1. Given below are two statements, one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: The spin only magnetic moment value for $[Fe(CN)_6]^{3-}$ is 1.74 BM, whereas for [Fe(H2O)6]$\left[Fe\left(H_2O\right)_6\right]^{3+}$ is 5.92 BM.

Reason B: In both complexes, Fe is present in $+3$ oxidation state.

In the light of the above statements, choose the correct answer from the options given below:

[2023 (06 Apr Shift 1)]

(1) A is false but R is true
(2) A is true but R is false
(3) Both A and R are true but R is NOT the correct explanation of A
(4) Both A and R are true andR is the correct explanation of A

2. Number of ambidentate ligands in a representative metal complex $[M(en)(SCN)_4]$ is _________. [en =ethylenediamine]

[2023 (06 Apr Shift 1)]

3. The IUPAC name of $K_3[Co(C_2O_4)_3]$ is:

[2023 (06 Apr Shift 2)]

(1) Potassium tris(oxalato)cobaltate(III)
(2) Potassium tris(oxalato)cobalt(III)
(3) Potassium trioxalatocobalt(III)
(4) Potassium trioxalatocobaltate(III)

4. Given below are two statements: one is labelled as "Assertion A" and the other is labelled as "Reason R"

Assertion A : In the complex $Ni(CO)_4$ and $Fe(CO)_5$, the metals have zero oxidation state.

Reason R : Low oxidation states are found when a complex has ligands capable of π-donor character in addition to the σ-bonding.

In the light of the above statements, choose the most appropriate answer from the options given below

[2023 (06 Apr Shift 2)]

(1) A is correct but R is not correct
(2) A is not correct but R is correct
(3) Both A and R are correct but R is NOT the correct explanation of A
(4) Both A and R are correct and R is the correct explanation of A

5. Element not present in Nessler's reagent is

[2023 (06 Apr Shift 2)]

(1) N
(2) Hg
(3) I
(4) K

6. Which of the following complex is octahedral, diamagnetic and the most stable?

[2023 (08 Apr Shift 1)]

(1) $Na_3[CoCl_6]$
(2) $\left[Ni\left(NH_3\right)_6\right]Cl_2$
(3) $K_3[Co(CN)_6]$
(4) $\left[Co\left(H_2O\right)_6\right]Cl_2$

7. The correct order of spin only magnetic moments for the following complex ions is

[2023 (08 Apr Shift 1)]

(1) $[Fe(CN)_6]^{3-} < [CoF_6]^{3-} < [MnBr_4]^{2-} < [Mn(CN)_6]^{3-}$
(2) $[CoF_6]^{3-} < [MnBr_4]^{2-} < [Fe(CN)_6]^{3-} < [Mn(CN)_6]^{3-}$
(3) $[Fe(CN)_6]^{3-} < [Mn(CN)_6]^{3-} < [CoF_6]^{3-} < [MnBr_4]^{2-}$
(4) $[MnBr_4]^{2-} < [CoF_6]^{3-} < [Fe(CN)_6]^{3-} < [Mn(CN)_6]^{3-}$

8. Match List-I with List-II

	LIST-I Coordination Complex		LIST-II Number of unpaired electrons
A.	$[Cr(CN)_6]^{3-}$	I.	0
B.	$[Fe(H_2O)_6]^{2+}$	II.	3
C.	$[Co(NH_3)_6]^{3+}$	III.	2
D.	$[Ni(NH_3)_6]^{2+}$	IV.	4

Choose the correct answer from the options given below:

[2023 (08 Apr Shift 2)]

(1) A-II, B-IV, C-I, D-III
(2) A-III, B-IV, C-I, D-II
(3) A-II, B-I, C-IV, D-III
(4) A-IV, B-III, C-II, D-I

9. The observed magnetic moment of the complex $[Mn(NCS)_6)]^{x-}$ is 6.06 BM. The numerical value of x is

[2023 (08 Apr Shift 2)]

10. The sum of oxidation state of the metals in $Fe(CO)_5$, VO^{2+} and WO_3 is

[2023 (08 Apr Shift 2)]

11. The octahedral diamagnetic low spin complex among the following is

[2023 (10 Apr Shift 1)]

(1) $[Co(NH_3)_6]^{3+}$
(2) $[CoF_6]^{3-}$
(3) $[CoCl_6]^{3-}$
(4) $[NiCl_4]^2$

12. In potassium ferrocyanide, there are ______ pairs of electrons in the t_{2g} set of orbitals.

[2023 (10 Apr Shift 1)]

