CBSE Test Paper-01

Class - 12 Chemistry (Coordination Compounds)

1. Tetraaminecopper(II) ion is a square planar complex with one unpaired electron. According to valence bond theory the hybrid state of copper should be
   a. dsp^2
   b. sp^3d^2
   c. d^2sp^3
   d. sp^3
2. Which of the following pair contains a complex salt and double salt respectively?
   a. $[Cu(NH_3)_4]SO_4$, $FeSO_4.7H_2O$
   b. $FeSO_4$, $K_4[Fe(CN)_6]$
   c. $MgSO_4.7H_2O$, $CuSO_4$
   d. $[Cu(NH_3)_4]SO_4$, $K_2SO_4.Al_2(SO_4)_3.24H_2O$
3. The type of isomerism that is exhibited by $[Co(NH_3)_5SO_4]Br$ and $[Co(NH_3)_5Br]SO_4$ is:
   a. Linkage isomerism
   b. Solvate isomerism
   c. Ionisation isomerism
   d. Coordination isomerism
4. The oxidation number of Fe in $K_4[Fe(CN)_6]$ is
   a. 0
   b. +1
   c. +3
   d. +2
5. The anti pernicious anaemia factor which is a coordination compound of Cobalt is:
   a. Cyanocobalamine
   b. Haemoglobin
   c. Desferrioxime B
   d. Carbonic anhydrase
6. Write formula for Hexammineplatinum (VI) Chloride.

7. What is the coordination number of central metal ion in $[Fe(C_2O_4)_3]^{2-}$.
8. Write formula forTetramminedichloridooplatinum (IV) Bromide.
9. What are the different shapes or coordination polyhedra in the complexes?
10. Name a ligand which is bidentate and give an example of the complex formed by this ligand.
11. Give the chemical formula of pentaammine chloro cobalt (III) chloride.
12. $[NiCl_4]^{2-}$ is paramagnetic while $[Ni(CO)_4]$is diamagnetic though both are tetrahedral. Why?
13. Draw the structures of following:
    a. cis-dichlorotetracyanochromate(III)
    b. Pentaamminenitrito-N-cobalt(III)
    c. Hexamethyldialuminium
14. Which isomerism is shown by a compound having ambidentate ligand? Give example.
15. Explain with two examples each of the following: Coordination entity, ligand coordination number, coordination polyhedron, homoleptic and heteroleptic.

CBSE Test Paper-01

Class - 12 Chemistry (Coordination Compounds)

Solutions

1. (a) dsp^2

   Explanation: Tetraaminecopper(II) ion is square planar. Square planar complexes have dsp^2 hybridisation. So hybridization is dsp^2.
2. (d) $[Cu(NH_3)_4]SO_4$, $K_2SO_4.Al_2(SO_4)_3.24H_2O$

   Explanation: $[Cu(NH_3)_4]SO_4$ this is a complex salt because it contains a coordination entity (central metal ion Cu^{2+} with 4 ligand molecules of NH_3 in coordination sphere) while $K_2SO_4.Al_2(SO_4)_3.24H_2O$ is double salt as it can dissociate completely into simple ions when it is dissolved in water.
3. (c) Ionisation isomerism

   Explanation: Ionisation isomerism arises when the counter ion in a complex salt is itself a potential ligand and can displace a ligand which can then become a counter ion. Here Br^- and SO_4^{2-} exchanged places as counter ion and ligand. So these complexes exhibit ionisation isomerism.
4. (d) +2

   Explanation: The ligand CN^- has charge of –1. So the overall charge carried by 6 CN^- ligands is -6. Each potassium ion K^+ carries a charge of +1. So 4 potassium ions carry an overall charge of +4. This implies that the overall charge on the coordination sphere is -4 to balance the +4 charge of the potassium ions. Let the oxidation number of Fe be x. Then

   x + (-6) = -4

   x = -4 - (-6)

   x = -4 + 6

   x = +2

   So, the oxidation number of Fe is +2.
5. (a) Cyanocobalamine

   Explanation: Vitamin B_{12}, cyanocobalamine, the antipernicious anaemia factor is a coordination compound of Cobalt.

