); (d) → (p)

Assertion-Reasoning Type

1. (a) 2. (a) 3. (b)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (a) 2. (c) 3. (a) 4. (a) 5. (c) 6. (d) 7. (d) 8. (a) 9. (d) 10. (c)
11. (a) 12. (d) 13. (a) 14. (d) 15. (b) 16. (a) 17. (a) 18. (d)

JEE (Advanced) Exercises

Single Correct Answer Type

1. (b) 2. (b) 3. (b) 4. (a) 5. (d) 6. (c) 7. (b) 8. (a) 9. (d) 10. (c)
11. (a) 12. (b) 13. (b) 14. (d) 15. (b) 16. (d) 17. (d) 18. (b) 19. (a) 20. (a)
21. (b) 22. (b)

Multiple Correct Answers Type

1. (b), (c) 2. (c), (d) 3. (a), (b), (c) 4. (a), (b), (d) 5. (a), (c)

Comprehension Type

1. (d) 2. (b) 3. (b) 4. (a) 5. (d) 6. (c)

Assertion-Reasoning Type

1. (c) 2. (a) 3. (a)

Matching Column Type

1. (a) → (p, s); (b) → (q, s); (c) → (r, t); (d) → (q, t)

Integer Answer Type

1. (6) 2. (4)

8

Periodic Table

JEE (Main) Exercises

Single Correct Answer Type

1. Which electronic configuration of neutral atom will have the highest first ionization potential?
   (a) $1s^2, 2s^2 2p^1$ (b) $1s^2, 2s^2 2p^3$
   (c) $1s^2, 2s^2 2p^2$ (d) $1s^2, 2s^2 2p^4$
2. K^+, Cl^-, Ca^{2+}, and S^{2-} ions are isoelectronics. The decreasing order of their size is:
   (a) $S^{2-} > Cl^- > K^+ > Ca^{2+}$
   (b) $Ca^{2+} > K^+ > Cl^- > S^{2-}$
   (c) $K^+ > Cl^- > Ca^{2+} > S^{2-}$
   (d) $Cl^- > S^{2-} > Ca^{2+} > K^+$
3. The ionization energy will be maximum for the process:
   (a) $Ba \longrightarrow Ba^{2+}$ (b) $Be \longrightarrow Be^{2+}$
   (c) $Cs \longrightarrow Cs^+$ (d) $Li \longrightarrow Li^+$
4. Which of the following ion has the largest radius?
   (a) Cl^- (b) S^{2-}
   (c) Na^+ (d) F^-
5. Which of the following is isoelectronic with carbon atom?
   (a) Na^+ (b) Al^{3+}
   (c) O^{2-} (d) N^+
6. Which of the following species has four lone pairs of electrons in its outer shell?
   (a) I (b) O^-
   (c) Cl^- (d) He
7. Which among the following element has the lowest value of ionization energy?
   (a) Mg (b) Ca
   (c) Ba (d) Sr
8. Which ion is not isoelectronic with O^{2-}?
   (a) N^{3-} (b) Na^+
   (c) F^- (d) Ti^+
9. Which of the following does not reflect the periodicity of elements?
   (a) Bonding behavior (b) Electronegativity
   (c) Ionization potential (d) Neutron/proton ratio
10. The element with strong electropositive nature is:
    (a) Cu (b) Cs
    (c) Cr (d) Ba
11. Which among the following has the highest ionic radius?
    (a) F^- (b) B^{3+}
    (c) O^{2-} (d) Li^+
12. Ionic radii of:
    (a) $Ti^{4+} < Mn^{7+}$ (b) $Cr^{6+} > Cr^{3+}$
    (c) $K^+ > Cl^-$ (d) $P^{3+} > P^{5+}$
13. The most electronegative element is:
    (a) Nitrogen (b) Fluorine
    (c) Oxygen (d) Chlorine
14. The set representing the correct order of first ionization enthalpy is:
    (a) K > Na > Li (b) Be > Mg > Ca

(c) B > C > N (d) Ge > Si > C

15. The correct order of atomic radii is:
(a) Na < Be < B (b) $F^- < O^{2-} < N^{3-}$
(c) Na < Li < K (d) $Fe^{3+} < Fe^{2+} < Fe^{4+}$

16. The outermost electronic configuration of the most electronegative element is:
(a) $ns^2\ np^3$ (b) $ns^2\ np^4$
(c) $ns^2\ np^5$ (d) $ns^2\ np^6$

17. Amongst the following elements (whose electronic configurations are given below) the one having the highest ionization is:
(a) [Ne] $3s^2\ 3p^1$ (b) [Ne] $3s^2\ 3p^3$
(c) [Ne] $3s^2\ 3p^2$ (d) [Ar] $3d^{10}, 4s^2\ 4p^3$

18. Which of the following set of ions represents a collection of isoelectronic species?
(a) $Ba^{2+}, Sr^{2+}, K^+, Ca^{2+}$ (b) $K^+, Cl^-, Ca^{2+}, Sc^{3+}$
(c) $N^{3-}, O^{2-}, F^-, S^{2-}$ (d) $Li^+, Na^+, Mg^{2+}, Ca^{2+}$

19. Aluminium is diagonally related to:
(a) Li (b) Si
(c) Be (d) B

20. Which of the following pair of atomic numbers represents *s*-block elements?
(a) 7, 15 (b) 6, 12
(c) 9, 17 (d) 3, 12

21. An element of atomic number 29 belongs to:
(a) *s*-block (b) *d*-block
(c) *p*-block (d) *f*-block

22. Which of the following has the largest radius?
(a) O^{2-} (b) Mg^{2+}
(c) Na^+ (d) F^-

23. The electronic configuration of an element is $1s^2, 2s^2\ 2p^6, 3s^2, 3p^3$. What is the atomic number of the element which is just below the above element in the periodic table?
(a) 34 (b) 49
(c) 33 (d) 31

24. Which of the following has the largest atomic size?
(a) Al (b) Al^{2+}
(c) Al^{3+} (d) Al^+

25. Alkaline earth metals form ions of the formula:
(a) M^+ (b) M^-
(c) M^{2+} (d) M^{2-}

26. Atomic number 56 belongs to which block?
(a) *s* (b) *p*
(c) *d* (d) *f*

27. Eka-aluminium and eka-silicon are known as:
(a) Gallium and germanium
(b) Aluminium and silicon
(c) Iron and sulphur
(d) Proton and silicon

28. Increasing order of electron gain enthalpy is:
(a) N < O < Cl < Al (b) O < N < Al < Cl
(c) N < Al < O < Cl (d) Cl < N < O < Al

29. According to modern periodic law, variations in the properties of elements are related to their:
(a) Atomic weights (b) Nuclear weights
(c) Atomic numbers (d) Neutron–proton ratios

30. Which of the following has maximum ionization enthalpy?
(a) K (b) Na
(c) Mg (d) Be

31. The electronic configuration of transition elements is exhibited by:
(a) ns^1 (b) $ns^2\ np^5$
(c) $ns^2\ (n-1)d^{10}$ (d) $(n-1)\ d^{1\text{-}10}\ ns^{0\text{-}2}$

32. Which of the following has the lowest ionization energy?
(a) Oxygen (b) Nitrogen
(c) Fluorine (d) Sulphur

33. If *A*, *B*, and *C* are the three elements of Dobereiner's triad, and atomic weights of *A* and *B* are 7 and 15, respectively, then the atomic weight of *C* is:
(a) 1 (b) 11
(c) 23 (d) 25

34. The incorrect hydrated radius order is:
(a) $Li^+_{(aq)} < Be^{2+}_{(aq)}$ (b) $Na^+_{(aq)} < Al^{3+}_{(aq)}$
(c) $I^-_{(aq)} > Cl^-_{(aq)}$ (d) $Ba^{2+}_{(aq)} < Ca^{2+}_{(aq)}$

35. The correct hydration energy order is:
(a) $Fe^{2+} > Fe^{3+}$ (b) $Cu^{2+} < Cu^+$
(c) $K^+ > Cs^+$ (d) $F^- < Br^-$

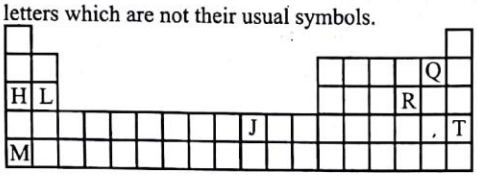
36. Atomic radii of fluorine and neon in Angstrom units are, respectively, given by:
(a) 0.72, 1.60 (b) 1.60, 1.60
(c) 0.72, 0.72 (d) 1.60, 0.72

37. Select the correct ionic radius order:
(a) $P^{3-} < P^{2-}$ (b) $P^{3-} < S^{3-}$
(c) $Na^+ < Mg^{2+}$ (d) $S^{2-} < Ca^{2+}$

38. Which of the following element is not a "*p*-" block element?

(a) P (b) Al
(c) Pb (d) Hg

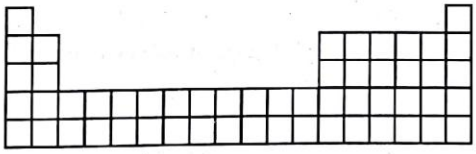
39. The diagram below shows a part of the skeleton of the periodic table in which elements are indicated by letters which are not their usual symbols.



Which one of the following statement is correct?
(a) The greatest ionic character of compounds formed by reaction of pairs of the listed elements would be exhibited by the compounds with the formula M_2
(b) The J^{2+} ion is colored and has an electronic configuration of $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^7$
(c) Element R is a gas at room temperature
(d) Element T is an inert gas with an electronic configuration $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^{10}, 4s^2, 4p^6$

40. What is the electronic configuration of the ground state of the magnesium cation, Mg^{2+}?
(a) $1s^2 2s^2 2p^6 3s^2$ (b) $1s^2 2s^2 2p^6 3s^1$
(c) $1s^2 2s^2 2p^6$ (d) $1s^2 2s^2 2p^4 3s^2$

41. The overall layout of the empty periodic table is shown below (up to element 54).



Answer the following question:
If X represents an element of atomic number 9 and Y an element of atomic number 20, the compound formed by these elements would be:
(a) Ionic with formula YX_2
(b) Covalent with formula YX_2
(c) Ionic with formula YX
(d) Covalent with formula YX

42. Which group III element is expected to have physical and chemical properties that are least similar to the other elements in that family?
(a) B (b) Al
(c) Ga (d) Tl

43. Which of the following moelcule has higher lattice energy?
(a) NaCl (b) Mg_3N_2
(c) Both (a) and (b) have equal lattice energy
(d) None of these

44. Which relationship between the radii of these species is correct?
(a) $Na < Na^+$; $F < F^-$ (b) $Na > Na^+$; $F > F^-$
(c) $Na < Na^+$; $F > F^-$ (d) $Na > Na^+$; $F < F^-$

45. Ionic radii are:
(a) Inversely proportional to effective nuclear charge
(b) Inversely proportional to the square of effective nuclear charge
(c) Directly proportional to effective nuclear charge
(d) Directly proportional to the square of effective nuclear charge

46. Which element has the smallest first-ionization energy?
(a) Mg (b) Al
(c) Si (d) P

47. Which property of an element is most dependent on the shielding effect?
(a) Atomic number (b) Atomic mass
(c) Atomic radius (d) Number of stable isotopes

48. Consider the ions Li^+, Na^+, Be^{2+}, and Mg^{2+}. Which two are closest to one another in size?
(a) Li^+ and Na^+ (b) Be^{2+} and Mg^{2+}
(c) Be^{2+} and Li^+ (d) Li^+ and Mg^{2+}

49. What is the electron configuration for a gas phase +3 ion of iron ($Z = 26$)?
(a) [Ar] $3d^5$ (b) [Ar] $4s^2\ 3d^3$
(c) [Ar] $4s^1\ 3d^4$ (d) [Ar] $4s^2\ 3d^6$

50. Which orbital fills completely immediately before the $4f$?
(a) $6s$ (b) $5p$
(c) $5d$ (d) $4d$

51. When the elements Li, Be, and B are arranged in order of increasing ionization energy, what is the correct order?
(a) Li, B, Be (b) B, Be, Li
(c) Be, Li, B (d) Li, Be, B

52. Of the elements given, which has the lowest ionization energy?
(a) N (b) P
(c) S (d) Cl

53. How many unpaired electrons are in a gaseous Fe^{2+} ion in its ground state?
(a) 0 (b) 2
(c) 4 (d) 6

54. Which of the following pair of symbols represents nuclei that have the same number of neutrons?

(a) $^{56}_{26}Fe$ and $^{58}_{28}Ni$ (b) $^{58}_{26}Fe$ and $^{56}_{26}Fe^{2+}$

(c) $^{57}_{27}Co$ and $_{26}Fe^{58}$ (d) $^{57}_{28}Ni$ and $^{58}_{28}Ni$

55. What is the electronic configuration for an Fe(III) ion in its ground state?

(a) $[Ar]3d^5$ (b) $[Ar]3d^6$

(c) $[Ar]4s^2\,3d^3$ (d) $[Ar]4s^2\,3d^6$

56. Select the correct order of ionic radii:

(a) $O^{2-} > S^{2-} > Se^{2-} > Te^{2-}$

(b) $Te^{2-} > S^{2-} > O^{2-} > Se^{2-}$

(c) $O^{2-} > Te^{2-} > S^{2-} > Se^{2-}$

(d) $Te^{2-} > Se^{2-} > S^{2-} > O^{2-}$

57. Select the correct order of ionic radii:

(a) $O^{2-} > F^- > Mg^{2+} > Na^+$

(b) $Na^+ > Mg^{2+} > O^{-2} > F^-$

(c) $O^{2-} > F^- > Na^+ > Mg^{2+}$

(d) $Mg^{2+} > Na^+ > F^- > O^{2-}$

58. Select the correct order of I.E.:

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

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

59. Which configuration represents atom having the highest second ionization energy?

(a) $1s^2, 2s^2\,2p^4$ (b) $1s^2, 2s^2\,2p^6$

(c) $1s^2, 2s^2\,2p^6, 3s^1$ (d) $1s^2, 2s^2\,2p^6, 3s^2$

60. From the electronic configuration of the given element *K*, *L*, *M*, and *N*, which one has the highest ionization potential:

(a) $K = [Ne]3s^2, 3p^2$ (b) $L = [Ne]3s^2, 3p^3$

(c) $M = [Ne]3s^2, 3p^1$ (d) $N = [Ar]3d^{10}, 4s^2, 4p^3$

61. The increasing order of the first ionization enthalpies of the elements B, P, S, and F (lowest first) is:

(a) F < S < P < B (b) P < S < B < F

(c) B < P < S < F (d) B < S < P < F

62. The process requiring the absorption of energy is:

(a) $F \longrightarrow F^-$ (b) $H \longrightarrow H^-$

(c) $Cl \longrightarrow Cl^-$ (d) $O \longrightarrow O^{2-}$

63. Which of the following has the largest size?

(a) Al (b) Al^+

(c) Al^{2+} (d) Al^{3+}

64. Which of the following is isoelectronic with carbon atom?

(a) Na^+ (b) Al^{3+}

(c) O^{2-} (d) N^+

65. The correct ionic radii order is:

(a) $N^{3-} > O^{2-} > F^- > Na^+$

(b) $N^{3-} > Na^+ > O^{2-} > F^-$

(c) $Na^+ > O^{2-} > N^{3-} > F^-$

(d) $O^{2-} > F^- > Na^+ > N^{3-}$

66. The radii of F, F^-, O, and O^{2-} are in the order of:

(a) $O^{2-} > F^- > F > O$ (b) $F^- > O^{2-} > F > O$

(c) $O^{2-} > O > F^- > F$ (d) $O^{2-} > F^- > O > F$

67. Which of the following sets represents the collection of isoelectronic species?

(a) $Na^+, Mg^{2+}, Al^{3+}, Cl^-$ (b) $Na^+, Ca^{2+}, Sc^{3+}, F^-$

(c) $K^+, Cl^-, Mg^{2+}, Sc^{3+}$ (d) $K^+, Ca^{2+}, Sc^{3+}, Cl^-$

68. The calculated value of magnetic moment of $_{23}V^{3+}$ is:

(a) 1.73 μ_B (b) 2.83 μ_B

(c) 3.87 μ_B (d) 4.90 μ_B

69. The ionic radii of Fe^{2+} and Fe^{3+} are *x* and *y*, respectively. The correct relationship between *x* and *y* is:

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

(c) $x = y$ (d) Cannot be predicted

70. Ce (58) is a member of:

(a) *s*-block (b) *p*-block

(c) *d*-block (d) *f*-block

71. The element with the highest ionization potential from the following is:

(a) Oxygen (b) Nitrogen

(c) Carbon (d) Boron

72. The ions O^{2-}, F^-, Na^+, Mg^{2+}, and Al^{3+} are isoelectronic. Their ionic radii show:

(a) An increase from O^{2-} to F^- and then a decrease from Na^+ to Al^{3+}

(b) A decrease from O^{2-} to F^- and then an increase from Na^+ to Al^{3+}

(c) A significant increase from O^{2-} to Al^{3+}

(d) A significant decrease from O^{2-} to Al^{3+}

73. Which one of the following grouping represents a collection of isoelectronic species? (At. no., Cs = 55 and Br = 35)

(a) N^{3-}, F^-, Na^+ (b) Ca^{2+}, Cs^+, Br

(c) Be, Al^{3+}, Cl^- (d) Na^+, Ca^{2+}, Mg^{2+}

74. The first ionization enthalpies of four consecutive elements present in the second period of the periodic table are 8.3, 11.3, 14.5, and 13.6 eV, respectively. Which

one of the following is the first ionization enthalpy of nitrogen?

(a) 13.6 (b) 14.5

(c) 11.3 (d) 8.3

75. The electronic configuration of the element which is just above the element with atomic number 43 in the same periodic group is:

(a) $1s^2, 2s^2, 2p^6, 3s^2\ 3p^6\ 3d^5, 4s^2$

(b) $1s^2, 2s^2, 2p^6, 3s^2\ 3p^6\ 3d^{10}, 4s^2\ 4p^5$

(c) $1s^2\ 2s^2\ 2p^6, 3s^2\ 3p^6\ 3d^6, 4s^1$

(d) $1s^2, 2s^2, 2p^6, 3s^2\ 3p^6\ 3d^{10}, 4s^1\ 4p^6$

76. If the atomic number of an element is 33, it will be placed in the periodic table in the:

(a) First group (b) Third group

(c) Fifth group (d) Seventh group

JEE (Advanced) Exercises

Single Correct Answer Type

1. Which one of the following ions has the smallest radius?

(a) C^{4-} (b) S^{2-}

(c) K^+ (d) Ca^{2+}

2. The most electropositive element is:

(a) Cs (b) Ga

(c) Li (d) Pb

3. Which of the following has the lowest ionization enthalpy?

(a) $4s^1$ (b) $3d^2$

(c) $3p^6$ (d) $2p^6$

4. Of the following elements, which one has the highest electronegativity?

(a) I (b) Br

(c) Cl (d) F

5. Which one of the following is the smallest cation?

(a) Na^+ (b) Mg^{2+}

(c) Ca^{2+} (d) Al^{3+}

6. Which one of the following ions has the lowest magnetic moment?

(a) Cu^{2+} (b) Ni^{2+}

(c) Co^{3+} (d) Fe^{2+}

7. The lanthanide contraction is responsible for the fact that:

(a) Zr and Y have about the same radius

(b) Zr and Nb have similar oxidation state

(c) Zr and Hf have about the same radius

(d) Zr and Zn have the same oxidation state

8. Select the correct order of electronegativity (E.N.):

(a) F > Cl > Br > I (b) N > P > As

(c) Both (a) and (b) (d) S > O > Se

9. Identify the least stable ion amongst the following:

(a) Li^- (b) Be^-

(c) B^- (d) C^-

10. General electronic configuration of outermost and penultimate shell is $(n-1)\ s^2\ (n-1)p^6(n-1)\ d^x\ ns^2$. If $n = 4$ and $x = 5$, then the number of protons in the nucleus will be:

(a) > 25 (b) < 24

(c) 25 (d) 30

11. Select the correct order of hydrated size of ion:

(a) $Li^+_{(aq.)} > Na^+_{(aq.)} > K^+_{(aq.)}$

(b) $Be^{2+}_{(aq.)} < Mg^{2+} < Ca^{2+}_{(aq.)}$

(c) $Al^{3+}_{(aq.)} < Mg^{2+}_{(aq.)} < Si^{4+}_{(aq.)}$

(d) $Cs^+_{(aq.)} > Rb^+_{(aq.)} > K^+_{(aq.)}$

12. Outer electronic configurations of K, Cu, and Cr are, respectively,

(a) $4s^1, 3d^{10}, 3d^5$ (b) $4s^2, 3d^{10}, 3d^4$

(c) $4s^1, 3d^9, 3d^4$ (d) $4s^1, 3d^9, 3d^4$

13. In which one of the following pairs the radius of the second species is greater than that of the first?

(a) Na, Mg (b) O^{2-}, N^{3-}

(c) Li^+, Be^{2+} (d) Ba^{2+}, Sr^{2+}

14. The electronic configurations of four elements are given below. Arrange these elements in the correct order of magnitude (without sign) of their electron affinity:

(i) $2s^2\ 2p^5$ (ii) $3s^2\ 3p^5$

(iii) $2s^2\ 2p^4$ (iv) $3s^2 3p^4$

Select the correct answer using the codes given below:

(a) (i) < (ii) < (iii) < (iv) (b) (ii) > (i) > (iv) > (iii)

(c) (i) < (iii) < (iv) < (ii) (d) (iii) < (iv) < (ii) < (i)

15. The electronic configuration of the atom having maximum difference between first and second ionization energies is:

(a) $1s^2, 2s^2, 2p^6, 3s^1$ (b) $1s^2, 2s^2\ 2p^6, 3s^2$

(c) $1s^2, 2s^2\ 2p^1$ (d) $1s^2, 2s^2\ 2p^6, 3s^2\ 3p^3$

16. The electronic configuration of the element with maximum electron affinity is:

(a) $1s^2, 2s^2\ 2p^3$ (b) $1s^2, 2s^2\ 2p^5$

(c) $1s^2, 2s^2\ 2p^6, 3s^2\ 3p^5$ (d) $1s^2, 2s^2\ 2p^6, 3s^2\ 3p^3$

17. Which of the following magnetic moment values will correspond to the highest ionization energy for Mn species?

(a) $2\sqrt{2}$ (b) $\sqrt{15}$

(c) $\sqrt{35}$ (d) $\sqrt{24}$

18. Select the correct statement:

(a) Ionic mobility of Al^{3+} is greater than that of Mg^{2+} in water

(b) K^+ (aq) has lesser ionic mobility than Ca^{2+} (aq)

(c) Cl^- (aq) has the highest ionic mobility among halide (aq) ions

(d) Ionic mobility of Cs^+(aq) is the highest among the alkali metal ions

19. Nishit Bhandari went to meet his friend Rohit, where he saw that his friend was doing the study of a particular chemistry book. But he could not find the theoretical value of bond length in H—F but he found that r_H and r_F are 0.37 Å and 0.72 Å, respectively, and electronegativities of F and H are 4.0 and 2.1, respectively. What is the bond length of H—F bond?

(a) 1.09 (b) 1.784

(c) 0.92 (d) 0.46

20. Which element exhibits both +1 and +3 oxidation numbers in its compounds?

(a) B (b) Be

(c) Sn (d) Tl

21. What is the number of unpaired electrons in a manganese atom ($Z = 25$) in its lowest energy states?

(a) 1 (b) 3

(c) 5 (d) 7

22. In which pair do both species have the same electron configurations?

(a) Se^{2-}, Kr (b) Mn^{2+}, Cr^{3+}

(c) Na^+, Cl^- (d) Ni, Zn^{2+}

23. Which of the following species is paramagnetic?

1. Ti^{4+}, 2. Fe^{2+}, 3. Zn^0

(a) 2 only (b) 3 only

(c) 1 and only (d) 2 and 3 only

24. When the elements C, N, and Si are arranged in order of increasing first ionization energy, what is the correct order?

(a) C < N < Si (b) N < C < Si

(c) Si < C < N (d) Si < N < C

25. Which gaseous ion in its ground state has the greatest number of unpaired electrons?

(a) Mn^{3+} (b) Fe^{3+}

(c) Co^{3+} (d) Ni^{3+}

26. Which element can exhibit more than one oxidation state in compounds?

1. Cr, 2. Pb, 3. Sr

(a) 1 only (b) 1 and 2 only

(c) 2 and 3 only (d) 1, 2, and 3

27. Which set of orbitals is listed in the sequential order of filling in a many-electron atom?

(a) 3*s*, 3*p*, 3*d* (b) 3*d*, 4*s*, 4*p*

(c) 3*d*, 4*p*, 5*s* (d) 4*p*, 4*d*, 5*s*

28. When the atoms Li, Be, B, and Na are arranged in order of increasing atomic radius, what is the correct order?

(a) B, Be, Li, Na (b) Li, Be, B, Na

(c) Be, Li, B, Na (d) Be, B, Li, Na

29. What is the total number of valence electrons in the peroxydisulphate, $S_2O_8^{2-}$, ion?

(a) 58 (b) 60

(c) 62 (d) 64

30. What is the total number of *p* electrons in a single phosphorus atom in its ground state?

(a) 3 (b) 5

(c) 9 (d) 15

31. Which pair of symbols identifies two elements that are metalloids?

(a) B and Ge (b) Mg and Si

(c) P and As (d) Ti and V

32. Select the correct order of ionic radii:

(a) $Ti^{2+} > Ti^{3+} > Ti^{4+}$ (b) $Ti^{4+} > Ti^{2+} > Ti^{3+}$

(c) $Ti^{3+} > Ti^{2+} > Ti^{4+}$ (d) $Ti^{4+} > Ti^{3+} > Ti^{2+}$

33. The metalloid among the following group of elements is:

(a) P (b) As

(c) Al (d) N

34. The correct order of radii is:

(a) N < Be < B (b) $F^- < O^{2-} < N^{3-}$

(c) Na < Li < K (d) $Fe^{3+} < Fe^{2+} < Fe^{4+}$

35. Which shows the highest lattice energy?

(a) RbF (b) CsF

(c) NaF (d) KF

36. Which of the following configurations is associated with biggest jump between 2nd and 3rd I.E.?
(a) $1s^2, 2s^2 2p^2$ (b) $1s^2, 2s^2 2p^6, 3s^1$
(c) $1s^2, 2s^2 2p^6, 3s^2$ (d) $1s^2, 2s^2 2p^1$

37. Alkali metals in each period have:
(a) Largest size (b) Lowest I.E.
(c) Highest I.E. (d) Highest electronegativity

38. The set representing the correct order of first ionization potential is:
(a) K > Na > Li (b) Be > Mg > Ca
(c) B > C > N (d) Ge > Si > C

39. Lattice energy of an ionic compound depends upon:
(a) Charge on the ions only
(b) Size of the ions only
(c) Packing of the ions only
(d) Charge and size of the ions

40. Which of the following is the correct order for electron gain enthalpy?
(a) S < O < Cl < F (b) O < S < F < Cl
(c) Cl < F < S < O (d) F < Cl < O < S

41. The oxidation states of Cr in $K_2Cr_2O_7$ and K_2CrO_4, respectively, are:
(a) 6+, 7+ (b) 7+, 6+
(c) 6+, 6+ (d) 7+, 7+

42. Which of the following electronic configuration would be associated with the highest magnetic moment?
(a) d^2 (b) d^4
(c) d^5 (d) d^7

43. Select equations having exothermic step.
(I) $S^-_{(g)} \longrightarrow S^{2-}_{(g)}$
(II) $Na^+_{(g)} + Cl^-_{(g)} \longrightarrow NaCl_{(s)}$
(III) $N_{(g)} \longrightarrow N^-_{(g)}$
(IV) $Al^{2+}_{(g)} \longrightarrow Al^{3+}_{(g)}$
Choose the correct code:
(a) II (b) I, II
(c) III and IV (d) II and III

44. Which of the following is not an actinide?
(a) Curium (b) Californium
(c) Uranium (d) Terbium

45. Europium belongs to:
(a) *s*-block (b) *p*-block
(c) *d*-block (d) *f*-block

46. Which of the following pairs has both members from the same group of the periodic table?
(a) Na, Ca (b) Na, Cl
(c) Ca, Cl (d) Cl, Br

47. Which one of the following belongs to representative group of elements in the periodic table?
(a) Lanthanum (b) Argon
(c) Chromium (d) Aluminium

48. Of cobalt and zinc salts, which are attracted in magnetic field?
(a) Cobalt salts (b) Zinc salts
(c) Both (a) and (b) (d) None of these

49. Which is the largest stable atom?
(a) V (b) Na
(c) Al (d) Pb

50. Which of the following is the strongest base?
(a) $Be(OH)_2$ (b) $Mg(OH)_2$
(c) $Al(OH)_3$ (d) $Si(OH)_4$

51. Which one of these is amphoteric oxide?
(a) CO_2 (b) SnO_2
(c) NO_2 (d) SO_2

52. Calculate the lattice energy of a salt $MX_{(s)}$ from the data given below:
Heat of formation of $MX(\Delta H) = -550$ kJ/mol
Heat of sublimation of $M(S) = 80$ kJ/mol
Heat of dissociation of $X_2(D) = 155$ kJ/mol
Ionization energy of $M(I) = 347$ kJ/mol
Electron affinity of $X(E) = -343$ kJ/mol
(a) – 838.5 kJ/mol (b) –938.5 kJ/mol
(c) –711.5 kJ/mol (d) –638.5 kJ/mol

53. Which of the following species has the highest electron gain enthalpy?
(a) F^- (b) S
(c) O^- (d) O

54. Two elements have electronegativities 1.2 and 3.0, respectively; the bond formed between them would be:
(a) Ionic (b) Covalent
(c) Coordinate (d) Metallic

55. Which of the following sets is of coinage metals?
(a) Cu, Ag, Au (b) Zn, Cd, Hg
(c) Au, Ag, Zn (d) Li, Na, K

56. The correct order of increasing electron affinity of halogens is:
(a) F < Cl < Br < I (b) I < Br < F < Cl
(c) I < Br < Cl < F (d) Br < I < F < Cl

57. If atomic number of inert gas is Z, then ionic bond is formed between:

(a) $(Z-1)$ and $(Z+1)$ (b) $(Z-2)$ and $(Z+2)$

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

58. Comment on the E.N. of Sb in SbF_3 and SbF_5:

(a) E.N. of Sb (SbF_3) > E.N. of Sb (SbF_5)

(b) E.N. of Sb (SbF_3) < E.N. of Sb (SbF_5)

(c) E.N. of Sb is identical in both cases

(d) No comment can be predicted

59. In which of the following compounds is the size of cation to anion ratio minimum?

(a) CsF (b) LiI

(c) LiF (d) CsI

60. Which of the following has 2nd I.P. < 1st I.P.?

(a) Mg (b) Ne

(c) C (d) None of these

61. In which of the following processes is the maximum amount of energy involved?

(a) $Cl \rightarrow Cl^-$ (b) $Br^{2-} \rightarrow Br$

(c) $F^- \rightarrow F$ (d) $I^- \rightarrow I$

62. Which of the following has the highest electron affinity?

(a) F (b) Br

(c) Cl (d) I

63. Which one of the following series is arranged in order of increasing ionic radius?

(a) $Mg^{2+} < S^{2-} < Cl^- < K^+ < Ca^{2+}$

(b) $Mg^{2+} < Ca^{2+} < K^+ < Cl^- < S^{2-}$

(c) $S^{2-} < Cl^- < K^+ < Mg^{2+} < Ca^{2+}$

(d) $S^{2-} < Mg^{2+} < Ca^{2+} < Cl^- < K^+$

64. What is the formula for the basic anhydride of $Ba(OH)_2$?

(a) Ba_2O (b) BaO

(c) BaO_2 (d) Ba

65. An element with the electron configuration $[Xe]4f^{14}5d^1 6s^2$ is:

(a) An alkaline earth element

(b) A transition element

(c) An inert gas (d) A rare earth

66. The formula of sodium tungstate is Na_2WO_4 and that of lead phosphate is $Pb_3(PO_4)_2$. What is the formula of lead tungstate?

(a) $PbWO_4$ (b) $Pb_2(WO_4)_3$

(c) $Pb_3(WO_4)_2$ (d) $Pb_3(WO_4)_4$

67. Which metal requires the least energy to exhibit the photoelectric effect?

(a) Cs (b) Ca

(c) Cu (d) Hg

68. Which set is expected to show the smallest difference in first ionization energy?

(a) He, Ne, Ar (b) B, N, O

(c) Mg, Mg^+, Mg^{2+} (d) Fe, Co, Ni

69. In which list are the elements arranged in order of increasing first ionization energy?

(a) Li, Na, K (b) S, O, F

(c) Na, Mg, Al (d) F, Ne, Na

70. All of the following possess complete d-shells except:

(a) Ag^+ (b) Cu^{2-}

(c) Ga^{3+} (d) Zn^{2-}

71. Which element exhibits the greatest number of oxidation states in its compounds?

(a) Ca (b) V

(c) Cu (d) Na

72. Which terms are exothermic for the formation of NaF(s)?

I. $Na_{(g)} \rightarrow Na^+_{(g)} + e^-$

II. $F_{(g)} + e^- \rightarrow F^-_{(g)}$

III. $Na^+_{(g)} + F^-_{(g)} \rightarrow NaF_{(s)}$

(a) I only (b) II only

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

73. The set(s) representing the correct order of ionic radius is/are:

(a) $Li^+ > Be^{2+} > Na^+ > Mg^{2+}$

(b) $Na^+ > Li^+ > Mg^{2+} > Be^{2+}$

(c) $Li^+ > Na^+ > Mg^{2+} > Be^{2+}$

(d) $Mg^{2+} > Be^{2+} > Li^+ > Na^+$

74. The formation of the oxide ion $O^{2-}(g)$ requires first an exothermic and then an endothermic step as shown below:

$O_{(g)} + e \longrightarrow O^-_{(g)}$; $\Delta H = -142$ kJ/mol

$O^-_{(g)} + e \longrightarrow O^{2-}_{(g)}$; $\Delta H = 844$ kJ/mol

This is because:

(a) O^- ion has comparatively larger size than oxygen atom

(b) Oxygen has high electron affinity

(c) O^- ion will lead to resisting of the addition of another electron

(d) Oxygen is more electronegative

75. Select the correct order of 2nd ionization energy of C, N, O, and F:

(a) C > N > O > F (b) N > C > O > F

(c) C < N < O < F (d) O > F > N > C

Multiple Correct Answers Type

1. Select the correct statement(s):

(a) Size of H^- is larger than F^-

(b) Rb is more electropositive compared to Ca

(c) Na^+ is more electronegative than Na

(d) Cl^- is more electronegative than F

2. Select the incorrect ionization energy order:

(a) Li < B < Be < C < N < O < F

(b) Na < Mg < Al < Si < S < P < Cl

(c) K < Ga < Ca < Ge < As < Se < Br

(d) Rb < Sr < In < Sn < Sb < Te < I

3. The statement(s) that is/are correct for the periodic classification of elements is/are:

(a) The properties of elements are periodic function of their atomic numbers

(b) Non-metallic elements are lesser in number than metallic elements

(c) The first ionization energies of the elements along the periods do not vary in a regular manner with the increase in atomic number

(d) For transition elements, the *d*-subshells are filled with electrons monotonically with increase in atomic number

4. Which of the following order(s) is/are correct?

(a) $NH_3 < PH_3 < AsH_3$ (Acidic)

(b) Li < Be < B < C ($I.E._1$)

(c) $Al_2O_3 < MgO < Na_2O < K_2O$ (Basic)

(d) $Li^+ < Na^+ < K^+ < Cs^+$ (Ionic radius)

5. Which is/are false about electronegativity order of the following elements?

(a) P > Si (b) C > N

(c) C > Br (d) Sr > Ca

6. Which of the following species has same number of unpaired electrons?

(a) Cr^{3+} (b) Mn^{2+}

(c) Fe^{3+} (d) Cu^{2+}

7. Select the correct statement(s):

(a) In general, more the ionization energy, more will be the electronegativity

(b) Electronegativity increases means metallic character increases

(c) In general, lower the ionization energy, higher will be the reducing property

(d) Cl has higher electron affinity than F

8. Which of the following statement is/are false?

(a) Lanthanum is the first element of lanthanides

(b) Actinium violates the Aufbau's principle

(c) Chromium violates the Pauli's exclusion principle

(d) Total 10 exchanges are possible for *d*-electrons in Zn

9. Which prediction(s) is/are incorrect according to the Lother Meyer's curve?

(a) Each peak of the curve is occupied by the alkali metals

(b) Alkaline earth metals occupy ascending positions of curve

(c) Atomic volume increases first and then decreases in a period (which is defined later) in Lother Meyer's curve

(d) Identically placed elements in the atomic volume *vs* atomic mass curve occur in the same period in the periodic table

10. Find the correct 2nd ionization energy order from the following option(s):

(a) Al > Mg (b) Te > Sb

(c) Fe > Fe^+ (d) In > Sr

11. Ionization energies of element *A* are given below in kJ/mol:

$I.E._1$	$I.E._2$	$I.E._3$
120	430	13000

If *A* reacts with different elements, which compounds are not possible:

(a) *A*F (b) A_2O

(c) A_3N (d) A_3N_2

12. The first ionization energy of oxygen is less than that of nitrogen. Which of the following is/are the incorrect reason(s) for this observation?