13. Match List-I with List-II.

List-I Complex		List-II Crystal Field splitting energy (Δ_0)	
A.	$[Ti(H_2O)_6]^{2+}$	I.	–1.2
B.	$[V(H_2O)_6]^{2+}$	II.	–0.6
C.	$[Mn(H_2O)_6]^{3+}$	III.	0
D.	$[Fe(H_2O)_6]^{3+}$	IV.	–0.8

Choose the correct answer from the options given below:

[2023 (10 Apr Shift 2)]

(1) A-II, B-IV, C-I, D-III
(2) A-IV, B-I, C-III, D-II
(3) A-IV, B-I, C-II, D-III
(4) A-II, B-IV, C-III, D-I

14. The correct order of the number of unpaired electrons in the given complexes is

(A) $[Fe(CN)_6]^{3-}$

(B) $[FeF_6]^{3-}$

(C) $[CoF_6]^{3-}$

(D) $[Cr(\text{ oxalate })_3]^{3-}$

(E) $[Ni(CO)_4]$

Choose the correct answer from the options given below:

[2023 (10 Apr Shift 2)]

(1) E < A < D < C < B

(2) E < A < B < D < C

(3) A < E, C < B < D

(4) A < E < D < C < B

15. The complex that dissolves in water is

[2023 (11 Apr Shift 1)]

(1) $(NH_4)_3[As(Mo_3O_{10})_4]$

(2) $Fe_4[Fe(CN)_6]_3$

(3) $K_3[Co(NO_2)_6]$

(4) $[Fe_3(OH)_2(OAc)_6]Cl$

16. The set which does not have ambidentate ligand(s) is

[2023 (11 Apr Shift 1)]

(1) $C_2O_4^{2-}$, ethylene diammine, H_2O

(2) $EDTA^{4-}, NCS^-, C_2O_4^{2-}$

(3) $NO_2^-, C_2O_4^{2-}, EDTA^{4-}$

(4) $C_2O_4^{2-}, NO_2^-, NCS^-$

17. Which of the following complex has a possibility to exist as meridional isomer?

[2023 (11 Apr Shift 1)]

(1) $[Co(NH_3)_3(NO_2)_3]$

(2) $[Pt(NH_3)_2Cl_2]$

(3) $[Co(en)_2Cl_2]$

(4) $[Co(en)_3]$

18. The ratio of spin-only magnetic moment values $\mu_{eff}[Cr(CN)_6]^{3-}/\mu_{eff}[Cr(H_2O)6]^{3+}$ is _______

[2023 (11 Apr Shift 1)]

19. If Ni^{2+} is replaced by Pt^{2+} in the complex $[NiCl_2Br_2]^{2-}$, which of the following properties are expected to get changed?

A. Geometry

B. Geometrical isomerism

C. Optical isomerism

D. Magnetic properties

[2023 (11 Apr Shift 2)]

(1) A and D

(2) A, B and C

(3) B and C

(4) A, B and D

20. Match List I with List II

LIST-I Complex		LIST-II Colour	
A.	$Mg(NH_4)PO_4$	I.	brown
B.	$K_3[Co(NO_2)_6]$	II.	white
C.	$MnO(OH)_2$	III.	yellow
D.	$Fe_4[Fe(CN)_6]_3$	IV.	blue

Choose the correct answer from the options given below:

[2023 (11 Apr Shift 2)]

(1) A-III, B-IV, C-II, D-I
(2) A-II, B-III, C-I, D-IV
(3) A-II, B-IV, C-I, D-III
(4) A-II, B-III, C-IV, D-I

21. Given below are two statements, one is labelled as assertion **A** and the other is labelled as Reason **R**.

assertion **A** : $[CoCl(NH_3)_5]^{2+}$ absorbs at lower wavelength of light with respect to $[Co(NH_3)_5(H_2O)]^{3+}$

Reason **R**: It is because the wavelenght of light absorbed depends on the oxidation state of the metal ion.

In the light of the above statements,choose the correct answer from the options given below:

[2023 (11 Apr Shift 2)]

(1) **A** is false but **R** is true
(2) **A** is true but **R** is false
(3) Both **A** and **R** are true and **R** is the correct explaination of **A**
(4) Both **A** and **R** are true and **R** is NOT the correct explaination of **A**

22. The magnetic moment is measured in Bohr Magneton (BM). Spin only magnetic moment of Fe in $[Fe(H_2O)_6]^{3+}$ and $[Fe(CN)_6]^{3-}$ complexes respectively is:

[2023 (11 Apr Shift 2)]

(1) 6.92 B. M. in both
(2) 3.87 B. M. and 1.732 B. M.
(3) 5.92 B. M. and 1.732 B. M.
(4) 4.89 B. M. and 6.92 B. M.

