

CHAPTER 17

The d- and f-Block Elements and Co-ordination Compounds

Section-A

JEE Advanced/ IIT-JEE

A Fill in the Blanks

- AgCN dissolves in excess KCN solution to give the complex compound (1980)
- Mn^{2+} can be oxidised to MnO_4^- by
(SnO_2 , PbO_2 , BaO_2) (1981 - 1 Mark)
- Galvanization of iron denotes coating with
(1983 - 1 Mark)
- Silver chloride is sparingly soluble in water because its lattice energy is greater than energy. (1987 - 1 Mark)
- The salts and are isostructural.
($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$, $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$) (1988 - 1 Mark)
- The type of magnetism exhibited by $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$ ion is (1994 - 1 Mark)
- The IUPAC name of $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ is (1994 - 1 Mark)
- When Fe(s) is dissolved in aqueous hydrochloric acid in a closed vessel, the work done is (1997 - 1 Mark)
- Silver jewellery items tarnish slowly in the air due to their reaction with (1997 - 1 Mark)
- Which of the following is the weakest base (1980)
(a) NaOH (b) $\text{Ca}(\text{OH})_2$
(c) KOH (d) $\text{Zn}(\text{OH})_2$
- One of the constituent of German silver is (1980)
(a) Ag (b) Cu
(c) Mg (d) Al
- Which of the following dissolve in hot conc. NaOH solution (1980)
(a) Fe (b) Zn
(c) Cu (d) Ag
- How many unpaired electrons are present in Ni^{2+} ?
(a) 0 (b) 2 (1981 - 1 Mark)
(c) 4 (d) 8
- Sodium thiosulphate is used in photography because of its
(a) reducing behaviour (1981 - 1 Mark)
(b) oxidising behaviour
(c) complex forming behaviour
(d) reaction with light
- Iron is rendered passive by treatment with concentrated
(a) H_2SO_4 (b) H_3PO_4 (1982 - 1 Mark)
(c) HCl (d) HNO_3
- In the metallurgy of iron, when limestone is added to the blast furnace, the calcium ion ends up in (1982 - 1 Mark)
(a) slag (b) gangue
(c) metallic calcium (d) calcium carbonate
- Zinc-copper couple that can be used as a reducing agent is obtained by : (1984 - 1 Mark)
(a) mixing zinc dust and copper gauze
(b) zinc coated with copper
(c) copper coated with zinc
(d) zinc and copper wires welded together

B True / False

- Copper metal reduces Fe^{2+} in an acid medium. (1982 - 1 Mark)
- Silver fluoride is fairly soluble in water. (1982 - 1 Mark)
- Silver chloride is more soluble in very concentrated sodium chloride solution than in pure water. (1984 - 1 Mark)
- Dipositive zinc exhibits paramagnetism due to loss of two electrons from 3d-orbital of neutral atom. (1987 - 1 Mark)
- Both potassium ferrocyanide and potassium ferricyanide are diamagnetic. (1989 - 1 Mark)
- Cu^+ disproportionates to Cu^{2+} and elemental copper in solution. (1991 - 1 Mark)

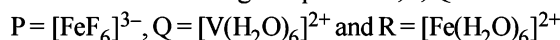
C MCQs with One Correct Answer

- When same amount of zinc is treated separately with excess of sulphuric acid and excess of sodium hydroxide, the ratio of volume of hydrogen evolved is (1979)
(a) 1 : 1 (b) 1 : 2
(c) 2 : 1 (d) 9 : 4
- Amongst the following, the lowest degree of paramagnetism per mole of the compound at 298 K will be shown by (1988 - 1 Mark)
(a) $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$ (b) $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
(c) $\text{FeSO}_4 \cdot 6\text{H}_2\text{O}$ (d) $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$

11. Amongst $\text{Ni}(\text{CO})_4$, $[\text{Ni}(\text{CN})_4]^{2-}$ and NiCl_4^{2-} (1991 - 1 Mark)
- $\text{Ni}(\text{CO})_4$ and NiCl_4^{2-} are diamagnetic and $[\text{Ni}(\text{CN})_4]^{2-}$ is paramagnetic
 - NiCl_4^{2-} and $[\text{Ni}(\text{CN})_4]^{2-}$ are diamagnetic and $\text{Ni}(\text{CO})_4$ is paramagnetic
 - $\text{Ni}(\text{CO})_4$ and $[\text{Ni}(\text{CN})_4]^{2-}$ are diamagnetic and NiCl_4^{2-} is paramagnetic
 - $\text{Ni}(\text{CO})_4$ is diamagnetic and NiCl_4^{2-} and $[\text{Ni}(\text{CN})_4]^{2-}$ are paramagnetic
12. Which one is solder? (1995S)
- Cu & Pb
 - Zn & Cu
 - Pb & Sn
 - Fe & Zn
13. Which pair gives Cl_2 at room temperature? (1995S)
- $\text{HCl}_{(\text{conc})} + \text{KMnO}_4$
 - $\text{NaCl} + \text{H}_2\text{SO}_{4(\text{conc})}$
 - $\text{NaCl} + \text{MnO}_2$
 - $\text{NaCl} + \text{HNO}_{3(\text{conc})}$
14. Which compound is formed when excess of KCN is added to aqueous solution of copper sulphate? (1996 - 1 Mark)
- $\text{Cu}(\text{CN})_2$
 - $\text{K}_2[\text{Cu}(\text{CN})_4]$
 - $\text{K}[\text{Cu}(\text{CN})_2]$
 - $\text{K}_3[\text{Cu}(\text{CN})_4]$
15. Which compound does not dissolve in hot, dilute HNO_3 ? (1996 - 1 Mark)
- HgS
 - PbS
 - CuS
 - CdS
16. An aqueous solution of FeSO_4 , $\text{Al}_2(\text{SO}_4)_3$ and chrome alum is heated with excess of Na_2O_2 and filtered. The materials obtained are : (1996 - 1 Mark)
- a colourless filtrate and a green residue
 - a yellow filtrate and a green residue
 - a yellow filtrate and a brown residue
 - a green filtrate and a brown residue
17. Ammonium dichromate is used in some fireworks. The green coloured powder blown in the air is (1997 - 1 Mark)
- CrO_3
 - Cr_2O_3
 - Cr
 - $\text{CrO}(\text{O}_2)$
18. The number of moles of KMnO_4 that will be needed to react with one mole of sulphite ion in acidic solution is (1997 - 1 Mark)
- $\frac{2}{5}$
 - $\frac{3}{5}$
 - $\frac{4}{5}$
 - 1
19. Which of the following is an organometallic compound? (1997 - 1 Mark)
- Lithium methoxide
 - Lithium acetate
 - Lithium dimethylamide
 - Methyl lithium.
20. Which of the following compounds is expected to be coloured? (1997 - 1 Mark)
- Ag_2SO_4
 - CuF_2
 - MgF_2
 - CuCl
21. In the dichromate anion, (1999 - 2 Marks)
- 4 Cr - O bonds are equivalent
 - 6 Cr - O bonds are equivalent
 - all Cr - O bonds are equivalent
 - all Cr - O bonds are nonequivalent
22. The geometry of $\text{Ni}(\text{CO})_4$ and $\text{Ni}(\text{PPh}_3)_2\text{Cl}_2$ are (1999 - 2 Marks)
- both square planar
 - tetrahedral and square planar, respectively
 - both tetrahedral
 - square planar and tetrahedral, respectively
23. The chemical processes in the production of steel from haematite ore involve (2000S)
- reduction
 - oxidation
 - reduction followed by oxidation
 - oxidation followed by reduction
24. The complex ion which has no 'd' electron in the central metal atom is (2001S)
- $[\text{MnO}_4]^-$
 - $[\text{Co}(\text{NH}_3)_6]^{3+}$
 - $[\text{Fe}(\text{CN})_6]^{3-}$
 - $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$
25. Anhydrous ferric chloride is prepared by (2002S)
- heating hydrated ferric chloride at a high temperature in a stream of air
 - heating metallic iron in a stream of dry chlorine gas
 - reaction of metallic iron with hydrochloric acid
 - reaction of metallic iron with nitric acid
26. When MnO_2 is fused with KOH , a coloured compound is formed, the product and its colour is: (2003S)
- K_2MnO_4 , purple green
 - KMnO_4 , purple
 - Mn_2O_3 , brown
 - Mn_3O_4 , black
27. In the process of extraction of gold, (2003S)
- $$\text{Roasted gold ore} + \text{CN}^- + \text{H}_2\text{O} \xrightarrow{\text{O}_2} [\text{X}] + \text{OH}^-$$
- $$[\text{X}] + \text{Zn} \longrightarrow [\text{Y}] + \text{Au}$$
- Identify the complexes [X] and [Y]
- $\text{X} = [\text{Au}(\text{CN})_2]^-$, $\text{Y} = [\text{Zn}(\text{CN})_4]^{2-}$
 - $\text{X} = [\text{Au}(\text{CN})_4]^{3-}$, $\text{Y} = [\text{Zn}(\text{CN})_4]^{2-}$
 - $\text{X} = [\text{Au}(\text{CN})_2]^-$, $\text{Y} = [\text{Zn}(\text{CN})_6]^{4-}$
 - $\text{X} = [\text{Au}(\text{CN})_4]^-$, $\text{Y} = [\text{Zn}(\text{CN})_4]^{2-}$
28. The species having tetrahedral shape is (2004S)
- $[\text{PdCl}_4]^{2-}$
 - $[\text{Ni}(\text{CN})_4]^{2-}$
 - $[\text{Pd}(\text{CN})_4]^{2-}$
 - $[\text{NiCl}_4]^{2-}$
29. The spin magnetic moment of cobalt in the compound $\text{Hg}[\text{Co}(\text{SCN})_4]$ is (2004S)
- $\sqrt{3}$
 - $\sqrt{8}$
 - $\sqrt{15}$
 - $\sqrt{24}$