(a) Lesser effective nuclear charge of oxygen than nitrogen

(b) Lesser atomic size of oxygen than nitrogen

(c) Greater inter-electron repulsion between two electrons in the same *p*-orbital counter balances the increase in effective nuclear charge on moving from nitrogen to oxygen

(d) Greater effective nuclear charge of oxygen than nitrogen

13. Which of the following ionization energy order(s) is/are correct?

(a) $F > Cl^-$ (b) $F > Cl$

(c) $Cl > F^-$ (d) $Cl^- < F^-$

14. Select the correct I.E. order for the following species:

(a) $Cl > Br$ (b) $Br^- > Cl^-$

(c) $Cl > Cl^-$ (d) $Br > Br^-$

15. In which of the following arrangements, is/are the sequence strictly according to the property written against them?

(a) $CO_2 < SiO_2 < SnO_2 < PbO_2$: increasing oxidizing power

(b) $HF < HCl < HBr < HI$: increasing acidic strength

(c) $NH_3 < PH_3 < AsH_3 < SbH_3$: increasing basic strength

(d) $B < C < O < N$: increasing first ionization energy

16. The elements which exist in liquid state at room temperature are:

(a) Na (b) Fr

(c) Hg (d) Ga

17. Which of the following element belongs to the halogen group?

(a) $1s^2, 2s^2\,2p^6, 3s^2\,3p^5$ (b) $1s^2, 2s^2\,2p^6, 3s^2\,3p^6, 4s^2$

(c) $[Ar]\,3d^{10}, 4s^2\,4p^5$ (d) $[Kr]\,4d^{10}, 5s^2\,5p^5$

18. According to Lother Meyer's curve, which of the following statement is/are correct:

(a) The elements having same properties will occupy the same position in the curve

(b) Alkaline earth metals are at the peaks of the curve

(c) Halogens are at the ascending part of the curve

(d) The atomic volume of the elements in a period initially decreases and then increases

19. For $_{24}Cr$, which of the following statements is/are correct:

(a) Number of electrons with principle quantum number 3 is 13

(b) Number of electrons with azimuthal quantum number 1 is 12

(c) Number of electrons with magnetic quantum number 0 is 12

(d) Number of minimum or maximum electrons with spin quantum number +1/2 is 9 or 15

20. Select the correct option(s):

(a) Pauli's exclusion principle states that no two electrons in an atom can have the same spin

(b) Quantum numbers *n, l,* and *m* for $5p_x$ orbital must be 5, 1, and –1, respectively

(c) Zn^{2+} is a diamagnetic species

(d) In the ground state of chromium atom, five electrons have magnetic quantum number –1

21. For which sets of elements, "diagonal relationship" exists?

(a) B, Si (b) Li, Mg

(c) B, Mg (d) Be, Al

22. The correct statements among the following are:

(a) Helium has the highest first I.P. in the periodic table

(b) The process $O^-_{(g)} + e^- \longrightarrow O^{2-}_{(g)}$ is exothermic

(c) The electron affinities of S and P are less than that of O and N, respectively

(d) In any period, the first ionization potential of noble gas is the highest

23. In which of the following arrangements is/are the order correct according to the property indicated against it?

(a) Increasing size: $Al^{3+} < Mg^{2+} < Na^+ < F^-$

(b) Increasing $I.E._1$: $B < C < O < N$

(c) Increasing $E.A._1$: $I < Br < F < Cl$

(d) Increasing metallic radius: $Li < Na < K < Rb$

24. Select the incorrect statement(s):

(a) *p*-orbital can accommodate $6e^-$

(b) $Na \xrightarrow{I.E._1} Na^+ \xrightarrow{I.E._2} Na^{2+} \xrightarrow{I.E._3}$; the correct order of ionization energy is $I.E._2 > I.E._3 > I.E._1$.

(c) Xe is a noble gas

(d) B is a non-metal

25. The correct statement(s) among the following is/are:

(a) The first ionization potential of Al is less than the first ionization potential of Mg

(b) The second ionization potential of Mg is greater than the second ionization potential of Na

(c) The first ionization potential of Na is less than the first ionization potential of Mg

(d) The third ionization potential of Mg is greater than the third ionization potential of Al

26. Stability of ions of Ge, Sn, and Pb will be in the order:

(a) $Ge^{2+} < Sn^{2+} < Pb^{2+}$

(b) $Ge^{4+} > Sn^{4+} > Pb^{4+}$

(c) $Sn^{4+} > Sn^{2+}$

(d) $Pb^{2+} > Pb^{4+}$

27. On moving down the group from F to I, which of the properties decrease?

(a) Ionic radius (b) Ionization energy

(c) Oxidizing agent (d) Electronegativity

28. Ionic radius of:

(a) $Fe^{2+} < Fe^{3+}$ (b) $Ne > Na^{+}$

(c) $Rb^{+} < K^{+}$ (d) $As^{3+} > As^{5+}$

29. An element X belongs to fourth period and fifteenth group of the periodic table. Which one of the following is/are false regarding the outer electronic configuration of X? It has:

(a) Partially filled *d*-orbital and completely filled *s*-orbital

(b) Completely filled *s*-orbital and completely filled *p*-orbital

(c) Completely filled *s*-orbital and half filled *p*-orbital

(d) Half filled *d*-orbital and completely filled *s*-orbital

30. If X^{2-} is isoelectronic with "O_2^+" and has $Z + 1$ neutrons (Z is atomic number of X^{2-}), then:

(a) The mass number of X^{2-} is 27

(b) The mass number of X^{2-} is 57

(c) The atomic number of X^{2-} is 28

(d) The number of protons in X^{2-} is 13

31. Which of the following properties are the properties of metals?

(a) They are sonorous

(b) They are in general poor conductor of heat and electricity

(c) They are malleable and ductile

(d) They are hard

32. Ionization energy depends upon:

(a) Principal quantum number

(b) Azimuthal quantum number

(c) Magnetic quantum number

(d) Spin quantum number

Comprehension Type

Comprehension-1: (Q. 1 to Q. 3)

If one electron has been removed from an atom, it becomes increasingly difficult to remove the second and subsequent electrons from the resulting positively charged ions on account of electrostatic attraction.

1. Suppose a gas mixture of F, Cl, Br, and I is irradiated with photons of frequency appropriate to ionize Cl. What ion(s) will be present in the mixture?

(a) F^+ only (b) Cl^+ only

(c) F^+, Cl^+, Br^+ only (d) Cl^+, Br^+, I^+ only

2. If the ionization values of elements are plotted against atomic number, then peaks are occupied by:

(a) Alkali metals (b) Alkaline earth metals

(c) Noble gas elements (d) Halogens

3. The numerical value of energy involved in the given process $K \longrightarrow K^-$ is less than that of which of the following processes?

(a) $K^- \longrightarrow K$ (b) $K \longrightarrow K^+$

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

Comprehension-2: (Q. 4 to Q. 6)

On moving across a period, the atomic size decreases and nuclear charge increases and therefore the force of attraction exerted by the nucleus on the electron in the outermost shell increases.

4. The first ionization potentials (in eV) of As and Se atoms, respectively, are:

(a) 14.6, 13.6 (b) 13.6, 14.6

(c) 13.6, 13.6 (d) 14.6, 14.6

5. For the process

$A_{(g)} + e^- \longrightarrow A^-_{(g)}$; $\Delta H = x$

and $A^-_{(g)} \longrightarrow A_{(g)} + e^-$; $\Delta H = y$

select correct alternate:

(a) Ionization energy of $A^-_{(g)}$ is y

(b) Electron affinity of $A_{(g)}$ is x

(c) Electron affinity of $A_{(g)}$ is $-y$

(d) All are correct statements

6. Potassium forms K^+ ion but it does not form K^{2+} because of:

(a) Very low value of $(I.E.)_1$ and $(I.E.)_2$

(b) Very high value of $(I.E.)_1$ and $(I.E.)_2$

(c) Low value of $(I.E.)_1$ and low value of $(I.E.)_2$

(d) Low value of $(I.E.)_1$ and high value of $(I.E.)_2$

Assertion-Reasoning Type

1. **Statement-I:** Cl^- and Ca^{2+} are isoelectronic species.
   Statement-II: Isoelectronic species should have same charges.
   (a) Statement-I is true; Statement-II is true; Statement-II is 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.
2. **Statement-I:** Cd is a transition element.
   Statement-II: Cd and Cd^{2+} both have completely filled *d*-orbitals in their ground state.
   (a) Statement-I is true; Statement-II is true; statement-II is 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.
3. **Statement-I:** 1st ionization energy of "P" is greater than "S".
   Statement-II: Z_{eff} value of "S" is greater than "P".
   (a) Statement-I is true; Statement-II is true; Statement-II is 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.
4. **Statement-I:** Mg^{2+} and Al^{3+} are isoelectronic but ionic radius of Al^{3+} is less than that of Mg^{2+}.
   Statement-II: The effective nuclear charge on the outershell electrons in Al^{3+} is more than that in Mg^{2+}.
   (a) Statement-I is true; Statement-II is true; Statement-II is 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.

Matching Column Type

1. Match the column:

Column-I	Column-II
(a) He	(p) High electron gain enthalpy
(b) Cl	(q) Most electropositive element
(c) Cs	(r) Strongest reducing agent
(d) Li	(s) Highest ionization energy

2. Match the column:

Column-I	Column-II
(a) Noble gas	(p) Sodium
(b) Transition element	(q) Argon
(c) Lanthanide	(r) Cerium
	(s) Chromium

3. Match the column:

Column-I	Column-II
(a) Zinc	(p) Solid at room temperature
(b) Hg	(q) Transition element
(c) Cr	(r) *d*-block element
	(s) Liquid at room temperature

4. Match the column:

Column-I	Column-II
(a) Electron affinity	(p) Depends upon effective nuclear charge
(b) Ionization potential	(q) Depends upon shielding constant
(c) Electronegativity	(r) Depends upon half filled and fully filled electronic configuration
	(s) Can be estimated from bond-energy data

5. Match the column:

Column-I	Column-II
(a) 89	(p) *d*-block or *p*-block
(b) 35	(q) 5th period element
(c) 37	(r) Violates Aufbau's principle
(d) 24	(s) Not lanthanides

6. Match the column:

Column-I (Characteristic involved in the given process of Column-II)	Column-II (Process described)
(a) Energy released	(p) $S \longrightarrow S^-$
(b) Energy absorbed	(q) $O^- \longrightarrow O^{2-}$
(c) Inert gas configuration is achieved	(r) $Sr \longrightarrow Sr^{2+}$
(d) Half filled configuration is achieved	(s) $N^- \longrightarrow N$
	(t) $Ge \longrightarrow Ge^-$

7. Match the column:

Column-I	Column-II
(a) 17	(p) Two unpaired *p*-electrons
(b) 32	(q) *p*-block element
(c) 82	(r) More negative ΔH_{eg} then elements on either side of it in the same period
	(s) Have higher ionization energy than that of previous elements of the respective group

Integer Answer Type

1. The minimum number of electrons having magnetic quantum number of zero for Ni is _____.
2. How many elements from the following are not transition elements?
   Zr, Co, Cd, Hg, Au, Cu
3. Find the number of metals from the following: As, Fe, Xe, Li, B, Cl, Ba, P, I, Si.
4. Calculate the effective nuclear charge for the outermost electron of oxygen atom.
5. If there were 8 periods in the periodic table and each orbital could have maximum 5 electrons, then how many maximum number of elements would be present in period 8?
6. The first four ionization energy values of an element are 120, 240, 520, and 6420 kcal. The number of valence electrons in the element is _____.
7. How many unpaired electron(s) is/are present in tri-positive titanium ion?
8. Calculate the effective nuclear charge for a 3*d*-electron of nickel atom.
9. Calculate the experimental bond moment (approximate, in debye) of the X—Y bond, if electronegativity of elements X and Y is 1 and 2.5, respectively, and bond length is 3.92 Å.
10. Calculate the difference in the number of protons of the largest element of the fourth period and the smallest element of the third period.
11. From the data given, calculate the energy deficit in the formation of $BeCl_2$ (it is a stable molecule).
    I.E.$_1$ for Be = 899 kJ/mol
    I.E.$_2$ for Be = 1757 kJ/mol
    I.A. for Cl = –348 kJ/mol

NCERT Exemplar Exercises

Single Correct Answer Type

1. Consider the isoelectronic species, Na^+, Mg^{2+}, F^-, and O^{2-}. The correct order of increasing length of their radii is _____.
   (a) $F^- < O^{2-} < Mg^{2+} < Na^+$
   (b) $Mg^{2+} < Na^+ < F^- < O^{2-}$
   (c) $O^{2-} < F^- < Na^+ < Mg^{2+}$
   (d) $O^{2-} < F^- < Mg^{2+} < Na^+$
2. The order of screening effect of electrons of *s*, *p*, *d* and *f* orbitals of a given shell of an atom on its outer shell electrons is:
   (a) $s > p > d > f$ (b) $f > d > p > s$
   (c) $p < d < s > f$ (d) $f > p > s > d$
3. The statement that is not correct for periodic classification of elements is:
   (a) The properties of elements are periodic function of their atomic numbers
   (b) Non-metallic elements are less in number than metallic elements
   (c) For transition elements, the 3*d*-orbitals are filled with electrons after 3*p*-orbitals and before 4*s*-orbitals
   (d) The first ionization enthalpies of elements generally increase with increase in atomic number as we go along a period
4. Among halogens, the correct order of amount of energy released in electron gain (electron gain enthalpy) is:
   (a) F > Cl > Br > I (b) F < Cl < Br < I
   (c) F < Cl > Br > I (d) F < Cl < Br < I
5. The period number in the long form of the periodic table is equal to

(a) Magnetic quantum number of any element of the period
(b) Atomic number of any element of the period
(c) Maximum Principal quantum number of any element of the period
(d) Maximum Azimuthal quantum number of any element of the period

6. The elements in which electrons are progressively filled in 4*f*-orbital are called
(a) Actinoids (b) Transition elements
(c) Lanthanoids (d) Halogens

7. Which of the following is the correct order of size of the given species:
(a) $I > I^- > I^+$ (b) $I+ > I^- > I$
(c) $I > I^+ > I^-$ (d) $I^- > I > I^+$

8. The formation of the oxide ion, $O^{2-}(g)$, from oxygen atom requires first an exothermic and then an endothermic step as shown below:

$O(g) + e^- \rightarrow O^-(g); \Delta H^\ominus = -141 \text{ kJ mol}^{-1}$

$O^-(g) + e^- \rightarrow O^{2-}(g); \Delta H^\ominus = +780 \text{ kJ mol}^{-1}$

Thus process of formation of O^{2-} in gas phase is unfavorable even though O^{2-} is isoelectronic with neon. It is due to the fact that:
(a) Oxygen is more electronegative
(b) Addition of electron in oxygen results in larger size of the ion
(c) Electron repulsion outweighs the stability gained by achieving noble gas configuration
(d) O^- ion has comparatively smaller size than oxygen atom

Paragraph

9. Comprehension given below is followed by some multiple choice questions. Each question has one correct option. Choose the correct option. In the modern periodic table, elements are arranged in order of increasing atomic numbers which is related to the electronic configuration. Depending upon the type of orbitals receiving the last electron, the elements in the periodic table have been divided into four blocks, viz, *s*, *p*, *d*, and *f*. The modern periodic table consists of 7 periods and 18 groups. Each period begins with the filling of a new energy shell. In accordance with the Aufbau principle, the seven periods (1 to 7) have 2, 8, 8, 18, 18, 32, and 32 elements respectively. The seventh period is still incomplete. To avoid the periodic table being too long, the two series of *f*-block elements, called lanthanoids and actinoids are placed at the bottom of the main body of the periodic table.

(i) The element with atomic number 57 belongs to:
(a) *s*-block (b) *p*-block
(c) *d*-block (d) *f*-block

(ii) The last element of the *p*-block in 6th period is represented by the outermost electronic configuration.
(a) $7s^2\,7p^6$ (b) $5f^{14}\,6d^{10}\,7s^2\,7p^0$
(c) $4f^{14}\,5d^{10}\,6s^2\,6p^6$ (d) $4f^{14}\,5d^{10}\,6s^2\,6p^4$

(iii) Which of the elements whose atomic numbers are given below, cannot be accommodated in the present set up of the long form of the periodic table?
(a) 107 (b) 118
(c) 126 (d) 102

(iv) The electronic configuration of the element which is just above the element with atomic number 43 in the same group is _____.
(a) $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^5\,4s^2$
(b) $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^5\,4s^3\,4p^6$
(c) $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^6\,4s^2$
(d) $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^7\,4s^2$

(v) The elements with atomic numbers 35, 53, and 85 are all _____.
(a) Noble gases (b) Halogens
(c) Heavy metals (d) Light metals

10. Electronic configurations of four elements A, B, C, and D are given below:
(a) $1s^2\,2s^2\,2p^6$ (b) $1s^2\,2s^2\,2p^4$
(c) $1s^2\,2s^2\,2p^6\,3s^1$ (d) $1s^2\,2s^2\,2p^5$

Which of the following is the correct order of increasing tendency to gain electron:
(a) a < c < b < d (b) a < b < c < d
(c) d < b < c < a (d) d < a < b < c

Multiple Correct Answers Type

In the following questions two or more options may be correct.

1. Which of the following sequences contain atomic numbers of only representative elements?
(a) 3, 33, 53, 87 (b) 2, 10, 22, 36
(c) 7, 17, 25, 37, 48 (d) 9, 35, 51, 88

2. Which of the following elements will gain one electron more readily in comparison to other elements of their group?
(a) S(g) (b) Na(g)
(c) O(g) (d) Cl(g)

3. Which of the following statements are correct?
   (a) Helium has the highest first ionization enthalpy in the periodic table
   (b) Chlorine has less negative electron gain enthalpy than fluorine
   (c) Mercury and bromine are liquids at room temperature
   (d) In any period, atomic radius of alkali metal is the highest
4. Which of the following sets contain only isoelectronic ions?
   (a) Zn^{2+}, Ca^{2+}, Ga^{3+}, Al^{3+}
   (b) K^+, Ca^{2+}, Sc^{3+}, Cl^-
   (c) P^{3-}, S^{2-}, Cl^-, K^+
   (d) Ti^{4+}, Ar, Cr^{3+}, V^{5+}
5. In which of the following options order of arrangement does **not** agree with the variation of property indicated against it?
   (a) $Al^{3+} < Mg^{2+} < Na^+ < F^-$ (increasing ionic size)
   (b) B < C < N < O (increasing first ionization enthalpy)
   (c) I < Br < Cl < F (increasing electron gain enthalpy)
   (d) Li < Na < K < Rb (increasing metallic radius)
6. Which of the following have no unit?
   (a) Electronegativity
   (b) Electron gain enthalpy
   (c) Ionization enthalpy
   (d) Metallic character
7. Ionic radii vary in:
   (a) Inverse proportion to the effective nuclear charge
   (b) Inverse proportion to the square of effective nuclear charge
   (c) Direct proportion to the screening effect
   (d) Direct proportion to the square of screening effect
8. An element belongs to 3rd period and group-13 of the periodic table. Which of the following properties will be shown by the element?
   (a) Good conductor of electricity
   (b) Liquid, metallic
   (c) Solid, metallic
   (d) Solid, non-metallic

Short Answer Type

1. Explain why the electron gain enthalpy of fluorine is less negative than that of chlorine.
2. Identify the group and valency of the element having atomic number 119. Also predict the outermost electronic configuration and write the general formula of its oxide.
3. Among the elements B, Al, C, and Si, (i) which element has the highest first ionization enthalpy? (ii) Which element has the most metallic character? Justify your answer in each case.
4. Choose the correct order of atomic radii of fluorine and neon (in pm) out of the options given below and justify your answer.
   (a) 72, 160 (b) 160, 160
   (c) 72, 72 (d) 160, 72
5. Nitrogen has positive electron gain enthalpy whereas oxygen has negative. However, oxygen has lower ionization enthalpy than nitrogen. Explain.
6. How would you explain the fact that first ionization enthalpy of sodium is lower than that of magnesium but its second ionization enthalpy is higher than that of magnesium?
7. Arrange the elements N, P, O, and S in the order of:
   (i) Increasing first ionization enthalpy
   (ii) Increasing non-metallic character
   Give reason for the arrangement assigned.
8. Explain the following:
   (a) Electronegativity of elements increase on moving from left to right in the periodic table.
   (b) Ionization enthalpy decrease in a group from top to bottom?
9. How does the metallic and non-metallic character vary on moving from left to right in a period?
10. The radius of Na^+ cation is less than that of Na atom. Give reason.
11. Among alkali metals which element do you expect to be least electronegative and why?

Matching Column Type

1. Match the correct atomic radius with the element.

Element	Atomic radius (pm)
Be	74
C	88

O	111
B	77
N	66

2. Match the correct ionization enthalpies and electron gain enthalpies of the following elements.

Elements		ΔH_1	ΔH_2	$\Delta_{eg} H$
(a) Most reactive non metal	(p)	419	3051	– 48
(b) Most reactive metal	(q)	1681	3374	– 328
(c) Least reactive element	(r)	738	1451	– 40
(d) Metal forming binary halide	(s)	2372	5251	+ 48

3. Electronic configuration of some elements is given in Column-I and their electron gain enthalpies are given in Column-II. Match the electronic configuration with electron gain enthalpy.

Column-I (Electronic configuration)	Column-II (Electron gain enthalpy/kJ mol^{-1})
(a) $1s^2\,2s^2\,sp^6$	(p) – 53
(b) $1s^2\,2s^2\,2p^6\,3s^1$	(q) – 328
(c) $1s^2\,2s^2\,2p^5$	(r) – 141
(d) $1s^2\,2s^2\,2p^4$	(s) + 48

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):** Generally, ionization enthalpy increases from left to right in a period.

   Reason (R): When successive electrons are added to the orbitals in the same principal quantum level, the shielding effect of inner core of electrons does not increase very much to compensate for the increased attraction of the electron to the nucleus.

   (a) Assertion is correct statement and reason is wrong statement.
   (b) Assertion and reason both are correct statements and reason is correct explanation of assertion.
   (c) Assertion and reason both are wrong statements.
   (d) Assertion is wrong statement and reason is correct statement.

2. **Assertion (A):** Boron has a smaller first ionization enthalpy than beryllium.

   Reason (R): The penetration of a $2s$ electron to the nucleus is more than the $2p$ electron hence $2p$ electron is more shielded by the inner core of electrons than the $2s$ electrons.

   (a) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
   (b) Assertion is correct statement but reason is wrong statement.
   (c) Assertion and reason both are correct statements and reason is correct explanation for assertion.
   (d) Assertion and reason both are wrong statements.

Long Answer Type

1. Discuss the factors affecting electron gain enthalpy and the trend in its variation in the periodic table.
2. Define ionization enthalpy. Discuss the factors affecting ionization enthalpy of the elements and its trends in the periodic table.
3. Write down the outermost electronic configuration of alkali metals. How will you justify their placement in group 1 of the periodic table?
4. Discuss and compare the trend in ionization enthalpy of the elements of group 1 with those of group 17 elements.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. According to the periodic law of elements, the variation in properties of elements is related to their
   (a) Nuclear masses
   (b) Atomic numbers
   (c) Nuclear neutron–proton number ratios
   (d) Atomic masses

   (AIEEE, 2003)

2. Which one of the following is an amphoteric oxide?
   (a) Na_2O (b) SO_2
   (c) B_2O_3 (d) ZnO

   (AIEEE, 2003)

3. Which one of the following ions has the highest value of ionic radius?
   (a) O^{2-} (b) B^{3+}
   (c) Li^{+} (d) F^{-}

(AIEEE, 2004)

4. Among Al_2O_3, SiO_2, P_2O_3, and SO_2, the correct order of acid strength is:
   (a) $Al_2O_3 < SiO_2 < SO_2 < P_2O_3$
   (b) $SiO_2 < SO_2 < Al_2O_3 < P_2O_3$
   (c) $SO_2 < P_2O_3 < SiO_2 < Al_2O_3$
   (d) $Al_2O_3 < SiO_2 < P_2O_3 < SO_2$

(AIEEE, 2004)

5. The formation of the oxide ion $O^{2-}_{(g)}$ requires first an exothermic and then an endothermic step as shown below.

$$O_{(g)} + e^- = O^-_{(g)}, \Delta H^\circ = -142 \text{ kJ mol}^{-1}$$
$$O^-_{(g)} + e^- = O^{2-}_{(g)}, \Delta H^\circ = +844 \text{ kJ mol}^{-1}$$

This is because
   (a) O^- ion will tend to resist the addition of another electron
   (b) Oxygen has high electron affinity
   (c) Oxygen is more electronegative
   (d) O^- ion has comparatively larger size than oxygen atom

(AIEEE, 2004)

6. Which of the following oxides is amphoteric in character?
   (a) SnO_2 (b) SiO_2
   (c) CO_2 (d) CaO

(AIEEE, 2005)

7. In which of the following arrangements, the order is NOT according to the property indicated against it?
   (a) Li < Na < K < Rb: increasing metallic radius
   (b) I < Br < F < Cl: increasing electron gain enthalpy
   (c) B < C < N < O: increasing first ionization enthalpy
   (d) $Al^{3+} < Mg^{2+} < Na^{+} < F^{-}$: increasing ionic size

(AIEEE, 2005)

8. In the following statements regarding the periodic trends of chemical reactivity of alkali metals and halogens, which of these statements gives the correct picture?
   (a) Chemical reactivity increases with increase in atomic number down the group in both the alkali metals and halogens
   (b) In alkali metals, the reactivity increases, whereas in the halogens, it decreases with increase in atomic number down the group
   (c) The reactivity decreases in the alkali metals but increases in the halogens with increase in atomic number down the group
   (d) In both the alkali metals and the halogens, the chemical reactivity decreases with increase in atomic number down the group

(AIEEE, 2006)

9. In which of the following arrangements, the sequence is not strictly according to the property written against it?
   (a) HF < HCl < HBr < HI: increasing acid strength
   (b) $NH_3 < PH_3 < AsH_3 < SbH_3$: increasing basic strength
   (c) B < C < O < N: increasing first ionization enthalpy
   (d) $CO_2 < SiO_2 < SnO_2 < PbO_2$: increasing oxidizing power

(AIEEE, 2008)

10. The correct sequence that shows the decreasing order of the ionic radii of the elements is:
   (a) $Al^{3+} > Mg^{2+} > Na^{+} > F^{-} > O^{2-}$
   (b) $Na^{+} > Mg^{2+} > Al^{3+} > O^{2-} > F^{-}$
   (c) $Na^{+} > F^{-} > Mg^{2+} > O^{2-} > Al^{3+}$
   (d) $O^{2-} > F^{-} > Na^{+} > Mg^{2+} > Al^{3+}$

(AIEEE, 2010)

11. Which one of the following orders presents the correct sequence of the increasing basic nature of the given oxides?
   (a) $Al_2O_3 < MgO < Na_2O < K_2O$
   (b) $MgO < K_2O < Al_2O_3 < Na_2O$
   (c) $Na_2O < K_2O < MgO < Al_2O_3$
   (d) $K_2O < Na_2O < Al_2O_3 < MgO$

(AIEEE, 2011)

12. The increasing order of the ionic radii of the given isoelectronic species is:
   (a) Cl^-, Ca^{2+}, K^+, and S^{2-}
   (b) S^{2-}, Cl^-, Ca^{2+}, and K^+
   (c) Ca^{2+}, K^+, Cl^-, and S^{2-}
   (d) K^+, S^{2-}, Ca^{2+}, and Cl^-

(AIEEE, 2012)

13. Which of the following represents the correct order of increasing first ionization enthalpy for Ca, Ba, S, Se, and Ar?

(a) Ca < S < Ba < Se < Ar
(b) S < Se < Ca < Ba < Ar
(c) Ba < Ca < Se < S < Ar
(4) Ca < Ba < S < Se < Ar

(JEE Main, 2013)

14. The first ionization potential of Na is 5.1 eV. The value of electron gain enthalpy of Na^+ will be:
(a) −2.55 eV (b) −5.1 eV
(c) −10.2 eV (d) +2.55 eV

(JEE Main, 2013)

JEE (Advanced) Exercises

Fill in the Blanks Type

1. The energy released when an electron is added to a neutral gaseous atom is called _____ of the atom. **(IIT-JEE, 1982)**
2. On Mulliken scale, the average of ionization potential and electron affinity is known as _____. **(IIT-JEE, 1985)**
3. Ca^{2+} has a smaller ionic radius than K^+ because it has _____. **(IIT-JEE, 1993)**
4. Compounds that formally contain Pb^{4+} are easily reduced to Pb^{2+}. The stability of the lower oxidation state is due to _____. **(IIT-JEE, 1997)**

True/False Type

1. The softness of group IA metals increases down the group with increasing atomic number. **(IIT-JEE, 1986)**
2. In group IA of alkali metals, the ionization potential decreases down the group. Therefore, lithium is a poor reducing agent. **(IIT-JEE, 1987)**
3. The decreasing order of electron affinity of F, Cl, and Br is F > Cl > Br. **(IIT-JEE, 1993)**
4. The basic nature of the hydroxides of group 13 (III A) decreases progressively down the group. **(IIT-JEE, 1993)**

Single Correct Answer Type

1. The correct order of second ionization potential of carbon, nitrogen, oxygen, and fluorine is:
(a) C > N > O > F (b) O > N > F > C
(c) O > F > N > C (d) F > O > N > C
(IIT-JEE, 1981)

2. The element with the highest first ionization potential is:
(a) Boron (b) Carbon
(c) Nitrogen (d) Oxygen
(IIT-JEE, 1982)

3. The first ionization potentials (in electron volts) of nitrogen and oxygen atoms are, respectively, given by:
(a) 14.5, 13.6 (b) 13.6, 14.6
(c) 13.6, 13.6 (d) 14.6, 14.6
(IIT-JEE, 1987)

4. Atomic radii of fluorine and neon (in Angstrom units) are, respectively, given by:
(a) 0.72, 1.60 (b) 1.60, 1.60
(c) 0.72, 0.72 (d) None of these
(IIT-JEE, 1987)

5. The electronegativity of the following elements increases in the order:
(a) C, N, Si, P (b) N, Si, C, P
(c) Si, P, C, N (d) P, Si, N, C
(IIT-JEE, 1987)

6. The first ionization potentials of Na, Mg, Al, and Si are in the order:
(a) Na < Mg > Al < Si (b) Na > Mg > Al > Si
(c) Na < Mg < Al > Si (d) Na > Mg > Al < Si
(IIT-JEE, 1988)

7. Which of the following is smallest in size?
(a) N^{3-} (b) O^{2-}
(c) F^- (d) Na^+
(IIT-JEE, 1989)

8. Among the following elements (whose electronic configurations are given below), the one having the highest ionization energy is:
(a) $[Ne]3s^23p^1$ (b) $[Ne]3s^23p^3$
(c) $[Ne]3s^23p^2$ (d) $[Ne]3d^{10}4s^24p^3$
(IIT-JEE, 1990)

9. Which of the following statements is not correct for the periodic classification of elements?
(a) The properties of elements are the periodic functions of their atomic numbers
(b) Non-metallic elements are lesser in number than metallic elements
(c) The first ionization energies of elements along a period do not vary in a regular manner with increase in atomic number
(d) For transition elements, the *d*-subshells are filled with electrons monotonically with increase in atomic number
(IIT-JEE, 1992)

10. Which of the following has the most stable +2 oxidation state?

(a) Sn (b) Pb
(c) Fe (d) Ag

(IIT-JEE, 1995)

11. Which of the following has the maximum number of unpaired electrons?

(a) Mg^{2+} (b) Ti^{3+}
(c) V^{3+} (d) Fe^{2+}

(IIT-JEE, 1996)

12. Which of the following statement is wrong?

(a) The first ionization potential of Al is less than the first ionization potential of Mg
(b) The second ionization potential of Mg is greater than the second ionization potential of Na
(c) The first ionization potential of Na is less than the first ionization potential of Mg
(d) The third ionization potential of Mg is greater than the third ionization potential of Al

(IIT-JEE, 1997)

13. The correct order of acidic strength is:

(a) $Cl_2O_7 > SO_2 > P_4O_{10}$
(b) $CO_2 > N_2O_5 > SO_3$
(c) $Na_2O > MgO > Al_2O_3$
(d) $K_2O > CaO > MgO$

(IIT-JEE, 2000)

14. The correct order of radii is:

(a) $N < Be < B$ (b) $F^- < O^{2-} < N^{3-}$
(c) $Na < Li < K$ (d) $Fe^{3+} < Fe^{2+} < Fe^{4+}$

(IIT-JEE, 2000)

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

H_2O, H_2S, H_2Se, and H_2Te

(a) H_2O because of hydrogen bonding
(b) H_2Te because of higher molecular weight
(c) H_2S because of hydrogen bonding
(d) H_2Se because of lower molecular weight

(IIT-JEE, 2000)

16. The set representing the correct order of first ionization potential is:

(a) K > Na > Li (b) Be > Mg > Ca
(c) B > C > N (d) Ge > Si > C

(IIT-JEE, 2001)

Multiple Correct Answers Type

1. Which of the following statements is/are true for the long form of the periodic table?

(a) It reflects the sequence of filling the electrons in the order of sub-energy levels *s*, *p*, *d*, and *f*
(b) It helps to predict the stable valency states of the elements
(c) It reflects trends in physical and chemical properties of the elements
(d) It helps to predict the relative ionicity of the bond between any two elements

(IIT-JEE, 1981)

2. Sodium sulphate is soluble in water whereas barium sulphate is sparingly soluble because:

(a) The hydration energy of sodium sulphate is more than its lattice energy
(b) The lattice energy of barium sulphate is more than its hydration energy
(c) The lattice energy has no role to play in solubility
(d) The hydration energy of sodium sulphate is less than its lattice energy

(IIT-JEE, 1989)

3. Ionic radii of:

(a) $Ti^{4+} < Mn^{7+}$ (b) $^{35}Cl^- < {}^{37}Cl^-$
(c) $K^+ > Cl^-$ (d) $P^{3+} > P^{5+}$

(IIT-JEE, 1999)

Assertion-Reasoning Type

Read the following questions and answer as per the directions given below:

(a) Statement-I is true; Statement-II is 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:** F atom has a less negative electron affinity than Cl atom.