23. Match List I with List II

	List I Complex		List II $CFSE\ (\Delta_0)$
A.	$[Cu(NH_3)_6]^{2+}$	I.	-0.6
B.	$[Ti(H_2O)_6]^{3+}$	II.	-2.0
C.	$[Fe(CN)_6]^{3-}$	III.	-1.2
D.	$[NiF_6]^{4-}$	IV.	-0.4

Choose the correct answer from the options given below:

[2023 (12 Apr Shift 1)]

(1) A(III), B(IV), C(I), D(II)
(2) A(I), B(IV), C(II), D(III)
(3) A(I), B(II), C(IV), D(III)
(4) A(II), B(III), C(I), D(IV)

24. The mismatched combinations are

A. Chlorophyll– Co

B. Water hardness– EDTA

C. Photography–$[Ag(CN)_2]^-$

D. Wilkinson catalyst–$[(Ph_3P)_3RhCl]$

E. Chelating ligand– D–Penicillamine

Choose the correct answer from the options given below.

[2023 (13 Apr Shift 1)]

(1) A, C and E only
(2) A and C only
(3) A and E only
(4) D and E only

25. The covalency and oxidation state respectively of boron in $[BF_4]^-$, are

[2023 (13 Apr Shift 2)]

(1) 3 and 5
(2) 3 and 4
(3) 4 and 4
(4) 4 and 3

26. Which of the following complexes will exhibit maximum attraction to an applied magnetic field?

[2023 (13 Apr Shift 2)]

(1) $[Ni(H_2O)_6]^{2+}$
(2) $[Co(en)_3]^{3+}$
(3) $[Zn(H_2O)_6]^{2+}$
(4) $[Co(H_2O)_6]^{2+}$

27. The total number of stereoisomers for the complex $[Cr(ox)_2ClBr]^{3-}$ (where ox = oxalate) is

[2023 (13 Apr Shift 2)]

(1) 3
(2) 2
(3) 4
(4) 1

28. The complex with highest magnitude of crystal field splitting energy (Δ_0) is

[2023 (15 Apr Shift 1)]

(1) $[Ti(OH_2)6]^{3+}$
(2) $[Cr(OH_2)_6]^{3+}$
(3) $[Mn(OH_2)_6]^{3+}$
(4) $[Fe(OH_2)_6]^{3+}$

29. The volume (in mL) of 0.1 M $AgNO_3$ required for complete precipitation of chloride ions present in 20 mL of 0.01 M solution of $[Cr(H_2O)_5Cl]Cl_2$ as silver chloride is_______

[2023 (15 Apr Shift 1)]

30. The homoleptic and octahedral complex of Co^{2+} and H_2O has ______ unpaired electron(s) in the t_{2g} set of orbitals.

[2023 (15 Apr Shift 1)]

ANSWER KEYS

1. (3)	**2.** (4)	**3.** (4)	**4.** (1)	**5.** (1)	**6.** (3)	**7.** (3)	**8.** (1)
9. (4)	**10.** (10)	**11.** (1)	**12.** (3)	**13.** (3)	**14.** (1)	**15.** (4)	**16.** (1)
17. (1)	**18.** (1)	**19.** (4)	**20.** (2)	**21.** (1)	**22.** (3)	**23.** (2)	**24.** (2)
25. (4)	**26.** (4)	**27.** (1)	**28.** (2)	**29.** (4)	**30.** (1)		

1. (3)

$\left[Fe(H_2O)_6\right]^{3+}$ has magnetic moment value of 5.92 BM because H_2O is a weak ligand and pairing will not occur. It involves sp^3d^2 hybridisation with five unpaired electrons (because magnetic moment is equal to 5.92 BM) and outer orbital complex is formed. Magnetic moment can be calculated by the formula $\mu_m = \sqrt{n(n+2)}$ BM where, μ_m =magnetic moment, n =number of unpaired electron(s).

$\mu_m = 1.74$ BM, $n = 1$

$\mu_m = 5.92$ BM, $n = 5$

In $\left[Fe(CN)_6\right]^{3-}$ complex CN^- is stronger ligand than H_2O according to spectrochemical series. Hence, four electrons will pair itself. It involves d^2sp^3 hybridisation with one unpaired electron and inner orbital complex is formed and has a value of only 1.74 BM.