30. The product of oxidation of I^- with MnO_4^- in alkaline medium is (2004S)
 (a) IO_3^- (b) I_2
 (c) IO^- (d) IO_4^-
31. $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ on heating liberates a gas. The same gas will be obtained by (2004S)
 (a) heating NH_4NO_2
 (b) heating NH_4NO_3
 (c) treating H_2O_2 with NaNO_2
 (d) treating Mg_3N_2 with H_2O
32. Which pair of compounds is expected to show similar colour in aqueous medium? (2005S)
 (a) FeCl_2 and CuCl_2 (b) VOCl_2 and CuCl_2
 (c) VOCl_2 and FeCl_2 (d) FeCl_2 and MnCl_2
33. Which kind of isomerism is exhibited by octahedral $\text{Co}(\text{NH}_3)_4\text{Br}_2\text{Cl}$? (2005S)
 (a) Geometrical and Ionization
 (b) Geometrical and Optical
 (c) Optical and Ionization
 (d) Geometrical only
34. CuSO_4 decolourises on addition of KCN , the product formed is (2006 - 3M, -1)
 (a) Cu^{2+} get reduced to form $[\text{Cu}(\text{CN})_4]^{3-}$
 (b) $[\text{Cu}(\text{CN})_4]^{2-}$
 (c) CuCN (d) $\text{Cu}(\text{CN})_2$
35. Among the following metal carbonyls, the C-O bond order is lowest in (2007)
 (a) $[\text{Mn}(\text{CO})_6]^+$ (b) $[\text{Fe}(\text{CO})_5]$
 (c) $[\text{Cr}(\text{CO})_6]$ (d) $[\text{V}(\text{CO})_6]^-$
36. Native silver metal forms a water soluble complex with a dilute aqueous solution of NaCN in the presence of (2008)
 (a) nitrogen (b) oxygen
 (c) carbon dioxide (d) argon
37. Among the following, the coloured compound is (2008)
 (a) CuCl
 (b) $\text{K}_3[\text{Cu}(\text{CN})_4]$
 (c) CuF_2
 (d) $[\text{Cu}(\text{CH}_3\text{CN})_4]\text{BF}_4$
38. The IUPAC name of $[\text{Ni}(\text{NH}_3)_4][\text{NiCl}_4]$ is (2008)
 (a) Tetrachloronickel (II) - tetraamminenickel (II)
 (b) Tetraamminenickel (II) - tetrachloronickel (II)
 (c) Tetraamminenickel (II) - tetrachloronickelate (II)
 (d) Tetrachloronickel (II) - tetrachloronickelate (0) Ans. (C)
39. Both $[\text{Ni}(\text{CO})_4]$ and $[\text{Ni}(\text{CN})_4]^{2-}$ are diamagnetic. The hybridisations of nickel in these complexes, respectively, are (2008)
 (a) sp^3 , sp^3 (b) sp^3 , dsp^2
 (c) dsp^2 , sp^3 (d) dsp^2 , sp^2
40. The spin only magnetic moment value (in Bohr magneton units) of $\text{Cr}(\text{CO})_6$ is (2009)
 (a) 0 (b) 2.84
 (c) 4.90 (d) 5.92
41. The ionisation isomer of $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}(\text{NO}_2)]\text{Cl}$ is (2010)
 (a) $[\text{Cr}(\text{H}_2\text{O})_4(\text{O}_2\text{N})]\text{Cl}_2$ (b) $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2](\text{NO}_2)$
 (c) $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}(\text{ONO})]\text{Cl}$ (d) $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2(\text{NO}_2)]\cdot\text{H}_2\text{O}$
42. The correct structure of ethylenediaminetetraacetic acid (EDTA) is (2010)
 (a) $\text{HOOC}-\text{H}_2\text{C}\rangle\text{N}-\text{CH}=\text{CH}-\text{N}\langle\text{CH}_2-\text{COOH}$
 $\text{HOOC}-\text{H}_2\text{C}\rangle\text{N}-\text{CH}_2-\text{CH}_2-\text{N}\langle\text{CH}_2-\text{COOH}$
 (b) $\text{HOOC}\rangle\text{N}-\text{CH}_2-\text{CH}_2-\text{N}\langle\text{COOH}$
 $\text{HOOC}\rangle\text{N}-\text{CH}_2-\text{CH}_2-\text{N}\langle\text{COOH}$
 (c) $\text{HOOC}-\text{H}_2\text{C}\rangle\text{N}-\text{CH}_2-\text{CH}_2-\text{N}\langle\text{CH}_2-\text{COOH}$
 $\text{HOOC}-\text{H}_2\text{C}\rangle\text{N}-\text{CH}_2-\text{CH}_2-\text{N}\langle\text{CH}_2-\text{COOH}$
 (d) $\text{HOOC}-\text{H}_2\text{C}\rangle\text{N}-\text{CH}(\text{CH}_2\text{COOH})-\text{CH}(\text{CH}_2\text{COOH})-\text{N}\langle\text{H}$
 $\text{H}\rangle\text{N}-\text{CH}_2-\text{CH}_2-\text{N}\langle\text{CH}_2-\text{COOH}$
 $\text{HOOC}-\text{H}_2\text{C}\rangle\text{N}-\text{CH}(\text{CH}_2\text{COOH})-\text{CH}(\text{CH}_2\text{COOH})-\text{N}\langle\text{H}$
 $\text{H}\rangle\text{N}-\text{CH}_2-\text{CH}_2-\text{N}\langle\text{CH}_2-\text{COOH}$
43. The complex showing a spin-only magnetic moment of 2.82 B.M. is: (2010)
 (a) $\text{Ni}(\text{CO})_4$ (b) $[\text{NiCl}_4]^{2-}$
 (c) $\text{Ni}(\text{PPh}_3)_4$ (d) $[\text{Ni}(\text{CN})_4]^{2-}$
44. Among the following complexes (K-P) $\text{K}_3[\text{Fe}(\text{CN})_6]$ (K), $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ (L), $\text{Na}_3[\text{Co}(\text{oxalate})_3]$ (M), the $[\text{Ni}(\text{H}_2\text{O})_6]\text{Cl}_2$ (N), $\text{K}_2[\text{Pt}(\text{CN})_4]$ (O) and $[\text{Zn}(\text{H}_2\text{O})_6](\text{NO}_3)_2$ (P) the diamagnetic complexes are (2011)
 (a) K, L, M, N (b) K, M, O, P
 (c) L, M, O, P (d) L, M, N, O
45. As per IUPAC nomenclature, the name of the complex $[\text{Co}(\text{H}_2\text{O})_4(\text{NH}_3)_2]\text{Cl}_3$ is: (2012)
 (a) Tetraaquadiaminecobalt (III) chloride
 (b) Tetraaquadiamminecobalt (III) chloride
 (c) Diaminetetraaquacobalt (II) chloride
 (d) Diamminetetraaquacobalt (III) chloride
46. The colour of light absorbed by an aqueous solution of CuSO_4 is: (2012)
 (a) orange-red (b) blue-green
 (c) yellow (d) violet
47. $\text{NiCl}_2 \cdot \{\text{P}(\text{C}_2\text{H}_5)_2(\text{C}_6\text{H}_5)\}_2$ exhibits temperature depend-ent magnetic behaviour (paramagnetic/diamagnetic). The coordination geometries of Ni^{2+} in the paramagnetic and diamagnetic states are respectively (2012)
 (a) tetrahedral and tetrahedral
 (b) square planar and square planar
 (c) tetrahedral and square planar
 (d) square planar and tetrahedral

48. Consider the following complex ions, P, Q and R.



The correct order of the complex ions, according to their spin-only magnetic moment values (in B.M.) is

(JEE Adv. 2013)