Statement-II: Additional electrons are repelled more effectively by 3*p* electrons in Cl atom than by 2*p* electron in F atom.

(IIT-JEE, 1998)

2. **Statement-I:** The first ionization energy of Be is greater than that of B.

Statement-II: 2*p*-orbital is lower in energy than 2*s*.

(IIT-JEE, 2000)

Integer Answer Type

1. In an atom, the total number of electrons having quantum numbers $n = 4$, $|m_\ell| = 1$ and $m_s = -\frac{1}{2}$ is

(JEE Advanced, 2014)

Subjective Type

1. Arrange the following in the given order.
   (a) Decreasing ionic size: $Mg^{2+}, O^{2-}, Na^+, F^-$
   (IIT-JEE, 1985)
   (b) Increasing first ionization energy: Mg, Al, Si, Na **(IIT-JEE, 1985)**
   (c) Increasing bond length: F_2, N_2, Cl_2, O_2
   (IIT-JEE, 1985)
   (d) The order of their increasing size: $Cl^-, S^{2-}, Ca^{2+}, Al^{3+}$
   (IIT-JEE, 1986)
2. Explain the following statement:
   "The first ionization energy of carbon atom is greater than that of boron atom, whereas the reverse is true for the second ionization energy".
   (IIT-JEE, 1989)
3. Arrange the following as stated:
   Increasing order of ionic size
   $N^{3-}, Na^+, F^-, O^{2-}, Mg^{2+}$
   (IIT-JEE, 1991)
4. Arrange the following ions in order of their increasing radii:
   $Li^+, Mg^{2+}, K^+, Al^{3+}$
   (IIT-JEE, 1997)

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

1. (b) Removal of electron from $2p$ half filled is more difficult.
2. (a) The size of isoelectronic species decreases with increase in atomic number.
3. (b) Ionization energy increases along the period.
4. (b) Anions are always larger than their parent atom. Also atomic radius increases down the group and decreases along the period.
5. (d) Each has six electrons.
6. (c) Cl^- has $1s^2, 2s^2, 2p^6, 3s^2\ 3p^6$ configuration.
7. (c) Ionization energy decreases down the group.
8. (d) Ti^+ has 21 electrons in it. Rest all have 10 electrons.
9. (d) Rest all are periodic properties of elements.
10. (b) Alkali metals are most electropositive elements.
11. (c) In O^{2-}, effective nuclear charge is minimum due to more number of electrons and thus the size of O^{2-} is maximum.

33. (c) $M_B = \frac{M_A + M_C}{2}$

$15 = \frac{7 + M_C}{2}$; $M_C = 23$

34. (c) Hydrated radius ∝ charge per unit on ion.
$I^-(aq) > Cl^-(aq)$

35. (c) Hydration energy $\propto \frac{1}{\text{Size of gaseous ion}}$
$K^+ > Cs^+$

36. (a) Ne > F order of size. Therefore, answer is "a" 0.72, 1.60.

37. (b) The more the negative charge, the more would be the size of the ion, and down the group size increases.

38. (d) Hg is a d-block element.

59. (c) Due to a jump in second ionization energy.

60. (b) From the electronic configuration of the given element K, L, M, and N; $L = [Ne]3s^2, 3p^3$ has the highest ionization potential than others.

61. (d) Ionization enthalpy increases along the period and decreases down the group.

62. (d) $E.A._1$ for elements is exothermic and $E.A._2$ is endothermic. Also $E.A._2$ for O > $E.A._1$ for O.

63. (a) Cations are always smaller than their parent atoms: $Al^{3+} < Al^{2+} < Al^+ < Al$.

64. (d) Both C and N^+ have six electrons.

65. (a) Addition of electrons to an atom results in an increase in its size.

66. (d) Size of anions is larger than their parent atom. Also, the more the ENC, the lesser the size.

67. (d) Each has 18 electrons.

69. (a) Due to higher Z_{eff} value of Fe^{3+} in comparison to Fe^{2+}, there is more contraction in size of Fe^{3+} than in Fe^{2+}.

JEE (Advanced) Exercises

Single Correct Answer Type

17. (a)

Magnetic moment $\mu = \sqrt{n(n+2)}$	Unpaired electrons n	Species of Mn
(a) $2\sqrt{2}$	2	Mn^{5+}
(b) $\sqrt{15}$	3	Mn^{4+}
(c) $\sqrt{35}$	5	Mn^{2+}
(d) $\sqrt{24}$	4	Mn^{3+}

Species with greater positive charge have higher I.E.

18. (b) Ionic mobility in water $\propto \dfrac{1}{\text{Size of hydrated ion}}$

(a) Size of aqueous ions $Al^{3+} > Mg^{2+}$

(b) Size of $K^+(aq) > Ca^{2+}(aq)$

(c) $I^-(aq)$ has the highest ionic mobility among halide (aq) ions.

(d) $Cs^+(aq)$ has the highest ionic mobility because of lesser hydrated radius than any of alkali metal ions (aq).

19. (c)
$$d_{H-F} = 0.37 + 0.72 - 0.09\,|4 - 2.1|$$
$$= 1.09 - 0.17 = 0.92\ \text{Å}$$

34. (b) The size of isoelectronic decreases with increase in atomic number.

35. (c) The smaller the size of cation, the more is the ionic character, and the more is the attraction among ions.

36. (c) The jump in ionization energy occurs when valence shell changes during removal of electron.

37. (b) Ionization energy increases along the period.

38. (b) The ionization potential decreases down the group.

39. (d) Lattice energy $\propto \dfrac{q_1 q_2}{d^2}$, where q_1, q_2 are the charge on ions and d is the distance of separation.

40. (b)

43. (a) $S^-_{(g)} \longrightarrow S^{2-}_{(g)}$ Electron affinity of an anion (endothermic)

$Na^+_{(g)} + Cl^-_{(g)} \longrightarrow NaCl_{(s)}$ Lattice energy (endothermic)

$N_{(g)} \longrightarrow N^-_{(g)}$ (exothermic)

More stable — Less stable

(Half filled p-subshell)

$Al^{2+}_{(g)} \longrightarrow Al^{3+}_{(g)}$ (endothermic)

(ionization is endothermic)

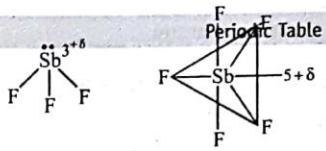
57. (c) If Z is the atomic number of the inert gas, then

$(Z-1) \Rightarrow$ halogens; $(Z+1) =$ alkali metals

$(Z-2) \Rightarrow$ oxygen family; $(Z+2) =$ alkaline earth metals

} forms ionic compound

58. (b)



Therefore, more electronegativity of Sb, as it has more +δ charge.

59. (b) $\dfrac{\text{Cation}}{\text{Anion}}$ ratio should be minimum.

Therefore, the largest anion and the smallest cation must be there; thus answer is LiI.

60. (d) $(I.P.)_2 > (I.P.)_1$ always as in case of $I.P._2$. Electron is removed from cation in which Z_{eff} has increased for the last electron.

61. (a) $Cl \rightarrow Cl^-$ [E.A.$_1$ of Cl]

and

$F^- \rightarrow F$ [−E.A.$_1$ of F]

As E.A. of Cl > E.A. of F, therefore, $Cl \rightarrow Cl^-$ will involve maximum energy.

74. (c) Anion (O^-) repels the test electron because of same charge.

Multiple Correct Answers Type

1. (a), (b), (c)

$H^- > F^-$ [true]

[larger]

(a), (b), (c) are all correct statements.

2. (a), (b), (c)

(i) I.E. order: $s > p > d > f$ for a particular principal quantum number.

(ii) I.E. depends upon half filled and fully filled configuration.

Factors (i) and (ii) disappear in the 5th and 6th periods because Z_{eff} dominates over all others.

7. (a), (c), (d)

(a) and (c) are correct

(b): EN↑, i.e., metallic character↓

(d): EA of Cl > EA of F

8. (a), (c), (d);

(a) False; lanthanum belongs to d-block.

(b) True; actinium violates Aufbau's principle; its configuration is [Rn] $7s^2\,6d^1$.

(c) False.

(d) False; configuration of Zn is [Ar] $3d^{10}\,4s^2$.

∴ Total exchanges are 20 not 10.

10. (a), (b), (d)

(a) $Al^+ \rightarrow 3s^2$ ∴ $Al^+ > Mg^+$

$Mg^+ \rightarrow 2s^2 2p^6, 3s^1$

(b) $Te^+ \rightarrow 5s^2\,5p^3$ $\therefore$ $Te^+ > Sb^+$

$Sb^+ \rightarrow 5s^2 5p^2$

(c) Successive I.E. of element increases.

$\therefore$ $Fe^{2+} > Fe^+$; the more is the charge, the more will be the I.E.

(d) $In^+ \rightarrow 5s^2\,5p^0$ $\therefore$ $In^+ > Sr^+$

$Sr^+ \rightarrow 5s^1$

11. (a), (b), (c)

$(I.E._1 - I.E._2)$ is very high. Therefore, A will be ionized only once and thus will form compounds with valency one like AF, A_2O, and A_3N.

13. (a), (b), (c)

The ionization energy order is $F > Cl > Cl^- > F^-$.

14. (a), (c), (d)

(a) Size of Cl is smaller than Br. $\therefore$ I.E. Cl > Br.

(c) I.E. of neutral atom is more than anion.

$\therefore$ $Cl > Cl^-$ and $Br > Br^-$.

18. (a), (c), (d)

Alkaline earth metals are at descending positions in the curve.

19. (a), (b), (c), (d)

Cr (24): $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^5\,4s^1$

(a) Number of electrons with principle quantum number 3 is $3s^2\,3p^6\,3d^5 = 2 + 6 + 5 = 13$

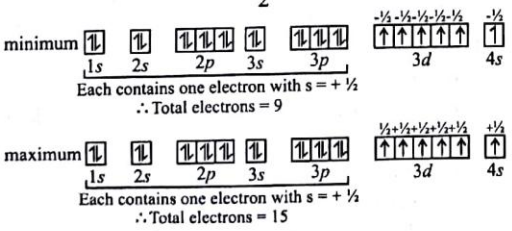
(b) Number of electrons with azimuthal quantum number 1 is $2p^6, 3p^6 = 6 + 6 = 12$

(c) Number of electrons with magnetic quantum number 0 is $3p^6$

electrons in $m = 0$ $\underset{2}{\underset{\smile}{1s^2}}\ \underset{2}{\underset{\smile}{2s^2}}\ \underset{2}{\underset{\smile}{2p^6}}\ \underset{2}{\underset{\smile}{3s^2}}\ \underset{2}{\underset{\smile}{3p^6}}\ \underset{1}{\underset{\smile}{3d^5}}\ \underset{1}{\underset{\smile}{4s^1}}$

Total = 12 electrons

(d) Number of minimum electrons with spin quantum number $s = +\frac{1}{2}$:



20. (c), (d)

(c) $Zn \longrightarrow [Ar]\,3d^{10}, 4s^2$

$Zn^{2+} \longrightarrow [Ar]\,3d^{10}, 4s^0 \Rightarrow$ diamagnetic

(d) $Cr \longrightarrow 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1, 3d^5$

$\downarrow$ $2e^-$ $\downarrow$ $2e^-$ $\downarrow$ $1e^-$

$5e^-$ having $m = -1$

21. (a), (b), (d)

B and Mg do not show diagonal relationship.

22. (a), (d)

"He" is the smallest inert gas.

$\therefore$ It has the highest I.P., and the $(I.P.)_1$ is highest for the noble gases in any period.

23. (a), (c), (d)

IE_1 of N > IE_1 of 0, due to half filled nature in N.

24. (a), (b)

(a) $\rightarrow$ p-orbital can accommodate a maximum of 2 electrons.

(b) $\rightarrow$ Na: $1s^2\,2s^2\,2p^6\,3s^1$ Na^{3+}: $1s^2\,2s^2\,2p^4$

Na^+: $1s^2\,2s^2\,2p^6$

Na^{2+}: $1s^2\,2s^2\,2p^5$ $I.E._3 > I.E._2 > I.E._1$

$I.E._3$ is greater than $I.E._2$ because to convert $Na^{2+} \rightarrow Na^{3+}$, electron is removed from a cation having more positive charge.

30. (a), (d)

X^{2-} is isoelectronic with "O_2^+" which has 7 + 8 = 15 electrons.

X has 13 electrons and 13 protons.

Number of neutrons $(n) = (Z + 1) = 13 + 1 = 14$.

Mass number $(a) = (p + n) = 13 + 14 = 27$.

32. (a), (b)

"n" and "l" decide the distance from the nucleus.

$\therefore$ Ionization energy depends on these two.

Comprehension Type

Comprehension-1 (Q. 1 to Q. 3)

1. (d) If the frequency is enough to ionize Cl, then I.E. of Br and I would be lesser than Cl; thus it can ionize them also.

2. (c) Noble gases have the highest I.E. in their respective periods.

3. (b) $K \longrightarrow K^-$ is on exothermic process, i.e., the energy involved has –ve value.

$K^- \longrightarrow K$ is opposite of $K \longrightarrow K^-$.

$\therefore$ Numerical value would be the same but sign will be opposite. But $K \rightarrow K^+$ is I.E. of K.

$\therefore$ It is higher than the above process as it is a having a positive value.

Comprehension-2 (Q. 4 to Q. 6)

4. (a) $I.E._1$ As > Se because of half filled configuration.

5. (a) $\Delta H_{eg} = -E.A.$

6. (d) $K \xrightarrow{I.E._1} K^+ \xrightarrow{I.E._2} K^{2+}$

$I.E._2 >> I.E._1$ ∴ Potassium gets ionized only once after which it attains inert gas configuration.

$K^+ = 1s^2, 2s^2\, 2p^6, 3s^2\, 3p^6$

Assertion-Reasoning Type

1. (c) **Statement-I:** True, as both have 18 electrons.

Statement-II: False, for isoelectronic species number of electrons are same, not the charge.

2. (d) Cd is a *d*-block element, not a transition element as its *d*-orbital is filled completely in Cd and Cd^{2+} both.

$Cd \rightarrow 3d^{10}\, 4s^2$, $Cd^{2+} \rightarrow 3d^{10}\, 4s^0$

Matching Column Type

3. (a) p, r; (b) r, s; (c) p, q, r

Zn and Hg are not transition elements because in their ground state and in the most stable oxidation state configuration, "*nd*" is completely filled.

4. (a) p, q, r; (b) p, q, r; (c) p, q, s;

Electronegativity is independent of configuration and it can be calculated by bond energy data by Pauling scale.

5. (a) p, r, s; (b) p, q, s; (c) s; (d) p, q, r, s.

(a) $89 \longrightarrow Ac$ (b) $35 \longrightarrow Br$

(c) $37 \longrightarrow Rb$ (d) $24 \longrightarrow Cr$

6. (a) p, s, t; (b) q, r; (c) q, r; (d) s, t

(a) Energy released

$S \longrightarrow S^-$ ΔH_{eg1}

$N^- \longrightarrow N$ as $N \longrightarrow N^-$ is $\Delta H_{eg1} = +ve$

(b) Energy absorbed

$Ge \longrightarrow Ge^-$ ΔH_{eg1}

$O^- \longrightarrow O^{2-}$ ΔH_{eg2}

$Sr \longrightarrow Sr^{2+}$ $I.E._1 + I.E._2$

(c) Inert gas configuration is achieved

$O^- \longrightarrow O^{2-}$, $Sr \longrightarrow Sr^{2+}$

(d) Half-filled configuration is achieved

$Ge \longrightarrow Ge^-$

$N^- \longrightarrow N$

7. (a) q, r; (b) p, q, r; (c) p, q, s

$Z = 17 \rightarrow$ $3s^2$ [↑↓] $3p^5$ [↑↓][↑↓][↑]

→ One unpaired electron

→ *p*-block element

→ ΔH_{eg} is more negative than sulphur and argon

$Z = 32$ [Ar] → $4s^2\, 4p^4$ [↑↓] [↑↓][↑][↑]

→ Two unpaired electrons; *p*-block element

→ Less negative ΔH_{eg} than the element to its right side in the same period

$Z = 81$ element is Tl [Xe] $6s^2$ [↑↓] $6p^1$ [↑][ ][ ]

→ One unpaired electron; *p*-block element I.E. is more than above element (exception.)

Integer Answer Type

1. (13) Ni: $1s^2\, 2s^2 2p^6\, 3s^2\, 3p^6\, 3d^8\, 4s^2$

Except 3*d*-subshell, remaining each subshell has two electrons; for them magnetic quantum number is zero, and 3*d*-subshell has one electron. Hence total number of electrons = 13.

2. (2) Cd and Hg are *d*-block elements but not transitional.

5. (125) Possible subshells are present in the 8th period: 8*s* 7*d* 6*f* 5*g* 8*p*

Total electrons = 5 + 25 + 35 + 45 + 15 = 125

6. (3) As there is very high difference between $I.E._3$ and $I.E._4$, thus it has three electrons in its valence shell.

9. (6) $\Delta X = E.N._y - E.N._x = 2.5 - 1.0 = 1.5$

% Ionic character = $16\Delta X + 3.5\,(\Delta X)^2$

$$\% \text{ Ionic character} = \frac{\mu_{exp}}{\mu_{theo}} \times 100$$

$$16(1.5) + 3.5\,(1.5)^2 = \frac{\mu_{exp} \times \frac{1}{3} \times 10^{-29}}{1.6 \times 10^{-19} \times 3.92 \times 10^{-10}} \times 100$$

$$\mu_{exp} = 5.99 \approx 6$$

10. (19) 3rd ⟶ Na Mg Al Si P S Cl (smallest) $_{18}Ar$

4th ⟶ K Ca Ga Ge As
Se Br $_{36}$Kr (largest)

Total protons = 36 – 17 = 19.

11. (1960) Be ⟶ Be^+ energy required = 899
Be^+ ⟶ Be^{2+} energy required = 1757

Be ⟶ Be^{2+} energy required = 2656
Cl ⟶ Cl^- energy released = – 348
For $2Cl^-$, energy released = – 696

Therefore, the energy deficit for the process
Be + 2Cl ⟶ $BeCl_2$ is
2656 – 696 = 1960 kJ/mol

NCERT Exemplar Exercises

Short Answer Type

1. The added electron in fluorine goes to second quantum level. Due to small size of fluorine it experiences repulsion from other electrons much more in comparison to that in chlorine because in chlorine, the electron is added to 3rd quantum level in which larger space is available for movement.
2. Group: 1, Valency: 1; Outermost electronic configuration = $8s^1$; Formula of Oxide = M_2O
3. (i) Carbon, (ii) Aluminium
4. (a)
5. The outermost electronic configuration of nitrogen ($2s^2 2p_x^1 2p_y^1 2p_z^1$) is very stable because p-orbital is half filled. Addition of extra electron to any of the 2p orbital requires energy. Oxygen has 4 electrons in 2p orbitals and acquires stable configuration i.e., $2p^3$ configuration after removing one electron.
6. After removing 1 electron from the sodium atom the ion formed acquires the configuration of inert gas, neon. The second electron is removed from one of the 2p-orbitals which are completely filled i.e., have a total of 6 electrons and are closer to the nucleus.
7. (i) S < P < N < O, (ii) P < S < N < O
8. (a) Decrease in size of atom and increase in nuclear charge.
   (b) Increase in atomic size.
9. Metallic character decreases and non metallic character increases in moving from left to right in a period. It is due to increase in ionization enthalpy and electron gain enthalpy.
10. Decrease of one shell.
11. Electronegativity decreases in a group from top to bottom. Thus, caesium is the least electronegative element.

Matching Column Type

1. Be = 111, O = 66, C = 77, B = 88, N = 74.
2. Most reactive non metal = (q), Most reactive metal = (p), Least reactive element = (s), Metal forming binary halide = (r)
3. (i) → (s); (ii) → (p); (iii) → (q); (iv) → (r)

Archives

JEE (Main) Exercises

Single Correct Answer Type

2. (d) Na_2O Basic Oxide
   SO_2 Acidic oxide
   B_2O_3 Acidic oxide
   ZnO Amphotoric oxide
   It can react with acid and base both.
   $ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$
   $ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$
3. (a) These are all elements of second period. Anions have large size than anion. F^- and O^{2-} are isoelectronic and Z_{eff} of F^- is more than O^{2-}.
4. (d) As we move left to right along period in L.F.P.T. acidic strength increases.
6. (a) SnO_2 Amphotaric, amphotaric oxides react with acid as well as base.
   $SnO_2 + 2NaOH \rightarrow Na_2SnO_3 + H_2O$
   $SnO_2 + 4HCl \rightarrow SnCl_4 + 2H_2O$
   SiO_2 is acidic oxide
   CO_2 is acidic oxide
   CaO is basic oxide
7. (c) Ionization energy of N is greater than O due to its half filled 2p-subshell.
8. (b)
9. (b) Due to small size of N, the charge density of l.p. is more.

10. (d) For isoelectronic species σ is same for all

$$\text{size} \propto \frac{1}{Z_{eff}}$$

Z is atomic number

$Z_{eff} = (Z - \sigma)$

11. (a) Basic strength of oxides increases down the group and decreases across a period from left to right.

12. (c) For isoelectronic species σ is same for all

$$\text{size} \propto \frac{1}{Z_{eff}}$$

Z is atomic number

$Z_{eff} = (Z - \sigma)$

13. (c)

(i) In a group the I.E. decreases.
Hence Ca > Ba
and S > Se

(ii) In a period, I.E. increases from left to right in general.
Hence Ar > S and Se > Ca
Hence the order is Ar > S > Se > Ca > Ba and the answer is (c).

14. (b) $Na \underset{-\Delta H_{e.g.}}{\overset{+I.E.}{\rightleftharpoons}} Na^+ + e^-$

$|I.E.| = |\Delta H_{e.g.}|$ Hence

$\Delta H_{e.g.}$ of $Na^+ = -5.1$ eV

JEE (Advanced) Exercises

Fill in the Blanks Type

1. The energy released when an electron is added to a neutral gaseous atom is called **electron gain enthalpy** of the atom.
2. On Mulliken scale, the average of ionization potential and electron affinity is known as **electronegativity**.
3. Ca^{2+} has a smaller ionic radius than K^+ because it has **higher *z/e* ratio**.
   In isoelectronic species, as the number of protons (atomic number) goes on increasing, the size goes on decreasing due to stronger attraction on the electrons.
4. Compounds that formally contain Pb^{4+} are easily reduced to Pb^{2+}. The stability of the lower oxidation state is due to **inert pair effect**.
   In the periodic table, inert pair effect increases down the group. So in group 14, the stability of smaller oxidation state of +2 goes on increasing down the group. Pb^{4+} has an oxidizing nature and Br^- and I^- have reducing nature, so Pb^{4+} is reduced to Pb^{2+}.

   $Pb^{4+} + 2Br^- \rightarrow Pb^{2+} + Br_2$

   $Pb^{4+} + 2I^- \rightarrow Pb^{2+} + I_2$

True/False Type

1. **True.**
   The softness of group IA metals increases down the group with increasing atomic number. This is a true statement.
2. **False.**
   In group IA of alkali metals, the ionization potential decreases down the group. But lithium is a very strong reducing agent because of its very high hydration energy.
3. **False.**
   The decreasing order of electron affinity of F, Cl, and Br is Cl > F > Br.
   In general, the electron affinity decreases down the group but the electron affinity for chlorine is more than that for fluorine, and similarly the electron affinity for sulphur is more than that for oxygen because in F and S, due to small size of the atom, the electrons are already crowded. Entry of one more electron results in more repulsions which leads to the absorption of some energy, so the energy released is less than what would be expected.
4. **False.**
   The basic nature of the hydroxides increases progressively down the group.

Single Correct Answer Type

1. **(c)** The correct order is O > F > N > C.
   From left to right, the ionization potential increases.

   $O^+: 1s^2 2s^2 2p^3$

   After losing one electron, oxygen atom acquires half-filled stable configuration, so its second ionization potential becomes larger than that for fluorine.
2. (c) $N: 1s^2 2s^2 2p^3$

   From left to right in a period, the first ionization potential increases. But in nitrogen, half-filled stable configuration is present, therefore its ionization potential is greater than that of oxygen.

3. (a) N:$1s^2 2s^2 2p^3$

From left to right in a period, the first ionization potential increases. But in nitrogen, half-filled stable configuration is present, therefore its ionization potential is greater than that of oxygen.

4. (a) In case of fluorine, it is covalent radius. In case of neon, it is van der Waals radius because it is a noble gas which is monatomic. van der Waals radius is always more than the covalent radius.

5. (c) Si < P < C < N
Electronegativity increases from left to right in a period.
Electronegativity decreases down the group in the periodic table.

6. (a) Na < Mg > Al < Si

From left to right, the ionization potential increases. But in magnesium, stable configuration is present, therefore its ionization potential is greater than that of aluminium.

Mg:$1s^2 2s^2 2p^6 3s^2$

7. (d) All of these are isoelectronic ions.
In isoelectronic species, as the number of protons (atomic number) goes on increasing, size goes on decreasing due to stronger attraction on the electrons.

8. (b) [Ne]$3s^2 3p^3$

From left to right in a period, the first ionization potential increases. Down the group, ionization potential decreases. In option (c), half-filled stable configuration is also present.

9. (d) Option (d) is incorrect because for transition elements, the *d*-subshells are filled with electrons regularly with increase in atomic number.

10. (b) In the periodic table, inert pair effect increases down the group. So in group 14, the stability of smaller oxidation state of +2 goes on increasing down the group. This makes Pb^{2+} a stable oxidation state.
In $Fe^{2+}(3d^6)$, the *d*-orbital is not completely filled. $Ag^+(4d^{10})$ is the most stable oxidation state of silver because due to fully filled *d*-subshell, removal of the second electron is very difficult.

11. (d) Mg^{2+} : $1s^2 2s^2 2p^6$

No unpaired electron

Ti^{3+}:$1s^2 2s^2 2p^6 3s^2 3p^6 3d^1$

One unpaired electron

V^{3+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2$

Two unpaired electrons

Fe^{2+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

Four unpaired electrons

12. (b) Na(z=11):$1s^2 2s^2 2p^6 3s^1$

Na^+:$1s^2 2s^2 2p^6$

After losing the first electron, sodium acquires a very stable noble gas configuration. Therefore, its second ionization potential is very high. So, it is incorrect to say that the second ionization potential of Mg is greater than the second ionization potential of Na.

13. (a) The correct order of acidic strength is

$Cl_2O_7 > SO_2 > P_4O_{10}$.

In the periodic table, the acidic nature of oxides increases from left to right. Acidic nature of oxides decreases down the group.

14. (b) $F^- < O^{2-} < N^{3-}$
All of these are isoelectronic ions.
In isoelectronic species, as the number of protons (atomic number) goes on increasing, the size goes on decreasing due to stronger attraction on the electrons.

15. (a) In hydrides of group 16, boiling point increases down the group because of increasing molecular mass. But water has an exceptionally high boiling point because it shows intermolecular hydrogen bonding.

16. (b) From left to right in a period, the first ionization potential increases. Down the group, ionization potential decreases.

Multiple Correct Answers Type

1. (a), (c), (d) Only (b) seems to be incorrect because in many cases, stable valency states are difficult to predict on the basis of the periodic table.

2. (a), (b) When the hydration energy is more than the lattice energy, the salt is soluble in water and vice versa.

3. (d) $Ti^{4+} < Mn^{7+}$
Higher the value of positive charge on the cation, the smaller the ionic size.

Assertion-Reasoning Type

1. (c) Statement-II is incorrect. In general, the electron affinity decreases down the group but the electron affinity for chlorine is more than that for fluorine, and similarly the electron affinity

for sulphur is more than that for oxygen because in F and S, due to small size of the atom, the electrons are already crowded. Entry of one more electron results in more repulsions, which leads to absorption of some energy, so the energy released is less than what is expected.

2. (c) Statement-II is incorrect. The first ionization energy of Be is greater than that of B because of its relatively stable electronic configuration. $2p$-orbital is rather higher in energy than $2s$.

Integer Answer Type

1. (6) For $n = 4$, orbitals are

0	−1	0	+1	−2	−1	0	+1	+2
				−3	−2	−1	0	+1	+2	+3

Total number of orbitals having $\{|m_l| = 1\} = 6$

Total number of electrons having $\left\{|m_l| = 1 \text{ and } m_s = -\frac{1}{2}\right\} = 6$

Subjective Type

1. (a) The decreasing order of ionic size is $O^{2-} > F^- > Na^+ > Mg^{2+}$.
All of these are isoelectronic ions.
In isoelectronic species, as the number of protons (atomic number) goes on increasing, size goes on decreasing due to stronger attraction on the electrons.

(b) The increasing order of first ionization energy is

Na < Al < Mg < Si

From left to right, the ionization energy increases. But in magnesium, stable configuration is present. Therefore, its ionization energy is greater than that of aluminium.

$Mg: 1s^2 2s^2 2p^6 3s^2$

(c) The increasing order of bond length is $N_2 < O_2 < F_2 < Cl_2$.
In nitrogen, triple bond is present which has the smallest bond length. In oxygen, double bond is present, which has smaller bond length than single bonds. In chlorine, bond length is larger than in fluorine due to larger size of the atom.

(d) The increasing order of size is

$Al^{+3} < Ca^{+2} < Cl^{\ominus} < S^{-2}$

All of these are isoelectronic ions.
In isoelectronic species, as the number of protons (atomic number) goes on increasing, size goes on decreasing due to stronger attraction on the electrons.

2. From left to right in the periodic table, the ionization energy increases; therefore, the first ionization energy of carbon atom is greater than that of boron.
The second ionization energy of boron is greater than that of carbon because after losing one electron, boron acquires a stable electronic configuration.

$B(z = 5): 1s^2 2s^2 2p^1$

$B^+: 1s^2 2s^2$

3. The increasing order of ionic sizes is

$Mg^{2+} < Na < F^- < O^{2-} < N^{3-}$

All of these are isoelectronic ions.
In isoelectronic species, as the number of protons (atomic number) goes on increasing, size goes on decreasing due to stronger attraction on the electrons.

4. $Al^{3+} < Mg^{2+} < Li^+ < K^+$
Al^{3+} and Mg^{2+} are isoelectronic ions.
In isoelectronic species, as the number of protons (atomic number) goes on increasing, size goes on decreasing due to stronger attraction on the electrons. K^+ is larger than Li^+ because on moving down the group, size decreases.

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (b)	2. (a)	3. (b)	4. (b)	5. (d)	6. (c)	7. (c)	8. (d)	9. (d)	10. (b)
11. (c)	12. (d)	13. (b)	14. (b)	15. (b)	16. (c)	17. (b)	18. (b)	19. (c)	20. (d)

21. (b)	22. (a)	23. (c)	24. (a)	25. (c)	26. (a)	27. (a)	28. (c)	29. (c)	30. (d)
31. (d)	32. (d)	33. (c)	34. (c)	35. (c)	36. (a)	37. (b)	38. (d)	39. (d)	40. (c)
41. (a)	42. (a)	43. (b)	44. (d)	45. (a)	46. (b)	47. (c)	48. (d)	49. (a)	50. (a)
51. (a)	52. (c)	53. (c)	54. (a)	55. (a)	56. (d)	57. (c)	58. (b)	59. (c)	60. (b)
61. (d)	62. (d)	63. (a)	64. (d)	65. (a)	66. (d)	67. (d)	68. (b)	69. (a)	70. (d)
71. (b)	72. (d)	73. (a)	74. (b)	75. (a)	76. (c)				

JEE (Advanced) Exercises

Single Correct Answer Type

1. (d)	2. (a)	3. (a)	4. (d)	5. (d)	6. (a)	7. (c)	8. (c)	9. (b)	10. (c)
11. (a)	12. (a)	13. (b)	14. (b)	15. (a)	16. (c)	17. (a)	18. (d)	19. (c)	20. (d)
21. (c)	22. (a)	23. (a)	24. (c)	25. (b)	26. (b)	27. (c)	28. (a)	29. (c)	30. (c)
31. (a)	32. (a)	33. (b)	34. (b)	35. (c)	36. (c)	37. (b)	38. (b)	39. (d)	40. (b)
41. (c)	42. (c)	43. (a)	44. (d)	45. (d)	46. (d)	47. (d)	48. (a)	49. (d)	50. (b)
51. (b)	52. (c)	53. (b)	54. (b)	55. (a)	56. (b)	57. (c)	58. (b)	59. (b)	60. (d)
61. (a)	62. (c)	63. (b)	64. (b)	65. (b)	66. (a)	67. (a)	68. (d)	69. (b)	70. (b)
71. (b)	72. (d)	73. (b)	74. (c)	75. (d)					

Multiple Correct Answers Type

1. (a), (b), (c)	2. (a), (b), (c)	3. (a), (b), (c)	4. (a), (c), (d)	5. (b), (c), (d)
6. (b), (c)	7. (a), (c), (d)	8. (a), (c), (d)	9. (b), (c), (d)	10. (a), (b), (d)
11. (a), (b), (c)	12. (a), (b), (d)	13. (a), (b), (c)	14. (a), (c), (d)	15. (a), (b), (d)
16. (b), (c), (d)	17. (a), (c), (d)	18. (a), (c), (d)	19. (a), (b), (c), (d)	20. (c), (d)
21. (a), (b), (d)	22. (a), (d)	23. (a), (c), (d)	24. (a), (b)	25. (a), (c), (d)
26. (a), (b), (c), (d)	27. (b), (c), (d)	28. (b), (c), (d)	29. (a), (b), (d)	30. (a), (d)
31. (a), (c), (d)	32. (a), (b)			

Comprehension Type

1. (d) 2. (c) 3. (b) 4. (a) 5. (a) 6. (d)

Assertion-Reasoning Type

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

Matching Column Type

1. (a) s; (b) p; (c) q; (d) r
2. (a) q; (b) s; (c) r
3. (a) p, r; (b) r, s; (c) p, q, r
4. (a) p, q, r; (b) p, q, r; (c) p, q, s
5. (a) p, r, s; (b) p, q, s; (c) s; (d) p, q, r, s
6. (a) p, s, t; (b) q, r; (c) q, r; (d) s, t
7. (a) q, r; (b) p, q, r; (c) p, q, s

Integer Answer Type

1. (13) 2. (2) 3. (3) 4. (4.55) 5. (125) 6. (3) 7. (1) 8. (7.55) 9. (6) 10. (19)
11. (1960)

NCERT Exemplar Exercises

Single Correct Answer Type

1. (b) 2. (a) 3. (c) 4. (c) 5. (c) 6. (c) 7. (d) 8. (c)
9. (i) (c), (ii) (c), (iii) (c), (iv) (a), (v) (b) 10. (a)

Multiple Correct Answers Type

1. (a), (d) 2. (a), (d) 3. (a), (c), (d) 4. (b), (c)
5. (b), (c) 6. (a), (d) 7. (a), (c) 8. (a), (c)

Assertion-Reasoning Type

1. (b) 2. (c)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (b) 2. (d) 3. (a) 4. (d) 5. (a) 6. (a) 7. (c) 8. (b) 9. (b) 10. (d)
11. (a) 12. (c) 13. (c) 14. (b)

JEE (Advanced) Exercises

Single Correct Answer Type

1. (c) 2. (c) 3. (a) 4. (a) 5. (c) 6. (a) 7. (d) 8. (b) 9. (d) 10. (b)
11. (d) 12. (b) 13. (a) 14. (b) 15. (a) 16. (b)

Multiple Correct Answers Type

1. (a), (c), (d) 2. (a), (b) 3. (d)

Assertion-Reasoning Type

1. (c) 2. (c)

Integer Answer Type

1. (6)

9

Chemical Bonding (Part-B)

JEE (Main) Exercises

Single Correct Answer Type

1. In which of the following is the O—N—O bond angle highest?
   (a) NO_2 (b) NO_2^+
   (c) NO_2^- (d) NO_3^-
2. Which of the following has higher bond dipole moment?
   (a) H—C (b) N—O
   (c) P—H (d) None of these
3. Which of the following orbital is more directional?
   (a) *s*-orbital (b) *p*-orbital
   (c) *sp*-orbital (d) None of these
4. Select the incorrect geometry for hybridization:
   (a) sp = linear (b) sp^3d = T.B.P.
   (c) sp^3d^2 = P.B.P (d) All are correct
5. In benzene, what is the hybridization on each carbon atom?
   (a) sp^2 (b) sp^3
   (c) sp^3d (d) sp
6. What hybridization is expected on the central atom of each of the following molecules?
   (i) BeH_2 (ii) CH_2Br_2
   (iii) PF_6^- (iv) BF_3
   (a) sp^2, sp, sp^3, sp^2 (b) sp, sp^3, sp^3d, sp^2
   (c) sp, sp^3, sp^3d^2, sp^2 (d) sp^2, sp, sp^2, sp^3
7. Predict the geometry of the following species and describe the hybridization on the central atom:
   (i) $PbCl_4$ (ii) SbF_6^-
   (iii) BH_4^- (iv) PCl_3
   (a) Tetrahedral sp^2, octahedral sp^3d^3, tetrahedral sp^3, tetrahedral sp^3, respectively
   (b) Tetrahedral sp^3, octahedral sp^3d^2, tetrahedral sp^3, tetrahedral sp^3, respectively
   (c) Tetrahedral sp^3, octahedral sp^3d^2, tetrahedral sp^3, pyramidal sp^3, respectively
   (d) Trigonal planar sp^2, octahedral sp^3d^2, tetrahedral sp, tetrahedral sp^2, respectively
8. What is the value of 1D in SI units?
   (a) 3.336×10^{-30} cm (b) 33.36×10^{-30} cm
   (c) 333.6×10^{-30} cm (d) None of these
9. Arrange the following types of interactions in order of increasing stability (covalent, van der Waals' force, hydrogen bonding):
   (a) Hydrogen bonding < covalent < van der Waals' force
   (b) Covalent < hydrogen bonding < van der Waals' force
   (c) Hydrogen < van der Waals' force < covalent bonding
   (d) van der Waals' force < hydrogen bonding < covalent
10. Which of the following is the correct order of strength of H-bonding in the given compound?

