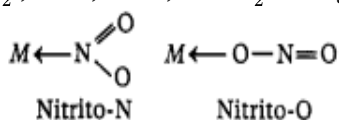


Solution

COORDINATION COMPOUNDS

Class 12 - Chemistry

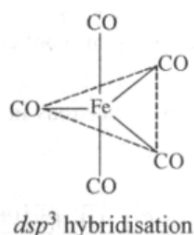
1. Tetrahedral complexes do not show geometrical isomerism (a type of stereoisomerism) because the relative positions of the unidentate ligands attached to the central metal atom are the same with respect to each other.
2. Coordination Number = 6
Oxidation State = +2
3. a. NH_4^+ , cannot act as ligand.
Due to the unavailability of lone pair of electrons/cannot act as a Lewis base.
b. Pentaamminenitrito-O-cobalt (III) chloride
4. a. $[\text{Co}(\text{NH}_3)_4(\text{H}_2\text{O})_2]\text{Cl}_3$
b. $[\text{Pt Br}_2(\text{en})_2](\text{NO}_3)_2$
5. Crystal field splitting energy increases in following complex ion in the order :
 $[\text{Cr}(\text{Cl})_6]^{3-}$, $[\text{Cr}(\text{CN})_6]^{3-}$, $[\text{Cr}(\text{NH}_3)_6]^{3+}$
6. Ligands which can ligate through two different atoms (with any one at a time) present in it are called ambidentate ligands. e.g. NO_2^- , SCN^- , CNO^- , etc. NO_2^- can ligate through two sites, e.g.



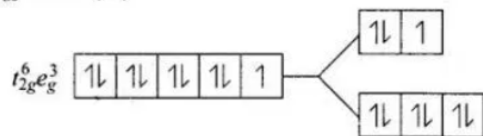
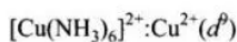
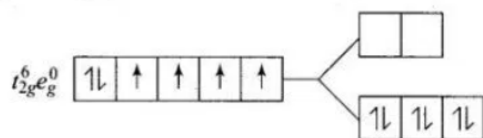
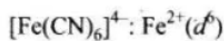
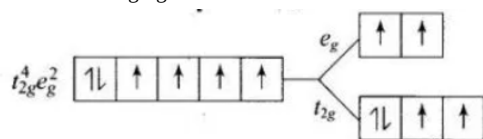
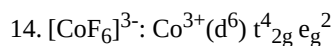
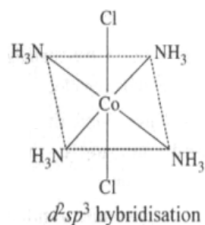
7. Complex compounds or coordination compounds are those compounds in which the metal atoms are bound to a number of anions or neutral molecules.
8. a. Triamminetriaquachromium (III) chloride
b. Potassium trioxalatoaluminate (III)
9. a. Due to the presence of an unpaired electron in d-orbital/ it shows a d-d transition.
b. Potassium trioxalatochromate(III)
10. cis $[\text{Pt}(\text{en})_2\text{Cl}_2]^{2+}$
11. In $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ Ni is in +2 state with the configuration $3d^8$, i.e. it has two unpaired electrons which do not pair up in the presence of weak H_2O ligand. Hence, it is coloured. The d-d transition absorbs red light and the complementary light emitted is green. In case of $[\text{Ni}(\text{CN})_4]^{2-}$ Ni is again in +2 state with the configuration $3d^8$ but in presence of the strong CN^- ligand, the two unpaired electrons in the 3d orbitals pair up. Thus, there is no unpaired electron present. Hence it is colour less.
12. a. Applications of coordination compounds are given as under:
 - i. Analytical chemistry: Transition metal ions may be estimated by adding reagents to a metal ion solution under suitable conditions to form an insoluble precipitate of metal- ligand complex. The precipitate is dried and weighed. Ni^{2+} is estimated by this process using dimethyl glyoxime.
 - ii. Extraction of metals : Au and Ag are extracted by forming cyanide complex and then adding Zn as a reducing agent.

b. Formation of complex is an exothermic process. Heat is evolved when a bond is formed between central metal ion and ligands. Stability of complex decreases with the increase in temperature because formation of complex is exothermic process. On heating, coordinate bond between central metal ion and ligand will break. This is in accordance with Le-chatelier principle.

13. i.

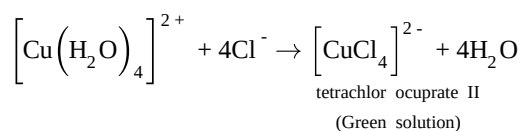


ii.



15. i. Aqueous CuSO_4 solution exists as $[\text{Cu}(\text{H}_2\text{O})_4] \text{SO}_4$ which has blue colour due to $[\text{Cu}(\text{H}_2\text{O})_4]^{2+}$ ions.

ii. When KF is added, the weak H_2O ligands are replaced by F^- ligands forming $[\text{CuF}_4]^{2-}$ ion which has bright green colour.



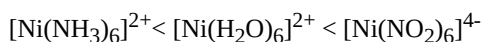
16. a. Complexes containing didentate or polydentate ligands are more stable than those containing monodentate ligands. In each of the given complex, Fe is in +3 state.