- (a) $R < Q < P$ (b) $Q < R < P$
(c) $R < P < Q$ (d) $Q < P < R$

49. Among $[\text{Ni}(\text{CO})_4]$, $[\text{NiCl}_4]^{2-}$, $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$, $\text{Na}_3[\text{CoF}_6]$, Na_2O_2 and CsO_2 , the total number of paramagnetic compounds is

(JEE Adv. 2016)

- (a) 2 (b) 3
(c) 4 (d) 5

D MCQs with One or More Than One Correct

1. Potassium manganate (K_2MnO_4) is formed when

(1988 - 1 Mark)

- (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 presence of a strong alkali
(d) potassium permanganate reacts with conc. sulphuric acid

2. The aqueous solutions of the following salts will be coloured in the case of

(1990 - 1 Mark)

- (a) $\text{Zn}(\text{NO}_3)_2$ (b) LiNO_3
(c) $\text{Co}(\text{NO}_3)_2$ (d) CrCl_3
(e) Potash alum

3. Among the following ions which one has the highest paramagnetism?

(1993 - 1 Mark)

- (a) $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ (b) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
(c) $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ (d) $[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$

4. Which of the following alloys contains(s) Cu and Zn?

(1993 - 1 Mark)

- (a) Bronze (b) Brass
(c) Gun metal (d) Type metal

5. In nitroprusside ion the iron and NO exist as Fe^{II} and NO^+ rather than Fe^{III} and NO. These forms can be differentiated by

(1998 - 2 Marks)

- (a) estimating the concentration of iron
(b) measuring the concentration of CN^-
(c) measuring the solid state magnetic moment
(d) thermally decomposing the compound.

6. Addition of high proportions of manganese makes steel useful in making rails of railroads, because manganese

- (a) gives hardness to steel (1998 - 2 Marks)
(b) helps the formation of oxides of iron
(c) can remove oxygen and sulphur
(d) can show highest oxidation state of +7.

7. If the bond length of CO bond in carbon monoxide is 1.128\AA , then what is the value of CO bond length in $\text{Fe}(\text{CO})_5$?

(2006 - 5M, -1)

- (a) 1.15\AA (b) 1.128\AA
(c) 1.13\AA (d) 1.118\AA

8. The compound(s) that exhibit(s) geometrical isomerism is (are)

(2009)

- (a) $[\text{Pt}(\text{en})\text{Cl}_2]$ (b) $[\text{Pt}(\text{en})_2]\text{Cl}_2$
(c) $[\text{Pt}(\text{en})_2\text{Cl}_2]\text{Cl}_2$ (d) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$

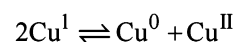
9. Reduction of the metal centre in aqueous permanganate ion involves

(2011)

- (a) 3 electrons in neutral medium
(b) 5 electrons in neutral medium
(c) 3 electrons in alkaline medium
(d) 5 electrons in acidic medium

10. The equilibrium

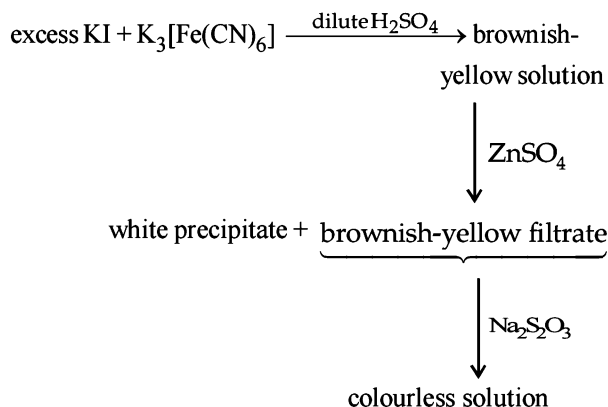
(2011)



in aqueous medium at 25°C shifts towards the left in the presence of

- (a) NO_3^- (b) Cl^-
(c) SCN^- (d) CN^-

11. For the given aqueous reactions, which of the statement (s) is (are) true?



- (a) The first reaction is a redox reaction. (2012)
(b) White precipitate is $\text{Zn}_3[\text{Fe}(\text{CN})_6]_2$.
(c) Addition of filtrate to starch solution gives blue colour.
(d) White precipitate is soluble in NaOH solution.

12. The pair(s) of coordination complexes/ions exhibiting the same kind of isomerism is(are)

(JEE Adv. 2013)

- (a) $[\text{Cr}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ and $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$
(b) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$ and $[\text{Pt}(\text{NH}_3)_2(\text{H}_2\text{O})\text{Cl}]^+$
(c) $[\text{CoBr}_2\text{Cl}_2]^{2-}$ and $[\text{PtBr}_2\text{Cl}_2]^{2-}$
(d) $[\text{Pt}(\text{NH}_3)_3](\text{NO}_3)\text{Cl}$ and $[\text{Pt}(\text{NH}_3)_3\text{Cl}]\text{Br}$

13. The pair(s) of reagents that yield paramagnetic species is/are

(JEE Adv. 2014)

- (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-ethylantraquinol

14. The correct statement(s) about Cr^{2+} and Mn^{3+} is(are)
[Atomic numbers of Cr = 24 and Mn = 25] (JEE Adv. 2015)
- Cr^{2+} is a reducing agent
 - Mn^{3+} is an oxidizing agent
 - Both Cr^{2+} and Mn^{3+} exhibit d^4 electronic configuration
 - When Cr^{2+} is used as a reducing agent, the chromium ion attains d^5 electronic configuration
15. Fe^{3+} is reduced to Fe^{2+} by using (JEE Adv. 2015)
- H_2O_2 in presence of NaOH
 - Na_2O_2 in water
 - H_2O_2 in presence of H_2SO_4
 - Na_2O_2 in presence of H_2SO_4

E Subjective Problems

- A certain inorganic compound (A) on heating loses its water of crystallisation. On further heating, a blackish brown powder (B) and two oxides of sulphur (C and D) are obtained. The powder (B) on boiling with hydrochloric acid gives a yellow solution (E). When H_2S is passed in (E) a white turbidity (F) and an apple green solution (G) are obtained. The solution (E) on treatment with thiocyanate ions gives a blood red coloured compound (H). Identify compounds from (A) to (H). (1978)
- A white amorphous powder (A) on heating yields a colourless, non-combustible gas (B) and a solid (C). The latter compound assumes a yellow colour on heating and changes to white on cooling. 'C' dissolves in dilute acid and the resulting solution gives a white precipitate on adding $\text{K}_4\text{Fe}(\text{CN})_6$ solution. 'A' dissolves in dilute HCl with the evolution of gas, which is identical in all respects with 'B'. The gas 'B' turns lime water milky, but the milkiness disappears with the continuous passage of gas. The solution of 'A', as obtained above, gives a white precipitate (D) on the addition of excess of NH_4OH and passing H_2S . Another portion of the solution gives initially a white precipitate (E) on the addition of sodium hydroxide solution, which dissolves on further addition of the base. Identify the compounds A, B, D, and E. (1979)
- State with balanced equations, what happens when
 - Silver is treated with hot concentrated sulphuric acid.
 - Ammonium dichromate is heated.
 - Hydrogen sulphide is passed through a solution of potassium permanganate acidified with dilute sulphuric acid. (1979)
- A solution of FeCl_3 in water gives a brown precipitate on standing. (1980)
- Complete the following equation (no balancing is needed) :

$$\text{SO}_2 + \text{MnO}_4^- + \dots \longrightarrow \text{SO}_4^{2-} + \text{Mn}^{2+} + \dots$$
 (1981 - 1 Mark)
- State with balanced equations what happens when :
 - sulphur dioxide gas is bubbled through an aqueous solution of copper sulphate in presence of potassium thiocyanate. (1982 - 1 Mark)
 - aqueous solution of ferric sulphate and potassium iodide are mixed. (1984 - 2 Marks)
 - aqueous solution of potassium manganate and acid are mixed. (1984 - 2 Marks)
 - aqueous solution of potassium chromate and acid are mixed. (1984 - 2 Marks)
 - potassium permanganate interacts with manganese dioxide in presence of potassium hydroxide; (1985 - 1 Mark)
 - potassium ferrocyanide is heated with concentrated sulphuric acid; (1985 - 1 Mark)
 - Gold is dissolved in *aqua regia*. (1987 - 1 Mark)
 - Write balanced equations for the extraction of silver from silver glance by cyanide process. (1988 - 1 Mark)
 - Silver chloride is treated with aqueous sodium cyanide and the product thus formed is allowed to react with zinc in alkaline medium. (1989 - 1 Mark)
 - Cobalt(II) solution reacts with KNO_2 in acetic acid medium. (1989 - 1 Mark)
 - Write balanced equations for the extraction of copper from copper pyrites by self-reduction. (1990 - 2 Marks)
 - A mixture of potassium dichromate and sodium chloride is heated with concentrated H_2SO_4 . (1990 - 1 Mark)
 - Iron reacts with cold dilute nitric acid. (1990 - 1 Mark)
 - Potassium permanganate is added to a hot solution of manganous sulphate. (1990 - 1 Mark)
 - Copper reacts with HNO_3 to give NO and NO_2 in molar ratio of 2 : 1. (1992 - 1 Marks)