(a) $HF < NH_3$ (b) $H_2O > H_2O_2$
(c) $H_2O_2 > H_2O$ (d) $NH_3 > H_2O$

11. Which of the following molecule has a planar structure?
(a) O_2SF_2 (b) OSF_2
(c) XeF_4 (d) ClO_4^-

12. What is the shape of ClF_2^- ion?
(a) Bent (b) Linear
(c) Pyramidal (d) None of these

13. Which of the following molecule is not hypovalent but completes its octet?
(a) $AlCl_3$ (b) $AlBr_3$
(c) AlF_3
(d) All are hypovalent and complete their octet

14. Which of the following species are planar?
(a) I_3^-, XeF_2, ClF_3 (b) H_2O, $\bar{O}Cl$, ICl_2^+
(c) XeF_5^-, XeF_4, BF_3 (d) All are correct

15. In which of the following molecules are all the bonds not of equal length?
(a) BCl_3 (b) PF_5
(c) CF_4 (d) SF_6

16. The pair having similar geometry is:
(a) BH_3, NH_3 (b) BeH_2, H_2O
(c) CH_4, CCl_4 (d) IF_5, PF_5

17. Which of the following molecules is not tetrahedral?
(a) CF_4 (b) SF_4
(c) CH_4 (d) SiF_4

18. Which of the following pair does not have similar geometries?
(a) CH_4, CCl_4 (b) BF_3, NH_3
(c) H_2O, H_2S (d) PCl_5, $SbCl_5$

19. Which type of shape is found in SF_2 molecule?
(a) V-shaped (b) Bipyramidal
(c) Linear (d) Irregular tetrahedron

20. Which of the following molecule/ion has a triangular pyramidal shape?
(a) BF_3 (b) H_3O^+
(c) NO_3^- (d) CO_3^{2-}

21. Graphite has a two-dimensional layer structure and the nearest layers are joined together by:
(a) Electrovalent bonds (b) Covalent bonds
(c) van der Waals' forces (d) Metallic bonds

22. In XeF_2, XeF_4, and XeF_6, the number of lone pairs on Xe, respectively, is:
(a) 2, 3, 1 (b) 1, 2, 3
(c) 4, 1, 2 (d) 3, 2, 1

23. The correct sequence of decrease in bond angles of following hydrides is:
(a) $NH_3 > PH_3 > AsH_3 > SbH_3$
(b) $NH_3 > AsH_3 > PH_3 > SbH_3$
(c) $SbH_3 > AsH_3 > PH_3 > NH_3$
(d) $PH_3 > NH_3 > AsH_3 > SbH_3$

24. A lone pair of electrons in an atom implies:
(a) A pair of valence electrons
(b) A pair of electrons
(c) A pair of electrons involved in bonding
(d) A pair of electrons not involved in bonding

25. Which of the following is soluble in water?
(a) CS_2 (b) C_2H_5OH
(c) CCl_4 (d) $CHCl_3$

26. Which one of the following groupings represents a collection of isoelectronic species?
[At. No.: Cs = 55, Br = 35]
(a) Be, Al^{3+}, Cl^- (b) Ca^{2+}, Cs^+, Br
(c) Na^+, Ca^{2+}, Mg^{2+} (d) N^{3-}, F^-, Na^+

27. The pair of species having identical shapes for molecules of both species is:
(a) BF_3, PCl_3 (b) PF_5, IF_5
(c) CF_4, SF_4 (d) XeF_2, CO_2

28. Which of the following ion is not tetrahedral in shape?
(a) BF_4^- (b) NH_4^+
(c) SF_4 (d) CF_4

29. Which of the following are arranged in the decreasing order of dipole moment?
(a) CH_3Cl, CH_3Br, CH_3F (b) CH_3Cl, CH_3F, CH_3Br
(c) CH_3Br, CH_3Cl, CH_3F (d) CH_3Br, CH_3F, CH_3Cl

30. Paramagnetism of oxygen is explained on the basis of which of the following electronic configuration?
(a) $1s^22s^22p^6$ (b) $1s^22s^22p^4$
(c) $1s^22s^2$ (d) None of these

31. An example of a polar covalent compound is:
(a) KCl (b) NaCl
(c) CCl_4 (d) HCl

32. Among the following, the molecule with the highest dipole moment is:
(a) CH_3Cl (b) CH_2Cl_2
(c) $CHCl_3$ (d) CCl_4

33. Shape of O_2F_2 is similar to that of:
(a) C_2F_2 (b) H_2O_2
(c) H_2F_2 (d) C_2H_2

34. The states of hybridization of boron and oxygen atoms in boric acid (H_3BO_3), respectively, are:
(a) sp^2 and sp^2 (b) sp^2 and sp^3
(c) sp^3 and sp^2 (d) sp^3 and sp^3

35. Decreasing order of C—C length in I. C_2H_4, II. C_2H_2, III. C_6H_6, IV. C_2H_6 is:
(a) IV > III > I > II (b) I > II > IV > III
(c) II > I > IV > III (d) IV > I > III > II

36. Which carbon is more electronegative?
(a) sp^3-hybridized carbon
(b) sp-hybridized carbon
(c) sp^2-hybridized carbon
(d) Always same irrespective of its hybrid state

37. Which of the following is least volatile?
(a) HF (b) HCl
(c) HBr (d) HI

38. Which of the following is not electron deficient?
(a) NH_3 (b) BF_3
(c) $AlCl_3$ (d) BH_3

39. Lattice energy of ionic compounds depends upon:
(a) Packing of ions only
(b) Charge and size of ions
(c) Charge on ion only
(d) Size of ions only

40. Which of the following gives the correct arrangement of compounds based on their bond strength?
(a) HF > HCl > HBr > HI (b) HI > HBr > HCl > HF
(c) HF > HBr > HCl > HI (d) HCl > HF > HBr > HI

41. Ionic compounds are formed most easily with:
(a) Low E.A., high I.E. (b) High E.A., low I.E.
(c) Low E.A., low I.E. (d) High E.A., high I.E.

42. Which of the following gas is linear?
(a) CO_2 (b) SO_2
(c) NO_2 (d) SO_3

43. Correct order of boiling point is:
(a) HF > HI > HBr > HCl
(b) HF > HBr > HI > HCl
(c) HCl > HBr > HI > HF
(d) HCl > HI > HBr > HF

44. Correct order of bond length is:
(a) $CO_3^{2-} > CO_2 > CO$ (b) $CO_2 > CO > CO_3^{2-}$
(c) $CO > CO_2 > CO_3^{2-}$ (d) None of these

45. Which molecule is only electron donor?
(a) NH_3 (b) BF_3
(c) PF_5 (d) AsF_5

46. Which of the following is sp^3-hybridized?
(a) NH_3 (b) BeH_2
(c) PCl_5 (d) $AlCl_3$

47. Among the following bonds, which has the most polar character?
(a) C — O (b) C — Br
(c) C — F (d) C — S

48. Octet rule is not valid for which of the following molecule?
(a) CO_2 (b) H_2O
(c) O_2 (d) CO

49. Which of the following has a giant covalent structure?
(a) PbO_2 (b) SiO_2
(c) NaCl (d) $AlCl_3$

50. In which of the following is the angle between the two covalent bonds greatest?
(a) CO_2 (b) CH_4
(c) NH_3 (d) H_2O

51. The correct order regarding the electronegativity of hybrid orbitals of carbon is:
(a) $sp < sp^2 > sp^3$ (b) $sp < sp^2 < sp^3$
(c) $sp > sp^2 < sp^3$ (d) $sp > sp^2 > sp^3$

52. The lattice energy order for lithium halide is:
(a) LiF > LiCl > LiBr > LiI
(b) LiCl > LiF > LiBr > LiI
(c) LiBr > LiCl > LiF > LiI
(d) LiI > LiBr > LiCl > LiF

53. π-Bonding occurs in each of the following except:
(a) CO_2 (b) C_2H_4
(c) CN^- (d) CH_4

54. The structure of XeF_4 is:
(a) Planar (b) Tetrahedral
(c) Square planar (d) Pyramidal

55. Compound formed by sp^3d-hybridization will have which of the following structure?
(a) Trigonal bipyramidal (b) T-shaped
(c) Linear
(d) Either of these depending on the number of lone pair of electrons on central atom

56. Which bond is more polar?
(a) Cl — Cl (b) N — F
(c) C — F (d) O — F

57. Which of the following has the highest bond angle?
(a) H_2O (b) H_2S
(c) NH_3 (d) PH_3

58. Which of the following has the lowest bond angle?
(a) NH_3 (b) BeF_2
(c) H_3O^+ (d) CH_4

59. Coordiante compounds are formed by:
(a) Transfer of electrons (b) Sharing of electrons
(c) Donation of electron pair
(d) None of these

60. Compounds formed by sp^3d^2-hybridization will have which of the following geometry?
(a) Square planar (b) Octahedral
(c) Trigonal bipyramidal (d) Pentagonal bipyramidal

61. As compared to covalent compounds, electrovalent compounds generally have:
(a) High m.pt. and low b.pt.
(b) Low m.pt. and high b.pt.
(c) High m.pt. and high b.pt.
(d) Low m.pt. and low b.pt.

62. Which of the following statement is not correct?
(a) Pi-bond always exists with sigma-bond according to V.B.T.
(b) Pi-bond can exist independently according to V.B.T.
(c) Pi-bond is weaker than sigma-bond
(d) Sigma-bond is less reactive than pi-bond

63. Which hybridization results in nonplanar orbitals?
(a) sp (b) sp^2
(c) sp^3 (d) dsp^2

64. For which of the following hybridization is the bond angle maximum?
(a) sp^2 (b) sp
(c) sp^3 (d) dsp^2

65. Among liq HF, liq NH_3, CH_4, CH_3OH, and N_2O_4, intermolecular hydrogen bond is expected in:
(a) All (b) All leaving one
(c) Three (d) None of these

66. CO_2 is isostructural with:
(a) $SnCl_2$ (b) $HgCl_2$
(c) H_2O (d) SCl_2

67. Which of the following has the shortest carbon–carbon bond length?
(a) C_6H_6 (b) C_2H_6
(c) C_2H_4 (d) C_2H_2

68. Which group of atoms have nearly the same atomic radius?
(a) Na, K, Rb, Cs (b) Li, Be, B, C
(c) Fe, Co, Ni (d) F, Cl, Br, I

69. Which set have the strongest tendency to form anions?
(a) Ga, In, Te (b) Na, Mg, Al
(c) N, O, F (d) V, Cr, Mn

70. A molecule in which sp^2-hybrid orbitals are used by the central atom in forming covalent bond is:
(a) He_2 (b) SO_2
(c) PCl_5 (d) N_2

71. Which has a zero dipole moment?
(a) ClF (b) PCl_3
(c) SiF_4 (d) $CFCl_3$

72. The hybridization of carbon atoms in C—C single bond of $CH \equiv C - CH = CH_2$ is:
(a) sp^3–sp^3 (b) sp^2–sp^3
(c) sp–sp^2 (d) sp^3–sp

73. Which has the lowest anion to cation size ratio?
(a) LiF (b) NaF
(c) CsI (d) CsF

74. In allene structure, three carbon atoms are joined by:
(a) Three σ- and three π-bonds
(b) Two σ- and one π-bond
(c) Two σ- and two π-bonds
(d) Three π- bonds only

75. H-bonding is not present in:
(a) Glycerine (b) Water
(c) H_2S (d) HF

76. 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^-

77. Which of the following has a regular tetrahedral geometry?
(a) SF_4 (b) BF_4^-
(c) XeF_4 (d) ClF_3

78. Which of the following has the least bond energy?
(a) H_2 (b) Mg_2
(c) F_2 (d) O_2^{2-}

79. Which is the best description of a covalent bond?
(a) Electrons are simultaneously attracted by more than one nucleus
(b) Filled orbitals of two or more atoms overlap one another

(c) Unoccupied orbitals of two or more atoms overlap one another

(d) Oppositely charged ions attract one another

80. Deduce the geometry of each of the following molecules:

(i) NH_3 (ii) C_2H_4 (iii) ClO_3^-

(a) Pyramidal, pyramidal, tetrahedral

(b) Pyramidal, tetrahedral, pyramidal

(c) Pyramidal, planar, tetrahedral

(d) Pyramidal, planar, pyramidal

81. What are the hybridization states of each carbon atom-(s) in the following molecules?

(i) $CH_3\dot{C}H_2CH_2CH_3$

(ii) $CH_2=CH-CH=CH_2$

(iii) $CH_3\dot{C}H=CH-CH_3$

(iv) $H-\dot{C}\equiv C-H$

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

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

82. Determine the geometry of each of the following molecules and hybridization about the central atom:

(i) $BeF_2(g)$ (ii) AlH_3 (iii) $CH\equiv CH$

(a) *sp* linear, sp^2 trigonal planar, sp^2 planar, respectively

(b) sp^2 planar, *sp* linear, sp^2 planar, respectively

(c) *sp* trigonal planar, sp^2 linear, sp^2 planar, respectively

(d) *sp* linear, sp^2 trigonal planar, *sp* linear, respectively

83. What is the hybridization of CH_2^{2+} ion?

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

(c) *sp* (d) sp^3d

84. What is the hybridization and shape of XeO_3 and ClO_4^-, respectively?

(a) sp^3 tetrahedral, sp^3 tetrahedral

(b) sp^3 tetrahedral, sp^3 pyramidal

(c) sp^3 pyramidal, sp^3 tetrahedral

(d) None of these

85. Which of the following molecule has a see-saw geometry?

(a) I_3^- (b) ICl_2^-

(c) ClF_3^- (d) $IO_2F_2^-$

86. The dipole moment of HBr is 2.60×10^{-30} cm and the interatomic spacing is 1.41 Å. What is the per cent ionic character of HBr?

(a) 10.11% (b) 9.11%

(c) 11.5% (d) 15%

87. A diatomic molecule has a dipole moment of 1.2 D, if its bond distance is 1.0 Å. What fraction of an electronic charge *e* exists on each atom?

(a) 20% of *e* (b) 21% of *e*

(c) 19% of *e* (d) 25% of *e*

88. Which of the possible molecule/species is having maximum values for dipole moment (where "A" is the central atom)?

(a) AX_3 (having one lone pair on central atom)

(b) AX_4 (tetrahedral)

(c) AX_4Y (having no lone pair on central atom)

(d) Cannot be predicted

89. Which of the following is an incorrect match?

(a) SiF_4 : Can act as Lewis acid

(b) Benzyne : All C-atoms are sp^2-hybridized

(c) PBr_3 : Nonpolar

(d) $CHF=C=CHF$: Nodal planes of π-bonds are not lying in the same plane

90. Which of the following two species have the same shape?

(I) NI_3 (II) I_3^- (III) SO_3^{2-} (IV) NO_3^-

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

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

91. SbF_5 reacts with XeF_4 and XeF_6 to form ionic compounds $[XeF_3^+][SbF_6]^-$ and $[XeF_5^+][SbF_6^-]$. The geometry of XeF_3^+ ion and XeF_5^+ ion, respectively, is:

(a) Square pyramidal, T-shaped

(b) Bent T-shaped, square pyramidal

(c) See-saw, square pyramidal

(d) Square pyramidal, see-saw

92. Which of the following is a neutral oxide?

(a) NO (b) NO_2

(c) N_2O_3 (d) N_2O_5

93. Which of the following is isoelectronic and isostructural with CO_2?

(a) NO_2 (b) NO_3^-

(c) NO_2^- (d) N_2O

94. Which out of SO_4^{2-}, SF_4, and SF_2 does not undergo sp^3-hybridization?

(a) SO_4^{2-} (b) SF_2 and SO_4^{2-}

(c) SF_2 (d) SF_4

95. In a system, the formation of chemical bond always decreases its:

(a) Kinetic energy (b) Potential energy

(c) Repulsive forces (d) Coordinate bond

96. Which one of the following arrangements of molecules is correct on the basis of the dipole moment?
(a) $BF_3 > NF_3 > NH_3$ (b) $NF_3 > BF_3 > NH_3$
(c) $NH_3 > BF_3 > NF_3$ (d) $NH_3 > NF_3 > BF_3$

97. Fluorine molecule is formed by:
(a) The axial *p–p* orbital overlap
(b) The side ways *p–p* orbital overlap
(c) The *s–s* orbital overlap
(d) The *s–p* orbital overlap

98. Which of the following has sp^2-hybridization?
(a) SO_2 (b) H_2O
(c) NH_3 (d) SO_3^{2-}

99. Chemical bond implies:
(a) Repulsion
(b) Attraction
(c) Attraction and repulsion
(d) None of these

100. In OF_2, the number of bond pairs and lone pairs of electrons is, respectively:
(a) 2, 6 (b) 2, 8
(c) 2, 10 (d) 2, 9

101. Which of the following does not contain a coordinate bond?
(a) BH_4^- (b) NH_4^+
(c) CO_3^{2-} (d) H_3O^+

JEE (Advanced) Exercises

Single Correct Answer Type

1. Which of the following are isoelectronic and isostructural: NO_3^-, CO_3^{2-}, ClO_3^-, SO_3?
(a) NO_3^- and CO_3^{2-} (b) SO_3 and NO_3^-
(c) ClO_3^- and CO_3^{2-} (d) CO_3^{2-} and SO_3

2. Which one of the following is a planar molecule?
(a) NH_3 (b) H_3O^+
(c) BCl_3 (d) PCl_3

3. If the molecule of HCl were totally polar, the expected value of dipole moment is 6.12 D but the experimental value is 1.03 D. Calculate the percentage ionic character:
(a) 17 (b) 83
(c) 50 (d) 0

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) $X \rightarrow Y$

5. Two ice cubes are pressed over each other and united to form one cube. Which force is responsible for holding them together?
(a) van der Waals' forces (b) Covalent attraction
(c) Hydrogen bond formation
(d) Dipole–dipole attraction

6. Multiple covalent bonds exist in the molecule of:
(a) F_2 (b) H_2
(c) N_2 (d) C_2H_6

7. The type of bonds present in $CuSO_4 \cdot 5H_2O$ are ..... only:
(a) Electrovalent and covalent
(b) Electrovalent and coordinate
(c) Electrovalent, covalent, coordinate, and H-bond
(d) Covalent and coordinate

8. Carbon atoms in $C_2(CN)_4$ are:
(a) *sp*-hybridized (b) sp^2-hybridized
(c) *sp*-and sp^2-hybridized
(d) *sp*, sp^2, and sp^3-hybridized

9. A triple bond is made of:
(a) One σ- and two π-bonds
(b) Two σ- and one π-bond
(c) Three σ- and three π-bonds
(d) One σ- and four π-bonds

10. The bonds present in N_2O_5 are:
(a) Ionic (b) Covalent and coordinate
(c) Covalent (d) Ionic and covalent

11. In which of the following molecules are all bonds not equal?
(a) AlF_3 (b) NF_3
(c) ClF_3 (d) BF_3

12. The hybridizations 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

13. The shape of ClO_4^- ion is:
(a) Square planar (b) Square pyramidal
(c) Tetrahedral (d) Trigonal bipyramidal

14. Which of the following species has a linear shape?

(a) NO_2^+ (b) O_3

(c) NO_2^- (d) SO_2

15. Which of the following is not isostructural with $SiCl_4$?

(a) PO_4^{3-} (b) NH_4^+

(c) SCl_4 (d) SO_4^{2-}

16. Which of the following has sp^2-hybridization?

(a) CO_2 (b) SO_2

(c) N_2O (d) CO

17. Intramolecular hydrogen bonding is found in:

(a) Salicyldehyde (b) Water

(c) Acetaldehyde (d) Phenol

18. Which combination is best explained by the coordinate covalent bond?

(a) $H_2 + I_2$ (b) $Mg + \frac{1}{2}O_2$

(c) $Cl + Cl$ (d) $H^+ + H_2O$

19. Two elements X and Y have following electronic configurations:

$X = 1s^2, 2s^2\ 2p^6, 3s^2\ 3p^6, 4s^2$ and

$Y = 1s^2, 2s^2\ 2p^6, 3s^2\ 3p^5$

The compound formed by the combination of X and Y is:

(a) XY_2 (b) X_5Y_2

(c) X_2Y_5 (d) XY_5

20. The hybridization of carbon in diamond, graphite, and acetylene is:

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

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

21. The angle between two covalent bonds is maximum in:

(a) CH_4 (b) H_2O

(c) CO_2 (d) SO_3

22. CO_2 has the same geometry as:

(i) $HgCl_2$ (ii) NO_2 (iii) $SnCl_4$ (iv) C_2H_2

(a) (i) and (iii) (b) (ii) and (iv)

(c) (i) and (iv) (d) (iii) and (iv)

23. Which of the following is an electron-deficient compound? (a) NH_3

(b) ICl

(c) BCl_3 (d) PCl_3

24. The bond between atoms of two elements of atomic number 37 and 53 is:

(a) Covalent (b) Ionic

(c) Coordinate (d) Metallic

25. The weakest among the following is:

(a) Ionic bond (b) Covalent bond

(c) Metallic bond (d) van der Waals' forces

26. An atom with atomic number 20 is most likely to combine chemically with the atom whose atomic number is:

(a) 11 (b) 16

(c) 18 (d) 10

27. Which of the following molecules will have a dipole moment?

(a) CO_2 (b) CCl_2

(c) XeF_2 (d) BeF_2

28. Which of the following molecules does not possess a permanent electric dipole moment?

(a) H_2S (b) SO_2

(c) SO_3 (d) CS_2

29. Among the following metals, interatomic forces are probably the weakest in:

(a) Cu (b) Ag

(c) Zn (d) Hg

30. The octet rule is not followed in:

(a) F_2 (b) NaF

(c) CaF_2 (d) BF_3

31. In which of the following is the bond angle maximum?

(a) NH_3 (b) NH_4^+

(c) PCl_3 (d) SCl_2

32. Which one of the following molecules will form a linear polymeric structure due to H-bonding:

(a) HCl (b) H_2O

(c) H_2S (d) NH_3

33. Which among the following has the largest dipole moment?

(a) NH_3 (b) H_2O

(c) HI (d) SO_3

34. In which of the following pairs is the bond angle 109° 28′?

(a) $[NH_4^+], [BF_4^-]$ (b) $[NH_4^+], [BF_3]$

(c) $NH_3, [BF_4^-]$ (d) $[NH_3], [BF_3]$

35. The pair of species having identical shape of both species is:

(a) BF_3, PCl_3 (b) PF_5, IF_5

(c) CF_4, SF_4 (d) XeF_2, CO_2

36. Which pair of molecules will have a permanent dipole moment for both members?

(a) NO_2 and O_3 (b) SiF_4 and CO_2
(c) SiF_4 and NO_2 (d) NO_2 and CO_2

37. The percentage *s*-character of the central atom in beryllium fluoride is:
(a) 25% (b) 33.3%
(c) 50% (d) 20%

38. In which of the following sets do we have sp^3d-hybridization?
(a) XeF_2, IBr_3, XeO_3 (b) IBr_3, SF_5^+, SF_5^-
(c) XeF_2, IBr_3, SF_5^+ (d) SF_5^+ and SF_5^-

39. Select the correct order for covalent radii:
(a) Octahedral radii > linear radii > tetrahedral radii
(b) Octahedral radii > tetrahedral radii > linear radii
(c) Linear radii > tetrahedral radii > octahedral radii
(d) Tetrahedral radii > octahedral radii > linear radii

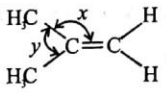
40. Which molecule among AX_3, AX_4, AX_5, and AX_6 is most likely to have a trigonal bipyramidal structure if *A* has no lone pair?
(a) AX_3 (b) AX_5
(c) Both (a) and (b) (d) AX_6

41. Which of the following structure is analogous of SO_3^{2-}?
(a) F_2SeO (b) F_2SeO_2
(c) SO_4^{2-} (d) SO_2

42. Select the correct statement:
(a) SF_4, CH_4, $SiCl_4$, and CCl_4 have tetrahedral structure
(b) BF_3, ClF_3, and ICl_3 have trigonal planar structure
(c) XeF_2, $BeCl_2$, and ICl_2^- have linear structure
(d) All are correct

43. Compare $F-\hat{I}-O$ and $F_{axial}-\hat{I}-F_{axial}$ bond angle in IOF_3 molecule:
(a) $F-\hat{I}-O > F_{axial}-\hat{I}-F_{axial}$
(b) $F_{axial}-\hat{I}-F_{axial} > F-\hat{I}-O$
(c) $F_{axial}-\hat{I}-F_{axial} = F-\hat{I}-O$
(d) None of these

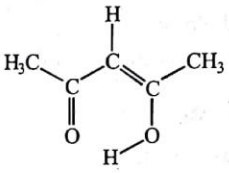
44. Compare bond angles *x* and *y* from the following molecule:



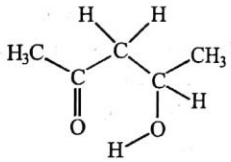
(a) $x > y$ (b) $y > x$
(c) $x = y$ (d) $x = y = 120°$

45. The dipole moment of LiH is 1.964×10^{-29} cm and the interatomic distance between Li and H in this molecule is 1.596 Å. What is the per cent ionic character in LiH?
(a) 78.6% (b) 86.7%
(c) 8.67% (d) 76.8%

46. The two molecules indicated below are capable of intramolecular hydrogen bonding which is likely to form more stable hydrogen bonds.



(*A*)



(*B*)

(a) *A* has higher H-bonding
(b) *B* has higher H-bonding
(c) Both *A* and *B* have equal H-bonding
(d) None of these

47. The HF_2^- ion exists in the solid state and also in liquid HF solution but not in dilute aqueous solution because:
(a) In aqueous solution, there is hydrogen bonding but each HF molecule hydrogen bond with the much more prevalent H_2O present instead of other HF molecules, and H_3O^+ and $F^{\ominus}$ are much more likely to be formed
(b) HF is weaker acid than H_2O
(c) HF has H-bonding
(d) None of these

48. SbF_5 reacts with XeF_4 and XeF_6 to form ionic compounds $[XeF_3^+][SbF_6]^-$ and $[XeF_5^+][SbF_6^-]$. The geometry of XeF_3^+ ion and XeF_5^+ ion, respectively, is:
(a) Square pyramidal, T-shaped
(b) Bent T-shaped, square pyramidal
(c) See-saw, square pyramidal
(d) Square pyramidal, see-saw

49. Select the correct option for following statements:
(I) sp^3 hybrid orbitals are at 90° to one another
(II) sp^3d^2 adjacent hybrid orbitals are at 90° to one another
(III) sp^2 hybrid orbitals are at 120° to one another

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

(a) T F T F (b) T T F F

(c) F T T T (d) F T F T

50. Which of the following is an example of a planar molecule having a net dipole moment?

(a) NF_3 (b) ClF_3

(c) XeO_3 (d) SO_3

51. Dipole moment is shown by:

(a) 1, 4-dichlorobenzene

(b) *cis*-1, 2-dichlorobutene

(c) *trans*-1, 2-dichlorobutene

(d) *trans*-2, 3-dichloro-2-butene

52. Which of the following has $p\pi$–$d\pi$ bonding?

(a) NO_3^- (b) SO_3^{2-}

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

53. The electronegativities of F, Cl, Br, and I are 4.0, 3.0, 2.8, and 2.5, respectively. The hydrogen halide with a high percentage of ionic character is:

(a) HF (b) HCl

(c) HBr (d) HI

54. 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 sigma bond at right angle

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

55. Which one of the following pairs of molecules will have a permanent dipole moments for both members?

(a) NO_2 and O_3 (b) SiF_4 and CO_2

(c) SiF_4 and NO_2 (d) NO_2 and CO_2

56. In the hypothetical molecule AX_2L_n (where A is central atom, X is surrounding atom, L is lone pair, n is the number of lone pair), for which possible value of "n" will the dipole moment of the molecule be minimum?

(a) Zero (b) 1

(c) 2 (d) 4

57. Which of the following is arranged in the increasing order of enthalpy of vaporization?

(a) NH_2, PH_3, AsH_3 (b) AsH_3, PH_3, NH_3

(c) NH_3, AsH_3, PH_3 (d) PH_3, AsH_3, NH_3

58. The number of π-bonds and σ-bonds in the Lewis structure of SO_3 is:

(a) 3 σ, 3 π (b) 3 σ, 2 π

(c) 3 σ, 1 π (d) None of these

59. In BrF_3 molecule, the lone pairs occupy equatorial position to minimize:

(a) Lone pair–bond pair repulsion only

(b) Bond pair–bond pair repulsion only

(c) Lone pair–lone pair repulsion and lone pair–bond pair repulsion

(d) Lone pair–lone pair repulsion only

60. The correct order of bond angles (smallest first) in H_2S, NH_3, BF_3, and SiH_4 is:

(a) $H_2S < SiH_4 < NH_3 < BF_3$

(b) $NH_3 < H_2S < SiH_4 < BF_3$

(c) $H_2S < NH_3 < SiH_4 < BF_3$

(d) $H_2S < NH_3 < BF_3 < SiH_4$

61. The molecular shapes of SF_4, CF_4, and XeF_4 are:

(a) Different with 0, 1, and 2 lone pairs of electrons on central atom, respectively

(b) Different with 1, 0, and 2 lone pairs of electrons on central atom

(c) Same with 2, 0, and 1 lone pairs

(d) Same with 1, 1 lone pair in each case

62. In silicon dioxide:

(a) One Si atom is bonded to two O atoms

(b) There are double bonds between Si and O atoms

(c) Each Si atom is surrounded by four O atoms and each oxygen atom is bonded to two Si atoms

(d) Each Si atom is surrounded by two O atoms and each O is bonded to two Si atoms

63. Which of the following statement is incorrect for the dipole moment measurement of the compound?

(a) It helps to predict the percentage ionic character in a bond

(b) It helps to predict the shape of the moelcule

(c) It helps to predict the particular *cis trans* isomers

(d) It helps to predict the bond energies of all bonds within the moelcule

64. Which of the following contains both polar and nonpolar covalent bonds?

(a) NH_4Cl (b) HCN

(c) H_2O_2 (d) CH_4

65. An sp^3 hybrid orbital contains:

(a) 1/4 *s*-character (b) 1/2 *s*-character

(c) 2/3 *s*-character (d) 3/4 *s*-character

66. Which contains a coordinate and a covalent bond?

(a) $BaCl_2$ (b) NH_4Cl

(c) HCl (d) H_2O

67. An atom of one element A has three electrons in its

outermost shell, and that of B has six electrons in the outermost orbit. The formula of the compound formed by these two will be:

(a) A_3B_6 (b) A_2B
(c) A_2B_3 (d) A_3B_2

68. Dative bond is present in:

(a) SO_3 (b) NH_3
(c) $BaCl_2$ (d) N_2

69. Which of the following pair of species is not isostructural?

(a) KrF_2, ICl_2^- (b) SO_3, SO_3^{2-}
(c) CO_3^{2-}, BO_3^{3-} (d) SiO_4^{4-}, IO_4^-

70. If "n" number of H_3PO_4 molecules are polymerized to produce chain molecule and ring molecule separately, then the number of P–O–P linkages formed is, respectively:

(a) n and $(n-1)$ (b) $(n-1)$ and $(n-1)$
(c) $(n-1)$ and n (d) n and n

71. The molecule having zero dipole moment is:

(a) CH_3Cl (b) CH_2Cl_2
(c) $CHCl_3$ (d) CCl_4

72. The solubility of KCl is relatively more in (where D in dielectric constant):

(a) C_6H_6 (D = 0) (b) $(CH_3)_2CO$ (D = 2)
(c) CH_3OH (D = 32) (d) CCl_4 (D = 0)

73. If a molecule MX_3 has a zero dipole moment, the sigma bonding orbitals used by M (at. no. < 21) are:

(a) Pure p (b) sp-hybrid
(c) sp^2-hybrid (d) sp^3-hybrid

74. In which molecule are all atoms coplanar?

(a) CH_4 (b) BF_3
(c) PF_3 (d) NH_3

75. Two lone pairs of electrons and two bond pairs are present in:

(a) NH_3 (b) BF_3
(c) CO_3^{2-} (d) NH_2^-

76. When the hybridization state of carbon atom changes from sp^3 to sp^2 and finally to sp, the angle between the hybridized orbitals:

(a) Decreases gradually (b) Decreases considerably
(c) Is not affected (d) Increases progressively

77. Which of the following is expected to have a linear structure?

(a) SO_2 (b) CO_2
(c) CO_3^{2-} (d) SO_4^{2-}

78. Which of the following phenomenon will occur when two atoms of same spin will react?

(a) Bonding will not occur
(b) Orbital overlap will not occur
(c) Both (a) and (b)
(d) None of these

79. Which is not linear?

(a) CO_2 (b) HCN
(c) C_2H_2 (d) H_2O

80. Among NH_3, $BeCl_2$, CO_2, and H_2O, the nonlinear molecules are:

(a) $BeCl_2$ and H_2O (b) $BeCl_2$ and CO_2
(c) NH_3 and H_2O (d) NH_3 and CO_2

81. Dipole moment is highest for:

(a) $CHCl_3$ (b) CH_4
(c) CHF_3 (d) CCl_4

82. Consider the following iodides:

PI_3	AsI_3	SbI_3
102°	100.2°	99°

The bond angle is maximum in PI_3 which is:

(a) Due to small size of phosphorus
(b) Due to more bond pair–bond pair repulsion in PI_3
(c) Due to less electronegativity of P
(d) None of these

83. Which of the following is the largest ion?

(a) Na^+ (b) Mg^{2+}
(c) O^{2-} (d) F^-

84. The ionization potential order for which set is correct:

(a) Li > K < Cs (b) B > Li > K
(c) Cs > Li > B (d) Cs > Li < K

85. For the type of interactions: (I) covalent bond, (II) van der Waals' forces, and (III) hydrogen bonding, which represents the correct order of increasing stability?