6. $[Pt(NH_3)_6]Cl_6$

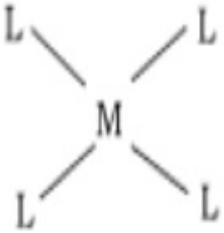
7. Six

8. $[Pt\ Cl_2(NH_3)_4]Br_2$

9. The various coordination polyhedra are –
   i. Octahedral

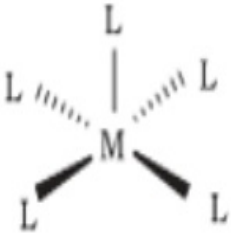
   ii. Tetrahedral

   iii. Square Planar



   iv. Trigonal bipyramidal

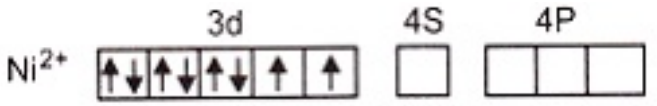
   v. Square pyramidal



10. Ethylene diamine (en) is bidentate ligand $[Co(en)_3]^{3+}$. Its IUPAC name is tris (ethylene diamine) cobalt (III) ion.

11. $[CO(NH_3)_5Cl]Cl_2$

12. In $[NiCl_4]^{2-}$ Ni is in +2 oxidation state electronic configuration = $3d^8 4s^0$.

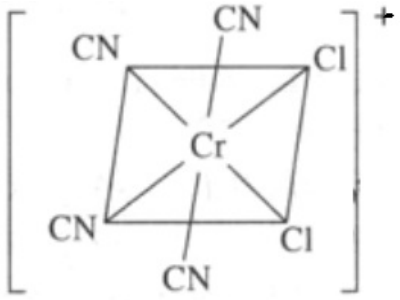


Cl^- is a weak ligand. It cannot pair up the electrons in 3d orbitals. Hence, it is paramagnetic. In $[Ni(CO)_4]$, Ni is in zero oxidation state and configuration is $-3d^8 4s^2$.

In the presence of CO ligand, the 4S electrons shift to 3d to pair up 3d electrons. Thus, there is no unpaired electron present. Hence it is diamagnetic.

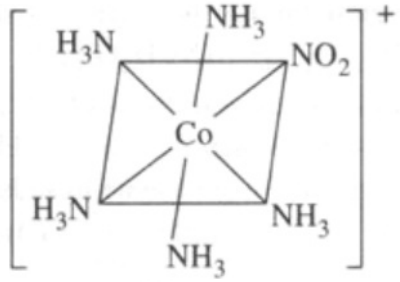
13. Structures of the three complex ions/molecules are given below:

a.

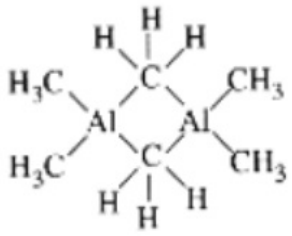


cis-isomer

b.



c.



14. A complex having ambident ligand will show linkage isomerism e.g $[Cr(NH_3)_5(NO_2)]Cl_2$

has NO_2^- as ambident Ligand and its Linkage isomer will be $[Cr(NH_3)_5(ONO)]Cl_2$.

15. **Coordination** entity: This entity usually constitutes a central metal atom or ion, to which are attached a fixed number of other atoms or ions or groups by coordinate bonds. Examples are $[Ni(CO)_4]$, $[COCl_3(NH_3)_3]$, etc.

    Ligands: It is an ion having at least one lone pair of electrons and capable of forming a coordinate bond with central atom / ion in the coordination entity.

    Examples are : Cl^-, $(OH)^-$, $(CN)^-$etc.

    Coordinate number: The total number of coordinate bonds with which central atom/ ion is linked to ligands in the coordination entity is called coordination number of central atom / ion.

    Coordination polyhedron : The spatial arrangement of the ligands which are directly attached to the central atom / ion defines a coordination polyhedron about the central atom.

    Examples are: $[Co(NH_3)_6]^{3+}$is octahedral,

    $[Ni(CO)_4]$is tetrahedral.

    Homoleptic and hedroleptic: Complexes in which a metal is bound to only one kind of donor groups are known as homoleptic.