$$\text{Cu} + \text{HNO}_3 \longrightarrow \dots + \text{NO} + \text{NO}_2 + \dots$$
 - Na_2CO_3 is added to a solution of copper sulphate. (1992 - 1 Marks)

$$\text{CuSO}_4 + \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} \longrightarrow \dots + \text{Na}_2\text{SO}_4 + \dots$$
 - Potassium dichromate and concentrated hydrochloric acid are heated together. (1992 - 1 Mark)
 - $\text{AgBr} + \text{Na}_2\text{S}_2\text{O}_3 \longrightarrow \dots + \dots$ (1993 - 1 Mark)
 - $(\text{NH}_4)_2\text{S}_2\text{O}_8 + \text{H}_2\text{O} + \text{MnSO}_4 \longrightarrow \dots + \dots + \dots$ (1993 - 1 Mark)
 - $[\text{MnO}_4]^{2-} + \text{H}^+ \longrightarrow \dots + [\text{MnO}_4]^- + \text{H}_2\text{O}$ (1994 - 1 Mark)

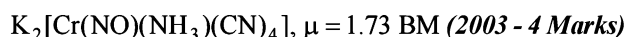
- (xxi) $\text{SO}_2(\text{aq}) + \text{Cr}_2\text{O}_7^{2-} + 2\text{H}^+ \longrightarrow \dots + \dots + \dots$
(1994 - 1 Mark)
- (xxii) Write a balanced equation for the reaction of argentite with KCN and name the products in solution.
(1996 - 1 Mark)
- (xxiii) Write balanced equations for the reaction of zinc with dilute nitric acid.
(1997 - 1 Mark)
7. Give balanced equations for extraction of silver from its sulphide ore
(1982 - 2 Marks)
8. Give reasons for the following :
- Silver bromide is used in photography.
(1983 - 1 Mark)
 - Most transition metal compounds are coloured.
(1986 - 1 Mark)
 - Zinc and not copper is used for the recovery of metallic silver from complex $[\text{Ag}(\text{CN})_2]^-$. Explain.
(1987 - 1 Mark)
 - The colour of mercurous chloride, Hg_2Cl_2 , changes from white to black when treated with ammonia.
(1988 - 1 Mark)
 - The species $[\text{CuCl}_4]^{2-}$ exists while $[\text{CuI}_4]^{2-}$ does not.
(1992 - 1 Mark)
 - CrO_3 is an acid anhydride.
(1999 - 2 Marks)
9. State the conditions under which the following preparation is carried out.
Potassium permanganate from manganese hydroxide.
Give the necessary equations which need not be balanced.
(1983 - 1 Mark)
10. What happens when :
- aqueous ammonia is added dropwise to a solution of copper sulphate till it is in excess. (1985 - 1 Mark)
 - CrCl_3 solution is treated with sodium hydroxide and then with hydrogen peroxide. (1985 - 1 Mark)
11. Mention the products formed when zinc oxide is treated with excess of sodium hydroxide solution. (1986 - 1 Mark)
12. What is the actual reducing agent of haematite in blast furnace?
(1987 - 1 Mark)
13. The acidic, aqueous solution of ferrous ion forms a brown complex in the presence of NO_3^- , by the following two steps. Complete and balance the equations : (1993 - 2 Marks)
- $$[\text{Fe}(\text{H}_2\text{O})_6]^{2+} + \text{NO}_3^- + \text{H}^+ \rightarrow \dots + [\text{Fe}(\text{H}_2\text{O}_6)]^{3+} + \text{H}_2\text{O}$$
- $$[\text{Fe}(\text{H}_2\text{O})_6]^{2+} + \dots \rightarrow \dots + \text{H}_2\text{O}$$
14. Identify the complexes which are expected to be coloured. Explain
(1994 - 2 Marks)
- $[\text{Ti}(\text{NO}_3)_4]$
 - $[\text{Cu}(\text{NCCH}_3)_4]^+ \text{BF}_4^-$
 - $[\text{Cr}(\text{NH}_3)_6]^{3+} 3\text{Cl}^-$
 - $\text{K}_3[\text{VF}_6]$
15. Write down the IUPAC names of the following compounds:
- $[\text{Co}(\text{NH}_3)_5\text{ONO}]\text{Cl}_2$ (1995 - 1 Mark)
 - $\text{K}_3[\text{Cr}(\text{CN})_6]$ (1995 - 1 Mark)
 - $[\text{Cr}(\text{NH}_3)_5\text{CO}_3]\text{Cl}$ (1996 - 1 Mark)
16. Compare qualitatively the first and second ionisation potentials of copper and zinc. Explain the observation.
(1996 - 2 Marks)
17. Write the formulae of the following complexes :
- Pentamminechlorocobalt(III) (1997 - 1 Mark)
 - Lithium tetrahydroaluminate(III). (1997 - 1 Mark)
18. When the ore haematite is burnt in air with coke around 2000°C 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.
(1998 - 4 Marks)
19. Work out the following using chemical equations
(1998 - 2 Marks)
- In moist air copper corrodes to produce a green layer on the surface.
20. A, B, and C are three complexes of chromium (III) with the empirical formula $\text{H}_{12}\text{O}_6\text{Cl}_3\text{Cr}$. All the three complexes have water and chloride ion as ligands. Complex A does not react with concentrated H_2SO_4 , whereas complexes B and C lose 6.75% and 13.5% of their original mass, respectively, on treatment with concentrated H_2SO_4 . Identify A, B and C.
(1999 - 6 Marks)
21. Write the chemical reaction associated with the 'brown ring test'.
(2000 - 2 Marks)
22. Draw the structures of $[\text{Co}(\text{NH}_3)_6]^{3+}$, $[\text{Ni}(\text{CN})_4]^{2-}$ and $[\text{Ni}(\text{CO})_4]$. Write the hybridisation of atomic orbitals of the transition metal in each case.
(2000 - 4 Marks)
23. (i) Write the chemical reactions involved in the extraction of metallic silver from argentite.
(ii) Write the balanced chemical equation for developing photographic films.
(2000 - 4 Marks)
24. A metal complex having composition $\text{Cr}(\text{NH}_3)_4\text{Cl}_2\text{Br}$ has been isolated in two forms (A) and (B). The form (A) reacts with AgNO_3 to give a white precipitate readily soluble in dilute aqueous ammonia, whereas (B) gives a pale yellow precipitate soluble in concentrated ammonia. Write the

The d- and f-Block Elements and Co-ordination Compounds

formula of (A) and (B) and state the hybridization of chromium in each. Calculate their magnetic moments (spin-only value). (2001 - 5 Marks)

25. Deduce the structure of $[\text{NiCl}_4]^{2-}$ and $[\text{Ni}(\text{CN})_4]^{2-}$ considering the hybridization of the metal ion. Calculate the magnetic moment (spin only) of the species. (2002 - 5 Marks)

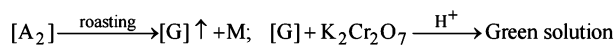
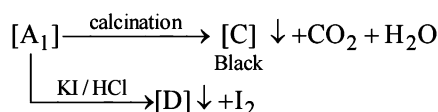
26. Write the IUPAC nomenclature of the given complex along with its hybridisation and structure.



27. Nickel chloride, when treated with dimethylglyoxime in presence of ammonium hydroxide, a bright red precipitate is obtained. Answer the following. (2004 - 4 Marks)

- Draw the structure of the complex showing H-bonds
- Give oxidation state of nickel and its hybridisation
- Predict the magnetic behaviour of the complex

28. Some reactions of two ores, A_1 and A_2 of the metal M are given below. (2004 - 4 Marks)

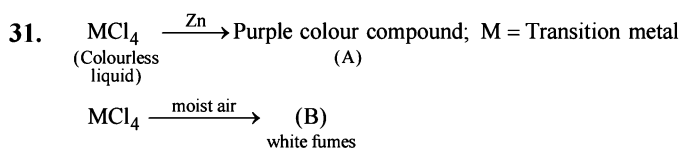


Identify A_1 , A_2 , M, C, D, and G and explain using the required chemical reactions.



