

Chapter 9: Coordination Compounds

NCERT Exemplar · Class 12 · Chemistry

I. Multiple Choice Questions (Type-I)

Question 1

Which of the following complexes formed by Cu^{2+} ions is most stable?

(i) $\text{Cu}^{2+} + 4\text{NH}_3 \rightleftharpoons [\text{Cu}(\text{NH}_3)_4]^{2+}$	logK	11.6
(ii) $\text{Cu}^{2+} + 4\text{CN}^- \rightleftharpoons [\text{Cu}(\text{CN})_4]^{2-}$	logK	27.3
(iii) $\text{Cu}^{2+} + 2\text{en} \rightleftharpoons [\text{Cu}(\text{en})_2]^{2+}$	logK	15.4
(iv) $\text{Cu}^{2+} + 4\text{H}_2\text{O} \rightleftharpoons [\text{Cu}(\text{H}_2\text{O})_4]^{2+}$	logK	8.9

Solution

Option (ii) is the answer.

Question 2

The colour of the coordination compounds depends on the crystal field splitting. What will be the correct order of absorption of wavelength of light in the visible region, for the complexes, $[\text{Co}(\text{NH}_3)_6]^{3+}$, $[\text{Co}(\text{CN})_6]^{3-}$, $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$

A.



B.



C.



D.



Answer

Correct option: C

Solution

Option (iii) is the answer.

Question 3

When 0.1 mol $\text{CoCl}_3(\text{NH}_3)_5$ is treated with an excess of AgNO_3 , 0.2 mol of AgCl

are obtained. The conductivity of the solution will correspond to

A.

1:3 electrolyte

B.

1:2 electrolyte

C.

1:1 electrolyte

D.

3:1 electrolyte

Answer

Correct option: B

Solution

Option (ii) is the answer.

Question 4

When 1 mol $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ is treated with an excess of AgNO_3 , 3 mol of AgCl are obtained. The formula of the complex is :

A.



B.



C.



D.



Answer

Correct option: D

Solution

Option (iv) is the answer.

Question 5

The correct IUPAC name of $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ is

A.

Diamminedichloridoplatinum (II)

B.

Diamminedichloridoplatinum (IV)

C.

Diamminedichloridoplatinum (0)

D.

Dichloridodiammineplatinum (IV)

Answer

Correct option: A

Solution

Option (i) is the answer.

Question 6

The stabilisation of coordination compounds due to chelation is called the chelate effect. Which of the following is the most stable complex species?

A.



B.



C.



D.



Answer

Correct option: C

Solution

Option (iii) is the answer.

Question 7

Indicate the complex ion which shows geometrical isomerism.

A.



B.



C.



D.



Answer

Correct option: A

Solution

Option (i) is the answer.

Question 8

The CFSE for octahedral $[\text{CoCl}_6]^{4-}$ is $18,000 \text{ cm}^{-1}$. The CFSE for tetrahedral $[\text{CoCl}_4]^{2-}$ will be

A.

$$18,000 \text{ cm}^{-1}$$

B.

$$16,000 \text{ cm}^{-1}$$

C.

$$8,000 \text{ cm}^{-1}$$

D.

$$20,000 \text{ cm}^{-1}$$

Answer

Correct option: C

Solution

Option (iii) is the answer.

Question 9

Due to the presence of ambidentate ligands coordination compounds show isomerism. Palladium complexes of the type $[\text{Pd}(\text{C}_6\text{H}_5)_2(\text{SCN})_2]$ and $[\text{Pd}(\text{C}_6\text{H}_5)_2(\text{NCS})_2]$ are

A.

linkage isomers

B.

coordination isomers

C.

ionisation isomers

D.

geometrical isomers

Answer

Correct option: A

Solution

Option (i) is the answer.

Question 10

The compounds $[\text{Co}(\text{SO}_4)(\text{NH}_3)_5]\text{Br}$ and $[\text{Co}(\text{SO}_4)(\text{NH}_3)_5]\text{Cl}$ represent

A.

linkage isomerism

B.

ionisation isomerism

C.

coordination isomerism

D.

no isomerism

Answer

Correct option: D

Solution

Option (iv) is the answer.

Question 11

A chelating agent has two or more than two donor atoms to bind to a single metal ion. Which of the following is not a chelating agent?