    Example $[CO(NH_3)_6]^{3+}$

    Complex in which a metal is bound to more than one kind of donor groups are called hetroleptic. Example : $[Co(NH_3)_4Cl_2]^+$

CBSE Test Paper-02

Class - 12 Chemistry (Coordination Compounds)

1. The isomers $[(C_6H_5)_3P_2Pd(SCN)_2]$ and $[(C_6H_5)_3P_2Pd(NCS)_2]$ show
   a. Linkage isomerism
   b. Coordination isomerism
   c. Geometrical isomerism
   d. Ionization isomerism
2. According to Werner's theory, the secondary valences of the central atom correspond to its
   a. Charge
   b. Oxidation number
   c. Effective atomic number
   d. Coordination number
3. Which of the following complexes can form d and l isomers?
   a. Trans - $[Co(en)_2Cl_2]^+$
   b. $[Co(NH_3)_3Cl_3]$
   c. Cis - $[Co(en)_2Cl_2]^+$
   d. $[Co(NH_3)_4Cl_2]^+$
4. Sodium pentacyanonitrosylferrate(II) is also called
   a. Sodium ferrocyanide
   b. Sodium sulphocyanide
   c. Sodium nitroprusside
   d. Sodium cobaltnitrite
5. The oxidation state of Ag in tollen's reagent is
   a. +2
   b. 0
   c. +1
   d. +1.5
6. Write formula for triamminediaquachlorocobalt (III) Chloride.

7. What is the IUPAC name of $[Co(en)_3]Cl_3$.

8. Give examples of complexes in
   a. Chemical analysis
   b. Industries

9. What is the difference between a double salt and a complex? Explain with an example.

10. What is the basis of formation of spectro-chemical series?

11. Write IUPAC names of the following coordination compounds:
   a. $K_3[Cr(C_2O_4)_3]$
   b. $Hg[Co(SCN)_4]$
   c. $[Co(NH_3)_5(CO_3)]Cl$

12. Using the valence bond approach, deduce the shape and magnetic character of $[Cr(CO)_6]$ [At. No. of Cr = 24]

13. What will be the correct order for the wavelengths of absorption in the stable region for the following:
   $[Ni(NO_2)_6]^{4-}$, $[Ni(NH_3)_6]^{2+}$, $[Ni(H_2O)_6]^{2-}$

14. Give evidence that $[Co(NH_3)_5Cl]SO_4$ and $[Co(NH_3)_5SO_4]Cl$ are ionization isomers.

15. Give the oxidation state, d-orbital occupation and coordination number of the central metal ion in the following complexes:
   i. $K_3[Co(C_2O_4)_3]$
   ii. cis$-[Cr(en)_2Cl_2]Cl$
   iii. $(NH_4)_2[CoF_4]$
   iv. $[Mn(H_2O)_6]SO_4$

CBSE Test Paper-02

Class - 12 Chemistry (Coordination Compounds)

Solutions

1. (a) Linkage isomerism

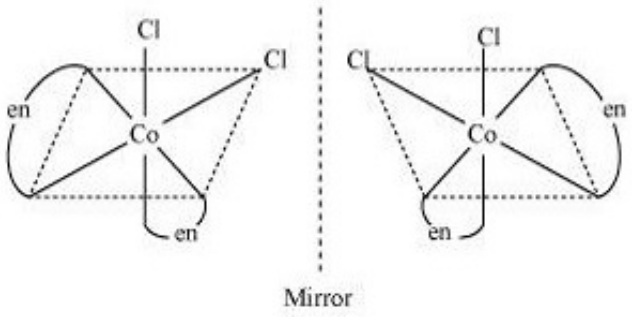
   Explanation: SCN^- is an ambidentate ligand i.e it can bind through two different donor atoms, either through S in SCN^- or through N in NCS^- . So it shows linkage isomerism which arises when an ambidentate ligand is present in the complex.

2. (d) Coordination number

   Explanation: According to Werner's theory, secondary valences are non-ionisable and are satisfied by neutral molecules or negative ions. Secondary valence is equal to the coordination number and is fixed for a metal.

3. (c) Cis - $[Co(en)_2Cl_2]^+$

   Explanation: Cis - $[Co(en)_2Cl_2]^+$ has non superimposable mirror images as shown.



   Hence, it shows optical isomerism and can form d (dextrorotatory) and l (laevorotatory) isomers.

4. (c) Sodium nitroprusside

   Explanation: $Na_2[Fe(CN)_5NO]$ i.e. Sodium pentacyanonitrosylferrate(II) is also called Sodium nitroprusside.

5. (c) +1

   Explanation: Tollen's reagent contains diamminesilver(I) complex. So oxidation state of Ag in tollen's reagent is +1.