What are (A) and (B)? Give IUPAC name of (A). Find the spin only magnetic moment of (B). (2005 - 4 Marks)

30. Write the chemical reaction involved in developing of a black and white photographic film. An aqueous $\text{Na}_2\text{S}_2\text{O}_3$ solution is acidified to give a milky white turbidity. Identify the product and write the balanced half chemical reaction for it. (2005 - 4 Marks)



Identify (A), (B) and MCl_4 . Also explain colour difference between MCl_4 and (A). (2005 - 4 Marks)

F Match the Following

DIRECTIONS (Q. No. 1 and 2) : Each question contains statements given in two columns, which have to be matched. The statements in Column-I are labelled A, B, C and D, while the statements in Column-II are labelled p, q, r, s and t. Any given statement in Column-I can have correct matching with ONE OR MORE statement(s) in Column-II. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example :
If the correct matches are A-p, s and t; B-q and r; C-p and q; and D-s then the correct darkening of bubbles will look like the given.

	p	q	r	s	t
A	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>
B	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
C	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
D	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

1. Match the complexes in Column I with their properties listed in Column II. (2007)

Column I

- $[\text{Co}(\text{NH}_3)_4(\text{H}_2\text{O})_2]\text{Cl}_2$
- $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
- $[\text{Co}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}$
- $[\text{Ni}(\text{H}_2\text{O})_6]\text{Cl}_2$

Column II

- geometrical isomers
- paramagnetic
- diamagnetic
- metal ion with +2 oxidation state

2. Match each of the reactions given in Column I with the corresponding product(s) given in Column II. (2009)

Column I

- $\text{Cu} + \text{dil HNO}_3$
- $\text{Cu} + \text{conc HNO}_3$
- $\text{Zn} + \text{dil HNO}_3$
- $\text{Zn} + \text{conc HNO}_3$

Column II

- NO
- NO_2
- N_2O
- $\text{Cu}(\text{NO}_3)_2$
- $\text{Zn}(\text{NO}_3)_2$

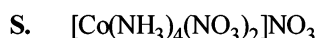
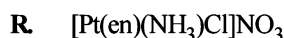
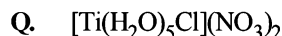
DIRECTIONS (Q. No. 3) : Following question has matching lists. The codes for the list have choices (a), (b), (c) and (d) out of which ONLY ONE is correct.

3. Match each coordination compound in List-I with an appropriate pair of characteristics from List- II and select the correct answer using the code given below the lists.

{en = $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$; atomic numbers : Ti = 22; Cr = 24; Co = 27; Pt = 78}

(JEE Adv. 2014)

List-I



List-II

1. Paramagnetic and exhibits ionisation isomerism
2. Diamagnetic and exhibits *cis-trans* isomerism
3. Paramagnetic and exhibits *cis-trans* isomerism
4. Diamagnetic and exhibits ionisation isomerism

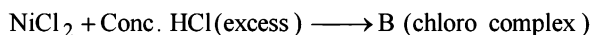
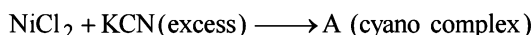
Code:

	P	Q	R	S
(a)	4	2	3	1
(b)	3	1	4	2
(c)	2	1	3	4
(d)	1	3	4	2

G Comprehension Based Questions

PASSAGE 1

The coordination number of Ni^{2+} is 4.



1. The IUPAC name of A and B are (2006 - 5M, -2)
 - (a) Potassium tetracyanonickelate (II), potassium tetrachloronickelate (II)
 - (b) Tetracyanopotassiumnickelate (II), tetrachloropotassiumnickelate (II)
 - (c) Tetracyanonickel (II), tetrachloronickel (II)
 - (d) Potassium tetracyanonickel (II), potassium tetrachloronickel (II)
2. Predict the magnetic nature of A and B (2006 - 5M, -2)
 - (a) Both are diamagnetic
 - (b) A is diamagnetic and B is paramagnetic with one unpaired electron
 - (c) A is diamagnetic and B is paramagnetic with two unpaired electrons
 - (d) Both are paramagnetic
3. The hybridization of A and B are (2006 - 5M, -2)
 - (a) dsp^2 , sp^3
 - (b) sp^3 , sp^3
 - (c) dsp^2 , dsp^2
 - (d) sp^3d^2 , d^2sp^3

PASSAGE 2

Copper is the most noble of the first row transition metals and occurs in small deposits in several countries. Ores of copper include chalcantite ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$), atacamite ($\text{Cu}_2\text{Cl}(\text{OH})_3$), cuprite (Cu_2O), copper glance (Cu_2S) and malachite ($\text{Cu}_2(\text{OH})_2\text{CO}_3$). However, 80% of the world copper production

comes from the ore chalcopyrite (CuFeS_2). The extraction of copper from chalcopyrite involves partial roasting, removal of iron and self-reduction. (2010)

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

PASSAGE 3

When a metal rod **M** is dipped into an aqueous colourless concentrated solution of compound **N**, the solution turns light blue. Addition of aqueous NaCl to the blue solution gives a white precipitate **O**. Addition of aqueous NH_3 dissolves **O** and gives an intense blue solution. (2011)

7. The metal rod **M** is
 - (a) Fe
 - (b) Cu
 - (c) Ni
 - (d) CO
8. The compound **N** is
 - (a) AgNO_3
 - (b) $\text{Zn}(\text{NO}_3)_2$
 - (c) $\text{Al}(\text{NO}_3)_3$
 - (d) $\text{Pb}(\text{NO}_3)_2$
9. The final solution contains
 - (a) $[\text{Pb}(\text{NH}_3)_4]^{2+}$ and $[\text{CoCl}_4]^{2-}$
 - (b) $[\text{Al}(\text{NH}_3)_4]^{3+}$ and $[\text{Cu}(\text{NH}_3)_4]^{2+}$
 - (c) $[\text{Ag}(\text{NH}_3)_2]^+$ and $[\text{Cu}(\text{NH}_3)_4]^{2+}$
 - (d) $[\text{Ag}(\text{NH}_3)_2]^+$ and $[\text{Ni}(\text{NH}_3)_6]^{2+}$

H Assertion & Reason Type Questions

Read the following statement-1 (Assertion/Statement) and Statement -2 (Reason/Explanation) and answer as per the options given below :

- (a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
 (b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
 (c) Statement-1 is True, Statement-2 is False
 (d) Statement-1 is False, Statement-2 is True
- Statement-1** : To a solution of potassium chromate if a strong acid is added it changes its colour from yellow to orange.
Statement-2 : The colour change is due to the oxidation of potassium chromate. (1988 - 2 Marks)
 - Statement-1** : Zn^{2+} is diamagnetic.
Statement-2 : Two electrons are lost from 4s orbital to form Zn^{2+} . (1998 - 2 Marks)
 - Statement-1** : The geometrical isomers of the complex $[\text{M}(\text{NH}_3)_4\text{Cl}_2]$ are optically inactive.
 and
Statement-2 : Both geometrical isomers of the complex $[\text{M}(\text{NH}_3)_4\text{Cl}_2]$ possess axis of symmetry. (2008 - 2 Marks)
 - Statement-1** : $[\text{Fe}(\text{H}_2\text{O})_5\text{NO}]\text{SO}_4$ is paramagnetic.
 and
Statement-2 : The Fe in $[\text{Fe}(\text{H}_2\text{O})_5\text{NO}]\text{SO}_4$ has three unpaired electrons. (2008)

I Integer Value Correct Type

- The number of water molecule(s) directly bonded to the metal centre in $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ is (2009 - 4 Marks)
- The oxidation number of Mn in the product of alkaline oxidative fusion of MnO_2 is (2009 - 4 Marks)

- Total number of geometrical isomers for the complex $[\text{RhCl}(\text{CO})(\text{PPh}_3)(\text{NH}_3)]$ is (2010)
- The volume (in mL) of 0.1 M AgNO_3 required for complete precipitation of chloride ions present in 30 mL of 0.01 M solution of $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2$, as silver chloride is close to (2011)
- EDTA^{4-} is ethylenediaminetetraacetate ion. The total number of N—Co—O bond angles in $[\text{Co}(\text{EDTA})]^{1-}$ complex ion is (JEE Adv. 2013)
- Consider the following list of reagents: (JEE Adv. 2014)
 Acidified $\text{K}_2\text{Cr}_2\text{O}_7$, alkaline KMnO_4 , CuSO_4 , H_2O_2 , Cl_2 , O_3 , FeCl_3 , HNO_3 and $\text{Na}_2\text{S}_2\text{O}_3$.
 The total number of reagents that can oxidise aqueous iodide to iodine is
- In the complex acetyl bromidodicarbonylbis (triethylphosphine) iron (II), the number of Fe—C bond(s) is (JEE Adv. 2015)
- Among the complex ions, $[\text{Co}(\text{NH}_2\text{—CH}_2\text{—CH}_2\text{—NH}_2)_2\text{Cl}_2]^+$, $[\text{CrCl}_2(\text{C}_2\text{O}_4)_2]^{3-}$, $[\text{Fe}(\text{H}_2\text{O})_4(\text{OH})_2]^+$, $[\text{Fe}(\text{NH}_3)_2(\text{CN})_4]^-$, $[\text{Co}(\text{NH}_2\text{—CH}_2\text{—CH}_2\text{—NH}_2)_2(\text{NH}_3)\text{Cl}]^{2+}$ and $[\text{Co}(\text{NH}_3)_4(\text{H}_2\text{O})\text{Cl}]^{2+}$, the number of complex ion(s) that show(s) *cis-trans* isomerism is (JEE Adv. 2015)
- For the octahedral complexes of Fe^{3+} in SCN^- (thiocyanato-S) and in CN^- ligand environments, the difference between the spin-only magnetic moments in Bohr magnetons (when approximated to the nearest integer) is [Atomic number of Fe = 26] (JEE Adv. 2015)
- In neutral or faintly alkaline solution, 8 moles of permanganate anion quantitatively oxidize thiosulphate anions to produce X moles of a sulphur containing product. The magnitude of X is (JEE Adv. 2016)
- The number of geometric isomers possible for the complex $[\text{CoL}_2\text{Cl}_2]^-$ ($\text{L} = \text{H}_2\text{NCH}_2\text{CH}_2\text{O}^-$) is (JEE Adv. 2016)