A.

thiosulphate

B.

oxalate

C.

glycinato

D.

ethane-1,2-diamine

Answer

Correct option: A

Solution

Option (i) is the answer.

Question 12

Which of the following species is not expected to be a ligand?

A.

NO

B.

NH₄⁺

C.

NH₂CH₂CH₂NH₂

D.

CO

Answer

Correct option: B

Solution

Option (ii) is the answer.

Question 13

What kind of isomerism exists between [Cr(H₂O)₆]Cl₃ (violet) and [Cr(H₂O)₅Cl]Cl₂·H₂O (greyish-green)?

A.

linkage isomerism

B.

solvate isomerism

C.

ionisation isomerism

D.

coordination isomerism

Answer

Correct option: B

Solution

Option (ii) is the answer.

Question 14

IUPAC name of $[\text{Pt}(\text{NH}_3)_2\text{Cl}(\text{NO}_2)]$ is :

- A. Platinum diaminechloronitrite
- B. Chloronitrito-N-ammineplatinum (II)
- C. Diamminechloridonitrito-N-platinum (II)
- D. Diamminechloronitrito-N-platinate (II)

Solution

Option (iii) is the answer.

II. Multiple Choice Questions (Type-II)

Question 15

The atomic number of Mn, Fe and Co are 25, 26 and 27 respectively. Which of the following inner orbital octahedral complexions are diamagnetic?

- (i) $[\text{Co}(\text{NH}_3)_6]^{3+}$
- (ii) $[\text{Mn}(\text{CN})_6]^{3-}$
- (iii) $[\text{Fe}(\text{CN})_6]^{4-}$

(iv) $[\text{Fe}(\text{CN})_6]^{3-}$

Solution

Option (i) and (iii) are the answers.

Question 16

The atomic number of Mn, Fe, Co and Ni are 25, 26, 27 and 28 respectively.

Which of the following outer orbital octahedral complexes have the same number of unpaired electrons?

(i) $[\text{MnCl}_6]^{3-}$

(ii) $[\text{FeF}_6]^{3-}$

(iii) $[\text{CoF}_6]^{3-}$

(iv) $[\text{Ni}(\text{NH}_3)_6]^{2+}$

Solution

Option (i) and (iii) is the answer.

Question 17

Which of the following options are correct for $[\text{Fe}(\text{CN})_6]^{3-}$ complex?

(i) d^2sp^3 hybridisation

(ii) sp^3d^2 hybridisation

(iii) paramagnetic

(iv) diamagnetic

Solution;

Option (i) and (iii) are the answers.

Solution

Solution coming soon.

Question 18

An aqueous pink solution of cobalt(II) chloride changes to deep blue on the addition of an excess of HCl. This is because_____.

- (i) $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ is transformed into $[\text{CoCl}_6]^{4-}$
- (ii) $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ is transformed into $[\text{CoCl}_4]^{2-}$
- (iii) tetrahedral complexes have smaller crystal field splitting than octahedral complexes.
- (iv) tetrahedral complexes have larger crystal field splitting than octahedral complex.

Solution

Option (ii) and (iii) are the answers.

Question 19

Which of the following complexes is homoleptic?

- (i) $[\text{Co}(\text{NH}_3)_6]^{3+}$
- (ii) $[\text{Co}(\text{NH}_3)_4 \text{Cl}_2]^+$
- (iii) $[\text{Ni}(\text{CN})_4]^{2-}$
- (iv) $[\text{Ni}(\text{NH}_3)_4 \text{Cl}_2]$

Solution

Option (i) and (iii) are the answers.

Question 20

Which of the following complexes are heteroleptic?

- (i) $[\text{Cr}(\text{NH}_3)_6]^{3+}$
- (ii) $[\text{Fe}(\text{NH}_3)_4 \text{Cl}_2]^+$
- (iii) $[\text{Mn}(\text{CN})_6]^{4-}$
- (iv) $[\text{Co}(\text{NH}_3)_4 \text{Cl}_2]$

Solution

Option (ii) and (iv) are the answers.

Question 21

Identify the optically active compounds from the following :

- (i) $[\text{Co}(\text{en})_3]^{3+}$
- (ii) $\text{trans-} [\text{Co}(\text{en})_2 \text{Cl}_2]^+$
- (iii) $\text{cis-} [\text{Co}(\text{en})_2 \text{Cl}_2]^+$
- (iv) $[\text{Cr}(\text{NH}_3)_5\text{Cl}]$

Solution

Option (i) and (iii) are the answers.