6. $[Co(NH_3)_3(H_2O)_2Cl]Cl_2$

7. Tris (ethylenediamine) Cobalt (III) Chloride

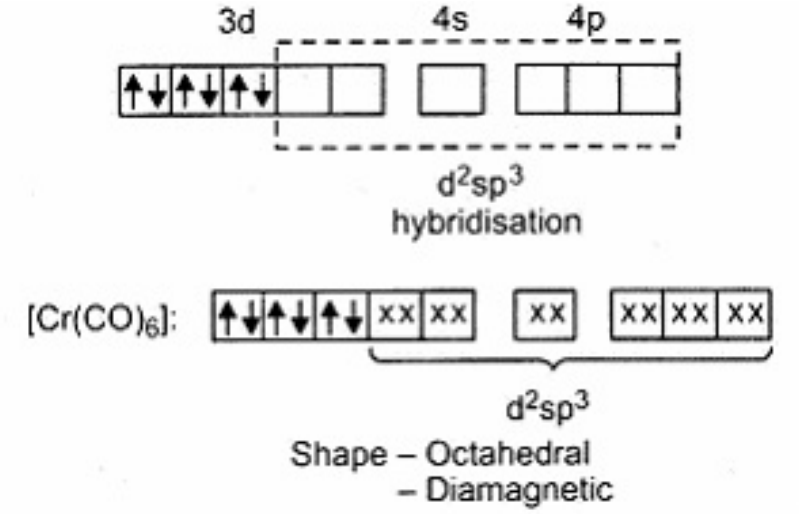
8. a. Chemical analysis – Qualitative and Quantitative analysis methods involve use of Ligands like EDTA, DMG etc.
   b. Industries - Hydrogenation of alkenes is done by using a sodium complex called Wilkinson catalyst. In black and white photography, silver complexes are used.

9. Double salts dissociate completely into simple ions when dissolved in water e.g., Mohr salt, $FeSO_4(NH_4)_2\ SO_4.\ 6H_2O$ will dissolve in water and give ferrous, ammonium and sulphate ions. On the other hand, the complex ions do not completely dissociate into all constituent ions e.g $K_4[Fe(CN)_6]$ will dissociate to give potassium ions and $[Fe(CN)_6]^{4-}$ ions only.

10. **Spectrochemical series:** The arrangements of ligands in order of their increasing field strength, i.e. increasing crystal field splitting energy (CFSE) value is called spectrochemical series.
    Crystal field splitting energy is the basis of formation of the spectrochemical series.

11. a. Potassium trioxalato electromate III
    b. Mercuric tetrathiiocyanatocobaltate III
    c. Pentaamminecarbonatocobalt (III) chloride.

12. Cr (24) Electronic configuration $[Ar]4s^1 3d^5$
    Oxidation state of Cr = 0
    In $[Cr(CO)_6]$ has electronic configuration [Ar] $4s^0 3d^5$ because CO will cause passing of electrons as it is a strong field ligand.



13. As metal ion is fixed, the increasing field strengths (CFSE) values of the ligands form the spectrochemical series are in order

    $H_2O < NH_3 < NO_2^-$

    Thus, the energies absorbed for excitation will be in the order

    $[Ni(H_2O)_6]^{2+} < [Ni(NH_3)_6]^{2+} < [Ni(NO_2)_6]^{4-}$

    The order of wavelength absorbed will be opposite of it.

    Since, $E = \frac{hc}{\pi}$

14. When ionization isomers are dissolved in water, they ionize to give different ions. These ions then react differently with different reagents to give different products.

    $[CO(NH_3)_5Cl]SO_4 + Ba^{2+} \rightarrow \underset{\text{White Precipitate}}{BaSO_4\downarrow}$

    $[CO(NH_3)_5Cl]SO_4 + Ag^+ \rightarrow$ No reaction

    $[CO(NH_3)_5\ SO_4]\ Cl + Ba^{2+} \rightarrow$ No reaction

    $[CO(NH_3)_5\ SO_4]\ Cl + Ag^+ \rightarrow \underset{\text{White precipitate}}{AgCl\downarrow}$

15. i. $K_3\left[Co(C_2O_4)_3\right]$

    The central metal ion is Co.

    Its coordination number is 6.

    The oxidation state can be given as:

    x – 6 = –3

    x = + 3

    The d orbital occupation for $Co^{3+} is, {t_{2g}}^6 {e_g}^0$

    ii. cis-$\left[Cr(en)_2Cl_2\right]Cl$

    The central metal ion is Cr.