(a) (I) < (III) < (II) (b) (II) < (III) < (I)
(c) (II) > (III) > (I) (d) (II) = (III) = (I)

86. Which of the moelcule/species has d^3s-hybridization?

(a) CrO_2Cl_2 (b) PCl_4^+
(c) NH_4^+ (d) ClO_3^-

87. Identify the least stable ion amongst the following:

(a) Li^- (b) Be^-
(c) B^- (d) C^-

88. Identity the pair in which the two species are isostructural:

(a) SiF_4 and SF_4 (b) IO_3^+ and XeO_3
(c) BH_4^- and NH_4^+ (d) PF_6^- and SF_6

89. The total right-angles ∠ClPCl present in PCl_5, PCl_4^+, PCl_6^- are _, _, _, respectively.
(a) 0, 1, 4 (b) 6, 0, 4
(c) 2, 4, 0 (d) 6, 0, 12

90. Which molecule has a trigonal planar geometry?
(a) IF_3 (b) PCl_3
(c) NH_3 (d) BF_3

91. The molecule having permanent dipole moment is:
(a) SF_4 (b) XeF_4
(c) SiF_4 (d) BF_3

92. What is the formal charge on the chlorine atom in the oxyacid $HOClO_2$ if it contains single bonds?
(a) 2– (b) 1–
(c) 1+ (d) 2+

93. The hybridization of P in phosphate ion (PO_4^{3-}) is the same as in:
(a) I in ICl_4^- (b) S in SO_3
(c) N in NO_3^- (d) S in SO_3^{2-}

94. The electronegativity difference between N and F is greater than N and H, yet the dipole moment of NH_3 (1.5 D) is greater than that of NF_3 (0.2 D). This is because:
(a) In NH_3 as well as NF_3, the atomic dipole and bond dipole are in the opposite direction
(b) In NH_3, the atomic dipole and bond dipole are in the opposite direction, whereas in NF_3 these are in the same direction
(c) In NH_3 as well as in NF_3 the atomic dipole and bond dipole are in the same direction
(d) In NH_3, the atomic dipole and bond dipole are in the same direction, whereas in NF_3 these are in the opposite direction

95. Which of the following species have undistorted octahedral structures?
1. SF_6 2. PF_6^-
3. SiF_6^{2-} 4. XeF_6
Select the correct answer using the codes given below:
(a) 2, 3, and 4 (b) 1, 3, and 4
(c) 2 and 3 (d) 1, 2, and 3

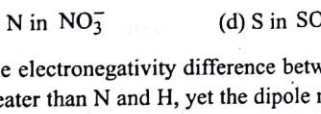
96. In the anion $HCOO^-$, the carbon–oxygen bonds are found to be of equal length. This is because:
(a) The anion $HCOO^-$ has two resonating structures
(b) The anion is obtained by the removal of a proton from the acid molecule
(c) Electronic orbitals of carbon are hybridized
(d) The C = O bond is weaker than the C — O bond

97. On analysis, a certain compound was found to contain 254 g of *X* and 80 g of *Y*. If the atomic weight of *X* is 127 and that of *Y* is 16, then the formula of the compound containing *X* and *Y* is:
(a) *XY* (b) X_2Y
(c) X_5Y_2 (d) X_2Y_5

98. How many bonding pairs and lone pairs surround the central atom in the I_3^- ion?

	Bonding pairs	Lone pairs
(a)	2	2
(b)	2	3
(c)	3	2
(d)	4	3

99. What hybrid orbitals are employed by carbon atoms 1, 2, and 3, respectively, as labeled in the compound shown?



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

100. Which reaction involves a change in the electron pair geometry for the underlined atom?
(a) $\underline{B}F_3 + F \rightarrow \underline{B}F_4^-$ (b) $\underline{N}H_3 + H^+ \rightarrow \underline{N}H_4^+$
(c) $2\underline{S}O_2 + O_2 \rightarrow 2\underline{S}O_3$ (d) $H_2\underline{O} + H^+ \rightarrow H_3\underline{O}^+$

Multiple Correct Answers Type

1. In V.B.T., the idea of hybridization was required to explain which of the following facts:
(a) The equivalence of the bonds in most of the compounds
(b) The stereochemistry of the molecules
(c) The better overlapping of the orbitals
(d) None of these

2. Which of the following molecule has/have structure similar to NH_3?
(a) PH_3 (b) H_3O^+
(c) SeF_3^+ (d) $\bar{C}H_3$

3. Which of the following properties of water is related to the hydrogen bonding?

(a) High boiling point (b) High heat of vaporization
(c) Low density of ice compared to water
(d) None of these

4. NH_3 is isoelectronic with:
(a) H_2O (b) CH_4
(c) HF (d) None of these

5. Which of the following molecule(s) is/are planar?
(a) ICl_2^- (b) IF_2^+
(c) SnI_2 (d) $CdBr_2$

6. Which of the following molecules are nonplanar and have a dipole moment?
(a) CH_2Cl_2 (b) $C_2H_2Cl_2$ (*cis*)
(c) ICl_2^- (d) NH_3

7. Which of the following molecules are planar and have an angular geometry?
(a) ClO_3^+ (b) Cl_2O^+
(c) H_3O^+ (d) BF_2^-

8. Which of the following molecule(s) have a bent shape?
(a) ClF_2^+ (b) ClF_2^-
(c) BF_2^- (d) None of these

9. Which of the following molecule(s) is/are having a square planar geometry?
(a) ICl_4^- (b) BrF_4^-
(c) XeF_4 (d) SF_4

10. Which of the following molecule(s) is/are having a linear geometry?
(a) XeF_2 (b) ICl_2^-
(c) I_3^- (d) CO_2

11. Which of the following molecule(s) is/are having a see-saw geometry?
(a) $TeBr_4$ (b) $TeCl_4$
(c) XeO_2F_2 (d) SF_4

12. Which of the following sets of moelcule(s) is/are having a V-shape but different hybridization?
(a) $SnCl_2$ and H_2O (b) SO_2 and NO_2^+
(c) BF_2^- and SCl_2 (d) OF_2 and SCl_2

13. sp^2-Hybridization is not shown by:
(a) $BeCl_2$ (b) BF_3
(c) NH_3 (d) XeF_2

14. Which statement(s) is/are correct?
(a) A double bond is shorter than a single bond
(b) A sigma bond is weaker than a π-bond
(c) A double bond is stronger than a sigma bond
(d) A covalent bond is stronger than a hydrogen bond

15. Which of the following molecule(s) is/are triangular pyramidal in shape?
(a) NH_3 (b) NCl_3
(c) PF_3 (d) BCl_3

16. Which oxide(s) of nitrogen is/are not isoelectronic with CO_2?
(a) NO_2 (b) N_2O
(c) NO (d) N_2O_2

17. Which of the following species are deficient?
(a) (b) Br^-
(c) BF_3 (d) NH_4^+

18. Which compound contains double bond or triple bond?
(a) C_2H_4 (b) H_2O
(c) N_2 (d) HCN

19. Which of the following molecule has/have structure similar to IF_5?
(a) PCl_5 (b) BrF_5
(c) SF_5^- (d) PF_5

20. Which of the following oxide(s) is/are amphoteric?
(a) CO_2 (b) SO_2
(c) SnO_2 (d) PbO_2

21. Which of the following acid(s) is/are monobasic?
(a) HPO_3 (b) H_3PO_3
(c) $H_4P_2O_7$ (d) H_3PO_2

22. Select the reaction in which coordinate bond is formed in product side:
(a) $BF_3 + F^- \longrightarrow BF_4^-$
(b) $CO + BF_3 \longrightarrow OCBF_3$
(c) $H_2O + H^+ \longrightarrow H_3O^+$
(d) $AlCl_3 + Cl^- \longrightarrow AlCl_4^-$

23. Which of the following molecules are planar and have a dipole moment?
(a) H_2S (b) I_3^-
(c) ClF_3 (d) H_2O

24. Which of the following molecule(s) is/are having two different types of bond lengths?
(a) PF_5 (b) PCl_5
(c) IF_7 (d) SF_6

25. Select the correct order of bond angle:

(a) $H_2O > H_2S$ (b) $NH_3 > PH_3$

(c) $OCl_2 > SCl_2$ (d) None of these

26. Which of the following molecule(s) is/are having a square pyramidal geometry?

(a) TeF_5^- (b) $XeOF_4$

(c) IF_5 (d) XeF_5^+

27. Which of the following moelcule(s) is/are having a V-shape?

(a) $SnCl_2$ (b) H_2O

(c) SO_2 (d) GeF_2

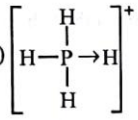
28. Which of the following statement(s) is/are correct?

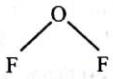
(a) Every AB_5 molecule does in fact have a square pyramid structure

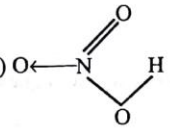
(b) Multiple bonds are always shorter than corresponding single bonds

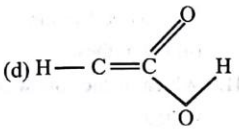
(c) The electron-deficient molecules can act as Lewis acids

29. Which of the following formula correctly represent the bonding capacity of the atom involved?

(a) 

(b) 

(c) 

(d) 

30. The bond strength increases:

(a) With increasing bond order

(b) With increasing extent of overlapping of orbitals

(c) With decreasing difference between energies of overlapping orbitals

(d) With decreasing bond order

31. Which of the following order(s) is/are correct in accordance with the property stated against it?

(a) Electronegativity: $F_2 > Cl_2 > Br_2 > I_2$

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

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

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

32. Which of the following molecule(s) is/are nonplanar as well as nonpolar?

(a) SF_4 (b) XeF_4

(c) CCl_4 (d) NF_4^+

33. The dipole moments of AX_3, YX_3, and ZW_3 are 4.97×10^{-30}, 0.60×10^{-30}, and zero cm respectively. Select the correct statement(s) for AX_3, YX_3, and ZW_3:

(a) Both AX_3 and YX_3 are planar

(b) Both AX_3 and YX_3 are pyramidal

(c) ZW_3 is pyramidal

(d) ZW_3 is planar

34. Which of the following molecule(s) is/are having a square pyramidal shape?

(a) PCl_5 (b) BrF_5

(c) IF_5 (d) None of these

35. Which of the following molecule(s) is/are having a tetrahedral structure?

(a) O_2SF_2 (b) OSF_2

(c) ClO_4^- (d) I_3^-

36. Which of the following molecule(s) is/are having a see-saw geometry?

(a) SF_4 (b) ClF_3

(c) BrF_5 (d) $TeCl_4$

37. Select the correct order of bond angle:

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

(b) $H_2O > OF_2$

(c) $NH_3 > NF_3$

(d) $OCl_2 > OF_2$

38. Select the correct order of bond angle:

(a) $NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$

(b) $H_2O > H_2S > H_2Se > H_2Te$

(c) $BF_3 = BCl_3 = BBr_3 = BI_3$

(d) $BF_3 < BCl_3 < BBr_3 < BI_3$

39. Which of the following molecule(s) is/are having a trigonal pyramidal geometry?

(a) ClO_3^- (b) $\overline{C}H_3$

(c) SO_3^{2-} (d) XeO_3

40. Which of the following sets of molecule(s) is/are having a linear shape but different hybridization?

(a) I_3^- and CO_2 (b) $HgCl_2$ and ICl_2^-

(c) XeF_2 and C_2H_2 (d) XeF_2 and $O\overline{C}l$

41. Identify the correct statements:

(a) N_3^- is linear

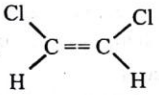
(b) ClF_3 has a dipole moment

(c) SF_4 has see-saw shape

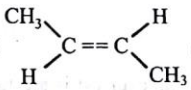
(d) XeF_4 is tetrahedral in shape

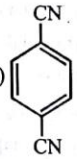
42. Which of the following has/have a least dipole

moment?

(a) 

(b) $CH_3—C≡C—CH_3$

(c) 

(d) 

43. Which pairs of atoms or ions will not have the same configuration?
(a) Li^+ and He^- (b) Cl^- and Ar
(c) Na and K (d) F^+ and Ne

Comprehension Type

Comprehension-1: (Q. 1 to Q. 3)

NH_3 has one lone pair and three bond pairs and undergoes self-ionization

$$2NH_3 \rightleftharpoons NH_4^+ + NH_2^-$$

1. The hybridization and shape of NH_2^- ion are:
(a) sp^2 and angular (b) sp^3 and angular
(c) sp^3 and linear (d) sp and linear

2. NH_2^- is isoelectronic and isostructural with:
(a) BH_3 (b) CH_4
(c) H_2O (d) H_3O^+

3. NH_4^+ ion is isoelectronic and isostructural with:
(a) H_3O^+ (b) CH_3^-
(c) CH_4 (d) CH_3^+

Comprehension-2: (Q. 4 to Q. 6)

When the central atom bears both the bond pair (b.p.) and the lone pair (l.p.), the structures are denoted by regular geometry.

4. Bond angles in NH_3 and H_2O are:
(a) 109° and 103° (b) 107 and 104.5°
(c) 102° and 104° (d) 109° and 90°

5. The shape of sp^3d^2-hybridized moelcule with 2 lone pairs will be:
(a) Octahedral (b) Square pyramidal
(c) Square planar (d) Tetrahedral

6. Which of the following pairs show maximum repulsion?
(a) Lone pair–lone pair (b) Lone pair–bond pair
(c) Bond pair–bond pair
(d) Bond pair–free radical pair

Comprehension-3: (Q. 7 to Q. 9)

Carbon exists in large number of oxidation of allotropic form. Covalency of carbon is four.

7. The nature of CO is:
(a) Acidic (b) Basic
(c) Amphoteric (d) Neutral

8. Hybridization of carbon in graphite is:
(a) sp (b) sp^2
(c) sp^3 (d) None of these

9. Oxidation state of carbon in $CHCl_3$ is:
(a) +1 (b) +2
(c) +4 (d) –2

Comprehension-4: (Q. 10 to Q. 13)

Different types of bonds are formed in the chemical compounds. These bonds have different strengths and bond energies associated with them. These bonds are formed in different environments associated with atoms and the compounds in which they are present.

10. Which of the following will form only σ-bond (generally)?
(a) s–s overlapping
(b) Hybrid orbital overlapping
(c) s–p overlapping
(d) All of these

11. Which of the following bonds has the highest bond energy?
(a) σ-bond (b) π-bond
(c) Hydrogen bond (d) Metallic bond

12. In C_3^{4-}, the number of σ-and π-bonds present between carbon atoms are:
(a) 1 σ and 1 π (b) 2 σ and 2 π
(c) 2 σ and 1 π (d) 2 σ bond only

13. Shape of the molecules is decided by:
(a) σ-bond (b) π-bond
(c) Both σ-and π-bonds (d) Neither σ- nor π-bond

Comprehension–5: (Q. 14 to Q. 16)

A polar bond is formed between two atoms of different electronegativity. A polar molecule results when there is only one polar bond, or more than one polar bond within it is not sufficiently symmetrically oriented to cancel the effects of the others.

14. Select the correct order of boiling point:
(a) $H_2O < HF$ (b) $H_2O > HF$
(c) $HF = H_2O$ (d) None of these

15. Select the correct order of dipole moment:
(a) $BF_3 < H_2O < H_2S$ (b) $H_2O > BF_3 > H_2S$
(c) $H_2S < H_2O < BF_3$ (d) $BF_3 < H_2S < H_2O$

16. Select the correct order of polarity of the bond in following molecule:
(a) $NH_3 < SbH_3 < AsH_3 < PH_3$
(b) $NH_3 > PH_3 > AsH_3 > SbH_3$
(c) $NH_3 < PH_3 < AsH_3 < SbH_3$
(d) $NH_3 > SbH_3 > AsH_3 > PH_3$

Comprehension-6: (Q. 17 to Q. 19)

Carbon exists in various allotropic forms of which diamond and graphite are crystalline and others are amorphous.

17. Which of the following is a good conductor of electricity?
(a) Diamond (b) Graphite
(c) Lamp black (d) Charcoal

18. Which of the following is used as lubricant?
(a) Graphite (b) Charcoal
(c) Diamond (d) Coke

19. Two layers of graphite are linked together with:
(a) Covalent bond
(b) van der Waals' forces
(c) Induced dipole interaction
(d) None of these

Comprehension-7: (Q. 20 to Q. 23)

The first ionization energy of Na, NO, Xe, and O_2 follows the order $Na < NO < Xe = O_2$. O_2 reacts with the powerful oxidizing agent PtF_6 to yield a compound O_2 [Pt F_6].

20. When Pt F_6 is allowed to react with other mentioned species, then the product(s) is/are:
(a) $Na[PtF_6]$
(b) $NO[PtF_6]$
(c) $Xe[PtF_6]$
(d) $Na[PtF_6]$, $NO[PtF_6]$, $Xe[PtF_6]$

21. Which of the following is first formed inert gas compound?
(a) Xe[Pt F_6] (b) Kr[Pt F_6]
(c) XeF_2 (d) XeO_3

22. The oxidation state of Xe in $Xe[PtF_6]$ is:
(a) +1 (b) +2
(c) +4 (d) +6

23. Which of the following inert gas has the smallest ionization energy?
(a) He (b) Ne
(c) Ar (d) Xe

Comprehension-8: (Q. 24 to Q. 26)

Polarity of a bond depends on the difference in the electronegativity of the bonded atoms. The higher the difference in the electronegativity, the higher will be the polarity of bond.

24. The type of bond present in hydrogen chloride is:
(a) Ionic (b) Nonpolar covalent
(c) Coordinate covalent (d) Polar covalent

25. The boiling point of ICl is about 40°C higher than Br_2. This might be because:
(a) I — Cl bond is stronger than Br — Br bond
(b) I.E. of I < I.E. of Br
(c) I — Cl is polar, whereas Br_2 is nonpolar
(d) The size of I > the size of Br

26. Which of the following bond is nonpolar?
(a) N—H (b) H—F
(c) F—F (d) O—H

Comprehension-9: (Q. 27 to Q. 29)

Hydrogen bond is an important aspect of chemical bonding. It is formed in the molecules where hydrogen is attached with highly electronegative atom. There are a number of consequences of hydrogen bonding.

27. H_2O is liquid but H_2S is gas; this is because of:
(a) Larger size of S (b) Acidic nature of H_2S
(c) Hydrogen bonding (d) Small size of O

28. Intramolecular hydrogen bonding is found in:
(a) Salicylaldehyde (b) Water
(c) Acetaldehyde (d) Phenol

29. The stickiness of honey which mainly consists of water and sugar is due to:
(a) Presence of sugar
(b) Strong bonding in sugar
(c) Hydrogen bonding
(d) Presence of some organic compound

Comprehension-10: (Q. 30 to Q. 32)

One hydrogen bonding represented as *X*— H ..... *D* denotes the interaction between the donor species *D* and the acceptor species *X*— H through the hydrogen end. H atom should remain between the atoms (i.e., *X* and *D*) of more electronegative nonmetallic elements.

30. B—H—B bridges (in boro hydrides) and W — H — W links in $(OC)_6$ W H W $(CO)_6$ will be considered as:

(a) van der Waals' force (b) Hydrogen bond
(c) Ionic bond (d) None of these
(W—H—B covalent bridge bond not H—bond)

31. Which of the following compound does not have hydrogen bonding?
(a) K_2HPO_4 (b) K_2HPO_3
(c) Chloralhydrate (d) H_2O

32. The strength of H-bonding order is:
(a) $H_2O > H_2O_2 > H–F$ (b) $H_2O_2 > H_2O > HF$
(c) $HF > H_2O > H_2O_2$ (d) $HF = H_2O = H_2O_2$

Comprehension-11: (Q. 33 to Q. 35)

The elements (VI A group) all form covalent hydrides. These are water, hydrogen sulphide, hydrogen selenide, hydrogen telluride, etc.

33. Which of the following hydrides has the smallest H—*X*—H bond angle?
(a) H_2O (b) H_2S
(c) H_2Se (d) H_2Te

34. Which of the following hydrides is thermally most stable?
(a) H_2O (b) H_2S
(c) H_2Se (d) H_2Te

35. Maximum number of hydrogen bonds formed by a water molecule are:
(a) 1 (b) 2
(c) 3 (d) 4

Comprehension-12: (Q. 36 and Q. 37)

Dipole moment is a vector quantity, i.e., it has both magnitude as well as direction. The overall value of the dipole moment of a polar molecule depends on its geometry and shape, i.e., vectorial addition of dipole moment of the constituent bonds.

36. Dipole moments: HCl (1.03 D) and HI (0.38 D) compare the magnitude of the partial charge on hydrogen atom in HCl with that on the hydrogen atom of HI. If it is assumed that the partial positive and negative charges are central on the hydrogen and halogen atoms, respectively, the distance between charge centers are calculated to be 1.27 and 1.61 Å for HCl and HI, respectively:
(a) The charge on the hydrogen atom of HCl is over 3 times that on the hydrogen atom of HI
(b) The charge on the hydrogen atom of HCl is over 2 times that on the hydrogen atom of HI
(c) The charge on the hydrogen atom of HCl is over 4 times that on the hydrogen atom of HI
(d) The charge on the hydrogen atom of HCl is over 5 times that on the hydrogen atom of HI

37. In above question, compare the magnitude of the partial charge on the hydrogen atom in HCl with that of a single charge positive ion which is 4.80×10^{-10} esu:
(a) The charge on the hydrogen atom of HCl is about one third the charge on a monopositive ion
(b) The charge on the hydrogen atom of HCl is about one-fourth the charge on a monopositive ion
(c) The charge on the hydrogen atom of HCl is about one-sixth the charge on a monopositive ion
(d) The charge on the hydrogen atom of HCl is about one-fifth the charge on a monopositive ion

Comprehension-13: (Q. 38 and Q. 39)

The percentage ionic character of a single bond may be estimated from the ratio of the observed dipole moment to the calculated moments, assuming oppositely charged ions located at distance equal to the bond length.

38. The observed dipole moment of HBr is 0.79 D. Calculate the percentage ionic character of the bond in HBr if bond distance is 1.42 Å:
(a) 16.9% (b) 12.0%
(c) 5.0% (d) 20%

39. The observed dipole moment of HI is 0.38 D. Calculate the percentage ionic character of the bonding HI if bond distance is 1.61 Å:
(a) 16.4% (b) 12%
(c) 5.0% (d) 20%

Comprehension-14: (Q. 40 to Q. 42)

Covalent bond length gives the inter-nuclear distance between the atoms covalently bonded. These can be measured from the X-ray studies of the crystals, and for gases, these are done by diffraction and spectroscopic method.

40. Arrange C—C, C = C, and C ≡ C in order of decreasing bond energy:
(a) C — C > C=C > C≡C
(b) C≡C > C—C > C=C
(c) C≡C > C=C > C—C
(d) None of these

41. Arrange C—C, C=C, and C ≡ C in order of decreasing bond length:
(a) C—C > C=C > C≡C

(b) C≡C > C=C > C—C
(c) C—C > C≡C > C=C
(d) C=C > C—C > C≡C

42. The As—Cl bond distance in $AsCl_3$ is 2.20 Å. Estimate the single-bonded covalent radius of As, if radius of chlorine atom is 0.99 Å:

(a) 1.21 Å (b) 12.1 Å
(c) 1.12 Å (d) 11.2 Å

Assertion-Reasoning Type

1. **Statement-1:** The covalent radii reported for F, O, and N are remarkably different from the values obtained from F — F (= 144 Pm), HO — OH (= 148 Pm), and H_2N — NH_2 (= 147 Pm), respectively.

Statement-2: The elongated bond lengths in F — F, O — O, and N — N bonds arise probably due to the repulsion among the nonbonding electrons housed on adjacent atoms.

(a) Statement-1 is true; Statement-2 is true; Statement-2 is correct explanation for Statement-1.
(b) Statement-1 is true; Statement-2 is true; 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:** The unshared pairs residing in pure σ-or π-orbital do not contribute in dipole moment.

Statement-2: The σ-orbital is spherically symmetrical, hence it contributes nothing. Similarly, the two lobes of a pure π-orbital are projected in opposite directions to cause no effect.

(a) Statement-1 is true; Statement-2 is true; Statement-2 is correct explanation for Statement-1.
(b) Statement-1 is true; Statement-2 is true; 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:** The carbon–carbon double bond energy in C_2H_4 is more than the carbon–carbon single bond energy in C_2H_6.

Statement-2: A σ-orbital has greater electron overlap between the atoms because its component σ-orbitals are directed toward each other, whereas the component π-orbitals making-up the π-orbital are directed perpendicular to the inter-nuclear axis.

(a) Statement-1 is true; Statement-2 is true; Statement-2 is correct explanation for Statement-1.
(b) Statement-1 is true; Statement-2 is true; 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:** Both PCl_5 and BrF_5 have identical shapes.

Statement-2: PCl_5 has trigonal bipyramidal shape, whereas BrF_5 has square pyramidal.

(a) Statement-1 is true; Statement-2 is true; Statement-2 is correct explanation for Statement-1.
(b) Statement-1 is true; Statement-2 is true; 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) Tetrahedral	(p) OSF_4
(b) Trigonal bipyramidal	(q) CrO_2Cl_2
(c) Square pyramidal	(r) SO_2Cl_2
(d) See-saw	(s) $XeOF_4$
	(t) $TeCl_4$

2. Match the column:

Column-I	Column-II
(a) H_3O^+	(p) Pyramidal
(b) $\overline{C}H_3$	(q) Planar
(c) XeF_5^-	(r) Nonplanar
(d) $SnCl_2$	(s) $\mu = 0$

3. 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

4. Match the column:

Column-I	Column-II
(a) HCP molecule	(p) Two σ-and 2π-bonds
(b) HCN molecule	(q) *sp*-hybridization
(c) $S_2O_3^{2-}$ ion	(r) Linear geometry
	(s) $3p_\pi - 3d_\pi$ pi-bonding

5. Match the column:

Column-I	Column-II
(a) NH_2^-	(p) $\mu = 0$
(b) NH_4^+	(q) Planar
(c) I_3^-	(r) $d_{x^2-y^2}$ is involved in hybridization
(d) PCl_6^-	(s) d_{z^2} is involved in hybridization
(e) PCl_2^+	(t) Bent structure

6. Match the column:

Column-I	Column-II
(a) ClF_3	(p) Planar molecule
(b) XeO_2F_2	(q) Nonpolar molecule
(c) ClF_6^+	(r) dz^2 orbital is involved in bonding
(d) NF_4^+	(s) Equatorial bonds are stronger than axial bonds
	(t) nonplanar molecule

7. Match Column-1 (molecule) with Column-II (shape):

Column-I	Column-II
(a) P_4	(p) Crown
(b) S_8	(q) Polymeric (dimeric)
(c) $AlCl_3$	(r) Tetrahedral
(d) PCl_5	(s) Trigonal bipyramidal

Integer Answer Type

1. How many molecules are planar from the following molecules?

   I_3^-, H_2O, ICl_2^-, C_2H_4, C_2H_2, H_3O^+

2. How many molecules have the same type of shape from the following molecules?

   H_3O^+, NH_3, ClO_3^+, PH_3, H_2O, $\overline{C}H_3$

3. The number of sigma bonds in P_4O_{10} is _____.
4. The total number of electrons that take part in forming bonds in N_2 is _____.
5. The number of σ-bonds and π-bonds in benzene are _____.
6. The number of unpaired electrons in a paramagnetic atom of an element with atomic number 16 is _____.
7. Find the number of proton donor acid(s) from the following:

   $B(OH)_3$, $Mg(OH)_2$, $Si(OH)_4$, $SO_2(OH)_2$, $Ba(OH)_2$

8. Find the number of acid(s) which are having hypo prefix in their name from the following:

   H_3PO_4, H_3PO_3, H_3PO_2, $HClO$, $H_4P_2O_6$, $H_2S_2O_6$

9. How many Cl — Cl bond(s) is/are present in Cl_2O_7?
10. How many S—O—S linkage(s) is/are present in $H_2S_3O_6$?
11. How many 3 member ring(s) is/are formed in CrO_5?
12. Find the sum of $P—\hat{P}—P$ angle and P — P side in P_4 molecule.
13. How many S — O — S linkages are there in dithionous acid?
14. Find the number of molecule(s) which is/are planar and having dipole moment:

    SF_4, PCl_3F_2, PCl_2F_3, I_3^-, BrF_3, ICl_2^-, XeF_4

15. Find the number of molecule(s) which is/are bent in shape but have different hybridization:

    XeF_2, BF_2^-, SF_2, H_2O, $SnCl_2$, I_3^+, I_3^-

16. Find the sum of atomicity of nitrogen and phosphorous.
17. In SF_6 molecule, find the maximum number of atoms that can lie on a single plane.
18. How many minimum atoms lie in same plane in $F_2C = C = CF_2$ molecule?
19. Find the number of molecule(s)/ion having Lewis acidic property from the following:

    H_2O, NH_3, H^+, BF_3, AlH_3, Cu^{+2}, $\overline{C}H_3$

20. Find the number of molecule(s)/ion having Lewis basic property from the following:

    H_2O, NH_3, CH_3NH_2, ROH, $FeCl_3$, SO_3

21. The nucleus of an element contains nine protons. Calculate its valency.
22. Find the maximum possible number of hydrogen bonds in which H_2O_2 molecule can participate.
23. Find the number of acid(s) which can form its meta derivative from the following:

    H_3BO_3, H_3PO_4, H_3PO_3, H_2SO_4, H_2SO_3

24. Find the number of acid(s) which are having pyro prefix in its name from the following:

    $H_4P_2O_7$, $H_4P_2O_5$, $H_2S_2O_7$, H_2SO_5

25. Find the number of acid(s) which are having per as well as peroxy prefix in its name from the following:

    C_6H_5COOOH, $HClO_4$, $H_2S_2O_8$, $H_4P_2O_8$, H_2SO_5, HNO_4

26. How many P—O—P linkage(s) is/are present in tetrapolyphosphoric acid?

27. How many S—S linkage(s) is/are present in $H_2S_4O_6$?

28. Find the number of sesquioxide(s) from the following:

Al_2O_3, C_3O_2, CO_2,
Pb_2O_3, B_2O_3, $C_{12}O_9$

29. Find the number of S — S linkage in $H_2S_2O_3$.

30. Find the number of molecule(s) which is/are nonplanar and have zero dipole moment in the above question.

31. How many $X-\hat{M}-X$ (90°) bond angle is/are present in pentagonal bipyramidal geometry?

32. Find the number of molecule(s) which do not exist:

NCl_3, PCl_3, PCl_5, NCl_5, OF_2,
OF_4, OF_6

33. Find the number of reaction(s) in which coordinate bond is/are formed in product side:

$BF_3 + F^- \longrightarrow BF_4^-$

$HF + SbF_5 \longrightarrow HSbF_6$

$PCl_3 + Cl^- \longrightarrow PCl_4^-$

$NH_3 + H^+ \longrightarrow NH_4^+$

$H_3O + H^+ \longrightarrow H_4O^{2+}$

34. How many maximum atoms lie in same plane in $F_2B-C\equiv C-BF_2$ molecule?

35. In NO_3^- ion, find the sum of bond pairs and lone pairs of electrons on nitrogen atom.

36. Find the number of bonds between two carbon atoms in CaC_2.

37. Find the number of lone pairs of electrons on Xe in $XeOF_4$.

38. Find the number of ion(s) which are having ionizable hydrogen from the following:

$H_2PO_2^-$, HPO_3^{2-}, $H_2P_2O_5^{2-}$, $H_4P_2O_7^{2-}$

39. Find the number of acid(s) which are having peroxy linkage from the following:

H_3PO_5, H_2SO_5, $H_2S_2O_7$, $H_2S_2O_8$, $HClO_4$

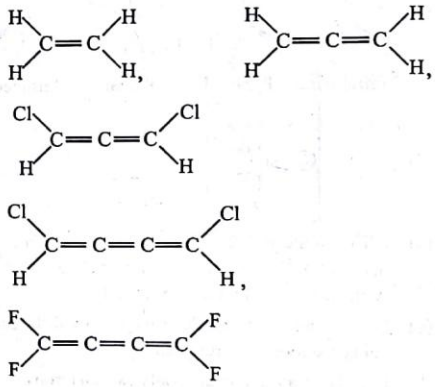
40. Find the ratio of number of σ-bonds and π-bonds in sodium hexa metaphosphate.

41. How many P—O—P bond(s) is/are present in $H_6P_6O_{18}$?

42. Find the sum of oxidation state of S-atom(s) in thio-sulphuric acid.

43. How many number of faces are there in P_4 molecule?

44. Find the number of molecule(s) which is/are planar as well as polar:



45. How many $X-\hat{M}-X$ (90°) bond angle is/are present in trigonal bipyramidal geometry?

46. How many maximum bond(s) is/are present in atoms of metals?

47. Potassium dichromate in alkaline solution with 30% H_2O_2 produces K_3CrO_8. How many peroxide linkages are found in the structure of K_3CrO_8?

Hints & Solutions

JEE (Main) Exercises

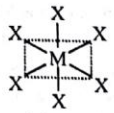
Single Correct Answer Type

2. (b)

	H — C	N — O
E.N.	= 2.1 2.5	3 3.5
E.N. difference	= 0.4	0.5
Bond dipole	= 0.39 D	1.51 D

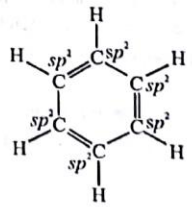
3. (c) *p*-orbital has equal-sized lobes. In *sp*-hybrid orbital most of the e^- probability is on one side, making the latter more directional in character.

4. (c)

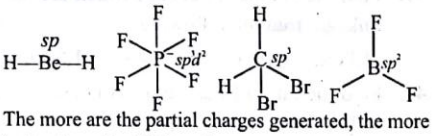


sp^3d^2-hybridized molecule has octahedral geometry.