Question 22

Identify the correct statements for the behaviour of ethane-1, 2-diamine as a ligand.

- (i) It is a neutral ligand.
- (ii) It is a didentate ligand.
- (iii) It is a chelating ligand.
- (iv) It is a unidentate ligand.

Solution

Option (i), (ii) and (iii) are the answers.

Question 23

Which of the following complexes show linkage isomerism?

- (i) $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]^{2+}$
- (ii) $[\text{Co}(\text{H}_2\text{O})_5\text{CO}]^{3+}$
- (iii) $[\text{Cr}(\text{NH}_3)_5\text{SCN}]^{2+}$
- (iv) $[\text{Fe}(\text{en})_2 \text{Cl}_2]^+$

Solution

Option (i) and (iii) are the answers.

III. Short Answer Type

Question 24

Arrange the following complexes in the increasing order of conductivity of their solution:

$[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$, $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$, $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$, $[\text{Cr}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$

Solution

The increasing order of conductivity is as follows:

Question 25

A coordination compound $\text{CrCl}_3 \cdot 4\text{H}_2\text{O}$ precipitates silver chloride when treated with silver nitrate. The molar conductance of its solution corresponds to a total of two ions. Write the structural formula of the compound and name it.

Solution

If it forms silver chloride then there is one free chlorine atom outside the coordination sphere. The structural formula has to be $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl}$. The name of this complex is tetraaquadichlorido chromium(III) chloride.

Question 26

A complex of the type $[\text{M}(\text{AA})_2\text{X}_2]^{n+}$ is known to be optically active. What does this indicate about the structure of the complex? Give one example of such complex.

Solution

The structure has to be cis-octahedral.

Example for such a complex is $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ which is optically active.

Question 27

The magnetic moment of $[\text{MnCl}_4]^{2-}$ is 5.92 BM. Explain giving a reason.

Solution

A magnetic moment of 5.92 BM means there are 5 unpaired electrons because

$$\text{Magnetic Moment} = \sqrt{n(n+2)}$$

The geometry tetrahedral with 5 unpaired electrons giving a magnetic moment of 5.92 BM as the four ligands are attached to Mn^{2+} .

Question 28

Based on crystal field theory explain why Co(III) forms a paramagnetic octahedral complex with weak field ligands whereas it forms a diamagnetic octahedral complex with strong field ligands.

Solution

The electronic configuration will be $t_{2g}^4 e_g^2$. It has 4 unpaired electron and paramagnetic. With weak ligand $\Delta_0 < p$. The configuration with strong field ligand will be $t_{2g}^6 e_g^0$, the $\Delta_0 > p$ and there won't be any unpaired electron therefore diamagnetic.

Question 29

Why are low spin tetrahedral complexes not formed?

Solution

For tetrahedral complexes, the crystal field splitting energy is too low. It is lower than pairing energy so, the pairing of electrons is not favoured and therefore the complexes cannot form low spin complexes.