    The coordination number is 6.

    The oxidation state can be given as:

    x + 2(0) + 2(–1) = +1

    x – 2 = +1

    x = +3

    The d orbital occupation for Cr^{3+} is ${t_{2g}}^3$.

    iii. $(NH_4)_2\left[CoF_4\right]$

The central metal ion is Co.

The coordination number is 4.

The oxidation state can be given as:

x – 4 = –2

x = + 2

The d orbital occupation for $Co^{2+} is, {e_g}^4 {t_{2g}}^3$.

iv. $[Mn(H_2O)_6]\,SO_4$

The central metal ion is Mn.

The coordination number is 6.

The oxidation state can be given as:

x + 0 = +2

x = +2

The d orbital occupation for Mn is ${t_{2g}}^3 {e_g}^2$.

CBSE Test Paper-03

Class - 12 Chemistry (Coordination Compounds)

1. The oxidation number of cobalt in $K[Co(CO)_4]$ is
   a. -1
   b. +1
   c. -3
   d. +3
2. Lithiumtetrahydridoaluminate is represented as
   a. $Al_2[LiH_4]_3$
   b. $Li[AlH_4]_2$
   c. $Al[\ LiH_4]$
   d. $Li[AlH_4]$
3. Which among the following has trigonal bipyramidal geometry?
   a. Pentacarbonyliron (0)
   b. Potassium tetracyanidonickelate(II)
   c. Tetracarbonylnickel(0)
   d. Hexaamminecobalt(II) nitrate
4. The correct name of the compound $[Cu(NH_3)_4](NO_3)_2$ is
   a. Cuprammonium nitrate
   b. Tetraamminecopper(I) nitrate
   c. Tetraamminecopper(II) nitrate
   d. Tetraamminecopper(II)dinitrate
5. Which of the following complex species involves d^2sp^3 hybridization?
   a. $[Cr(NH_3)_6]^{3+}$
   b. $[Fe(CN)_6]^{3-}$
   c. $[Co(N\{H_3)_6]^{3+}$
   d. $[CoF_6]^{3-}$

6. What is the coordination number of central metal ion in $[Fe(C_2O_4)_3]^{3-}$?
7. What are complex compounds?
8. Name the metal present in haemoglobin.
9. Explain why a chelating complex is more stable than unchelated complex.
10. Give IUPAC name of linkage isomer of $[(NH_3)_3Pt(NO_2)]Cl$.
11. Describe briefly the nature of bonding in metal carbonyl.
12. Draw the structures of the given:
    i. cis-dichloro tetracyano chromate III
    ii. pentaammine nitrite-N-cobalt (III)
    iii. Hexamethyldialuminium.
13. a. What are ambidentate ligands? Give example.
    b. Write the IUPAC names of the following:
        i. $K_3[Fe(C_2O_4)_3]$
        ii. $Pt[(NH_3)_6]Cl_4$
    c. Draw the structure of cis isomer of $[Co(NH_3)_4Cl_2]^+$
14. $[Fe(CN)_6]^{4-}$ and $[Fe(H_2O)_6]^{2+}$ are different colours in dilute solution why?
15. Write the formulas for the following coordination compounds:
    i. Tetraamminediaquacobalt (III) chloride
    ii. Potassium tetracyanonickelate (II)
    iii. Tris(ethane-1,2-diamine) chromium(III) chloride
    iv. Amminebromidochloridonitrito-N-platinate (II)
    v. Dichloridobis(ethane-1,2-diamine)platinum(IV) nitrate
    vi. Iron(III) hexacyanoferrate (II)

CBSE Test Paper-03

Class - 12 Chemistry (Coordination Compounds)

Solutions

1. (a) -1

   Explanation: Potassium ion K^+ carries a +1 charge. So the overall charge on the given complex is -1. Now CO is a neutral ligand. Hence the oxidation number of Co in this complex is -1.

2. (d) $Li[AlH_4]$

   Explanation: The cation is named first and then the anion. When the anion is the complex then the -ate is added to the name of the central metal. Here there are 4 hydride ligands represented as H^- each carries a charge of -1 and hence a total of -4 charge on the ligands. Lithium ion is represented by Li^+ and carries a +1 charge which means the charge on the complex is -1. In the complex, central metal atom/ion is written followed by the ligands in alphabetical order.
   Lithium tetrahydridoaluminate(III) is $Li[AlH_4]$.