Section-B JEE Main / AIEEE

- A square planar complex is formed by hybridisation of which atomic orbitals? [2002]
 (a) s, p_x, p_y, d_{yz} (b) $s, p_x, p_y, d_{x^2-y^2}$
 (c) s, p_x, p_y, d_{z^2} (d) s, p_y, p_z, d_{xy}
- The type of isomerism present in nitropentammine chromium (III) chloride is [2002]
 (a) optical (b) linkage
 (c) ionization (d) polymerisation.
- $\text{CH}_3\text{—Mg—Br}$ is an organo metallic compound due to [2002]
 (a) Mg—Br bond (b) C—Mg bond
 (c) C—Br bond (d) C—H bond.
- Most common oxidation states of Ce (cerium) are [2002]
 (a) +2, +3 (b) +2, +4
 (c) +3, +4 (d) +3, +5.
- Arrange Ce^{+3} , La^{+3} , Pm^{+3} and Yb^{+3} in increasing order of their ionic radii. [2002]
 (a) $\text{Yb}^{+3} < \text{Pm}^{+3} < \text{Ce}^{+3} < \text{La}^{+3}$
 (b) $\text{Ce}^{+3} < \text{Yb}^{+3} < \text{Pm}^{+3} < \text{La}^{+3}$
 (c) $\text{Yb}^{+3} < \text{Pm}^{+3} < \text{La}^{+3} < \text{Ce}^{+3}$
 (d) $\text{Pm}^{+3} < \text{La}^{+3} < \text{Ce}^{+3} < \text{Yb}^{+3}$.
- Which of the following ions has the maximum magnetic moment? [2002]
 (a) Mn^{+2} (b) Fe^{+2}
 (c) Ti^{+2} (d) Cr^{+2} .
- The most stable ion is [2002]
 (a) $[\text{Fe}(\text{OH})_3]^{3-}$ (b) $[\text{Fe}(\text{Cl})_6]^{3-}$
 (c) $[\text{Fe}(\text{CN})_6]^{3-}$ (d) $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$.

8. When KMnO_4 acts as an oxidising agent and ultimately forms $[\text{MnO}_4]^{-2}$, MnO_2 , Mn_2O_3 , Mn^{+2} then the number of electrons transferred in each case respectively is
 (a) 4, 3, 1, 5 (b) 1, 5, 3, 7 [2002]
 (c) 1, 3, 4, 5 (d) 3, 5, 7, 1.
9. The radius of La^{3+} (Atomic number of La = 57) is 1.06\AA . Which one of the following given values will be closest to the radius of Lu^{3+} (Atomic number of Lu = 71) ?
 (a) 1.40\AA (b) 1.06\AA [2003]
 (c) 0.85\AA (d) 1.60\AA
10. Ammonia forms the complex ion $[\text{Cu}(\text{NH}_3)_4]^{2+}$ with copper ions in alkaline solutions but not in acidic solutions. What is the reason for it ? [2003]
 (a) In acidic solutions protons coordinate with ammonia molecules forming NH_4^+ ions and NH_3 molecules are not available
 (b) In alkaline solutions insoluble $\text{Cu}(\text{OH})_2$ is precipitated which is soluble in excess of any alkali
 (c) Copper hydroxide is an amphoteric substance
 (d) In acidic solutions hydration protects copper ions
11. One mole of the complex compound $\text{Co}(\text{NH}_3)_5\text{Cl}_3$, gives 3 moles of ions on dissolution in water. One mole of the same complex reacts with two moles of AgNO_3 solution to yield two moles of AgCl (s). The structure of the complex is [2003]
 (a) $[\text{Co}(\text{NH}_3)_3\text{Cl}_3] \cdot 2\text{NH}_3$
 (b) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2] \text{Cl} \cdot \text{NH}_3$
 (c) $[\text{Co}(\text{NH}_3)_4\text{Cl}] \text{Cl}_2 \cdot \text{NH}_3$
 (d) $[\text{Co}(\text{NH}_3)_5\text{Cl}] \text{Cl}_2$
12. In the coordination compound, $\text{K}_4[\text{Ni}(\text{CN})_4]$, the oxidation state of nickel is [2003]
 (a) 0 (b) +1
 (c) +2 (d) -1
13. 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 coloured fumes and droplets of a metal appear on the cooler parts of the test tube. The red solid is [2003]
 (a) HgI_2 (b) HgO
 (c) Pb_3O_4 (d) $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
14. A reduction in atomic size with increase in atomic number is a characteristic of elements of [2003]
 (a) d-block (b) f-block
 (c) radioactive series (d) high atomic masses
15. What would happen when a solution of potassium chromate is treated with an excess of dilute nitric acid? [2003]
 (a) $\text{Cr}_2\text{O}_7^{2-}$ 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 $\text{Cr}_2\text{O}_7^{2-}$ are formed
16. Which one of the following nitrates will leave behind a metal on strong heating ? [2003]
 (a) Copper nitrate (b) Manganese nitrate
 (c) Silver nitrate (d) Ferric nitrate
17. Of the following outer electronic configurations of atoms, the highest oxidation state is achieved by which one of them ? [2004]
 (a) $(n-1)d^3 ns^2$ (b) $(n-1)d^5 ns^1$
 (c) $(n-1)d^8 ns^2$ (d) $(n-1)d^5 ns^2$
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 [2004]
 (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 vapour contained in the humid air
19. Among the properties (a) reducing (b) oxidising (c) complexing, the set of properties shown by CN^- ion towards metal species is [2004]
 (a) c, a (b) b, c
 (c) a, b (d) a, b, c
20. The coordination number of a central metal atom in a complex is determined by [2004]
 (a) the number of ligands around a metal ion bonded by sigma and pi-bonds both
 (b) the number of ligands around a metal ion bonded by pi-bonds
 (c) the number of ligands around a metal ion bonded by sigma bonds
 (d) the number of only anionic ligands bonded to the metal ion.
21. Which one of the following complexes is an outer orbital complex ? [2004]
 (a) $[\text{Co}(\text{NH}_3)_6]^{3+}$ (b) $[\text{Mn}(\text{CN})_6]^{4-}$
 (c) $[\text{Fe}(\text{CN})_6]^{4-}$ (d) $[\text{Ni}(\text{NH}_3)_6]^{2+}$
 (Atomic nos. : Mn = 25; Fe = 26; Co = 27, Ni = 28)
22. Coordination compounds have great importance in biological systems. In this context which of the following statements is **incorrect** ? [2004]
 (a) Cyanocobalamin is B_{12} and contains cobalt
 (b) Haemoglobin is the red pigment of blood and contains irons
 (c) Chlorophylls are green pigments in plants and contain calcium
 (d) Carboxypeptidase - A is an exzyme and contains zinc.