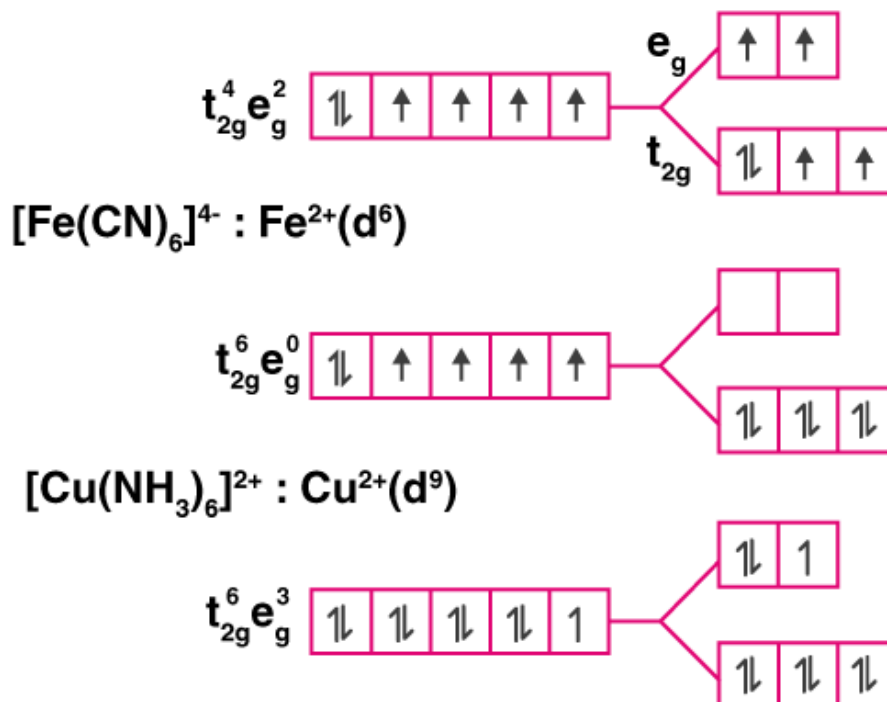
Question 30

Give the electronic configuration of the following complexes based on

Crystal Field Splitting theory.

$[\text{CoF}_6]^{3-}$, $[\text{Fe(CN)}_6]^{4-}$ and $[\text{Cu(NH}_3)_6]^{2+}$.

Solution



Question 31

Explain why [Fe(H₂O)₆]³⁺ has a magnetic moment value of 5.92 BM whereas

[Fe(CN)₆]³⁻ has a value of only 1.74 BM.

Solution

For [Fe(H₂O)₆]³⁺, H₂O is a weak field ligand won't cause pairing of electrons. So, the number of unpaired electrons will be 5.

Question 32

Arrange following complex ions in increasing order of crystal field splitting energy (DO) :

[Cr(Cl)₆]³⁻, [Cr(CN)₆]³⁻, [Cr(NH₃)₆]³⁺.

Solution

The increasing order of crystal field energy is

This is also the order of field strength of the ligands according to the spectrochemical series.

Question 33

Why do compounds having similar geometry have a different magnetic moment?

Solution

They differ in the number of paired and unpaired electrons. A strong field ligand will cause pairing of electrons while a weak field ligand will not cause pairing. Pairing or not pairing will change the number of unpaired electrons, which affects the magnetic moment.

Question 34

$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ is blue while CuSO_4 is colourless. Why?

Solution

In $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, there are water molecules that act as ligands. The electrons will excite to higher d orbital and show colour. Whereas, in CuSO_4 , there are no water molecules to act as ligands, so no crystal field splitting happens.

Question 35

Name the type of isomerism when ambidentate ligands are attached to a central metal ion. Give two examples of ambidentate ligands.

Solution

Ambidentate ligands are those having different two binding sites.

Examples: Isothiocyanato Thiocyanato and Nitrite-N Nitrito-O

The type of isomerism when ambidentate ligands are attached to a central metal ion is called linkage isomerism because they only differ in the atom that is linked to the central metal ion.

V. Matching Type

Note: In the following questions match the items given in Columns I and II.

Question 36

Match the complex ions given in Column I with the colours given in Column II

and assign the correct code :

Column I (Complex ion)	Column II (Colour)
A. $[\text{Co}(\text{NH}_3)_6]^{3+}$	1. Violet
B. $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$	2. Green
C. $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$	3. Pale blue
D. $(\text{Ni}(\text{H}_2\text{O})_4(\text{en}))^{2+}(\text{aq})$	4. Yellowish orange
	5. Blue

Code :

(i) A (1) B (2) C (4) D (5)

(ii) A (4) B (3) C (2) D (1)

(iii) A (3) B (2) C (4) D (1)

(iv) A (4) B (1) C (2) D (3)

Solution

Option (ii) is the answer.

Question 37

Match the coordination compounds given in Column I with the central metal atoms given in Column II

and assign the correct code :

Column I (Coordination Compound)	Column II (Central metal atom)
A. Chlorophyll	1. rhodium
B. Blood pigment	2. cobalt
C. Wilkinson catalyst	3. calcium
D. Vitamin B12	4. iron
	5. magnesium

Code :

(i) A (5) B (4) C (1) D (2)

(ii) A (3) B (4) C (5) D (1)

(iii) A (4) B (3) C (2) D (1)

(iv) A (3) B (4) C (1) D (2)

Solution

Option (i) is the answer.