In Bothe the complexes the oxidation state of iron is +3.

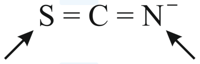
2. (4)

Ambidentate ligand has two or more donor atoms, but during complex formation, only one donor atom is attached to central metal. SCN^- ion has donor atoms N and S.

Examples of ambidentate ligands include NO_2^- and SO_3^{2-}. So,4 SCN^- ligands are ambidentate.

$[M(en)(SCN)_4]$

$S = C = N^-$



3. (4)

Ligands that include a numerical prefix in the name use the prefixes bis for 2, tris for 3, or tetrakis for 4 to indicate their number.

If the complex ion is an anion, we drop the ending of the metal name and add –ate.

In the given coordination compound, Co is the cobalt metal, $C_2O_4^{2-}$ are the ligands named as oxalato.

The charge on $[Co(C_2O_4)_3]$ is -3 and oxalate is having charge of -2.

$X + 3(-2) = -3$

$X = +3$

Hence, the IUPAC name of the compound $K_3[Co(C_2O_4)_3]$ is Potassium trioxalatocobaltate(III).

4. (1)

The ligand carbon monoxide has no charge, hence metals have zero oxidation state in both $Ni(CO)_4$ and $Fe(CO)_5$. Low oxidation states are found when a complex has ligands capable of π-acceptor character in addition to the σ-bonding.

In the complexes, $Ni(CO)_4$ & $Fe(CO)_5$, the ligand CO is $\pi-$acceptor character in addition to the $\sigma -$ bonding.

5. (1)

Nessler's reagent is an aqueous solution of potassium iodide, mercuric chloride, and potassium hydroxide. Its chemical formula is K_2HgI_4. It is used to detect the presence of ammonia. It turns into pale brown colour in presence of ammonia.

So, N is not present in Nessler's reagent.

6. (3)

The coordination compound $K_3[Co(CN)_6]$contains a cobalt(III) ion, which has a d^6 electronic configuration. The cyanide ligands in this complex are indeed strong field ligands, which means they will cause a large splitting of the d orbitals. So here cobalt is in $+3$ state having $3d^6$ configuration and also cyanide ligand which is a strong field ligand so, it is most stable and will have octahedral shape. The given compounds have the following nature:

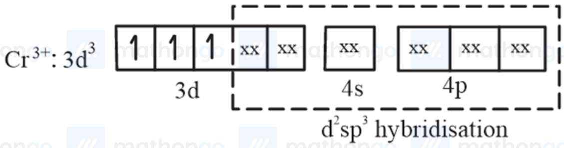
(1) $Na_3[CoCl_6]$ – Paramagnetic
(2) $[Ni(NH_3)_6]Cl_2$ – Paramagnetic
(3) $K_3[Co(CN)_6]$– Diamagnetic
(4) $[Co(H_2O)_6]Cl_2$ – Paramagnetic

7. (3)

$[MnBr_4]^{2-}$ is a tetrahedral complex. The electronic configuration Mn^{2+}ise^{2}t$_2^3$ and it has 5 unpaired electrons.
$\therefore \mu=\sqrt{5(5+2)}=\sqrt{35}$ B. M.
$[CoF_6]^{3-}$ is an octahedral complex and it is high spin complex. The electronic configuration of Co^{3+} is $t_{2g}^4 e_g{}^2$, it has 4 unpaired electrons
$\therefore \mu=\sqrt{4(4+2)}=\sqrt{24}$ B.M.
$[Mn(CN)_6]^{3-}$ is an octahedral complex and it is low spin complex. The electronic configuration Mn^{3+} is $t_{2g}^4 e_g^0$ it has two unpaired electrons
$\therefore \mu=\sqrt{2(2+2)}=\sqrt{8}$ B.M
$[Fe(CN)_6]^{3-}$ is an octahedral complex and it is low spin complex. The electronic configuration of Fe^{3+} is t_{2g}^5 eg^0 and it has one unpaired electron.
$\therefore \mu=\sqrt{1(1+2)}=2\sqrt{3}$ B.M
Hence the correct answer is option 3

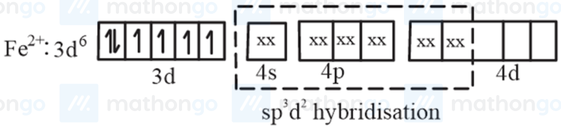
8. (1)