23. Cerium ($Z = 58$) is an important member of the lanthanoids. Which of the following statements about cerium is **incorrect**? [2004]
- The +4 oxidation state of cerium is not known in solutions
 - The +3 oxidation state of cerium is more stable than the +4 oxidation state
 - The common oxidation states of cerium are +3 and +4
 - Cerium (IV) acts as an oxidizing agent
24. Which one of the following has largest number of isomers?
- $[\text{Ir}(\text{PR}_3)_2\text{H}(\text{CO})]^{2+}$ [2004]
 - $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$
 - $[\text{Ru}(\text{NH}_3)_4\text{Cl}_2]^+$
 - $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ ($\text{R} = \text{alkyl group}$, $\text{en} = \text{ethylenediamine}$)
25. The correct order of magnetic moments (spin only values in B.M.) among is [2004]
- $[\text{Fe}(\text{CN})_6]^{4-} > [\text{MnCl}_4]^{2-} > [\text{CoCl}_4]^{2-}$
 - $[\text{MnCl}_4]^{2-} > [\text{Fe}(\text{CN})_6]^{4-} > [\text{CoCl}_4]^{2-}$
 - $[\text{MnCl}_4]^{2-} > [\text{CoCl}_4]^{2-} > [\text{Fe}(\text{CN})_6]^{4-}$
 - $[\text{Fe}(\text{CN})_6]^{4-} > [\text{CoCl}_4]^{2-} > [\text{MnCl}_4]^{2-}$
(Atomic nos. : $\text{Mn} = 25$, $\text{Fe} = 26$, $\text{Co} = 27$)
26. The oxidation state Cr in $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]^+$ is
- 0
 - +1
 - +2
 - +3
- [2005]
27. Heating mixture of Cu_2O and Cu_2S will give [2005]
- Cu_2SO_3
 - $\text{CuO} + \text{CuS}$
 - $\text{Cu} + \text{SO}_3$
 - $\text{Cu} + \text{SO}_2$
28. The oxidation state of chromium in the final product formed by the reaction between KI and acidified potassium dichromate solution is: [2005]
- +3
 - +2
 - +6
 - +4
29. Calomel (Hg_2Cl_2) on reaction with ammonium hydroxide gives [2005]
- HgO
 - Hg_2O
 - $\text{NH}_2 - \text{Hg} - \text{Hg} - \text{Cl}$
 - HgNH_2Cl
30. The lanthanide contraction is responsible for the fact that [2005]
- Zr and Zn have the same oxidation state
 - Zr and Hf have about the same radius
 - Zr and Nb have similar oxidation state
 - Zr and Y have about the same radius
31. The IUPAC name of the coordination compound $\text{K}_3[\text{Fe}(\text{CN})_6]$ is [2005]
- Tripotassium hexacyanoiron (II)
 - Potassium hexacyanoiron (II)
 - Potassium hexacyanoferrate (III)
 - Potassium hexacyanoferrate (II)
32. Which of the following compounds shows optical isomerism? [2005]
- $[\text{Co}(\text{CN})_6]^{3-}$
 - $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3-}$
 - $[\text{ZnCl}_4]^{2-}$
 - $[\text{Cu}(\text{NH}_3)_4]^{2+}$
33. Which one of the following cyano complexes would exhibit the lowest value of paramagnetic behaviour? [2005]
- $[\text{Co}(\text{CN})_6]^{3-}$
 - $[\text{Fe}(\text{CN})_6]^{3-}$
 - $[\text{Mn}(\text{CN})_6]^{3-}$
 - $[\text{Cr}(\text{CN})_6]^{3-}$
- (At. Nos : $\text{Cr} = 24$, $\text{Mn} = 25$, $\text{Fe} = 26$, $\text{Co} = 27$)
34. The value of the 'spin only' magnetic moment for one of the following configurations is 2.84 BM. The correct one is
- d^5 (in strong ligand field) [2005]
 - d^3 (in weak as well as in strong fields)
 - d^4 (in weak ligand fields)
 - d^4 (in strong ligand fields)
35. Which of the following factors may be regarded as the main cause of lanthanide contraction? [2005]
- Greater shielding of 5d electrons by 4f electrons
 - Poorer shielding of 5d electrons by 4f electrons
 - Effective shielding of one of 4f electrons by another in the subshell
 - Poor shielding of one of 4f electron by another in the subshell
36. The IUPAC name for the complex $[\text{Co}(\text{NO}_2)(\text{NH}_3)_5]\text{Cl}_2$ is : [2006]
- pentaammine nitrito-N-cobalt(II) chloride
 - pentaammine nitrito-N-cobalt(III) chloride
 - nitrito-N-pentaamminecobalt(III) chloride
 - nitrito-N-pentaamminecobalt(II) chloride
37. A metal, M forms chlorides in its +2 and +4 oxidation states. Which of the following statements about these chlorides is correct? [2006]
- MCl_2 is more ionic than MCl_4
 - MCl_2 is more easily hydrolysed than MCl_4
 - MCl_2 is more volatile than MCl_4
 - MCl_2 is more soluble in anhydrous ethanol than MCl_4

38. Nickel ($Z = 28$) combines with a uninegative monodentate ligand X^- to form a paramagnetic complex $[NiX_4]^{2-}$. The number of unpaired electron(s) in the nickel and geometry of this complex ion are, respectively : [2006]
 (a) one, square planar (b) two, square planar
 (c) one, tetrahedral (d) two, tetrahedral
39. In $Fe(CO)_5$, the $Fe - C$ bond possesses [2006]
 (a) ionic character (b) σ -character only
 (c) π -character (d) both σ and π characters
40. Lanthanoid contraction is caused due to [2006]
 (a) the same effective nuclear charge from Ce to Lu
 (b) the imperfect shielding on outer electrons by 4f electrons from the nuclear charge
 (c) the appreciable shielding on outer electrons by 4f electrons from the nuclear charge
 (d) the appreciable shielding on outer electrons by 5d electrons from the nuclear charge
41. How many EDTA (ethylenediaminetetraacetic acid) molecules are required to make an octahedral complex with a Ca^{2+} ion? [2006]
 (a) One (b) Two
 (c) Six (d) Three
42. The "spin-only" magnetic moment [in units of Bohr magneton, (μ_B)] of Ni^{2+} in aqueous solution would be (At. No. Ni = 28) [2006]
 (a) 6 (b) 1.73
 (c) 2.84 (d) 4.90
43. The stability of dihalides of Si, Ge, Sn and Pb increases steadily in the sequence [2007]
 (a) $PbX_2 \ll SnX_2 \ll GeX_2 \ll SiX_2$
 (b) $GeX_2 \ll SiX_2 \ll SnX_2 \ll PbX_2$
 (c) $SiX_2 \ll GeX_2 \ll PbX_2 \ll SnX_2$
 (d) $SiX_2 \ll GeX_2 \ll SnX_2 \ll PbX_2$
44. Identify the incorrect statement among the following:
 (a) 4f and 5f orbitals are equally shielded. [2007]
 (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 lanthanoids is very similar.
45. Which of the following has a square planar geometry?
 (a) $[PtCl_4]^{2-}$ (b) $[CoCl_4]^{2-}$ [2007]
 (c) $[FeCl_4]^{2-}$ (d) $[NiCl_4]^{2-}$
 (At. nos.: Fe = 26, Co = 27, Ni = 28, Pt = 78)
46. The actinoids exhibit more number of oxidation states in general than the lanthanoids. This is because [2007]
 (a) the 5f orbitals extend further from the nucleus than the 4f orbitals
 (b) the 5f orbitals are more buried than the 4f orbitals
 (c) there is a similarity between 4f and 5f orbitals in their angular part of the wave function
 (d) the actinoids are more reactive than the lanthanoids.
47. The coordination number and the oxidation state of the element 'E' in the complex $[E(en)_2(C_2O_4)]NO_2$ (where (en) is ethylene diamine) are, respectively, [2008]
 (a) 6 and 2 (b) 4 and 2
 (c) 4 and 3 (d) 6 and 3
48. Larger number of oxidation states are exhibited by the actinoids than those by the lanthanoids, the main reason being [2008]
 (a) 4f orbitals more diffused than the 5f orbitals
 (b) lesser energy difference between 5f and 6d than between 4f and 5d orbitals
 (c) more energy difference between 5f and 6d than between 4f and 5d orbitals
 (d) more reactive nature of the actinoids than the lanthanoids
49. In which of the following complexes of the Co (at. no. 27), will the magnitude of Δ_o be the highest? [2008]
 (a) $[Co(CN)_6]^{3-}$ (b) $[Co(C_2O_4)_3]^{3-}$
 (c) $[Co(H_2O)_6]^{3+}$ (d) $[Co(NH_3)_6]^{3+}$
50. 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 oxidised by oxalic acid to chlorine [2008]
 (b) furnishes H^+ ions in addition to those from oxalic acid
 (c) reduces permanganate to Mn^{2+}
 (d) Oxidises oxalic acid to carbon dioxide and water
51. Which of the following has an optical isomer [2009]
 (a) $[Co(en)(NH_3)_2]^{2+}$ (b) $[Co(H_2O)_4(en)]^{3+}$
 (c) $[Co(en)_2(NH_3)_2]^{3+}$ (d) $[Co(NH_3)_3Cl]^+$
52. In context with the transition elements, which of the following statements is incorrect? [2009]
 (a) In the highest oxidation states, the transition metal 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.
53. Which of the following pairs represent linkage isomers? [2009]
 (a) $[Pd(PPh_3)_2(NCS)_2]$ and $[Pd(PPh_3)_2(SCN)_2]$
 (b) $[Co(NH_3)_5NO_3]SO_4$ and $[Co(NH_3)_5SO_4]NO_3$
 (c) $[PtCl_2(NH_3)_4]Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$
 (d) $[Cu(NH_3)_4][PtCl_4]$ and $[Pt(NH_3)_4][CuCl_4]$

