Coordination Compounds

1. 0.02 mole of $[Co(NH_3)_5Br]Cl_2$ and 0.02 mole of $[Co(NH_3)_5Cl]SO_4$ are present in 200 cc of a solution X. Calculate the number of moles of the precipitate Y formed when the solution X is treated with excess silver nitrate.
2. 50 mL of 0.2 M solution of a compound with empirical formula $CoCl_3.4NH_3$ on treatment with excess of $AgNO_3(aq)$ yields 1.435g of AgCl. Ammonia is not removed by treatment with concentrated H_2SO_4. How many ionisable chlorine atoms are present in the formula of the compound?
3. The ion $Co(en)Cl_2Br_2^-$ is expected to have x isomers. Find the value of x.
4. How many of the following compounds have optical isomers?
   (I) $[Co(en)_3]Br_3$ (III) $[Co(NH_3)_3Br_3]$
   (II) $[Co(en)_2Br_2]Br$ (IV) $[Co(en)(NH_3)_2Br_2]Br$
5. Considering H_2O as a weak field ligand, find the number of unpaired electrons in $[Mn(H_2O)_6]^{2+}$.
   (At. no. of Mn = 25)
6. What is the crystal field stabilization energy for high spin d^6 octahedral complex?
7. How many of the following complexes are optically inactive?
   (i) trans-$[Co(NH_3)_4I_2]^+$ (ii) cis-$[Co(NH_3)_2(en)_2]^{3+}$
   (iii) trans-$[Co(NH_3)_2(en)_2]^{3+}$
8. What is the coordination number of Fe(II) in oxyhaemoglobin?
9. If PQRS are four different ligands, then how many geometric isomers will be found for square planar [Pt. PQRS]$^{2+}$?
10. How many of the following complexes (**K**–**P**) are diamagnetic?
    $K_3[Fe(CN)_6]$ (**K**), $[Co(NH_3)_6]Cl_3$ (**L**), $Na_3[Co(oxalate)_3]$ (**M**), the $[Ni(H_2O)_6]Cl_2$ (**N**), $K_2[Pt(CN)_4]$ (**O**) and $[Zn(H_2O)_6](NO_3)_2$ (**P**)
11. Among $[Ni(CO)_4]$, $[NiCl_4]^{2-}$, $[Co(NH_3)_4Cl_2]Cl$, $Na_3[CoF_6]$, Na_2O_2 and CsO_2, find the total number of paramagnetic compounds.
12. Find 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 $[Cr(H_2O)_5Cl]Cl_2$.
13. $EDTA^{4-}$ is ethylenediaminetetraacetate ion. What is the total number of N—Co—O bonds in $[Co(EDTA)]^{1-}$ complex ion?
14. Among the complex ions, $[Co(NH_2–CH_2–CH_2–NH_2)_2Cl_2]^+$, $[CrCl_2(C_2O_4)_2]^{3-}$, $[Fe(H_2O)_4(OH)_2]^+$, $[Fe(NH_3)_2(CN)_4]^-$, $[Co(NH_2–CH_2–CH_2–NH_2)_2(NH_3)Cl]^{2+}$ and $[Co(NH_3)_4(H_2O)Cl]^{2+}$, Find the number of complex ion(s) that show(s) *cis-trans* isomerism.
15. Find the total no. of unpaired e^- present in the following complexes.
    (I) $[Fe(CO)_5]$ (III) $[Cr(CO)_6]$
    (II) $[Fe(CN)_6]^{4-}$ (IV) $[Mn(CN)_6]^{4-}$

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SOLUTIONS

1. (0.04) When excess of $AgNO_3$ and $BaCl_2$ are added to solution X.

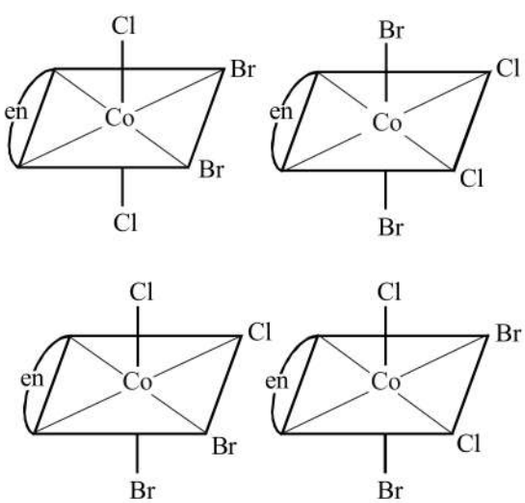
$$\underset{\substack{1\,mol\\0.02\,mol}}{[Co(NH_3)_5Br]Cl_2} + \underset{2\,mol}{2AgNO_3} \rightarrow$$

$$\underset{1\,mol}{[Co(NH_3)_5Br](NO_3)_2} + \underset{\substack{2\,mol\\0.02\times2=0.04\,mol}}{2AgCl(ppt.)(Y)}$$