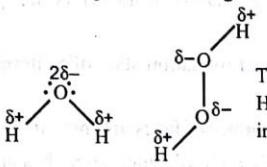
5. (a)



6. (c)

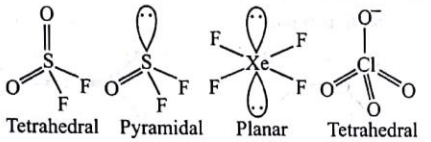


10. (b) The more are the partial charges generated, the more is the strength of H-bonding.



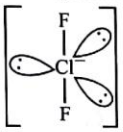
The strength of H-bonding is more in H_2O.

11. (c)



Tetrahedral Pyramidal Planar Tetrahedral

12. (b)



13. (c) AlF_3 is ionic and during the formation of ionic bond, octets of Al^{3+} and F^- have been completed. $AlCl_3$ and $AlBr_3$ are covalent and hypovalent.

47. (c) C—F bond has more electronegativity difference, F being the most electronegative.

48. (b) In H_2O, H-atom contains only two electrons.

49. (b) SiO_2 possesses giant molecular structure due to tetra valence and catenation nature of Si.

50. (a) CO_2 has 180° angle.

51. (d) As the *s* character increases in hybridized orbitals, its electronegativity increases.

	sp	sp^2	sp^3
s character	50%	33.3%	25%

52. (a) $\text{L.E.} = -\dfrac{Kq_1q_2}{r}$

53. (d) CH_4 is a saturated molecule having all the four sigma bonds.

54. (c) XeF_4 has sp^3d^2-hybridized Xe atom having two lone pair of electrons and thus, octahedral geometry changes to square planar due to lone pair effect.

55. (d) sp^3d-hybridization leads to trigonal bipyramidal geometry if no lone pair is present, e.g., PCl_5; in ClF_3, geometry is T shaped due to the presence of two lone pairs of electrons. In XeF_2, geometry is linear due to the presence of three lone pairs of electrons.

56. (c) Due to large electronegativity difference in C and F atoms.

57. (c) Bond angles decrease down the group.

$\therefore$ $H_2O > H_2S$. Also bond angle of $H_2O < NH_3$ due to lone pair effect.

58. (a) Due to the presence of lone pair on N atom.

59. (c) Coordiante bonding involves sharing of an electron pair provided by a donor atom to acceptor atom.

60. (b) sp^3d^2-hybridization leads to octahedral geometry.

61. (c) Due to stronger coulombic forces of attractions.

62. (b) H_2O is V-shaped.

63. (c) sp^3-hybridization leads to a tetrahedral geometry.

64. (b) *sp*-hybridization leads to bond angle of 180°.

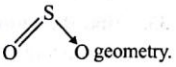
65. (c) Liq. NH_3, liq. HF, and CH_3OH show H-bonding.

66. (b) Both CO_2 and $HgCl_2$ are linear (*sp*-hybridization).

67. (d) Bond length decreases with increase in *s*-character.

68. (c) Due to shielding effect of $(n-1)$ *d*-subshell.

69. (c) All are nonmetals.

70. (b) SO_2 has sp^2-hybridization due to  geometry.

71. (c) SiF_4 has regular tetrahedral geometry.

72. (c) $\equiv$C— has 2σ- and 2π- (thus, *sp*-hybridization); —CH= has 3σ- and 1π- (thus, sp^2-hybridization). Remember hybridized orbitals do not form π-bonds.

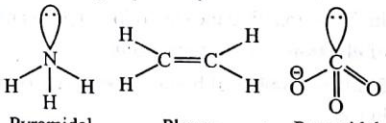
73. (d) Cs^+ is the biggest ion among these. F^- is the smallest.

74. (c) Allene is $CH_2 = C = CH_2$.

75. (c) H-bonding is noticed in molecules having H atom attached on N, O, or F.

76. (d) I_3^-, XeF_4, SF_4, and ClO_3^- have 3, 2, 1, 1 lone pair of electrons, respectively.

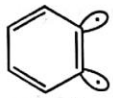
80. (d)



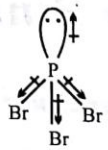
Pyramidal Planar Pyramidal

88. (d) Values of dipole moment cannot be predicted as we donot know about the electronegativities of the atoms.

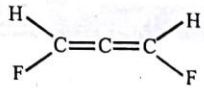
89. (c) $SiF_4 \rightarrow$ Si has vacant d-orbital and so can act as Lewis acid.



→ In benzyne all C-atoms are sp^2 hybridized.

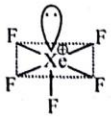


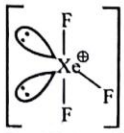
→ This is polar moelcule.



→ The nodal planes of π-bonds are perpendicular to each other.

91. (b)

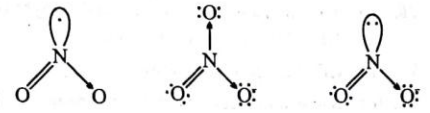




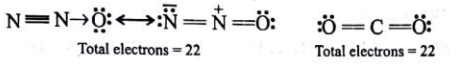
Bent T-shaped

92. (a) NO_2, N_2O_3, and N_2O_5 are acidic oxides
NO , N_2O, and CO are neutral oxides

93. (d)



Total electrons = 23 Total electrons = 32 Total electrons = 24



Total electrons = 22 Total electrons = 22

JEE (Advanced) Exercises

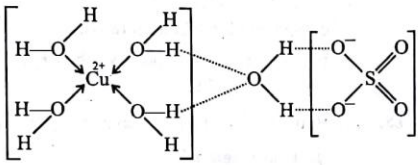
Single Correct Answer Type

4. (a) X loses electron, Y gives it.

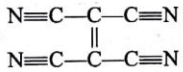
5. (c) H_2O possesses the tendency for H-bonding.

6. (c) N_2 has triple (multiple) bond.

7. (c) Cu^{2+} and SO_4^{2-}

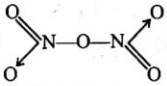


8. (c) $C_2(CN)_4$ is

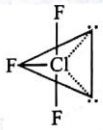


9. (a) Triple bond contains 1σ- and 2π-bonds.

10. (b) N_2O_5 has the structure



11. (c) Cl in ClF_3 has sp^3d-hybridization



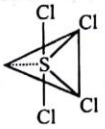
and possesses two axial Cl—F bonds and one equatorial bond.
Two lone pairs are at equatorial position and give rise to bent "T" shape to ClF_3.

12. (b) The hybridized states of N in NO_2^+, NO_3^- and NO_4^+ are sp, sp^2, and sp^3, respectively.

13. (c) ClO_4^- has sp^3-hybridization on Cl atom.

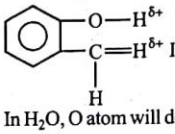
14. (a) $O=\overset{+}{N}=O$, N has no lone pair.

15. (c) S in SCl_4 is sp^3d-hybridized and possesses a see-saw structure.
$SiCl_4$ is tetrahedral.



16. (b) SO_2 has sp^2-hybridization.

17. (a)



Intramolecular H-bonding.

18. (d) In H_2O, O atom will donate electron pair to H^+ forming H_3O^+.

19. (a) $[X]^{2+}[2Y]^-$ or XY_2

20. (a) Based on geometry of molecule.

21. (c) Carbon in CO_2 has sp-hybridization.

22. (c) Both $HgCl_2$ and C_2H_2 are linear like CO_2 because of sp-hybridization.

23. (c) BCl_3 has six electrons in outer shell of boron atom.

24. (b) 37 is atomic number of Rb (the electropositive element) and 53 is atomic number of iodine (the electronegative element).

25. (d) van der Waals' forces are the weakest; rest of all involves ionic or partially ionic (dipole) forces of attractions.

26. (b) Element with atomic number 20 is metal (Ca); it will combine with nonmetal.

28. (d) CS_2 is linear having zero dipole moment.

29. (d) Hg exists in liquid state.

30. (d) Boron in BF_3 has only six electrons.

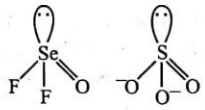
31. (b) NH_4^+ has angle of 109° 28′.

32. (b) HF forms $(HF)_n$ linear polymeric structure due to H-bonding.

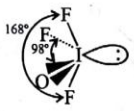
34. (a) Both NH_4^+ and BF_4^- have sp^3-hybridization.

35. (d) XeF_2 (sp^3d with 3 lone pair) and CO_2(sp) are linear.

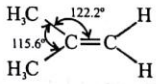
41. (a)



43. (b)

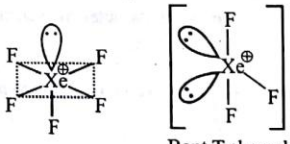


44. (a)



The VSEPR model considers double and triple bonds to have slightly greater repulsive effects than single bonds because of the repulsive effect of π-electrons.

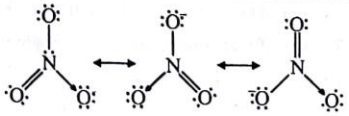
48. (b)



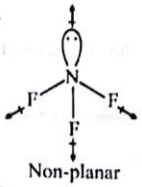
Bent T-shaped

49. (c) (I) sp^3 hybrid orbitals are at 109.28′ to each other

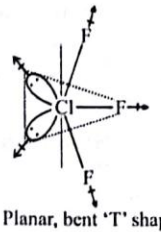
(IV)



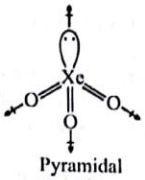
Bond order of N—O bond = $\frac{4}{3}$ = 1.33

50. (b) (a) 

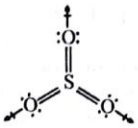
Non-planar (pyramidal) $\mu_D \neq 0$

(b) 

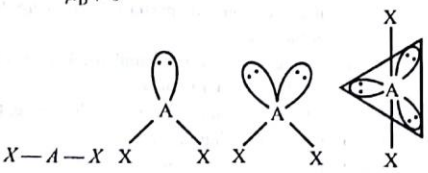
Planar, bent 'T' shape $\mu_D \neq 0$

(c) 

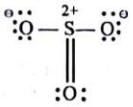
Pyramidal $\mu_D \neq 0$

(d) 

Trigonal planar $\mu = 0$

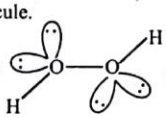
56. (a) 

$X—A—X$ $\mu = 0$; $\mu \neq 0$; $\mu \neq 0$; $\mu = 0$

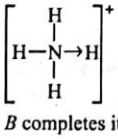
58. (c) 

Therefore, there are 3 σ and 1 π bond.

63. (d) With the knowledge of dipole moment, we cannot tell anything about the bond energies of all bonds within the molecule.

64. (c) H_2O_2 has  structure; O—O bond is nonpolar; O—H is polar.

65. (a) One of s-orbital + 3 of p-orbital = sp^3.

66. (b)  Cl^-, NH_4^+, and Cl^- form ionic bond.

67. (c) B completes its octet by sharing 2 electron pairs; A completes its octet by sharing of three electrons: A_2B_3, e.g., B_2O_3.

68. (a) $O \leftarrow S{=}O$ two O atoms are having coordinate (dative) linkage.

71. (d) Due to regular tetrahedral geometry.

72. (c) Polar solutes are more soluble in polar solvents.

73. (c) e.g., BF_3, a nonpolar molecule having sp^2-hybridization.

74. (b) Due to sp^2-hybridization.

75. (d) NH_2^- has sp^3-hybridization having two covalent bonds and two lone pairs on N-atom.

76. (d) The bond angles in sp^3, sp^2, and sp-hybridization are 109°, 120°, and 180°, respectively.

77. (b) CO_2 has sp-hybridization.

78. (c) Same spin electrons in two atoms do not take part in bonding.

79. (d) H_2O is V-shaped.

80. (c) Both NH_3 and H_2O have sp^3-hybridization. CO_2 and $BeCl_2$ are linear (sp-hybridization).

81. (c) C — F bond is more polar than C — Cl.

83. (c) Anions are larger in size than their parent atom.

84. (b) IP_1 of B > IP_1 of Li because E.N. of boron is more than Li. Also IP_1 of Li > IP_1 of K because removal of electron in K occurs from $4s$.

85. (b) It is the order of stability.

87. (b) Li^-: $1s^2, 2s^2$; Be^-: $1s^2, 2s^2, 2p^1$; in Li, addition of electron has taken place in $2s$ orbital; in Be^-, addition of electron has taken place in $2p$ orbital loosing its $2s$ completely filled configuration.

EA_1 for Be is more positive than EA_1 for Li. Thus, Be^- is least stable.

88. (c) Both NH_4^+ and $[BF_4]^-$ have tetrahedral shape due to sp^3-hybridization.

89. (d) PCl_5 = Trigonal bipyramidal

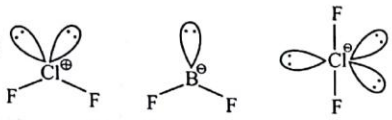
PCl_4^+ = Tetrahedral

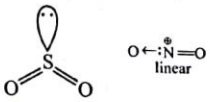
PCl_6^- = Square bipyramidal

90. (d) B in BF_3 has sp^2-hybridization.

91. (a) SF_4 has sp^3d^2-hybridization and see-saw geometry.

Multiple Correct Answers Type

8. (a), (c) 

12. (a), (c) 

linear

13. (a), (c), (d)

$BeCl_2$–sp; BF_3–sp^2; NH_3–sp^3; XeF_2–sp^3d

14. (a), (c), (d)

Sigma bond formation involves more overlapping and thus is stronger.

15. (a), (b), (c)

BCl_3 has sp^2-hybridization. Rest all have sp^3-hybridization having one lone pair of electron, and thus are pyramidal in nature.

16. (a), (c), (d)

Both N_2O and CO_2 have 22 electrons.

18. (a), (c), (d)

H_2O has bent shape. No π-bond; H H bonding.

28. (b), (c), (d)

IF_5 is square pyramidal (sp^3d^2-hybridization in I); PCl_5 is trigonal bipyramidal (sp^3d-hybridization in P).

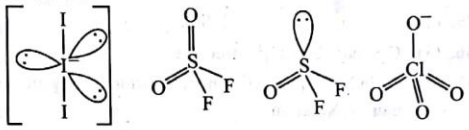
29. (a), (b), (c)

One carbon has three bonds and others five, whereas each should have four bonds.

30. (a), (b), (c)

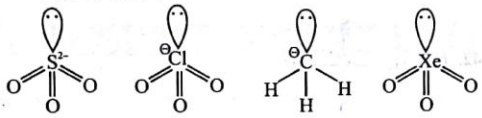
Characteristics of bond order concept.

35. (a), (c)



Linear Tetrahedral Pyramidal Tetrahedral

40. (a), (b), (c), (d)



43. (a), (c), (d)

Both Cl^- and Ar possess $1s^2, 2s^2 2p^6, 3s^2 3p^6$ configuration.

Comprehension Type

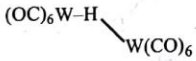
Comprehension-5: (Q. 14 and Q. 15)

14. (b) Both the molecules have the same number e^-, but ICl has dipole moment and should have the higher boiling point.

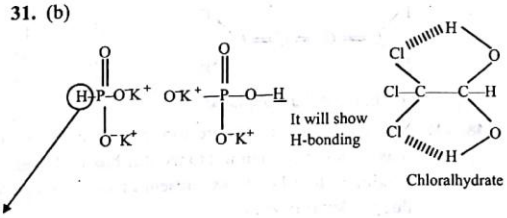
15. (d) BF_3 has zero dipole moment

Comprehension-10: (Q. 30 to Q. 31)

30. (d)



31. (b)



Since it is not connected to electronegative atom and hence, it will not show H-bonding.

Comprehension-14: (Q. 42)

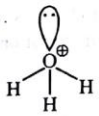
42. (a) Internuclear distance – radius of chlorine atom = radius of As-atom.

$$2.20\ Å - 0.99\ Å = 1.21\ Å$$

Matching Column Type

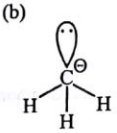
2. (a) p, r; (b) p, r; (c) q, s; (d) q

(a)



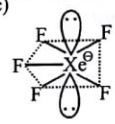
(i) Pyramidal
(ii) sp^3-hybridization
(iii) Nonplanar
(iv) $\mu \neq 0$, polar

(b)



(i) Pyramidal
(ii) sp^3-hybridization
(iii) Nonplanar
(iv) $\mu \neq 0$, polar

(c)



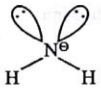
(i) sp^3d^3-hybridization
(ii) Planar
(iii) $\mu = 0$
(iv) Nonpolar

(d) $SnCl_2$

(i) sp^2-hybridization
(ii) Planar
(iii) $\mu \neq 0$
(iv) Polar

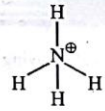
5. (a) q, t; (b) p; (c) p, q, s; (d) p, r, s (e) q, t

(a)



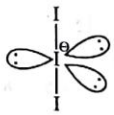
(i) Bent structure
(ii) sp^3-hybridization
(iii) Planar
(iv) $\mu \neq 0$, polar

(b)



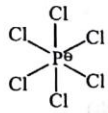
(i) Tetrahedral structure
(ii) Nonplanar
(iii) sp^3-hybridization
(iv) $\mu = 0$
(v) Nonpolar

(c)



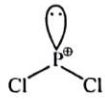
(i) sp^3d-hybridization
(ii) dz^2 is involved in hybridization
(iii) Linear, planar
(iv) $\mu = 0$, nonpolar

(d)



(i) sp^3d^2-hybridization
(ii) $d_{x^2-y^2}, d_{z^2}$ orbitals are involved in hybridization
(iii) Nonplanar
(iv) $\mu = 0$, nonpolar

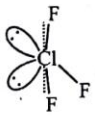
(e)



(i) sp^3-hybridization
(ii) Bent structure
(iii) Planar
(iv) $\mu \neq 0$, polar

6. (a) p, r, s; (b) r, s, t; (c) q, r, t; (d) q, t

(a)



(i) sp^3d-hybridization

(ii) dz^2 is involved in bonding

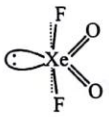
(iii) Axial bond lengths are longer than that of equatorial bonds, it means equatorial bonds are stronger than the axial bonds

(iv) Planar molecule

(v) Polar

(vi) $\mu \neq 0$

(b)



(i) sp^3d

(ii) dz^2 orbital is involved in bonding

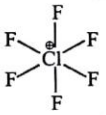
(iii) Nonplanar

(iv) Equatorial bonds are stronger than the axial bonds

(v) Polar

(vi) $\mu \neq 0$

(c)



(i) sp^3d^2

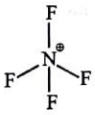
(ii) $d_{x^2-y^2}$ and d_{z^2} orbitals are involved in bonding

(iii) Nonplanar

(iv) Nonpolar

(v) $\mu = 0$

(d)



(i) sp^3d hybridization

(ii) Nonplanar

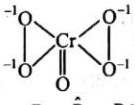
(iii) Nonpolar

(iv) $\mu = 0$

Integer Answer Type

6. (2) S_2 molecule is paramagnetic like O_2 having 2 unpaired electrons.

11. (2)



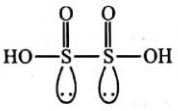
Two three member rings are present.

12. (18) P — $\hat{P}$ — P bond angle = 12

P—P side = 6

Sum = 12 + 6 = 18

13. (0)

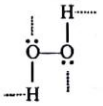


S—O—S linkage = 0

16. (6) Atomicity of nitrogen = 2 (N_2)

Atomicity of phosphorous = 4 (P_4)

22. (4)

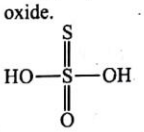


One site available for H-bonding at each H atom and two at O atom due to two lone pairs and partial –ve charge.

25. (3) $H_2S_2O_8$ = peroxydisulphuric acid is not a per acid; per acid of S is H_2SO_5.

$H_4P_2O_8$ = peroxy diphosphoric acid is not a per acid; per acid of P is H_3PO_5.

28. (3) If oxygen per atom is 1.5, then oxide is called sesquioxide.



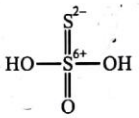
29. (1) S—S linkage = 1

36. (3) C_2^{2-} has $[C \equiv C]^{2-}$ structure.

37. (1) Xe in $XeOF_4$ has sp^3d^2-hybridization having one lone pair on Xe-atom.

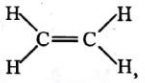
40. (4) $\dfrac{\text{Number of } \sigma \text{ bonds}}{\text{Number of } \pi \text{ bonds}} = \dfrac{24}{6} = 4$

42. (4)

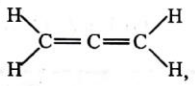


Sum of oxidation state = 6 – 2 = 4

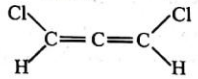
44. (1)



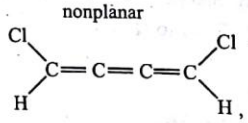
$\mu = 0$, nonpolar planar



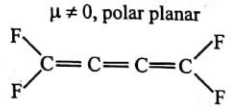
$\mu = 0$, nonpolar nonplanar



$\mu \neq 0$, nonpolar nonplanar

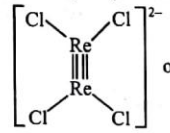


$\mu \neq 0$, polar planar



$\mu = 0$, nonpolar nonplanar

46. (4) Maximum three bonds are formed between two atoms of nonmetal, but in atoms of *d*-block elements, maximum four bonds are present in some moelcule due to (delta) δ-bond.



one $\sigma + 2\,\pi + 1\,\delta$ bond

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (b)	2. (b)	3. (c)	4. (c)	5. (a)	6. (c)	7. (c)	8. (a)	9. (d)	10. (b)
11. (c)	12. (b)	13. (c)	14. (d)	15. (b)	16. (c)	17. (b)	18. (b)	19. (a)	20. (b)
21. (c)	22. (d)	23. (a)	24. (d)	25. (b)	26. (d)	27. (d)	28. (c)	29. (b)	30. (b)
31. (d)	32. (a)	33. (b)	34. (a)	35. (a)	36. (b)	37. (a)	38. (a)	39. (b)	40. (a)
41. (b)	42. (a)	43. (a)	44. (a)	45. (a)	46. (a)	47. (c)	48. (b)	49. (b)	50. (a)
51. (d)	52. (a)	53. (d)	54. (c)	55. (d)	56. (c)	57. (c)	58. (a)	59. (c)	60. (b)
61. (c)	62. (b)	63. (c)	64. (b)	65. (c)	66. (b)	67. (d)	68. (c)	69. (c)	70. (b)
71. (c)	72. (c)	73. (d)	74. (c)	75. (c)	76. (d)	77. (b)	78. (b)	79. (a)	80. (d)
81. (b)	82. (d)	83. (c)	84. (d)	85. (d)	86. (c)	87. (d)	88. (d)	89. (c)	90. (c)
91. (b)	92. (a)	93. (d)	94. (d)	95. (b)	96. (d)	97. (a)	98. (a)	99. (b)	100. (b)
101. (c)									

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a)	2. (c)	3. (a)	4. (a)	5. (c)	6. (c)	7. (c)	8. (c)	9. (a)	10. (b)
11. (c)	12. (b)	13. (c)	14. (a)	15. (c)	16. (b)	17. (a)	18. (d)	19. (a)	20. (a)
21. (c)	22. (c)	23. (c)	24. (b)	25. (d)	26. (b)	27. (b)	28. (d)	29. (d)	30. (d)
31. (b)	32. (b)	33. (b)	34. (a)	35. (d)	36. (a)	37. (c)	38. (c)	39. (b)	40. (b)
41. (a)	42. (c)	43. (b)	44. (a)	45. (d)	46. (a)	47. (a)	48. (b)	49. (c)	50. (b)
51. (b)	52. (b)	53. (a)	54. (a)	55. (a)	56. (a)	57. (d)	58. (c)	59. (d)	60. (c)
61. (b)	62. (c)	63. (d)	64. (c)	65. (a)	66. (b)	67. (c)	68. (a)	69. (b)	70. (c)
71. (d)	72. (c)	73. (c)	74. (b)	75. (d)	76. (d)	77. (b)	78. (c)	79. (d)	80. (c)
81. (c)	82. (b)	83. (c)	84. (b)	85. (b)	86. (a)	87. (b)	88. (c)	89. (d)	90. (d)
91. (a)	92. (d)	93. (d)	94. (d)	95. (d)	96. (a)	97. (d)	98. (b)	99. (c)	100. (a)

Multiple Correct Answers Type

1. (a), (b), (c)	2. (a), (b), (c), (d)	3. (a), (b), (c)	4. (a), (b), (c)	5. (a), (b), (c),(d)
6. (a), (d)	7. (b), (d)	8. (a), (c)	9. (a), (b), (c)	10. (a), (b), (c), (d)
11. (a), (b), (c), (d)	12. (a), (c)	13. (a), (c), (d)	14. (a), (c), (d)	15. (a), (b), (c)
16. (a), (c), (d)	17. (a), (c)	18. (a), (c), (d)	19. (b), (c)	20. (c), (d)
21. (a), (d)	22. (a), (b), (c), (d)	23. (a), (c), (d)	24. (a), (b), (c)	25. (a), (b), (c)
26. (a), (b), (c), (d)	27. (a), (b), (c), (d)	28. (b), (c)	29. (a), (b), (c)	30. (a), (b), (c)
31. (a), (c), (d)	32. (c), (d)	33. (b), (d)	34. (b), (c)	35. (a), (c)
36. (a), (d)	37. (a), (b), (c), (d)	38. (a), (b), (c)	39. (a), (b), (c), (d)	40. (a), (b), (c), (d)
41. (a), (b), (c)	42. (b), (c), (d)	43. (a), (c), (d)		

Comprehension Type

Comprehension-1	1. (b)	2. (c)	3. (c)	
Comprehension-2	4. (b)	5. (c)	6. (a)	
Comprehension-3	7. (d)	8. (b)	9. (b)	
Comprehension-4	10. (d)	11. (a)	12. (b)	13. (a)
Comprehension-5	14. (b)	15. (d)	16. (d)	

Comprehension-6	**17.** (b)	**18.** (a)	**19.** (b)	
Comprehension-7	**20.** (d)	**21.** (a)	**22.** (a)	**23.** (d)
Comprehension-8	**24.** (d)	**25.** (c)	**26.** (c)	
Comprehension-9	**27.** (c)	**28.** (a)	**29.** (c)	
Comprehension-10	**30.** (d)	**31.** (b)	**32.** (c)	
Comprehension-11	**33.** (d)	**34.** (a)	**35.** (d)	
Comprehension-12	**36.** (a)	**37.** (c)		
Comprehension-13	**38.** (b)	**39.** (c)		
Comprehension-14	**40.** (c)	**41.** (a)	**42.** (a)	

Assertion-Reasoning Type

1. (a) **2.** (a) **3.** (b) **4.** (d)

Matching Column Type

1. (a) q, r; (b) p; (c) s; (d) t
2. (a) p, r; (b) p, r; (c) q, s; (d) q
3. (a) p, q; (b) s; (c) r; (d) t
4. (a) p, q, r; (b) p, q, r; (c) s
5. (a) q, t; (b) p; (c) p, q, s; (d) p, r, s; (e) q, t
6. (a) p, r, s; (b) r, s, t; (c) q, r, t; (d) q, t
7. (a) r; (b) p; (c) q; (d) s

Integer Answer Type

1. (5)	**2.** (4)	**3.** (16)	**4.** (6)	**5.** (12), (3)	**6.** (2)	**7.** (2)	**8.** (4)	**9.** (0)	**10.** (0)
11. (2)	**12.** (18)	**13.** (0)	**14.** (1)	**15.** (5)	**16.** (6)	**17.** (5)	**18.** (5)	**19.** (4)	**20.** (4)
21. (1)	**22.** (4)	**23.** (3)	**24.** (3)	**25.** (3)	**26.** (3)	**27.** (3)	**28.** (3)	**29.** (1)	**30.** (1)
31. (10)	**32.** (3)	**33.** (4)	**34.** (8)	**35.** (4)	**36.** (3)	**37.** (1)	**38.** (1)	**39.** (3)	**40.** (4)
41. (6)	**42.** (4)	**43.** (4)	**44.** (1)	**45.** (6)	**46.** (4)	**47.** (4)			

10

Hydrogen and Its Compounds

JEE (Main) Exercises

Single Correct Answer Type

1. Hydrogen burns in air with a:
   (a) Light bluish flame (b) Yellow flame
   (c) Green flame (d) None of these
2. Which pair does not show hydrogen isotopes?
   (a) Ortho hydrogen and para hydrogen
   (b) Protium and deuterium
   (c) Deuterium and tritium
   (d) Tritium and protium
3. Hydrogen from HCl can be prepared by:
   (a) Mg (b) Cu
   (c) P (d) Pt
4. The color of hydrogen is:
   (a) Black (b) Yellow
   (c) Orange (d) Colorless
5. Ordinary hydrogen at room temperature is a mixture of:
   (a) 75% of o-hydrogen + 25% of p-hydrogen
   (b) 25% of o-hydrogen + 75% of p-hydrogen
   (c) 50% of o-hydrogen + 50% of p-hydrogen
   (d) 1% of o-hydrogen + 99% of p-hydrogen
6. The adsorption of hydrogen by metals is called:
   (a) Dehydrogenation (b) Hydrogenation
   (c) Occlusion (d) Absorption
7. Which of the following produces hydrolith with dihydrogen?
   (a) Mg (b) Al
   (c) Cu (d) Ca
8. The metal which displaces hydrogen from a boiling caustic soda solution is:
   (a) As (b) Zn
   (c) Mg (d) Fe
9. In context with the industrial preparation of hydrogen from water gas ($CO + H_2$), which of the following is the correct statement?
   (a) CO is removed by absorption in aqueous Cu_2Cl_2 solution
   (b) H_2 is removed through occlusion with Pd
   (c) CO is oxidized to CO_2 with steam in the presence of a catalyst followed by absorption of CO_2 in alkali
   (d) CO and H_2 are fractionally separated using differences in their densities
10. Which is poorest reducing agent?
    (a) Nascent hydrogen
    (b) Atomic hydrogen
    (c) Dihydrogen
    (d) All have same reducing strength
11. An ionic compound is dissolved simultaneously in heavy water and simple water. Its solubility is:
    (a) Larger in heavy water
    (b) Smaller in heavy water
    (c) Same in both
    (d) Smaller in simple water
12. Ortho-hydrogen and para-hydrogen resemble in which of the following properties?