$[Cr(CN)_6]^{3-}$ ion, oxidation state of Cr is +3 and its valence shell electronic configuration is $3d^3$. There are 3 unpaired electrons in 3d orbital.
(A). $[Cr(CN)_6]^{3-}$

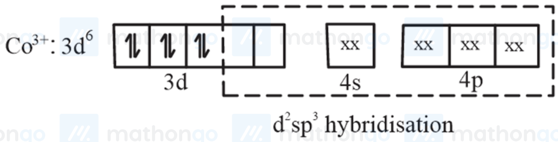


No. of unpaired electrons = 3

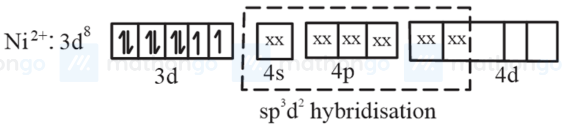
$[Fe(H_2O)_6]^{2+}$ ion, oxidation state of Fe is +2 and its valence shell electronic configuration is $3d^6$. There are 4 unpaired electrons in 3d orbital. So, you can say the hybridisation here would be $sp^3 d^2$.
(B). $[Fe(H_2O)_6]^{2+}$



No. of unpaired electrons = 4
$[Co(NH_3)_6]^{3+}$ in this oxidation state of central metal atom is +3 and it has no unpaired electrons.
(C). $[Co(NH_3)_6]^{3+}$



No. of unpaired electrons = 0
$[Ni(NH_3)_6]^{2+}$ the oxidation state of Ni is Ni^{2+} and it has two unpaired electrons.
(D) $[Ni(NH_3)_6]^{2+}$



No. of unpaired electrons = 2
So the correct option among the given is A.

9. (4)

The complex $[Mn(NCS)_6)]^{x-}$ has a magnetic moment of 6.06 BM. This indicates that the complex has unpaired electrons, which contribute to its magnetic moment.
Number of unpaired electrons $= 5\left(Mn^{2+} \; : \; 3d^5\right)$.

So Mn must be in +2 oxidation state Mn^{2+}.
$\Rightarrow 2 + (-6) = -x$
$\Rightarrow -4 = -x$
$\Rightarrow x = 4$

The numerical value of x is 4, so the complex is $[Mn(NCS)_6)]^{4-}$.

10. (10)

In the complex $Fe(CO)_5$, take the oxidation number of Fe be x . Carbonyl is a neutral ligand which doesn't have any charge. So the oxidation number of Fe would be

$x - 0 \times 5 = 0 = 0$

Hence, the oxidation number of iron in this complex is 0.

let oxidation state of vanadium in $VO^{2+} = x$.

so,

$x + (-2) = +2$

$\Rightarrow x = +2 + 2 = +4$

Tungsten trioxide consists of one tungsten atom and three oxygen atoms. Tungsten is a d−block metal from group 6 and has an oxidation state +6 in the compound.

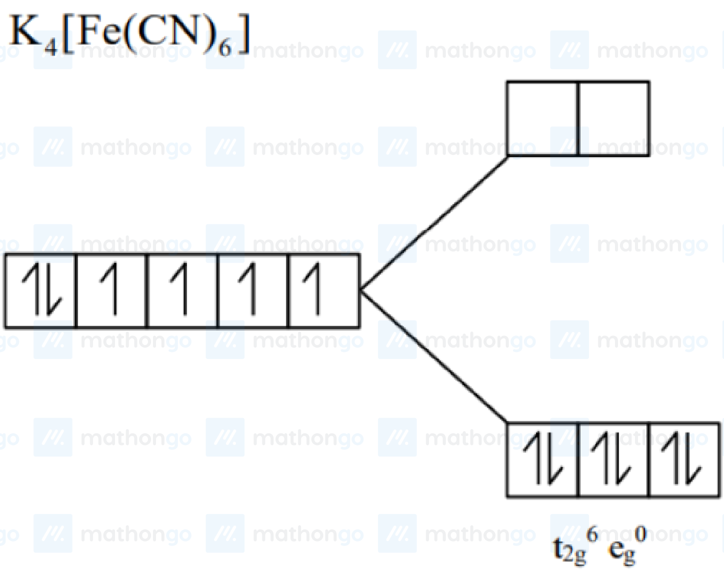
Then, Sum of oxidation state of metals in the given compounds = 10

11. (1)

In case of strong field ligand containing complexes, electrons get pair up against the Hund's rule to get required number of hybrid orbitals. Among the given complexes' ammonia is a strong-filed ligand and other ligands are weak filed ligands. $[Co(NH_3)_6]^{3+}$ has d^2sp^3 (inner orbital complex) with zero unpaired electrons. Hence, it is octahedral with diamagnetic character and low spin complex. $[CoF_6]^{3-}$ and $[CoCl_6]^{3-}$ are octahedral but having unpaired electrons. $[NiCl_4]^{2-}$ is not octahedral.