54. Knowing that the chemistry of lanthanoids (Ln) is dominated by its +3 oxidation state, which of the following statements is incorrect? [2009]
- The ionic size of Ln (III) decrease in general with increasing atomic number
 - Ln (III) compounds are generally colourless.
 - Ln (III) hydroxide are mainly basic in character.
 - Because of the large size of the Ln (III) ions the bonding in its compounds is predominantly ionic in character.
55. A solution containing 2.675 g of $\text{CoCl}_3 \cdot 6\text{NH}_3$ (molar mass = 267.5 g mol^{-1}) is passed through a cation exchanger. The chloride ions obtained in solution were treated with excess of AgNO_3 to give 4.78 g of AgCl (molar mass = 143.5 g mol^{-1}). The formula of the complex is (At. mass of Ag = 108 u) [2010]
- $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$
 - $[\text{CoCl}_2(\text{NH}_3)_4]\text{Cl}$
 - $[\text{CoCl}_3(\text{NH}_3)_3]$
 - $[\text{CoCl}(\text{NH}_3)_5]\text{Cl}_2$
56. Which one of the following has an optical isomer? [2010]
- $[\text{Zn}(\text{en})(\text{NH}_3)_2]^{2+}$
 - $[\text{Co}(\text{en})_3]^{3+}$
 - $[\text{Co}(\text{H}_2\text{O})_4(\text{en})]^{3+}$
 - $[\text{Zn}(\text{en})_2]^{2+}$
- (en = ethylenediamine)
57. Which of the following facts about the complex $[\text{Cr}(\text{NH}_3)_6]\text{Cl}_3$ is wrong? [2011]
- The complex involves d^2sp^3 hybridisation and is octahedral in shape.
 - The complex is paramagnetic.
 - The complex is an outer orbital complex
 - The complex gives white precipitate with silver nitrate solution.
58. In context of the lanthanoids, which of the following statements is not correct? [2011]
- There is a gradual decrease in the radii of the members with increasing atomic number in the series.
 - All the members exhibit +3 oxidation state.
 - Because of similar properties the separation of lanthanoids is not easy.
 - Availability of 4f electrons results in the formation of compounds in +4 state for all the members of the series.
59. The magnetic moment (spin only) of $[\text{NiCl}_4]^{2-}$ is : [2011]
- 1.82 BM
 - 5.46 BM
 - 2.82 BM
 - 1.41 BM
60. The outer electron configuration of Gd (Atomic No. : 64) is : [2011]
- $4f^3 5d^5 6s^2$
 - $4f^8 5d^0 6s^2$
 - $4f^4 5d^4 6s^2$
 - $4f^7 5d^1 6s^2$
61. Which among the following will be named as dibromidobis (ethylene diamine) chromium (III) bromide? [2012]
- $[\text{Cr}(\text{en})_3]\text{Br}_3$
 - $[\text{Cr}(\text{en})_2\text{Br}_2]\text{Br}$
 - $[\text{Cr}(\text{en})\text{Br}_4]^-$
 - $[\text{Cr}(\text{en})\text{Br}_2]\text{Br}$
62. Iron exhibits +2 and +3 oxidation states. Which of the following statements about iron is incorrect? [2012]
- Ferrous oxide is more basic in nature than the ferric oxide.
 - Ferrous compounds are relatively more ionic than the corresponding ferric compounds.
 - Ferrous compounds are less volatile than the corresponding ferric compounds.
 - Ferrous compounds are more easily hydrolysed than the corresponding ferric compounds.
63. Which of the following complex species is not expected to exhibit optical isomerism? [JEE M 2013]
- $[\text{Co}(\text{en})_3]^{3+}$
 - $[\text{Co}(\text{en})_2\text{Cl}_2]^+$
 - $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$
 - $[\text{Co}(\text{en})(\text{NH}_3)_2\text{Cl}_2]^+$
64. Which of the following arrangements does not represent the correct order of the property stated against it? [JEE M 2013]
- $\text{V}^{2+} < \text{Cr}^{2+} < \text{Mn}^{2+} < \text{Fe}^{2+}$: paramagnetic behaviour
 - $\text{Ni}^{2+} < \text{Co}^{2+} < \text{Fe}^{2+} < \text{Mn}^{2+}$: ionic size
 - $\text{Co}^{3+} < \text{Fe}^{3+} < \text{Cr}^{3+} < \text{Sc}^{3+}$: stability in aqueous solution
 - $\text{Sc} < \text{Ti} < \text{Cr} < \text{Mn}$: number of oxidation states
65. 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 $E_{\text{M}^{3+}/\text{M}^{2+}}^0$ value? [JEE M 2013]
- Cr (Z = 24)
 - Mn (Z = 25)
 - Fe (Z = 26)
 - Co (Z = 27)
66. The octahedral complex of a metal ion M^{3+} with four monodentate ligands L_1, L_2, L_3 and L_4 absorb wavelengths in the region of red, green, yellow and blue, respectively. The increasing order of ligand strength of the four ligands is: [JEE M 2014]
- $L_4 < L_3 < L_2 < L_1$
 - $L_1 < L_3 < L_2 < L_4$
 - $L_3 < L_2 < L_4 < L_1$
 - $L_1 < L_2 < L_4 < L_3$

67. Which series of reactions correctly represents chemical reactions related to iron and its compound? [JEE M 2014]

- (a) $\text{Fe} \xrightarrow{\text{dil. H}_2\text{SO}_4} \text{FeSO}_4 \xrightarrow{\text{H}_2\text{SO}_4, \text{O}_2} \text{Fe}_2(\text{SO}_4)_3 \xrightarrow{\text{heat}} \text{Fe}$
- (b) $\text{Fe} \xrightarrow{\text{O}_2, \text{heat}} \text{FeO} \xrightarrow{\text{dil. H}_2\text{SO}_4} \text{FeSO}_4 \xrightarrow{\text{heat}} \text{Fe}$
- (c) $\text{Fe} \xrightarrow{\text{Cl}_2, \text{heat}} \text{FeCl}_3 \xrightarrow{\text{heat, air}} \text{FeCl}_2 \xrightarrow{\text{Zn}} \text{Fe}$
- (d) $\text{Fe} \xrightarrow{\text{O}_2, \text{heat}} \text{Fe}_3\text{O}_4 \xrightarrow{\text{CO}, 600^\circ\text{C}} \text{FeO} \xrightarrow{\text{CO}, 700^\circ\text{C}} \text{Fe}$

68. Which of the following compounds is not colored yellow? [JEE M 2015]

- (a) $(\text{NH}_4)_3[\text{As}(\text{Mo}_3\text{O}_{10})_4]$ (b) BaCrO_4
 (c) $\text{Zn}_2[\text{Fe}(\text{CN})_6]$ (d) $\text{K}_3[\text{Co}(\text{NO}_2)_6]$

69. Match the catalysts to the correct processes : [JEE M 2015]

- | Catalyst | Process |
|----------------------------|-------------------------------------|
| (A) TiCl_4 | (i) Wacker process |
| (B) PdCl_2 | (ii) Ziegler - Natta polymerization |
| (C) CuCl_2 | (iii) Contact process |
| (D) V_2O_5 | (iv) Deacon's process |
- (a) (A) - (ii), (B) - (iii), (C) - (iv), (D) - (i)
 (b) (A) - (iii), (B) - (i), (C) - (ii), (D) - (iv)
 (c) (A) - (iii), (B) - (ii), (C) - (iv), (D) - (i)
 (d) (A) - (ii), (B) - (i), (C) - (iv), (D) - (iii)

70. The number of geometric isomers that can exist for square planar complex $[\text{Pt}(\text{Cl})(\text{py})(\text{NH}_3)(\text{NH}_2\text{OH})]^+$ is (py = pyridine): [JEE M 2015]

- (a) 4 (b) 6
 (c) 2 (d) 3

71. The color of KMnO_4 is due to : [JEE M 2015]

- (a) $\text{L} \rightarrow \text{M}$ charge transfer transition
 (b) $\sigma - \sigma^*$ transition
 (c) $\text{M} \rightarrow \text{L}$ charge transfer transition
 (d) $d - d$ transition

72. Which of the following compounds is metallic and ferromagnetic? [JEE M 2016]

- (a) VO_2 (b) MnO_2
 (c) TiO_2 (d) CrO_2

73. Which one of the following complexes shows optical isomerism? [JEE M 2016]

- (a) *trans* $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$
 (b) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$
 (c) $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$
 (d) *cis* $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$
 (en = ethylenediamine)

74. The pair having the same magnetic moment is:

[At. No.: Cr = 24, Mn = 25, Fe = 26, Co = 27]

- (a) $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$
 (b) $[\text{CoCl}_4]^{2-}$ and $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
 (c) $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{CoCl}_4]^{2-}$
 (d) $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$

[JEE M 2016]