(a) Thermal conductivity
(b) Magnetic properties
(c) Chemical properties
(d) Heat capacity

13. Hydrogen can be prepared by mixing steam and water gas at 673 K in the presence of Fe_2O_3 and Cr_2O_3. This process is called:
(a) Nelson's process (b) Serpeck's process
(c) Bosch's process (d) Parke's process

14. An element reacts with hydrogen to form a compound 'A' which on treatment with water liberates hydrogen gas. The element can be:
(a) Nitrogen (b) Chlorine
(c) Selenium (d) Calcium

15. Which of the following halogen has maximum affinity for hydrogen?
(a) F_2 (b) Cl_2
(c) Br_2 (d) I_2

16. Hydrogen is not obtained when zinc reacts with:
(a) Cold water (b) Hot NaOH solution
(c) Conc. H_2SO_4 (d) Dil. HCl

17. The oxidation states shown by hydrogen are:
(a) –1 only (b) Zero only
(c) +1, –1, 0 (d) +1 only

18. Which element forms maximum compound in chemistry?
(a) O (b) H
(c) Si (d) C

19. When SO_3 is treated with heavy water the product is /are:
(a) Deuterium and sulphuric acid
(b) Deuterium and sulphurous acid
(c) Only deuterium
(d) Dideutero sulphuric acid

20. Which of the following gas is insoluble in water?
(a) SO_2 (b) NH_3
(c) H_2 (d) CO_2

21. The gas used in the hydrogenation of vegetable oils in the presence of nickel as catalyst is:
(a) Methane (b) Ethane
(c) Ozone (d) Hydrogen

22. The conversion of atomic hydrogen into ordinary hydrogen is:
(a) Exothermic change
(b) Endothermic change
(c) Nuclear change
(d) Photochemical change

23. Triatomic hydrogen is called:
(a) Deuterium (b) Hyzone
(c) Ortho form (d) Hydronium ion

24. $LiAlH_4$ is obtained by reacting an excess of .... with an ethereal solution of $AlCl_3$:
(a) LiCl (b) LiH
(c) Li (d) LiOH

25. Chemical A is used for water softening to remove temporary hardness. A reacts with sodium carbonate to generate caustic soda. When CO_2 is bubbled through a solution of A, it turns cloudy. What is the chemical formula of A?
(a) $CaCO_3$ (b) CaO
(c) $Ca(OH)_2$ (d) $Ca(HCO_3)_2$

26. Which is the lightest gas?
(a) Nitrogen (b) Helium
(c) Oxygen (d) Hydrogen

27. The property of hydrogen which distinguish it from alkali metals is:
(a) Its electropositive character
(b) Its affinity for non-metal
(c) Its reducing character
(d) Its non-metallic character

28. Synthetic detergents are more effective in hard water than soaps because:
(a) They are highly soluble in water
(b) Their Ca^{++} and Mg^{++} salts are water soluble
(c) Their Ca^{++} and Mg^{++} salts are insoluble in water
(d) None of the above

29. Which of the following pairs of ions makes the water hard?
(a) Na^+, SO_4^{2-} (b) K^+, HCO_3^-
(c) Ca^{2+}, NO_3^- (d) NH4 +, Cl^-

30. H_2O is hard if it contains:
(a) $NaHCO_3$ (b) $MgSO_4$
(c) KCl (d) NaCl

31. Hardness of water is due to presence of salts of:
(a) Na^+ and K^+ (b) Ca^{2+} and Mg^{2+}
(c) Ca^{2+} and K^+ (d) Ca^{2+} and Na^{2+}

32. Temporary hardness of water is due to the presence of:
(a) Magnesium bicarbonate

(b) Calcium chloride
(c) Magnesium sulphate
(d) Calcium carbonate

33. Which of the following acid is formed when SiF_4 react with water?
(a) SiF_4 (b) H_2SiF_4
(c) H_2SO_4 (d) H_2SiF_6

34. The low density of ice compared to water is due to:
(a) Induced dipole–induced dipole interactions
(b) Dipole-induced–dipole interaction
(c) Hydrogen bonding interactions
(d) Dipole–dipole interactions

35. Lead pipes are not used for carrying drinking water because:
(a) They are covered with a coating of lead carbonate
(b) They are corroded by air and moisture
(c) Water containing dissolved air attacks lead forming soluble hydroxide
(d) None of the above

36. Which of the following will cause pure demineralised water:
(a) Passing water through cation exchange resin followed by anion exchanger resin succesively
(b) Passing water through anion exchange resin
(c) Passing water through sand
(d) Passing water through alumina

37. Permutit is the technical name given to:
(a) Aluminates of calcium and sodium
(b) Silicates of calcium and sodium
(c) Hydrated silicates of aluminium and sodium
(d) Silicates of calcium and magnesium

38. Which of the following is correct about heavy water?
(a) Water at 4°C having maximum density is known as heavy water
(b) It is heavier than water (H_2O)
(c) It is formed by the combination of heavier isotope of hydrogen and oxygen
(d) None of the above

39. The boiling point of water is exceptionally high because:
(a) There is covalent bond between H and O
(b) Water molecules are linear
(c) Water molecules associate due to hydrogen bonding
(d) Water molecules are not linear

40. Match List I with List II and select the correct answer using the codes given below the lists

List I	List II
(a) Heavy water	(p) Bicarbonates of Mg and Ca in water
(b) Temporary hard water	(q) No foreign ions in water
(c) Soft water	(r) D_2O
(d) Permanent hard water	(s) Sulphates and chlorides of Mg and Ca in water

Codes

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

41. What is formed when calcium carbide reacts with heavy water?
(a) C_2D_2 (b) CaD_2
(c) Ca_2D_2O (d) CD_2

42. Metal which does not react with cold water but evolves H_2 with steam is:
(a) Na (b) K
(c) Pt (d) Fe

43. Why do calcium ions make water hard but sodium ions do not?
(a) Calcium forms insoluble compounds with stearate ions present in soap
(b) Sodium forms insoluble compounds with stearate ions present in soap
(c) Calcium forms soluble compounds with stearate ions present in soap
(d) Both calcium and sodium form insoluble compounds with stearate ions present in soap

44. Hydrogen has three isotopes protium, deuterium, and tritium, these isotopes differ from each other:
(a) These isotopes differ from one another in respect of the number of neutrons
(b) These isotopes differ from one another in respect of the number of proton
(c) These isotopes differ from one another in respect of the number of electrons
(d) None of these

45. Blackened oil painting can be restored into original form by the action of:

(a) Chlorine (b) BaO_2
(c) H_2O_2 (d) MnO_2

46. The reaction of $H_2S + H_2O_2 \rightarrow S + 2H_2O$ manifests
(a) Acidic nature of H_2O_2
(b) Alkaline nature of H_2O_2
(c) Oxidizing nature of H_2O_2
(d) Reducing action of H_2O_2

47. What is product of the reaction of H_2O_2 with Cl_2?
(a) $O_2 + HOCl$ (b) $HCl + O_2$
(c) $H_2O + HCl$ (d) $HCl + H_2$

48. H_2O_2 will oxidize:
(a) $KMnO_4$ (b) H_2S
(c) $K_2Cr_2O_7$ (d) $PbSO_4$

49. Fenton's reagent is
(a) $FeSO_4 + H_2O_2$ (b) Zn + HCl
(c) Sn + HCl (d) None of these

50. H_2O_2 is manufactured these days:
(a) By the action of H_2O_2 on BaO_2
(b) By the action of H_2SO_4 on Na_2O_2
(c) By electrolysis of 50% H_2SO_4
(d) By burning hydrogen in excess of oxygen

51. Which is false about H_2O_2?
(a) Act as both oxidizing and reducing agents
(b) Two OH bonds lies in the same plane
(c) Very pale blue liquid
(d) It can be oxidized by ozone

52. The structure of H_2O_2 is:
(a) Half open book like (b) Linear
(c) Closed book (d) Pyramidal

53. On shaking H_2O_2 with acidified potassium dichromate and ether, ethereal layer becomes:
(a) Green (b) Red
(c) Blue (d) Black

54. Which one of the following undergoes reduction with hydrogen peroxide in an alkaline medium?
(a) Mn^{2+} (b) HOCl
(c) PbS (d) Fe^{2+}

55. Polyphosphates are used as water softening agents because they:
(a) Form soluble complexes with anionic species
(b) Precipitate anionic species
(c) Forms soluble complexes with cationic species
(d) Precipitate cationic species

56. HCl is added to following oxides. Which one would give H_2O_2?
(a) MnO_2 (b) PbO_2
(c) BaO_2 (d) None of these

57. Out of the two allotropic forms of dihydrogen, the form with lesser molecular energy is:
(a) Ortho
(b) Meta
(c) Para
(d) All have same energy

58. Very pure hydrogen (99.9) can be made by which of the following processes?
(a) Reaction of methane with steam
(b) Mixing natural hydrocarbons of high molecular weight
(c) Electrolysis of water
(d) Reaction of salts like hydrides with water

59. Which of the following salts are responsible for hardness of water:
(a) Chloride of Ca and Mg
(b) Sulphates of Ca and Mg
(c) Bicarbonates of Ca and Mg
(d) All of these

60. Which of the following method(s) is/are used to removal of temporary hardness:
(a) By boiling (b) Clark's method
(c) Both (a) and (b) (d) None of these

61. Which of the following method(s) is/are used to removal of parmanent hardness:
(a) Calgon's method
(b) Ion-exchange method
(c) Synthetic resins method
(d) All of these

62. Metallic or non-stoichiometric (or interstitial) hydrides are formed by:
(a) Many *d*-block and *f*-block elements
(b) Many *s*-block elements
(c) Many *p*-block elements
(d) None of these

63. In which of the following hydrides, the law of constant composition does not hold good:
(a) Saline hydride (b) Metallic hydride
(c) Molecular hydride (d) All of these

64. Which of the following properties of water leads in comparison to H_2S and H_2Se due to H-bonding:

(a) Low freezing point
(b) Low boiling point
(c) Low heat of vaporization
(d) High heat of fuszion

65. Select the incorrect statements about ice:
(a) At atmospheric pressure ice crystallizes in the hexagonal form, but at very low temperature it condenses to cubic form
(b) Density of ice is less than that of water therefore, an ice cube floats on water
(c) In winter season ice formed on surface of a lake provides thermal insulation
(d) Volume of ice is less than that of water

66. Which of the following is the method for the manufacture of ammonia by the Haber process:
(a) $N_2 + O_2 \rightarrow NO$
(b) $N_2 + 3H_2 \xrightarrow[\text{200 atm., Fe}]{673} 2NH_3$
(c) $NH_3 + O_2 \rightarrow NO$
(d) None of these

67. Which of the following statement is correct for ionic hydrides:
(a) The ionic hydrides are crystalline
(b) The ionic hydrides are non-volatile
(c) The ionic hydrides are non-conducting in solid state
(d) All are correct

68. $LiH + \underline{B}_2H_6 \rightarrow 2Li\underline{B}H_4$,
find the change in hybridization of underlined atom.
(a) $sp^2 \rightarrow sp^3$ (b) $sp^3 \rightarrow sp^2$
(c) $sp \rightarrow sp^3$ (d) None

69. Which of the following isotope is called as heavy hydrogen:
(a) Protium (b) Deuterium
(c) Tritium (d) All of these

70. Which of the following isotope of hydrogen is radioactive and emits low energy $\beta^{\ominus}$ particles ($t_{1/2}$, 12.33 years)
(a) Protium (b) Deuterium
(c) Tritium (d) All of these

71. Isotopes of hydrogen have same electronic configuration and they have almost the same chemical properties but the only difference is in their rates of reactions.
(a) Mainly due to their different enthalpy of bond dissociation
(b) Mainly due to their different size
(c) Mainly due to their same number of e^-
(d) Mainly due to their same number of proton

72. In physical properties isotopes of hydrogen differ considerably due to their:
(a) Large size difference
(b) Significant mass difference
(c) Large atomic number difference
(d) None of these

73. H_2 gas is usually prepared by the reaction of
(a) Zn + dil. HCl (b) Zn + dil. H_2SO_4
(c) Zn + NaOH (d) All of these

74. High purity (> 99.95 %) dihydrogen is obtained by:
(a) Electrolysis of acidified water using platinum electrodes
(b) Electrolyzing warm aqueous barium hydroxide solution between nickel electrodes
(c) Electrolysis of brine solution
(d) Reaction of steam on hydrocarbons or coke at high temperature in the presence of catalyst

75. The mixture of CO and H_2 is called:
(a) Water gas (b) Producer gas
(c) Coal gas (d) All of these

76. $(CO + H_2)$ mixture is called:
(a) Synthesis gas (b) Syn gas
(c) Both (a) and (b) (d) None of these

77. Nowadays syn gas is produced from:
(a) Sewage
(b) Saw–dust
(c) Scrap wood and newspaper
(d) All of these

78. The process of producing syn gas from coal is called coal gasification, which of the following reaction is correct for coal gasification.
(a) $CO_{(g)} + 2H_{2(g)} \xrightarrow{\text{Cobalt}} CH_3OH_{(l)}$
(b) $3H_{2(g)} + N_{2(g)} \xrightarrow[\text{Fe}]{} 2NH_{3(g)}$
(c) $C_{(s)} + H_2O_{(g)} \xrightarrow{1270\text{ K}} CO_{(g)} + H_{2(g)}$
(d) None of these

79. Which of the following reaction is called water gas shift / Bosch reaction
(a) $C_{(s)} + H_2O_{(g)} \xrightarrow{1270\text{ K}} CO_{(g)} + H_{2(g)}$
(b) $CO_{(g)} + H_2O_{(g)} \xrightarrow[Fe_2O_3 - Cr_2O_3]{673\text{ K}} CO_{2(g)} + H_{2(g)}$
(c) $H_2 + CO + RCH{=}CH_2 \rightarrow RCH_2CH_2CHO$
(d) None of these

80. Select the correct statement about dihydrogen:
(a) It is colorless, odorless, and tasteless
(b) It is combustible gas
(c) It is lighter than air and insoluble in water
(d) All of these

81. When H_2 reacts with halogen X_2 then order of reactivity is:
(a) $F_2 > Cl_2 > Br_2 > I_2$ (b) $Cl_2 > F_2 > Br_2 > I_2$
(c) $Br_2 > I_2 > Cl_2 > F_2$ (d) $I_2 > Br_2 > Cl_2 > F_2$

NCERT Exemplar Exercises

Single Correct Answer Type

1. Hydrogen resembles halogens in many respects for which several factors are responsible. Of the following factors which one is most important in this respect?
(a) Its tendency to lose an electron to form a cation
(b) Its tendency to gain a single electron in its valence shell to attain stable electronic configuration
(c) Its low negative electron gain enthalpy value.
(d) Its small size

2. Why does H^+ ion always get associated with other atoms or molecules?
(a) Ionization enthalpy of hydrogen resembles that of alkali metals
(b) Its reactivity is similar to halogens
(c) It resembles both alkali metals and halogens
(d) Loss of an electron from hydrogen atom results in a nucleus of very small size as compared to other atoms or ions. Due to small size it cannot exist free

3. Metal hydrides are ionic, covalent or molecular in nature. Among LiH, NaH, KH, RbH, CsH, the correct order of increasing ionic character is:
(a) LiH > NaH > CsH > KH > RbH
(b) LiH < NaH < KH < RbH < CsH
(c) RbH > CsH > NaH > KH > LiH
(d) NaH > CsH > RbH > LiH > KH

4. Which of the following hydride is electron precise hydride?
(a) B_2H_6 (b) NH_3
(c) H_2O (d) CH_4

5. Radioactive elements emit α, β, and γ rays and are characterized by their halflives. The radioactive isotope of hydrogen is:
(a) Protium (b) Deuterium
(c) Tritium (d) Hydronium

6. Consider the reactions
(i) $H_2O_2 + 2HI \rightarrow I_2 + 2H_2O$
(ii) $HOCl + H_2O_2 \rightarrow H_3O^+ + Cl^- + O_2$
Which of the following statements is correct about H_2O_2 with reference to these reactions? Hydrogen perioxide is _____.
(a) An oxidizing agent in both (i) and (ii)
(b) An oxidizing agent in (i) and reducing agent in (ii)
(c) A reducing agent in (i) and oxidizing agent in (ii)
(d) A reducing agent in both (i) and (ii)

7. The compound that gives H_2O_2 on treatment with dilute H_2SO_4 is:
(a) PbO_2 (b) $BaO_2.8H_2O + O_2$
(c) MnO_2 (d) TiO_2

8. Which of the following equations depict the oxidizing nature of H_2O_2?
(a) $2MnO_4^- + 6H+ 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$
(b) $2Fe^{3+} + 2H^+ + H_2O_2 \rightarrow 2Fe^{2+} + 2H_2O + O_3$
(c) $2I + 2H^+ + H_2O_2 \rightarrow I_2 + 2H_2O$
(d) $KIO_4 + H_2O_2 \rightarrow KIO_3 + H_2O + O_2$

9. Which of the following equation depicts reducing nature of H_2O_2?
(a) $2[Fe(CN)_6]^{4-} + 2H^+ + H_2O_2 \rightarrow 2[Fe(CN)_6]^{3-} + 2H_2O$
(b) $I_2 + H_2O_2 + 2OH^- \rightarrow 2I^- + 2H_2O + O_2$
(c) $Mn^{2+} + H_2O_2 \rightarrow Mn^{4+} + 2OH^-$
(d) $PbS + 4H_2O_2 \rightarrow PbSO_4 + 4H_2O$

10. Hydrogen peroxide is:
(a) An oxidizing agent
(b) A reducing agent
(c) Both an oxidizing and a reducing agent
(d) Neither oxidizing nor reducing agent

11. Which of the following reactions increases production of dihydrogen from synthesis gas?
(a) $CH_4(g) + H_2O(g) \xrightarrow[Ni]{1270\,N} CO(g) + 3H_2(g)$
(b) $C(s) + H_2O(g) \xrightarrow{1270\,K} CO(g) + H_2(g)$

(c) $CO(g) + H_2O(g) \xrightarrow[\text{Catalyst}]{673\,K} CO_2(g) + H_2(g)$

(d) $C_2H_6 + 2H_2O \xrightarrow[\text{Ni}]{1270\,K} 2CO + 5H_2$

12. When sodium peroxide is treated with dilute sulphuric acid, we get:

(a) Sodium sulphate and water
(b) Sodium sulphate and oxygen
(c) Sodium sulphate, hydrogen, and oxygen
(d) Sodium sulphate and hydrogen peroxide

13. Hydrogen peroxide is obtained by the electrolysis of:

(a) Water
(b) Sulphuric acid
(c) Hydrochloric acid
(d) Fused sodium peroxide

14. Which of the following reactions is an example of use of water gas in the synthesis of other compounds?

(a) $CH_4(g) + H_2O(g) \xrightarrow[\text{Ni}]{1270\,N} CO(g) + H_2(g)$

(b) $CO(g) + H_2O(g) \xrightarrow[\text{Catalyst}]{673\,K} CO_2(g) + H_2(g)$

(c) $C_nH_{2n+2} + nH_2O(g) \xrightarrow[\text{Ni}]{1270\,K} nCO + (2n+1)H_2$

(d) $CO(g) + 2H_2(g) \xrightarrow[\text{Catalyst}]{\text{Cobalt}} CH_3OH(\ell)$

15. Which of the following ions will cause hardness in water sample?

(a) Ca^{2+} (b) Na^+
(c) Cl (f) K^+

16. Which of the following compounds is used for water softening?

(a) $Ca_3(PO_4)_2$ (b) Na_3PO_4
(c) $Na_6P_6O_{18}$ (d) Na_2HPO_4

17. Elements of which of the following group(s) of periodic table do not form hydrides.

(a) Groups 7, 8, 9 (b) Group 13
(c) Groups 15, 16, 17 (d) Group 14

18. Only one element of which group forms hydride.

(a) Group 6 (b) Group 7
(c) Group 8 (d) Group 9

Multiple Correct Answers Type

In the following questions two or more options may be correct.

1. Which of the following statements are not true for hydrogen?

(a) It exists as diatomic molecule
(b) It has one electron in the outermost shell
(c) It can lose an electron to form a cation which can freely exist
(d) It forms a large number of ionic compounds by losing an electron

2. Dihydrogen can be prepared on commercial scale by different methods. In its preparation by the action of steam on hydrocarbons, a mixture of CO and H_2 gas is formed. It is known as:

(a) Water gas (b) Syngas
(c) Producer gas (d) Industrial gas

3. Which of the following statement(s) is/are correct in the case of heavy water?

(a) Heavy water is used as a moderator in nuclear reactor
(b) Heavy water is more effective as solvent than ordinary water
(c) Heavy water is more associated than ordinary water
(d) Heavy water has lower boiling point than ordinary water

4. Which of the following statements about hydrogen are correct?

(a) Hydrogen has three isotopes of which protium is the most common
(b) Hydrogen never acts as cation in ionic salts
(c) Hydrogen ion H^+, exists freely in solution
(d) Dihydrogen does not act as a reducing agent

5. Some of the properties of water are described below. Which of them is/are not correct?

(a) Water is known to be a universal solvent
(b) Hydrogen bonding is present to a large extent in liquid water
(c) There is no hydrogen bonding in the frozen state of water
(d) Frozen water is heavier than liquid water

6. Hardness of water may be temporary or permanent. Permanent hardness is due to the presence of:

(a) Chlorides of Ca and Mg in water
(b) Sulphates of Ca and Mg in water
(c) Hydrogen carbonates of Ca and Mg in water
(d) Carbonates of alkali metals in water

7. Which of the following statements is correct?

(a) Elements of group 15 form electron deficient hydrides

(b) All elements of group 14 form electron precise hydrides

(c) Electron precise hydrides have tetrahedral geometries

(d) Electron-rich hydrides can act as Lewis acids

8. Which of the following statements is correct?
   (a) Hydrides of group 13 act as Lewis acids
   (b) Hydrides of group 14 are electron deficient hydrides
   (c) Hydrides of group 14 act as Lewis acids
   (d) Hydrides of group 15 act as Lewis bases

9. Which of the following statements is correct?
   (a) Metallic hydrides are deficient of hydrogen
   (b) Metallic hydrides conduct heat and electricity
   (c) Ionic hydrides do not conduct electricity in solid state
   (d) Ionic hydrides are very good conductors of electricity in solid state

Short Answer Type

1. How can production of hydrogen from water gas be increased by using water gas shift reaction?
2. What are metallic/interstitial hydrides? How do they differ from molecular hydrides?
3. Name the classes of hydrides to which H_2O, B_2H_6 and NaH belong.
4. If same mass of liquid water and a piece of ice is taken, then why is the density of ice less than that of liquid water?
5. Complete the following equations:
   (a) $PbS\,(s) + H_2O_2(aq) \rightarrow$
   (b) $CO(g) + 2H_2(g) \xrightarrow[\text{Catalyst}]{\text{Cobalt}}$
6. Give reasons:
   (a) Lakes freeze from top towards bottom.
   (b) Ice floats on water.
7. What do you understand by the term 'auto protolysis of water'? What is its significance?
8. Discuss briefly de-mineralization of water by ion exchange resin.
9. Molecular hydrides are classified as electron deficient, electron precise and electron-rich compounds. Explain each type with two examples.
10. How is heavy water prepared? Compare its physical properties with those of ordinary water.
11. Write one chemical reaction for the preparation of D_2O_2.
12. Calculate the strength of 5 volume H_2O_2 solution.
13. (a) Draw the gas phase and solid phase structure of H_2O_2.
    (b) H_2O_2 is a better oxidizing agent than water. Explain.
14. Melting point, enthalpy of vaporization and viscosity data of H_2O and D_2O is given below:

	H_2O	D_2O
Melting point / K	373.0	374.4
Enthalpy of vaporization at (373 K)/ kJ mol^{-1}	40.66	41.61
Viscosity/centipoise	0.8903	1.107

On the basis of these data, explain in which of these liquids intermolecular forces are stronger?

15. Dihydrogen reacts with dioxygen (O_2) to form water. Write the name and formula of the product when the isotope of hydrogen which has one proton and one neutron in its nucleus is treated with oxygen. Will the reactivity of both the isotopes be the same towards oxygen? Justify your answer.
16. Explain why HCl is a gas and HF is a liquid.
17. When the first element of the periodic table is treated with dioxygen, it gives a compound whose solid state floats on its liquid state. This compound has an ability to act as an acid as well as a base. What products will be formed when this compound undergoes autoionization?
18. Rohan heard that instructions were given to the laboratory attendent to store a particular chemical i.e., keep it in the dark room, add some urea in it, and keep it away from dust. This chemical acts as an oxidizing as well as a reducing agent in both acidic and alkaline media. This chemical is important for use in the pollution control treatment of domestic and industrial effluents.
    (a) Write the name of this compound.
    (b) Explain why such precautions are taken for storing this chemical.
19. Give reasons why hydrogen resembles alkali metals?
20. Hydrogen generally forms covalent compounds. Give reason.
21. Why is the ionization enthalpy of hydrogen higher than that of sodium?

22. Basic principle of hydrogen economy is transportation and storage of energy in the form of liquid or gaseous hydrogen. Which property of hydrogen may be useful for this purpose? Support your answer with the chemical equation if required.
23. What is the importance of heavy water?
24. Write the Lewis structure of hydrogen peroxide.
25. An acidic solution of hydrogen peroxide behaves as an oxidizing as well as reducing agent. Illustrate it with the help of a chemical equation.
26. With the help of suitable examples, explain the property of H_2O_2 that is responsible for its bleaching action?
27. Why is water molecule polar?
28. Why does water show high boiling point as compared to hydrogen sulphide? Give reasons for your answer.
29. Why can dilute solutions of hydrogen peroxide not be concentrated by heating. How can a concentrated solution of hydrogen peroxide be obtained?
30. Why is hydrogen peroxide stored in wax lined bottles?
31. Why does hard water not form lather with soap?
32. Phosphoric acid is preferred over sulphuric acid in preparing hydrogen peroxide from peroxides. Why?
33. How will you account for 104.5° bond angle in water?
34. Write redox reaction between fluorine and water.
35. Write two reactions to explain amphoteric nature of water.

Matching Column Type

1. Correlate the items listed in Column-I with those listed in Column-II. Find out as many correlations as you can.

Column-I	Column-II
(a) Synthesis gas	(p) $Na_2[Na_4(PO_3)_6]$
(b) Dihydrogen	(q) Oxidizing agent
(c) Heavy water	(r) Used in softening of water
(d) Calgon	(s) Reducing agent
(e) Hydrogen peroxide	(t) Stoichiometric compounds of *s*-block elements
(f) Salt-like hydrides	(u) Produced by prolonged electrolysis of water
	(v) Zn + NaOH
	(w) Zn + dil. H_2SO_4
	(x) Synthesis of methanol
	(y) Mixture of CO and H_2

2. Match Column-I with Column-II for the given properties/applications mentioned therein.

Column-I	Column-II
(a) H	(p) Used in the name of perhydrol
(b) H_2	(q) Can be reduced to dihydrogen by NaH
(c) H_2O	(r) Can be used in hydroformylation of olefin
(d) H_2O_2	(s) Can be used in cutting and welding

3. Match the terms in Column-I with the relevant item in Column-II.

Column-I	Column-II
(a) Electrolysis of water produces	(p) Atomic reactor
(b) Lithium aluminium hydride is used as	(q) Polar molecule
(c) Hydrogen chloride is a	(r) Combines on metal surface to generate high temperature
(d) Heavy water is used in	(s) Reducing agent
(e) Atomic hydrogen	(t) Hydrogen and oxygen

4. Match the items in Column-I with the relevant item in Column-II.

Column-I	Column-II
(a) Hydrogen peroxide is used as a	(p) Zeolite
(b) Used in Calgon method	(q) Perhydrol
(c) Permanent hardness of water is removed by	(r) Hexametaphosphate
	(s) Propellant

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 options given below each question.

1. **Assertion (A):** Permanent hardness of water is removed by treatment with washing soda.

   Reason (R): Washing soda reacts with soluble magnesium and calcium sulphate to form insoluble carbonates.

   (a) Statements A and R both are correct and R is the correct explanation of A.
   (b) A is correct but R is not correct.
   (c) A and R both are correct but R is not the correct explanation of A.
   (d) A and R both are false.

2. **Assertion (A):** Some metals like platinum and palladium, can be used as storage media for hydrogen.

   Reason (R): Platinum and palladium can absorb large volumes of hydrogen.

   (a) Statements A and R both are correct and R is the correct explanation of A.
   (b) A is correct but R is not correct.
   (r) A and R both are correct but R is not the correct explanation of A.
   (d) A and R both are false.

Long Answer Type

1. Atomic hydrogen combines with almost all elements but molecular hydrogen does not. Explain.
2. How can D_2O be prepared from water? Mention the physical properties in which D_2O differs from H_2O. Give at least three reactions of D_2O showing the exchange of hydrogen with deuterium.
3. How will you concentrate H_2O_2? Show differences between structures of H_2O_2 and H_2O by drawing their spatial structures. Also mention three important uses of H_2O_2.
4. (a) Give a method for the manufacture of hydrogen peroxide and explain the reactions involved therein.
   (b) Illustrate oxidizing, reducing and acidic properties of hydrogen peroxide with equations.
5. What mass of hydrogen peroxide will be present in 2 litres of a 5 molar solution? Calculate the mass of oxygen which will be liberated by the decomposition of 200 mL of this solution.
6. A colorless liquid 'A' contains H and O elements only. It decomposes slowly on exposure to light. It is stabilized by mixing urea to store in the presence of light.
   (a) Suggest possible structure of A.
   (b) Write chemical equations for its decomposition reaction in light.
7. An ionic hydride of an alkali metal has significant covalent character and is almost unreactive towards oxygen and chlorine. This is used in the synthesis of other useful hydrides. Write the formula of this hydride. Write its reaction with Al_2Cl_6.
8. Sodium forms a crystalline ionic solid with dihydrogen. The solid is nonvolatile and non-conducting in nature. It reacts violently with water to produce dihydrogen gas. Write the formula of this compound and its reaction with water. What will happen on electrolysis of the melt of this solid.

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

1. (a) Hydrogen burns in air with light bluish flame.
2. (a) Ortho-hydrogen and para-hydrogen are nuclear isomers based on nuclear spin, isomers of hydrogen are protium, deuterium, and tritium.
3. (a) $Mg + HCl \rightarrow MgCl_2 + H_2$
   Cu, P, and Pt are weak reducing agent.
4. (d) Hydrogen is colorless.
5. (a) Ordinary hydrogen at room temperature is a mixture of 75% of ortho-hydrogen and 25% of para-hydrogen.
6. (c) Occlusion—The property of metal to absorb any gas is called occlusion.
7. (d) $Ca + H_2 \rightarrow CaH_2$ (Hydrolith)
8. (b) $Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2 \uparrow$
10. (c) Reacitivity order
    Atomic hydrogen > Nascent hydrogen > Molecular hydrogen

11. (b) Solubility of ionic compound smallar in heavy water than simple water because value of dielectric constant $|c^2|N.m^2$ for water 78.39 and D_2O 78.06

13. (c) $CO_{12} + H_2O_{(d)} \xrightarrow[\text{(Catalyst)}]{673\,K, Fe_2O_3|Cr_2O_3} CO_{2(2)} + H_{2(g)}$

This is called water-gas shift reaction/Bosch process.

14. (d) $Ca + H_2 \rightarrow \underset{\text{(A)}}{CaH_2} \xrightarrow{H-OH} Ca(OH)_2 + H_2$
(Hydrolith)

16. (c) $Zn + \text{conc. } H_2SO_4 \rightarrow ZnSO_4 + SO_2 \uparrow$

19. (d) $SO_3 + D_2O \rightarrow D_2SO_4$ (Dideutero sulphuric acid)

25. (c) $\underset{\text{(A)}}{Ca(OH)_2} + Na_2CO_3 \rightarrow CaCO_3 + NaOH$

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

$Ca(OH)_2$ is used to remove temporary hardness in Clark's method.

30. (b) Presence of calcium and magnesium salts in the form of hydrogen carbonate, chloride, and sulphate in water makes water hard water.

32. (a) Temporary hardness is due to the presence of magnesium and calcium hydrogen carbonate.

57. (c) In ortho-hydrogen spin of nucleus is same, so they will repeal each other and because of this repulsion internal energy of ortho-hydrogen increase, so, ortho-hydrogen has more internal energy.

66. (b) $N_2 + 3H_2 \xrightarrow[200\text{ atm, Fe}]{673\,K} 2NH_3(g)$, $OH^{\oplus} =$ 92.6 kJ/mol

69. (b) Deuterium is called heavy hydrogen.

70. (c) Tritium

75. (a) The mixture of CO and H_2 is called water gas.

76. (c) The mixture of CO and H_2 is called water gas. As this mixture of CO and H_2 is used for the synthesis of methonol and a number of hydrocarbons, it is also called synthesis gas or syngas.

81. (a) H_2 reacts with halogen, X_2 to give hydrogen halide

$H_{2(g)} + X_{2(g)} \rightarrow 2\,HX_{(g)}$ (X = F, Cl, Br, I)

order of reactivity

$F_2 > Cl_2 > Br_2 > I_2$

While the reaction with fluorine occurs even in dark, with iodine it requires a catalyst.

NCERT Exemplar Exercises

Short Answer Type

12. 5 volume H_2O_2 solution means that hydrogen peroxide contained in 1 volume of this solution will decompose to give 5 volumes of oxygen at STP i.e. if 1 L of this solution is taken, then 5 L of oxygen can be produced from this at STP. Chemical equation for the decomposition of H_2O_2 is $2H_2O_2(l) \rightarrow O_2(g) + H_2O(l)$.

It shows that 68 g H_2O_2 gives 22.7 L of O_2 at STP, so 5 L oxygen will be obtained from:

$$\frac{68\text{ g} \times 5\text{L}}{22.7\text{L}} = \frac{3400}{227}\text{ g}\,H_2O_2 = 14.9\text{ g} \approx 15\text{ g}\,H_2O_2$$

i.e., 15 g H_2O_2 dissolved in 1 L solution will give 5 L oxygen or 1.5 g H_2O_2/100 mL solution will give 500 mL oxygen. Thus 15 g/L or 1.5% solution is known as 5 volume solution of H_2O_2.

15. [**Hint:** Heavy water; Bond dissociation energy of dihydrogen is less than dideuterium]

17. [**Hint:** $H_2O + H_2O \rightarrow H_3O^+ + {}^-OH$]

18. (a) H_2O_2

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (a)	**2.** (a)	**3.** (a)	**4.** (d)	**5.** (a)	**6.** (c)	**7.** (d)	**8.** (b)	**9.** (c)	**10.** (c)
11. (b)	**12.** (c)	**13.** (c)	**14.** (d)	**15.** (a)	**16.** (c)	**17.** (c)	**18.** (b)	**19.** (d)	**20.** (c)
21. (d)	**22.** (a)	**23.** (b)	**24.** (b)	**25.** (c)	**26.** (d)	**27.** (d)	**28.** (b)	**29.** (b)	**30.** (b)
31. (b)	**32.** (a)	**33.** (d)	**34.** (c)	**35.** (c)	**36.** (a)	**37.** (c)	**38.** (c)	**39.** (c)	**40.** (d)
41. (a)	**42.** (d)	**43.** (a)	**44.** (d)	**45.** (c)	**46.** (c)	**47.** (b)	**48.** (b)	**49.** (a)	**50.** (c)
51. (b)	**52.** (a)	**53.** (c)	**54.** (b)	**55.** (c)	**56.** (c)	**57.** (c)	**58.** (d)	**59.** (d)	**60.** (c)
61. (d)	**62.** (a)	**63.** (b)	**64.** (d)	**65.** (d)	**66.** (b)	**67.** (d)	**68.** (d)	**69.** (b)	**70.** (c)

71. (a) **72.** (b) **73.** (d) **74.** (b) **75.** (a) **76.** (c) **77.** (d) **78.** (c) **79.** (b) **80.** (d) **81.** (a)

NCERT Exemplar Exercises

Single Correct Answer Type

1. (b) **2.** (d) **3.** (b) **4.** (d) **5.** (c) **6.** (b) **7.** (b) **8.** (c) **9.** (b) **10.** (c) **11.** (c) **12.** (d) **13.** (b) **14.** (d) **15.** (a) **16.** (c) **17.** (a) **18.** (a)

Multiple Correct Answers Type

1. (c), (d) **2.** (a), (b) **3.** (a), (c) **4.** (a), (b) **5.** (c), (d) **6.** (a), (b) **7.** (b), (c) **8.** (a), (d) **9.** (a), (b), (c)

Matching Column Type

1. (a) → (x, y); (b) → (s, t, u, v, w); (c) → (t, u); (d) → (p, r); (e) → (q), (s) (f) → (t)

2. (a) → (s); (b) → (r); (c) → (q); (d) → (p)

3. (a) → (t); (b) → (s); (c) → (q); (d) → (p); (E) → (r)

4. (a) → (q, s); (b) → (r); (c) → (p, r)

Assertion-Reasoning Type

1. (a) **2.** (b)

Long Answer Type

5. 68 g, 3.2 g

11

f-Block Elements

JEE (Main) Exercises

Single Correct Answer Type

1. Lanthanoids used in glass blower's goggles are:
   (a) Pr and Nd (b) Eu and Gd
   (c) Tb and Dy (d) Pm and Sm

2. Most common oxidation state of lanthanoid series is:
   (a) +2 (b) +3
   (c) +4 (d) +1

3. The electronic configuration of actinoids cannot be assigned with degree of certainty because of:
   (a) Overlapping of inner orbitals
   (b) Free movement of electrons over all the orbitals
   (c) Small energy difference between 5*f* and 6*d* levels
   (d) None of above

4. Consider the following statements in respect of lanthanoids:
   (i) The basic strength of hydroxides of lanthanoids increases from $La(OH)_3$ to $Lu(OH)_3$.
   (ii) The lanthanoid ions Lu^{3+}, Yb^{2+}, and Ce^{4+} are diamagnetic. Which of the statement(s) given above is/are correct?
   (a) (i) Only (b) (ii) Only
   (c) Both (i) and (ii) (d) Neither (i) nor (ii)

5. Lanthanoid contraction implies:
   (a) Decrease in density
   (b) Decrease in mass
   (c) Decrease in ionic radii
   (d) Decrease in radioactivity

6. If the lanthanoid element with x *f* electrons has a pink color, then the lanthanoid with $(14 - x)$ *f* electrons will have the color as:
   (a) Blue (b) Red
   (c) Green (d) Pink

7. In aqueous solution, Eu^{2+} ion acts as:
   (a) An oxidizing agent (b) A reducing agent
   (c) Either (a) or (b) (d) None of these

8. The actinoids showing +7 oxidation state are:
   (a) U, Np (b) Pu, Am
   (c) Np, Pu (d) Am, Cm

9. Among the lanthanoids the one obtained by synthetic method is:
   (a) Lu (b) Pm
   (c) Pr (d) Gd

10. Across the lanthanoid series, the basicity of the lanthanoid hydroxides:
    (a) Increases
    (b) Decreases
    (c) First increases and then decreases
    (d) First decreases and then increases

11. The reason for the stability of Gd^{3+} ion is:
    (a) 4*f* subshell—half filled

(b) 4 *f* subshell—completely filled
(c) Possesses the general electronic configuration of noble gases
(d) 4 *f* subshell empty

12. Most common oxidation states shown by cerium are:
(a) +2, +4 (b) +3, +4
(c) +3, +5 (d) +2, +3

13. The +3 ion of which one of the following has half filled 4 *f* subshell?
(a) La (b) Lu
(c) Gd (d) Ac

14. Arrange Ce^{3+}, La^{3+}, Pm^{3+}, and Yb^{3+} in *increasing order* of their ionic radii:
(a) $Yb^{3+} < Pm^{3+} < Ce^{3+} < La^{3+}$
(b) $Ce^{3+} < Yb^{3+} < Pm^{3+} < La^{3+}$
(c) $Yb^{3+} < Pm^{3+} < La^{3+} < Ce^{3+}$
(d) $Pm^{3+} < La^{3+} < Ce^{3+} < Yb^{3+}$

15. The radius of La^{3+} (At. No. of La = 57) is 1.06 Å. Which one of the following given values will be closest to the radius of Lu^{3+} (At. No. of Lu = 71)?
(a) 1.40 Å (b) 1.06 Å
(c) 0.85 Å (d) 1.60 Å

16. A reduction in atomic size with increase in atomic number is a characteristic of elements of:
(a) *d*-block (b) *f*-block
(c) Radioactive series (d) High atomic masses

17. Cerium (Z = 58) is an important member of the lanthanoids. Which of the following statement about cerium is incorrect?
(a) The common oxidation states of cerium are +3 and +4
(b) Cerium(IV) acts as an oxidizing agent
(c) The +4 oxidation state of cerium is more stable in solutions
(d) The +3 oxidation state of cerium is more stable than the +4 oxidation state

18. The lanthanoid contraction is responsible for the fact that:
(a) Zr and Nb have similar oxidation state
(b) Zr and Y have about the same radius
(c) Zr and Zn have the same oxidation state
(d) Zr and Hf have about the same radius

19. Lanthanoid contraction is caused due to
(a) The same effective nuclear charge from Ce to Lu
(b) The imperfect shielding on outer electrons by 4*f* electrons from the nuclear charge
(c) The appreciable shielding on outer electrons by 4*f* electrons from the nuclear charge
(d) The appreciable shielding on outer electrons by 5*d* electrons from the nuclear charge

20. The actinoids exhibit more number of oxidation states in general than the lanthanoids. This is because:
(a) The 5*f* orbitals extend further from the nucleus than the 4*f* orbitals
(b) The 5*f* orbitals are more buried than the 4*f* orbitals
(c) There is a similarity between 4*f* and 5*f* orbitals in their angular part of the wave function
(d) The actinoids are more reactive than the lanthanoids

21. The group of elements in which the differentiating electron enters into the antepenultimate shell of atoms is called:
(a) *f*-block elements (b) *p*-block elements
(c) *s*-block elements (d) *d*-block elements

22. Knowing that the chemistry of lanthanoids (Ln) is dominated by its +3 oxidation state, which of the following statement is incorrect?
(a) The ionic sizes of Ln(III) decrease in general with increasing atomic number
(b) Ln(III) compounds are generally colorless
(c) Ln(III) hydroxides are mainly basic in character
(d) Because of the large size of the Ln(III) ions, the bonding in its compounds is predominantly ionic in character

23. Which is *not correct* statement about the chemistry of 3*d* and 4*f* series elements?
(a) 3*d*-elements show more oxidation states than 4*f*-series elements
(b) The energy difference between 3*d* and 4*s* orbitals is very little
(c) Europium(II) is more stable than Ce(II)
(d) The paramagnetic character in 3*d*-series elements increases from scandium to copper

24. The maximum oxidation state exhibited by actinoid elements is:
(a) +5 (b) +4
(c) +7 (d) +8

25. Which of the following lanthanoid ion is paramagnetic?

(a) Ce^{4+} (b) Yb^{2+}
(c) Lu^{3+} (d) Eu^{2+}

26. In context of the lanthanoids, which of the following statement is not correct?
(a) There is a gradual decrease in the radii of the members with increasing atomic number in the series
(b) All the members exhibit +3 oxidation state
(c) Because of similar properties, the separation of lanthanoids is not easy
(d) Availability of 4*f* electrons results in the formation of compounds in +4 state for all the members of the series

27. The outer electronic configuration of Gd (At. No. = 64) is:
(a) $4f^3\ 5d^5\ 6s^2$ (b) $4f^8\ 5d^0\ 6s^2$
(c) $4f^4\ 5d^4\ 6s^2$ (d) $4f^7\ 5d^1\ 6s^2$

28. Consider the following statements:
(i) $La(OH)_3$ is the least basic among hydroxides of lanthanoid.
(ii) Zr^{4+} and Hf^{4+} possess almost the same ionic radii.
(iii) Ce^{4+} can act as an oxidizing agent.