12. (3)

Potassium ferrocyanide, $K_4[Fe(CN)_6]$, has a central iron ion that is coordinated with six cyanide ligands in an octahedral geometry. The oxidation state of the iron ion in potassium ferrocyanide is +2, hence has d^2sp^3 hybridised state. On applying C. F. T. it shows that all the 6 electrons of d subshell are present in the form of three pairs in t_{2g} orbitals. Hence answer is 3.



13. (3)

d-orbital is degenerate which split into two levels e_g and t_2g in the presence of ligands. This splitting is due to the presence of ligands. This is called the crystal-field splitting and the energy difference between the two levels is called the crystal-field splitting energy, Δ0.

(A) Ti^{2+} : $4s^0 3d^2$
$t_{2g}\ e^- = 2$
$e_g\ e^- = 0$
$\Delta_0 = 2(-.4\Delta_0) = -.8\Delta_0$
(B) V^{2+} : $4s^0 3d^3$
$t_{2g}\ e^- = 3$
$e_g\ e^- = 0$
$\Delta_0 = 3(-.4\Delta_0)$
$= \ -1.2\Delta_0$
(C) $Mn^{3+} = 4s^0 3d^4$
$t_{2g}\ e^- = 3$
$e_g\ e^- = 1$
$\Delta_0 = 3(-.4\Delta_0) + 1(.6\Delta_0)$
$= -1.2\Delta_0 + 0.6\Delta_0$
$= \ -0.6\Delta_0$
(D) $Fe^{3+} = 4\ s^0 3d^5$
$t_{2g}\ e^- = 3$
$e_g\ e^- = 2$
$\Delta_0 = 3(-.4\Delta_0) + 2(.6\Delta_0)$
$= -1.2\Delta_0 + 1.2\Delta_0 = 0$

14. (1)

The number of unpaired electrons in coordination complexes is determined by the nature of the central metal ion, the coordination number, and the identity and arrangement of the ligands around the metal ion. Based on these factors, the correct order of the number of unpaired electrons in the given complexes is:

A	$[Fe(CN)_6]^{3-}$: $Fe^{3+}(3d^5)$ (Pairing of electrons takes place)	1
B	$[FeF_6]^{3-}$: $Fe^{3+}(3d^5)$	5
C	$[CoF_6]^{3-}$: $Co^{3+}(3d^6)$	4
D	$[Cr(\text{ oxalate })_3]^{3-}$: $Cr^{3+}(3d^3)$	3
E	$[Ni(CO)_4]$: $Ni(3d^{10})$ (Pairing of electrons takes place)	0

No. of unpaired electrons order: E < A < D < C < B

15. (4)

$[Fe_3(OH)_2(OAc)_6]Cl$ is a coordination complex containing iron ions coordinated with hydroxide and acetate ligands. When dissolved in water, this complex can undergo hydrolysis and dissociation.
So, $[Fe_3(OH)_2(OAc)_6]Cl$ dissolves in water. Rest of the complexes form precipitate.

16. (1)

Ligand which has two different donor atoms and either of the two donor atom is attached to the metal during complex formation is called ambidentate ligand.
Among the given ligands $NCS^-(SCN^-)$ and $NO_2^-(ONO^-)$ are ambidentate ligands
$C_2O_4^{2-}$ (bidentate),ethylenediamine(bidentate) and H_2O(monodentate) ligands are not ambidentate.

17. (1)

The type of the complex $[MA_3B_3]$ exhibit the geometrical isomerism fac-mer isomerism. When three ligands and the metal are in one plane, the isomer is said to be meridional, or mer.
$[Co(NH_3)_3(NO_2)_3]$ can show facial and meridional isomerism.