As $\text{C}_2\text{O}_4^{2-}$ is didentate chelating ligand, hence is the most stable complex.

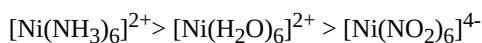
b. As metal ion is fixed, the wavelength of absorption will be decided by the field strengths (CFSE values) of the ligands.

From the spectrochemical series, the order of CFSE is: $\text{H}_2\text{O} < \text{NH}_3 < \text{NO}_2$

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



As wavelength and energy are inversely related. The wavelengths absorbed will be in the opposite order:



17. **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 $[\text{Ni}(\text{CO})_4]$, $[\text{COCl}_3(\text{NH}_3)_3]$, 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^- , $(\text{OH})^-$, $(\text{CN})^-$ 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: $[\text{Co}(\text{NH}_3)_6]^{3+}$ is octahedral,

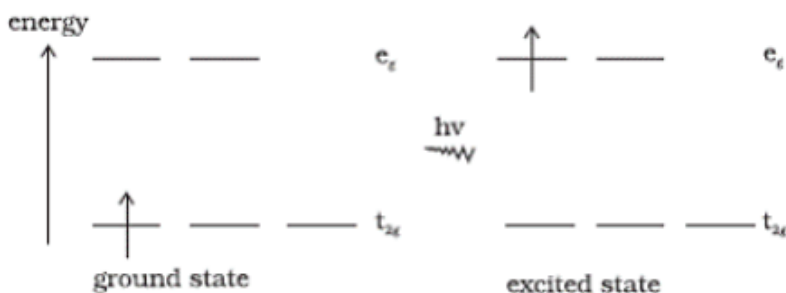
$[\text{Ni}(\text{CO})_4]$ is tetrahedral.

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

Example $[\text{CO}(\text{NH}_3)_6]^{3+}$

Complex in which a metal is bound to more than one kind of donor groups are called hetroleptic. Example : $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$

18. Co-ordination compounds exhibit colour, which is attributed to the crystal field theory, corresponding to the d-d transition of elements. For example, the excitation of an electron from the empty state as e_g , will absorb light that will excite the electron from (3 orbitals of lower energy) t_{2g} to (2 orbital of higher energy) e_g as in case of $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$. When light corresponding to the energy of the yellow-green region is absorbed by the complex, this would excite the electron from t_{2g} level to the e_g level ($t_{2g}^1 e_g^0 \rightarrow t_{2g}^0 e_g^1$). Thus the complex is violet in color.



But in the absence of ligand, there is no crystal field splitting and substance become colourless as in the case of $[\text{Ti}(\text{H}_2\text{O})_6]\text{Cl}_3$, when water molecules are removed it becomes colourless.

19. i. Coordination entity: A coordination entity is an electrically charged radical or species carrying a positive or negative charge.

In a coordination entity, the central atom or ion is surrounded by a suitable number of neutral molecules or negative ions (called ligands). For example:

$[\text{Ni}(\text{NH}_3)_6]^{2+}$, $[\text{Fe}(\text{CN})_6]^{4+}$ = cationic complex

$[\text{PtCl}_4]^{2-}$, $[\text{Ag}(\text{CN})_2]^-$ = anionic complex

$[\text{Ni}(\text{CO})_4]$, $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]$ = neutral complex

- ii. Ligands

The neutral molecules or negatively charged ions that surround the metal atom in a coordination entity or a coordinial complex are known as ligands. For example, NH_3 , H_2O , Cl and OH^- . Ligands are usually polar in nature and possess at least one unshared pair of valence electrons.

- iii. Coordination number:

The total number of ligands (either neutral molecules or negative ions) that get attached to the central metal atom in the coordination sphere is called the coordination number of the central metal atom. It is also referred to as its ligancy.

For example:, there as six chloride ions attached to Pt in the coordinate sphere. Therefore, the coordination number of Pt is 6.

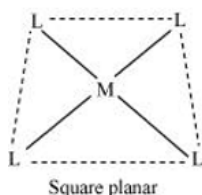
a. In the complex, $\text{K}_2[\text{PtCl}_6]$

b. Similarly, in the complex $[\text{Ni}(\text{NH}_3)_4]\text{Cl}_2$, the coordination number of the central atom (Ni) is 4.

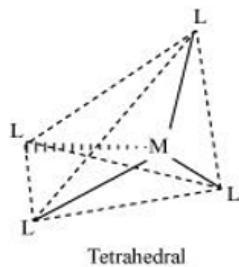
- iv. Coordination polyhedron:

Coordination polyhedrons about the central atom can be defined as the spatial arrangement of the ligands that are directly attached to the central metal ion in the coordination sphere. For example:

- a.



b.



v. Homoleptic complexes: These are those complexes in which the metal ion is bound to only one kind of a donor group. For eg: $[\text{Co}(\text{NH}_3)_6]^{3+}$, $[\text{PtCl}_4]^{2-}$, etc.

vi. Heteroleptic complexes: Heteroleptic complexes are those complexes where the central metal ion is bound to more than one type of a donor group.

For e.g.: $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$, $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$

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