3. (a) Pentacarbonyliron (0)

   Explanation: Iron (Z=26) has an electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$. CO being a strong field ligand, causes pairing of electrons in the d orbital and shifting of 4s electrons to 3d orbital. With a coordination number 5 it results in $sp^3 d$ hybridisation and hence a trigonal bipyramidal geometry.

4. (c) Tetraamminecopper(II) nitrate

   Explanation: In ionic compound, cation is named first and then the anion. If cation is the complex then ligands are named first in alphabetical order and then the central metal atom/ion with its oxidation state in paranthesis in roman numerals. Here, NH_3 (ammine) is the neutral ligand and there are 4 NH_3 bound to Cu (copper). Nitrate NO_3^- is the anion there are two NO_3^- outside the square bracket each carries -1 charge so there is a total of -2 charge on anions and thus the complex carries a total of +2 charge. Since ammine is a neutral ligand so Cu has +2 oxidation state. So, $[Cu(NH_3)_4](NO_3)_2$ is tetraamminecopper(II) nitrate.

5. (b) $[Fe(CN)_6]^{3-}$

   Explanation: In this complex there are 6 CN^- ligands means a total of -6 charge on ligands. There is a charge of -3 on the complex so oxidation state of Fe is +3. Atomic number of Fe is 26. So the electronic configuration of Fe^{+3} is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$.Coordination number of the metal is 6 so the complex has octahedral geometry and since CN^- is a strong field ligand so it causes pairing and hence inner orbital complex is formed. So the hybridization is $d^2 sp^3$.

6. Six

7. Complex compounds or coordination compounds are those compounds in which the metal atoms are bound to a number of anions or neutral molecules.

8. Fe

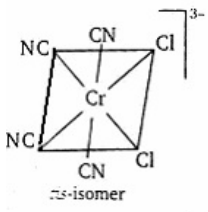
9. Chelating complex is more stable than unchelated complex because there is strong force of attraction between cation and polydenatate ligand as compared to monodentate ligand.

10. The linkage isomer is $[Pt(ONO)(NH_3)_3]Cl$

    IUPAC Name - triaminenitrito-o-platinum II chloride.

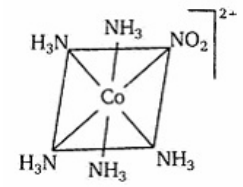
11. The metal carbon bond in metal carbonyls possess both S & P character. The M-C σ bond is formed by the donation of lone pair of electrons on the carbonyl carbon into a vacant orbital of the metal. M-C π bond is formed by the donation of a pair of electrons from a filled d-orbital of metal into the antibonding πorbital of carbon monoxide.

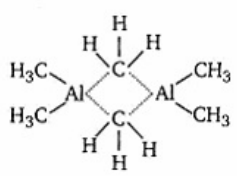
12. i.



cis-isomer

ii.



iii. 

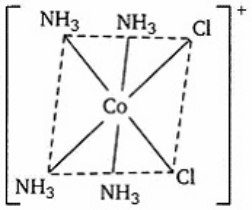
13. a. Ambidenctate ligand. Ligands which can ligate (link) through two different atoms present in it are called ambidentate ligands, e.g. NO_2^-, SCN^-, $\underset{Thiocyanato}{M \leftarrow SCN}$

$\underset{Isothiocyanato}{M \leftarrow NCS}$

b. i. Potassium Trioxalato Ferrate (III)

ii. Hexaamine platinum (IV) chloride

c. cis- $[Co(NH_3)_4Cl_2]^+$



14. In both the complexes, Fe is in +2 state with the configuration $3d^6$, i.e. it has four unpaired electrons.

As the ligands H_2O and CN^- posses different crystal field splitting energy (Δ_0) they absorb different components of the visible light (VIBGYOR) for d-d transition. Hence, the transmitted colours are different.

15. i. $[CO(H_2O)_2(NH_3)_4]Cl_3$

ii. $K_2[Ni(CN)_4]$

iii. $[Cr(en)_3]Cl_3$

iv. $[Pt(NH)_3BrCl(NO_2)]^-$

v. $[PtCl_2(en)_2](NO_3)_2$

vi. $Fe_4[Fe(CN)_6]_3$