18. (1)

In case of Cr^{3+} ion , the valence shell electronic configuration is same whether the ligand is strong field or weak field.
The spin only magnetic moment , $\mu_{eff} = \sqrt{n(n+2)}$ BM
The valence shell electronic configuration of Cr^{3+} is $3d^3$, hence, it has three unpaired electrons.
μ_{eff} of $[Cr(CN)_6]^{-3} = \sqrt{15}$ B.M.
μ_{eff} of $[Cr(H_2O)]_6^{+3} = \sqrt{15}$ B.M.
Ratio = 1

19. (4)

When Ni^{2+} is replaced by Pt^{2+} in the complex $[NiCl_2Br_2]^{2-}$, the following properties are expected to be changed:

A. Geometry: Since Pt^{2+} and Ni^{2+} have different coordination preferences and atomic sizes, the replacement is likely to result in a change in the geometry of the complex. That is it changes to square planar.

B. Geometrical isomerism: If the replacement of Ni^{2+} with Pt^{2+} leads to a change in the ligand arrangement, it can result in the generation of cis and trans isomers.

C. Magnetic properties: $[PtCl_2Br_2]^{2-}$ is diamagnetic.

Both the complex species are optically inactive.

20. (2)

The formula $Mg(NH_4)PO_4$ represents magnesium ammonium phosphate it is white in colour. $K_3[Co(NO_2)_6]$ is known as potassium hexanitritocobaltate(III). It is yellow in colour. The yellow colour is due to the presence of the cobalt ion (Co3+) in the complex, which absorbs certain wavelengths of light and reflects yellow light. $MnO(OH)_2$is brown in colour. $Fe_4[Fe(CN)_6]_3$ is blue in colour.

Complex	Colour
$Mg(NH_4)PO_4$	White
$K_3[Co(NO_2)_6]$	Yellow
$MnO(OH)_2$	Brown
$Fe_4[Fe(CN)_6]_3$	Blue

21. (1) $[CoCl(NH_3)_5]^{2+}$absorbs with higher wavelength of light with respect to $[Co(NH_3)_5(H_2O)]^{3+}$ because Cl^- is weaker ligand than H_2O. The crystal field stabilisation is higher for $[Co(NH_3)_5(H_2O)]^{3+}$, hence we can say that wavelength of light absorbed depends upon the oxidation state of the metal ion.

22. (3)

The spin only magnetic moment can be calculated as follows

$\mu = \sqrt{n(n+2)}\ BM$

n =Number of unpaired electrons

$[Fe(H_2O)_6]^{3+} = d^5(\text{High spin complex}) = 5$.unpaired electrons

$\mu = \sqrt{5 \times 7} = \sqrt{35}$

$= 5.92$ B. M.

$[Fe(CN)_6]^{3+} = d^5(\text{Low spin complex}) = 1$

$\mu = \sqrt{1 \times 3} = \sqrt{3}$

$= 1.732$ B. M.

23. (2)

$CFSE = (-0.4\ nt_{2g} + 0.6\ ne_g)\Delta_0$

nt_{2g} = Number of electrons in t_{2g} orbital

ne_g =number of electrons in eg orbital.

Crystal Field Stabilisation Energy for the given complexes is as follows:

(A)	$[Cu(NH_3)_6]^{2+}$ Cu^{2+}. $3d^6$, $t_{2g}^6\ e_g^3$	$CFSE$ $=(-6 \times 0.4 + 3 \times 0.6)\Delta_0$ $= -0.6\Delta_0$
(B)	$[Ti(H_2O)_6]^{3+}$ Ti^{3+} : $3d^1$, $t_{2g}^1\ e_g^0$	$CFSE = -1 \times 0.4\Delta_0$ $= -0.4\Delta_0$
(C)	$[Fe(CN)_6]^{3-}$ Fe^{3+} : $3d^5$, $t_{2g}^5\ e_g^0$	$CFSE = -5 \times 0.4\Delta_0$ $= -2.0\ \Delta_0$
(D)	$[NiF_6]^{4-}$ Ni^{2+} : $3d^8$, $t_{2g}^6\ e_g^2$	$CFSE$ $=(-6 \times 0.4 + 2 \times 0.6)\Delta_0$ $= -1.2\ \Delta_0$

So the correct option is B.

24. (2)

The chlorophyll molecule has a central magnesium atom engulfed by a nitrogen-containing structure called a porphyrin ring; attached to the ring is a long carbon-hydrogen side chain.

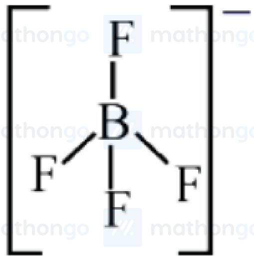
Hardness of water is determined by titrating with a standard solution of ethylene diamine tetra acetic acid (EDTA) which is a complexing agent. Since EDTA is insoluble in water, the disodium salt of EDTA is taken for this experiment. EDTA can form four or six coordination bonds with a metal ion.