Which of the above is/are true?
(a) (i) and (iii) (b) (ii) and (iii)
(c) (ii) only (d) (i) and (ii)
(e) (i) only

29. On which factors, the stability of oxidation states of lanthanoid elements depends?
(a) Enthalpy
(b) Internal energy
(c) Combined effects of hydration enthanlpy and ionization enthalpy
(d) Electronic configuration

NCERT Exemplar Exercises

Single Correct Answer Type

1. Which of the following oxidation state is common for all lanthanoids?
(a) +2 (b) +3
(c) +4 (d) +5

2. There are 14 elements in actinoid series. Which of the following elements does not belong to this series?
(a) U (b) Np
(c) Tm (d) Fm

3. Gadolinium belongs to 4*f* series. Its atomic number is 64. Which of the following is the correct electronic configuration of gadolinium?
(a) [Xe] $4f^7 5d^1 6s^2$ (b) [Xe] $4f^6 5d^2 6s^2$
(c) [Xe] $4f^8 6d^2$ (d) [Xe] $4f^9 5s^1$

4. Although Zirconium belongs to 4*d* transition series and Hafnium to 5*d* transition series even then they show similar physical and chemical properties because _____.
(a) Both belong to *d*-block
(b) Both have same number of electrons
(c) Both have similar atomic radius
(d) Both belong to the same group of the periodic table

Multiple Correct Answers Type

1. Generally transition elements and their salts are colored due to the presence of unpaired electrons in metal ions. Which of the following compounds are colored?
(a) $KMnO_4$ (b) $Ce(SO_4)_2$
(c) $TiCl_4$ (d) Cu_2Cl_2

2. Which of the following actinoids show oxidation states up to +7?
(a) Am (b) Pu
(c) U (d) Np

3. General electronic configuration of actionoids is $(n-2)f^{1-14}\ (n-1)d^{0-2}ns^2$. Which of the following actinoids have one electron in 6*d* orbital?
(a) U (Atomic no. 92) (b) Np (Atomic no. 93)
(c) Pu (Atomic no. 94) (d) Am (Atomic no. 95)

4. Which of the following lanthanoids show +2 oxidation state besides the characteristic oxidation state +3 of lanthanoids?
(a) Ce (b) Eu
(c) Yb (d) Ho

5. Although +3 is the characteristic oxidation state for lanthanoids but cerium also shows +4 oxidation state because _____.
(a) It has variable ionization enthalpy
(b) It has a tendency to attain noble gas configuration
(c) It has a tendency to attain f^0 configuration
(d) It resembles Pb^{4+}

Short Answer Type

1. Ionization enthalpies of Ce, Pr, and Nd are higher than Th, Pa, and U. Why?
2. Although Zr belongs to $4d$ and Hf belongs to $5d$ transition series but it is quite difficult to separate them. Why?
3. Although +3 oxidation state is the characteristic oxidation state of lanthanoids but cerium shows +4 oxidation state also. Why?
4. The second and third rows of transition elements resemble each other much more than they resemble the first row. Explain why?

Matching Column Type

1. Match the compounds/elements given in Column-I with uses given in Column-II.

Column-I (Compound/element)	Column-II (Use)
(a) Lanthanoid oxide	(p) Production of iron alloy
(b) Lanthanoid	(q) Television screen
(c) Misch metal	(r) Petroleum cracking
(d) Magnesium-based alloy is	(s) Lanthanoid metal + iron constituent of
(e) Mixed oxides of	(t) Bullet lanthanoids are employed
	(u) In X-ray screen

2. Match the statements given in Column-I with the oxidation states given in Column-II.

Column-I	Column-II
(a) Oxidation state of Mn in MnO_2 is	(p) + 2
(b) Most stable oxidation state of Mn is	(q) + 3
(c) Most stable oxidation state of Mn in oxides is	(r) + 4
(d) Characteristic oxidation state of lanthanoids is	(s) + 5
	(t) + 7

3. Match the property given in Column-I with the element given in Column-II.

Column-I (Property)	Column-II (Element)
(a) Lanthanoid which shows +4 oxidation state	(p) Pm
(b) Lanthanoid which can show +2 oxidation state	(q) Ce
(c) Radioactive lanthanoid	(r) Lu
(d) Lanthanoid which has $4f^7$ electronic configuration in +3 oxidation state	(s) Eu
(e) Lanthanoid which has $4f^{14}$ electronic configuration in +3 oxidation state	(t) Gd
	(u) Dy

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 the assertion.

(b) Both assertion and reason are true but reason is not the correct explanation of assertion.

(c) Assertion is not true but reason is true.

(d) Both assertion and reason are false.

1. **Assertion:** Separation of Zr and Hf is difficult.

   Reason: Because Zr and Hf lie in the same group of the periodic table.

2. **Assertion:** Actinoids form relatively less stable complexes as compared to lanthanoids.

   Reason: Actinoids can utilize their $5f$ orbitals along with $6d$ orbitals in bonding but lanthanoids do not use their $4f$ orbital for bonding.

3. On the basis of lanthanoid contraction, explain the following:
   (a) Nature of bonding in La_2O_3 and Lu_2O_3
   (b) Trends in the stability of oxo salts of lanthanoids from La to Lu
   (c) Stability of the complexes of lanthanoids
   (d) Radii of $4d$ and $5d$-block elements
   (e) Trends in acidic character of lanthanoid oxides

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. Most common oxidation states of Ce (cerium) are:
   (a) +2, +3 (b) +2, +4
   (c) +3, +4 (d) +3, +5

   (AIEEE, 2002)

2. Arrange Ce^{+3}, La^{+3}, Pm^{+3}, and Yb^{+3} in increasing order of their ionic radii:
   (a) $Yb^{+3} < Pm^{+3} < Ce^{+3} < La^{+3}$
   (b) $Yb^{+3} < Pm^{+3} < La^{+3} < Ce^{+3}$
   (c) $La^{3+} < Ce^{3+} < Yb^{3+} < Pm^{3+}$
   (d) $Pm^{+3} < La^{+3} < Ce^{+3} < Yb^{+3}$

(AIEEE, 2002)

3. The radius of La^{3+} (atomic number of La = 57) is 1.06 Å. Which one of the following given values will be closest to the radius of Lu^{3+} (Atomic number of Lu = 71)?
   (a) 1.40 Å (b) 1.06 Å
   (c) 0.85 Å (d) 1.60 Å

(AIEEE, 2002)

4. A reduction in atomic size with increase in atomic number is a characteristic of:
   (a) *d*-block elements
   (b) *f*-block elements
   (c) Radioactive series elements
   (d) High atomic mass elements

(AIEEE, 2003)

5. Cerium (Z = 58) is an important member of the lanthanides. Which of the following statements about cerium is incorrect?
   (a) The +4 oxidation state of cerium is not known in solutions
   (b) The +3 oxidation state of cerium is more stable than the +4 oxidation state
   (c) The common oxidation states of cerium are +3 and +4
   (d) Cerium (IV) acts as an oxidizing agent

(AIEEE, 2004)

6. The lanthanide contraction is responsible for the fact that:
   (a) Zr and Zn have the same oxidation state
   (b) Zr and Hf have about the same radius
   (c) Zr and Nb have similar oxidation state
   (d) Zr and Y have about the same radius

(AIEEE, 2005)

7. Which of the following factors may be regarded as the main cause of lanthanide contraction?
   (a) Greater shielding of 5*d*-electrons by 4*f*-electrons
   (b) Poorer shielding of 5*d*-electrons by 4*f*-electrons
   (c) Effective shielding of one of 4*f*-electrons by another in the subshell
   (d) Poor shielding of one of 4*f*-electrons by another in the subshell

(AIEEE, 2005)

8. Lanthanide contraction is caused due to:
   (a) The same effective nuclear charge from Ce to Lu
   (b) The imperfect shielding on outer electrons by 4*f*-electrons from the nuclear charge
   (c) The appreciable shielding on outer electrons by 4*f*-electrons from the nuclear charge
   (d) The appreciable shielding on outer electrons by 5*d*-electrons from the nuclear charge

(AIEEE, 2006)

9. Identify the incorrect statement among the following statements:
   (a) 4*f*- and 5*f*-orbitals are equally shielded
   (b) *d*-block elements show irregular and erratic chemical properties among themselves
   (c) La and Lu have partially filled *d*-orbitals and no other partially filled orbitals
   (d) The chemistry of various lanthanides is very similar

(AIEEE, 2007)

10. The actinides exhibit more number of oxidation states in general than the lanthanides. This is because:
   (a) The 5*f*-orbitals extend further from the nucleus than the 4*f*-orbitals
   (b) The 5*f*-orbitals are more buried than the 4*f*-orbitals
   (c) There is a similarity between 4*f*- and 5*f*-orbitals in their angular part of the wave function
   (d) The actinides are more reactive than the lanthanides

(AIEEE, 2007)

11. Larger number of oxidation states is exhibited by the actinides than those by the lanthnides because:
   (a) 4*f*-orbitals are more diffused than the 5*f* orbitals
   (b) Of lesser energy difference between 5*f*- and 6*d*-orbitals than between 4*f*- and 5*d*-orbitals
   (c) Of more energy difference between 5*f*- and 6*d*-orbitals than between 4*f*- and 5*d*-orbitals
   (d) Of more reactive nature of the actinides than the lanthanides

(AIEEE, 2008)

12. Knowing that the chemistry of lanthanides (Ln) is dominated by its +3 oxidation state, which of the following statements is incorrect?
   (a) The ionic size of Ln(III) decreases in general with increasing atomic number

(b) Ln(III) compounds are generally colorless
(c) Ln(III) hydroxide is mainly basic in character
(d) Because of the large size of the Ln(III) ions, the bonding in its compounds is predominantly ionic in character

(AIEEE, 2009)

13. In context of the lanthanides, which of the following statements is not correct?
(a) There is a gradual decrease in the radii of the members with increasing atomic number in the series
(b) All the members exhibit +3 oxidation state
(c) Because of similar properties, the separation of lanthanides is not easy
(d) Availability of 4*f*-electrons results in the formation of compounds in +4 oxidation state for all the members of the series

(AIEEE, 2011)

14. The outer electron configuration of Gd (Atomic No. = 64) is:
(a) $4f^3\ 5d^5\ 6s^2$ (b) $4f^8\ 5d^{10}\ 6s^2$
(c) $4f^4\ 5d^4\ 6s^2$ (d) $4f^7\ 5d^1\ 6s^2$

(AIEEE, 2011)

Hints & Solutions

JEE (Main) Exercises

Single Correct Answer Type

1. (a) Pr and Nd: Lantharoids used in glass blower's goggles.

2. (b) +3 Most common oxidation state of larthanoid series.

3. (c) The electronic configuration of actinoids cannot be assigned with degree of certainty because of small energy difference between *sf* and *bd* levels.

4. (b) $La(OH)_3$ is most basic in nature while $Lu(OH)_3$ least basic.

5. (c) Lanthanoid contraction implies decrease in ionic radii.

6. (d) The ions often with $4f^n$ configuration have similar color to those ions having $4f^{14-n}$ configuration.

7. (b) In aqueous solution, E_4^{+2} ions acts as a reducing agent.

8. (c) Np and PU actinoids showing +7 oxidation state.

11. (a) $Gd = 4f^7\ 5d^1\ 6s^2$
$Gd^{+2} = 4f^7$
4*f* subshell half filled

12. (b) The formation of Ce^{+4} is favored by its noble gas configuration, but it is a strong oxidant reverting to the common +3 0.5. The value of E° for Ce^{+4}/Ce^{+3} is 1.74 V which suggests that it can oxidize water.

13. (c) $Gd = 4f^7\ 5d^1\ 6s^2$
$Gd^{+3} = 4f^7$

14. (a) The overall decrease in atomic and ionic radii from lanthanum to lutetium
$$Yb^{+3} < Pm^{+3} < Ce^{+3} < La^{+3}$$

15. (c) The overall decreases in atomic and ionic radii from lanthanum to lutetium
$$La^{+3} = 1.06\ Å$$
$$Lu^{+3} = 0.85\ Å$$

17. (c) The E° value for Ce^{+4}/Ce^{+3} is 1.74 V which suggests that it can oxidize water.

20. (a) There is a greater range of oxidation states, which is in part attributed to the fact that the 5*f*, 6*d*, and 7*s* levels are of comparable energies.

22. (b) The lanthanide ions have unpaired electrons in their orbitals, thus these ions absorb visible region of light and undergo *f-f* transition and hence exhibit color.

29. (c) The stability of oxidation states of lanthanoid elements depends on combined effects of hydration enthalpy and ionization enthalpy.

NCERT Exemplar Exercises

Short Answer Type

1. Hint: It is because in the beginning, when 5*f* orbitals begin to be occupied, they will penetrate less into the inner core of electrons. The 5*f* electrons will therefore, be more effectively shielded from the nuclear charge than 4*f* electrons of the corresponding lanthanoids. Therefore outer electrons are less firmly held and they are available for bonding in the actinoids.

2. Hint: Due to lanthanoid contraction, they have almost same size (Zr, 160 pm) and (Hf, 159 pm).

3. It is because after losing one more electron, Ce acquires stable $4f^0$ electronic configuration.

4. Due to lanthanoid contraction, the atomic radii of the second and third row transition elements is almost same. So, they resemble each other much more as compared to first row elements.

Assertion-Reasoning Type

3. **Hint:**
   (a) As the size decreases, covalent character increases. Therefore, La_2O_3 is more ionic and Lu_2O_3 is more covalent.
   (a) As the size decreases from La to Lu, stability of oxosalts also decreases.
   (c) Stability of complexes increases as the size of lanthanoids decreases.
   (d) Radii of 4*d*- and 5*d*-block elements will be almost same.
   (e) Acidic character of oxides increases from La to Lu.

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (c) +3, +4
2. (a) $La^{3+} > Ce^{3+} > Pm^{3+} > Yb^{3+}$

   In lanthanides, there is fairly regular decrease in the sizes with increasing atomic numbers.
3. (c) Refer Solution 2.
4. (b) Refer Solution 2.

   The overall decrease in atomic and ionic radii from lanthanum to lutetium (the lanthanide contraction) is a unique feature in the chemistry of the lanthanides.
5. (a) Formation of Ce^{+4} is favored due to its noble gas configuration. Thus, answer is (a). +3 is the common most oxidation state though for cerium.
6. (b) The filling of 4*f* before 5*d*-orbital results in a regular decrease in atomic radii called lanthanide contraction, which essentially compensates for the expected increase in atomic size with increasing atomic number. The net result of the lanthanide contractions is that the corresponding elements of second and the third *d*-series exhibit similar radii (e.g., Zr 160 pm, Hf 159 pm) and have very similar physical and chemical properties.
7. (d) Lanthanide contraction can be defined as the following:

   Due to high electrostatic attraction of protons on *ns* and *np* electrons, coupled with poor shielding of $(n-1)$ of electrons, there is continuous decrease in size from left to right in the series. As a result of lanthanide contraction, the radii of the members of the third transition series are very similar to those of the corresponding members of the second series.
8. (c) Refer Solution 7, $m = \sqrt{n(n+2)}$

   In Ni^{2+}, unpaired electrons is 2.

   $\therefore m = \sqrt{2(2+2)} = \sqrt{8}$
   $= 2.828$
   $= 2.84$
9. (a) Shielding of 5*f* is low as compared with 4*f*.
10. (a) Due to lesser energy differences between 5*f* and 6*d* than between 4*f*- and 5*d*-orbitals.
11. (b) Lesser energy difference between 5*f*- and 6*d*-orbitals as compared with 4*f*- and 5*d*-orbitals.
12. (b) Most of Ln^{3+} compounds are colored.
13. (d) Because +4 state, 0.5 for lanthanides is occasional.
14. (d) It is a fact.

Answers

JEE (Main) Exercises

Single Correct Answer Type

1. (a)	2. (b)	3. (c)	4. (b)	5. (c)	6. (d)	7. (b)	8. (c)	9. (b)	10. (b)
11. (a)	12. (b)	13. (c)	14. (a)	15. (c)	16. (b)	17. (c)	18. (d)	19. (b)	20. (a)
21. (a)	22. (b)	23. (d)	24. (c)	25. (d)	26. (d)	27. (d)	28. (b)	29. (c)	

NCERT Exemplar Exercises

Single Correct Answer Type

1. (b) **2.** (c) **3.** (a) **4.** (c)

Multiple Correct Answers Type

1. (a), (b) **2.** (b), (d) **3.** (a), (b) **4.** (b), (c) **5.** (b), (c)

Matching Column Type

1. (a) → (q); (b) → (p); (c) → (s); (d) → (t); (e) → (r)

2. (a) → (r); (b) → (p); (c) → (t); (d) → (q)

3. (a) → (q); (b) → (s); (c) → (p); (d) → (t); (e) → (r)

Assertion-Reasoning Type

1. (a) **2.** (b)

Archives

JEE (Main) Exercises

Single Correct Answer Type

1. (c) **2.** (a) **3.** (c) **4.** (b) **5.** (a) **6.** (b) **7.** (d) **8.** (c) **9.** (a) **10.** (a)
11. (b) **12.** (b) **13.** (d) **14.** (d)

12 Quantum Number

JEE (Advanced) Exercises

Single Correct Answer Type

1. Spin only magnetic moment of dipositive ion of Zn is:
   (a) 0 (b) $\sqrt{8}$ BM
   (c) $\sqrt{24}$ BM (d) $\sqrt{35}$ BM

2. In boron atom screening on the last electron is due to:
   (a) Electrons of 'K' shell only
   (b) All the electrons of K and L shell
   (c) 2-Electrons of 1*s* and 2*s* each
   (d) All the electrons of L shell only

3. The zero probability of finding the electron in p_x orbitals:
   (a) Two opposite sides of the nucleus along *x*-axis
   (b) In the nucleus
   (c) Same on all the sides around the nucleus
   (d) None of these

4. Which electronic configuration does not follow the Pauli's exclusion principle?
   (a) $1s^2, 2s^2, 2p^4$ (b) $1s^2, 2s^2, 2p^4, 3s^2$
   (c) $1s^2, 2p^4$ (d) $1s^2, 2s^2\ 2p^6, 3s^3$

5. In which of the following orbitals, there is zero probability of finding electron in *XY* plane:
   (a) p_x (b) p_y
   (c) d_{xy} (d) d_{xz}

6. Choose the correct set of quantum number of last electron of $_{29}$Cu:
   (a) $3, 1, 0, +\frac{1}{2}$ (b) $3, 2, -3, +\frac{1}{2}$
   (c) $3, 2, -2, -\frac{1}{2}$ (d) None of these

7. Which of the following statement is **Correct**?
   (a) Total number of electrons in a subshell is $2\ell + 1$
   (b) p_z, $d_{x^2-y^2}$ and d_{z^2} orbitals are non-axial
   (c) Only *s*-orbitals has directional orientation while p_z, *d*, and *f*-orbitals have non-directional properties
   (d) Spin multiplicity of N-atom is 4

8. Find the sum of maximum number of electrons having +1 and –1 value of '*m*' in Ti:
   (a) 6 (b) 8
   (c) 10 (d) 12

9. Imagine a Universe in which four quantum numbers can have same possible value as in our universe except the magnetic quantum number (*m*) can have integral values from 0 to $\pm(\ell + 1)$. Find the electronic configuration of atomic number 20.
   (a) $1s^6\ 2s^6\ 2p^8$
   (b) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$
   (c) $1s^4\ 2s^4\ 2p^6\ 3s^4\ 3p^2$
   (d) $1s^2\ 1p^6\ 2s^2\ 1d^{10}$

10. Choose the correct set of quantum number of last electron entered of $_{29}$Cu:

(a) $3, 1, 0, +\frac{1}{2}$ (b) $3, 2, -3, +\frac{1}{2}$

(c) $3, 2, -2, -\frac{1}{2}$ (d) None of these

11. Find the correct set of quantum numbers for 30th electron entered into Ga (At. No. 31):

	n	l	m	s
(a)	4	1	0	$-\frac{1}{2}$
(b)	4	1	1	$+\frac{1}{2}$
(c)	3	2	–1	$+\frac{1}{2}$
(d)	4	0	0	$-\frac{1}{2}$

12. The subshell which are filled just before and just after the filling of $5p$ subshell are respectively:

(a) $5sd, 5d$ (b) $4d, 6s$

(c) $4d, 4f$ (d) $6s, 4f$

13. The value of $(n \times l \times m)$ for the last electron entered in K is:

(a) 2 (b) 3

(c) 4 (d) 0

Multiple Correct Answers Type

1. Which of the following is/are correct:

(a) In single electron species subshells of same shell are degenerate in the absence of external electric and magnetic field

(b) In multielectron atoms, orbitals of same subshell are degenerate in the absence of external electric and magnetic field

(c) $3d$ subshell is filled completely before $4s$

(d) Energy order of subshell s in single electron species is decided by $(n + \ell)$ rule

2. Which of the following set of quantum numbers is/are valid for electrons of ground state electronic configuration of elements, having atomic no. up to 25.

	n	ℓ	m	s
(a)	3	2	0	$+\frac{1}{2}$
(b)	4	0	0	$+\frac{1}{2}$
(c)	4	1	0	$-\frac{1}{2}$
(d)	2	2	+1	$+\frac{1}{2}$

3. Which of the following may have same set of quantum no?

(a) Last electron of Ga and last electron of Zn

(b) Unpaired electron of S and entered electron in S^-

(c) Last electron of Sc and last e^- of Cr

(d) Unpaired electron in $2p$ orbital of N and unpaired electron in $2p$ orbital of F

4. Select the incorrect statement:

(a) In $d_{x^2-y^2}$ orbital 2 nodal planes are in xz and yz plane

(b) d_{xy} and $d_{x^2-y^2}$ have one common nodal plane

(c) One $4d$ orbital contains only 2 electrons of same spin

(d) One $3d$ orbital contains a total of 10 electrons

5. Choose the correct statement among the following:

(a) Number of orbitals in n^{th} shell are n^2

(b) Number of orbitals in a subshell are $(2\ell + 1)$

(c) Number of subshell in n^{th} shell are n

(d) Number of electrons in an orbital of subshell are $2(2\ell + 1)$

6. Select the incorrect statement(s) from the following options:

(a) The nodal plane of p_x identical with that of p_y orbital

(b) d_{yz} orbital has two nodal plane which are xz and yz planes

(c) p_x, p_y, and p_z orbitals have the same value of 'ℓ'

(d) d_{xy}, $d_{x^2-y^2}$, and d_{z^2} orbitals have the different orientation in space but have the same value of 'm'

7. Which of the following can be a stable ground state electronic configuration (only valence shell) of carbon atom?

(a) [↑↓] [↓|↓|] $2s^2$ $2p^2$ (b) [↑↓] [↓| |↓] $2s^2$ $2p^2$

(c) [↑↓] [|↑|↑] $2s^2$ $2p^2$ (d) [↑↓] [|↓|↓] $2s^2$ $2p^2$

8. Choose the correct statement among the following:

(a) Number of orbitals in n^{th} shell are n^2

(b) Number of orbitals in ℓ^{th} subshell are $(2\ell + 1)$

(c) Number of subshell in n^{th} shell are n

(d) Number of electrons in an orbital of ℓth subshell are $2(2\ell + 1)$

Comprehension Type

Comprehension-1: (Q. 1 to Q. 3)

The plane and point at which zero electron density exists is known as nodal plane and nodal point. Nodal plane also refers as angular node. Number of angular nodes depends on shape of orbital only and size of orbital has no role in it.

Based on the comprehension above, answer the following questions:

1. Ratio of number of nodal plane in $6d_{xy}$ orbital to $3dxz$ is:
   (a) 0 (b) 1
   (c) 2 (d) 3
2. Which of the following pair of orbitals contains at least one common nodal plane:
   (a) p_x and p_y (b) d_{xz} and d_{z^2}
   (c) d_{xy} and p_z (d) d_{xz} and p_x
3. Select the correct statement:
   (a) In d_{z^2} orbital 2 nodal planes are in xz and yz plane
   (b) d_{z^2} and $d_{x^2-y^2}$ have one common nodal plane
   (c) One $4d$ orbital contains only 2 electrons of opposite spin
   (d) One $3d$ orbital contains a total of 10 electrons

Comprehension-2: (Q. 4 to Q. 6)

Imagine a universe in which the four quantum number can have the following values.

$n = 1$ to ∞
$\ell = 0$ to n
$m = -(\ell + 1)$ to $+(\ell + 1)$ including zero
$s = +\frac{1}{2}$ and $-\frac{1}{2}$

Answer the following questions based on the above values:

4. Total number of elements in the III period of periodic table is:
   (a) 8 (b) 20
   (c) 30 (d) 15
5. If Aufbau $(n + \ell)$ rule is valid then block of Zn is: [Atomic number of Zn = 30]
   (a) s-block (b) p-block
   (c) d-block (d) f-block
6. Spin only magnetic moment (μ) of the element sulphur (S) is: [Atomic number of S = 16]
   (a) 0 (b) $\sqrt{3}$ BM
   (c) $\sqrt{8}$ BM (d) $\sqrt{15}$ BM

Comprehension-3: (Q. 7 and Q. 8)

Imagine a universe in which the four quantum number varies as:

$n = 1, 2, 3, \ldots \infty$
$\ell = 0$ to n
$m = -2\ell$ to $+2\ell$
$s = +\frac{1}{2}$ and $-\frac{1}{2}$

By using above concept of atom, answer the following:

7. Maximum electrons which can be accommodated in 3rd shell are:
   (a) 32 (b) 18
   (c) 56 (d) 48
8. If ground state electronic configuration of $_{17}Cl$ is written by using above set of definition of quantum number, then last electron will enter in:
   (a) $3p$ (b) $1d$
   (c) $2s$ (d) $2p$

Comprehension-4: (Q. 9 and Q. 10)

Electronic configuration of penultimate shell of an element is $2s^2\ 2p^6$. In valence shell, 2 electrons are in s and 4 electrons are in p-subshell. If atomic mass is twice to that of atomic number, then answer the following questions: **(Take: $N_A = 6 \times 10^{23}$)**

9. Total number of protons present in 6.4 g of the element:
   (a) 1×10^{24} (b) 1.2×10^{23}
   (c) 2×10^{24} (d) 19.2×10^{23}
10. Maximum number of electrons in an atom of the given element having $\ell = 1$ and $s = -\frac{1}{2}$
    (a) 11 (b) 6
    (c) 4 (d) 1

Matching Column Type

1. Match the column:

1. Column-I	Column-II
(a) Fe^{+2}	(p) Set of quantum number for last e^- $n = 2, \ell = 1, m = 1, s = +\frac{1}{2}$
(b) Mn^{+4}	(q) Magnetic moment (μ) = zero
(c) Zn^{+2}	(r) Spin multiplicity (SM) = 4
(d) Na^+	(s) Total number of exchange pair in $3d$-subshell = 10
	(t) Paramagnetic

Integer Answer Type

1. Find maximum number of electrons in 'Al' in which $\frac{l \times m}{n} = 0$. [At. no. of Al = 13]
2. Find total number of orbitals in 'S' atom, for which $|m| \le 1$ and contains at least one electron. [At. no. of S = 16]
3. Ltal number of '5s' electrons in 'Pd' is _____. [At. no. of Pd = 46]
4. Total no. of exchange pair possible in $3d^8$ electronic configuration is _____.

   [If answer is in double digits, then add all the digits, till obtain the single digit]
5. Find the $(n + l)$ value for the last electron entered into Hf.
6. Find |total spin| of $3d$ electron Fe^{+x} ion, if its magnetic moment is $\sqrt{24}$ BM.
7. Find total number of orbitals in which electron density is observed along any of the axis (x or y or z). $s, p_x, p_y, p_z, d_{xy}, d_{xz}, d_{yz}, d_{z^2}, d_{x^2-y^2}$.
8. Find the $(n + l)$ value for the last electron entered into Ga. [Atomic no. 31]
9. What is the value of $(n + \ell)$ for the unpaired e^- in an atom of an element which is present in the third period and seventeenth group of the periodic table.
10. In multielectronic atom, maximum number of degenerated orbitals present in 3rd shell.
11. Calculate maximum number of electrons in $_{25}Mn$ which have $n = 3$, $m = 0$ and $s = +\frac{1}{2}$.
12. Find the total number of orbitals present in 'M' shell of an atom.
13. Find the $(n + \ell)$ value for $4f$ orbital.
14. Find the value of $n + \ell$ for the last electron of $_{19}K$.
15. Find the maximum number of electrons in Cr atom which have $m = -1$ and $s = +\frac{1}{2}$ but $n \ne 2$.
16. In case of s and p-orbital electrons, each of the $(n-2)^{th}$ shell electrons shield the nth shell (valence shell) electron by.
17. Find the maximum number of electrons having $(n + l + m)$ equal to zero in Cr, if it follows aufbau principle.
18. Find the number of electrons having $(n \times l + m) = 3$ for Kr-atom (At. number: $Z = 36$).
19. Find the maximum number of e^- having m value ≤ 1 in Cr.

Hints & Solutions

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a) According to E.C. Zn^{2+} ion has no unpaired electron so spin only magnetic moment for Zn^{2+} ion is 0.

   $Zn^{2+} \Rightarrow 1s^2, 2s^2, 2p^6, 3s^2, 3p^6\, 3d^{10}, 4s^0$

2. (c) E.C. of B is $1s^2, 2s^2, 2p^1$
   in which last electron of $2p$ is shielded by electron of $1s$, $2s$

9. (a) $m = 0$ to $\pm(\ell + 1)$

   $n = 1$ $\ell = 0$ $m = -1, 0, 1$
   $n = 2$ $\ell = 1$ $m = -2, -1, 0, 1, 2$
   $n = 3$ $\ell = 2$ $m = -3, -2, -1, 0, 1, 2, 3$

   Hence s subshell will have 3 orbitals
   and p subshell will have 5 orbitals
   d subshell will have 7 orbitals
   hence configuration is
   $1s^6\, 2s^6\, 2p^8$

13. (d) K[Ar] $4s^1$

   $n = 4$
   $\ell = 0$
   $m = 0$
   $n \times \ell \times m = 0$

Integer Answer Type

1. (9) $_{13}A\ell$

O	O	−1 0 +1	O	O
↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑
1s	2s	2p	3s	3p
$n = 1$	$n = 2$	$n = 2$	$n = 3$	$n = 3$
$\ell = 0$	$\ell = 0$	$\ell = 1$	$\ell = 0$	$\ell = 1$

2. (9)

↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑ ↑ ↑
1s	2s	2p	3s	3p

3. (0) Electronic configuration of Pd

   [Kr], $4d^{10}, 5s^0$

4. (4) ↑↓ ↑↓ ↑↓ ↑↓ ↑↓

   Total no. of exchange pair $= \frac{5(5-1)}{2} + \frac{3(3-1)}{2}$
   $= 10 + 3 = 13$

10. (5) In 3rd shell $3s$, $3p$, $3d$ subshells are present and maximum 5 degenerated orbitals are present in d-subshell.

Answers

JEE (Advanced) Exercises

Single Correct Answer Type

1. (a) 2. (c) 3. (b) 4. (d) 5. (d) 6. (c) 7. (d) 8. (c) 9. (a) 10. (c)
11. (c) 12. (b) 13. (d)

Multiple Correct Answers Type

1. (a), (b) 2. (a), (b) 3. (c), (d) 4. (a), (b), (c), (d)
5. (a), (b), (c) 6. (a), (b), (d) 7. (a), (c), (d) 8. (a), (b), (c)

Comprehension Type

Comprehension-1 1. (b) 2. (d) 3. (c)
Comprehension-2 4. (c) 5. (b) 6. (a)
Comprehension-3 7. (c) 8. (d)
Comprehension-4 9. (d) 10. (b)

Matching Column Type

1. (a) $\rightarrow$ s, t; (b) $\rightarrow$ r, t; (c) $\rightarrow$ q; (d) $\rightarrow$ p, q

Integer Answer Type

1. (9) 2. (9) 3. (0) 4. (4) 5. (7) 6. (2) 7. (6) 8. (5) 9. (4) 10. (5)
11. (3) 12. (9) 13. (7) 14. (4) 15. (2) 16. (1) 17. (0) 18. (6) 19. (022)