Question 38

Match the complex ions given in Column I with the hybridisation and number of unpaired electrons given in Column II and assign the correct code :

Column I (Complex ion)	Column II (Hybridisation, number of unpaired electrons)
A. $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$	1. dsp^2 , 1
B. $[\text{Co}(\text{CN})_4]^{2-}$	2. sp^3d^2 , 5
C. $[\text{Ni}(\text{NH}_3)_6]^{2+}$	3. d^2sp^3 , 3
D. $[\text{MnF}_6]^{4-}$	4. sp^3 , 4
	5. sp^3d^2 , 2

Code :

(i) A (3) B (1) C (5) D (2)

(ii) A (4) B (3) C (2) D (1)

(iii) A (3) B (2) C (4) D (1)

(iv) A (4) B (1) C (2) D (3)

Solution

Option (i) is the answer

Question 39

Match the complex species given in Column I with the possible isomerism given in Column II and assign the correct code :

Column I (Complex species)	Column II (Isomerism)
A. $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$	1. Optical
B. $\text{cis-}[\text{Co}(\text{en})_2\text{Cl}_2]^+$	2. Ionisation
C. $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]\text{Cl}_2$	3. Coordination
D. $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$	4. Geometrical
	5. Linkage

Code :

(i) A (1) B (2) C (4) D (5)

(ii) A (4) B (3) C (2) D (1)

(iii) A (4) B (1) C (5) D (3)

(iv) A (4) B (1) C (2) D (3)

Solution

Option (iv) is the answer

Question 40

Match the compounds given in Column I with the oxidation state of cobalt present in it (given in Column II) and assign the correct code.

Column I (Compound)	Column II (Oxidation state of Co)
A. $[\text{Co}(\text{NCS})(\text{NH}_3)_5](\text{SO}_3)$	1. +4
B. $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{SO}_4$	2. 0
C. $\text{Na}_4[\text{Co}(\text{S}_2\text{O}_3)_3]$	3. +1
D. $[\text{Co}_2(\text{CO})_8]$	4. +2
	5. +3

Code :

(i) A (1) B (2) C (4) D (5)

(ii) A (4) B (3) C (2) D (1)

(iii) A (5) B (1) C (4) D (2)

(iv) A (4) B (1) C (2) D (3)

Solution

Option (ii) is the answer.

V. Assertion and Reason Type

Note: In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(i) Assertion and reason both are true, the reason is the correct explanation of assertion.

(ii) Assertion and reason both are true but the reason is not the correct explanation of assertion.

(iii) An assertion is true, the reason is false.

(iv) The assertion is false, the reason is true.

Question 41

Assertion: Toxic metal ions are removed by the chelating ligands.

Reason: Chelate complexes tend to be more stable.

Solution

Option (i) is correct.

Question 42

Assertion : $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_2$ and $[\text{Fe}(\text{H}_2\text{O})_6]\text{Cl}_2$ are reducing in nature.

Reason: Unpaired electrons are present in their d-orbitals.

Solution

Option (ii) is correct.

Question 43

Assertion: Linkage isomerism arises in coordination compounds containing ambidentate ligand.

Reason: Ambidentate ligand has two different donor atoms.

Solution

Option (i) is correct

Question 44

Assertion: Complexes of MX_6 and MX_5L type (X and L are unidentate) do not show geometrical isomerism.

Reason: Geometrical isomerism is not shown by complexes of coordination number 6.

Solution

Option (iii) is correct.

Question 45

Assertion : $[\text{Fe}(\text{CN})_6]^{3-}$ ion shows magnetic moment corresponding to two unpaired electrons.

Reason: Because it has d^2sp^3 type hybridisation.

Solution

Option (iv) is correct.

Class 12 Chemistry NCERT Exemplar Problems for Coordination Compounds

Coordination Compounds is one of the most interesting and easy chapters in the CBSE Class 12 Chemistry. In this chapter, students get to learn and understand the terms like central ion, atom, ligand, coordination sphere, coordination polyhedron and oxidation number. They will also learn the rules of the nomenclature of coordination compounds.

Important Concepts to Study in Chapter 9 Coordination Compounds

1. Werner's Theory of Coordination Compounds
2. Definitions of Some Important Terms Pertaining to Coordination Compounds
3. Nomenclature of Coordination Compounds
4. Isomerism in Coordination Compounds
5. Bonding in Coordination Compounds
6. Bonding in Metal Carbonyls
7. Stability of Coordination Compounds
8. Importance and Applications of Coordination Compounds.

To help students score good marks in exams, we have provided the NCERT Exemplar Class 12 Chemistry Chapter 9 Coordination Compounds.