Silver bromide is used in photography as a component of an emulsion that helps develop a photographic image. Silver bromide is sensitive to light, and when suspended in gelatin, silver bromide's grains create a photographic emulsion.

Wilkinson's catalyst is the common name for chloridotris(triphenylphosphine)rhodium(I), a coordination complex of rhodium with the formula $\left[(Ph_3P)_3RhCl\right]$

D-Penicillamine is chelating ligand.

25. (4)



Number of covalent bond formed by Boron is 4.

$[BF_4]^-$ Covalency $= 4$

The oxidation state of an element represents the charge it would have if all the bonding electrons were assigned to the more electronegative atom in the bond.

Oxidation number of fluorine is -1

Then,

$B + 4x(-1) = -1$

$B - 4 = -1$

$B = +3$

Oxidation state $= +3$ for Boron

26. (4)

Complex having maximum number of unpaired electrons will exhibit maximum attraction to applied magnetic field.

$\left[Zn(H_2O)_6\right]^{2+} \rightarrow d^{10}$ system, $t^6{}_{2g}\ eg^4$, 0 unpaired electrons

$\left[Co(H_2O)_6\right]^{2+} \rightarrow d^7$ system, $t^5{}_{2g}\ eg^2$, 3 unpaired electrons

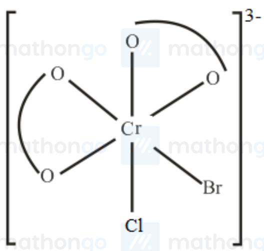
$[Co(en)_3]^{3+} \rightarrow d^6$ system, $t^6{}_{2g}\ eg^0$, 0 unpaired electrons

$\left[Ni(H_2O)_6\right]^{2+} \rightarrow d^8$ system, $t^6{}_{2g}\ eg^2$, 2 unpaired electrons.

So Option D is correct.

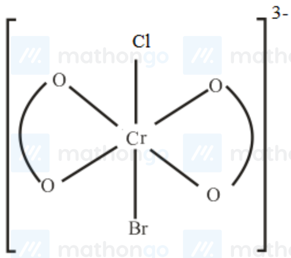
27. (1)

The complex $\left[Cr(ox)_2ClBr\right]^{3-}$ exhibits two geometrical isomers. Among these isomers Cis-isomer is optically active. Hence, the total number of stereoisomers for the given complex is 3.



Optically active

Cis-isomer



Optically inactive

Trans isomer

28. (2)

Crystal field stabilisation energy of the complex can be calculated as follows,

CFSE = number of t_{2g} electrons $\times(-0.4)+$ number of e_g electrons $\times(0.6)$

Complex	CFSE
$[Ti(OH_2)_6]^{3+}(t_{2g}{}^1e_g{}^0)$	$-0.4\,\Delta_0$
$[Cr(H_2O)_6]^{3+}(t_{2g}{}^3e_g{}^0)$	$-1.2\,\Delta_0$
$[Mn(H_2O)_6]^{3+}(t_{2g}{}^3e_g{}^1)$	$-0.6\,\Delta_0$
$[Fe(H_2O)_6]^{3+}(t_{2g}{}^3e_g{}^2)$	0

29. (4)

$(Cr(H_2O)_5Cl)Cl_2 \longrightarrow (Cr(H_2O)_5Cl)+2\,Cl^-$

Number of ionisable Cl^- in $(Cr(H_2O)_5Cl)Cl_2$ is 2.

Molarity of Cl^- ions $= 0.01\times 2 = 0.02$ M

$\therefore$ Millimoles of Cl^- ions in the given solution

$= 20\times 0.02$

$\therefore$ Millimoles of $AgNO_3$ required $= 20\times 0.2$

$V\times 0.1 = 20\times 0.02$

$V = 4$ mL

30. (1)

The electronic configuration of Co^{2+} is $3d^7$. In an octahedral complex of Co^{2+} with H_2O ligands, the d orbitals split into two sets of energy levels: t_{2g} (lower energy) and e_g (higher energy).

In this case, since the complex is octahedral, we have six ligands surrounding the central cobalt ion. Each ligand donates a pair of electrons to the cobalt ion, occupying the available d orbitals.

So, $[Co(H_2O)_6]^{2+} = d^7$(High spin)$= t_{2g}^5\,e_g^2$

In the t_{2g} set of orbitals, there will be 1 unpaired electron