2. (1) Moles of $AgCl = \frac{1.435}{143.5} = 0.01$; 50 mL of 0.2 M complex $\equiv$ 0.01 mol

$$[Co(NH_3)_4Cl_2]Cl \rightarrow [Co(NH_3)_4Cl_2]^+ + Cl^-$$

3. (4)



4. (1) $[Co(NH_3)_3Br_3]$ shows optical isomerism.

5. (5) Since H_2O is a weak ligand, it will not cause pairing of electrons in the metal ion Mn^{2+}. Thus electronic configuration of the metal (Mn^{2+}) in the complex will be

$$_{25}Mn^{2+} : 1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$$

i.e. 5 unpaired electrons.

6. (0) d^6 in high spin octahedral complex

e_g ↑ ↑

t_{2g} ↑↓ ↑ ↑

CFSE = [0.6 × 2] + [–0.4 × 4] = 0

7. (2) (i) & (ii) are optically inactive.

8. (6) The C. N. of Fe(II) in oxyhaemoglobin is 6.

9. (3)

10. (4)

Complex	No. of electrons in outer *d* orbital	No. of unpaired electron (s)
$[Fe(CN)_6]^{3-}$	$3d^5$	1 (CN^- causes pairing of electrons)
$[Co(NH_3)_6]^{3+}$	$3d^6$	–
$[Co(oxal.)_3]^{3-}$	$3d^6$	–
$[Ni(H_2O)_6]^{2+}$	$3d^8$	2
$[Pt(CN)_4]^{2-}$	$5d^8$	D (CN^- causes pairing of electrons)
$[Zn(H_2O)_6]^{2+}$	$3d^{10}$	–

Thus L, M, O and P are diamagnetic.

11. (3)

Compound/Ion	Magnetic nature of compound
$[Ni(CO)_4]$	Diamagnetic
$[NiCl_4]^{2-}$	Paramagnetic
$[Co(NH_3)_4Cl_2]Cl$	Diamagnetic
$Na_3[CoF_6]$	Paramagnetic
Na_2O_2	Diamagnetic
CsO_2	Paramagnetic

So total number of paramagnetic compounds is 3.

12. (6) m moles of $[Cr(H_2O)_6Cl]Cl_2 = 0.01 \times 30 = 0.3$

m moles of $Cl^- = 0.3 \times 2 = 0.6$

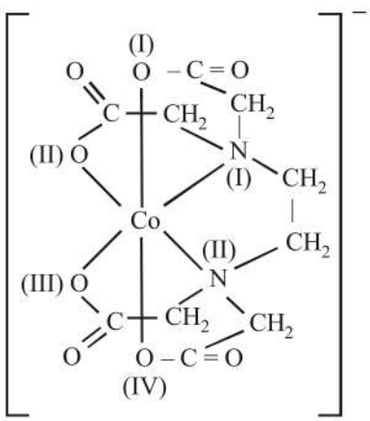
[1 mole of complex gives 2 Cl^- ions]

m moles of Ag^+ = m moles of Cl^-

$0.1 \times V = 0.6$

V = 6 mL

13. (8)



Total no. of N – Co – O bonds are 8.

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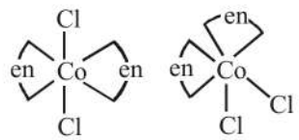
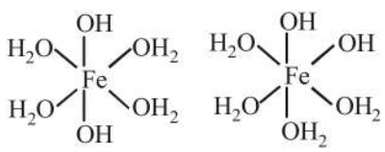
14. (6) All the complexes given show cis-trans isomerism

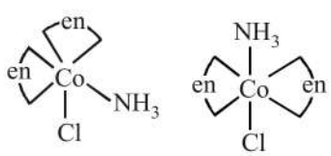
$[Co(NH_2—CH_2—CH_2—NH_2)_2Cl_2]^+$



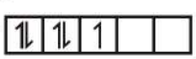
$[Fe(H_2O)_4(OH)_2]^+$



$[Co(NH_2–CH_2–CH_2–NH_2)_2(NH_3)Cl]^{2+}$



15. (1) Mn^{2+} : $3d^5\ 4s^0$

$[Mn(CN)_6]^{4-}$ 

Complexes (I, II, III) are diamagnetic hence they have no unpaired electrons.

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