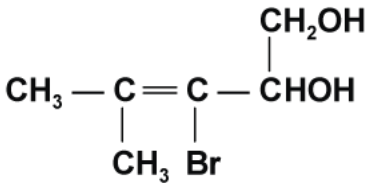
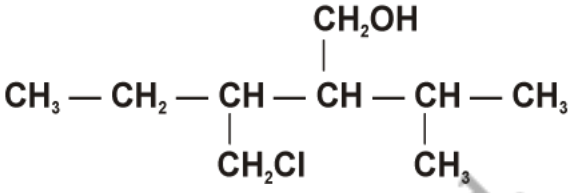
Date: 23/10/2021

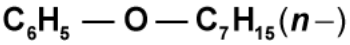
Q1. Give IUPAC name of the following compound:



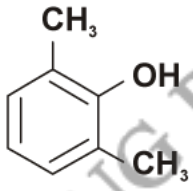
Q2. Give IUPAC name of the following compound:



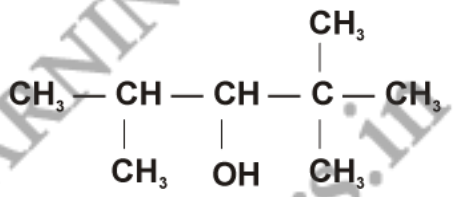
Q3. Give IUPAC name of the following compound:



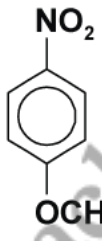
Q4. Give IUPAC name of the following compound:



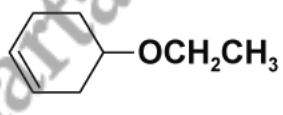
Q5. Give IUPAC name of the following compound:



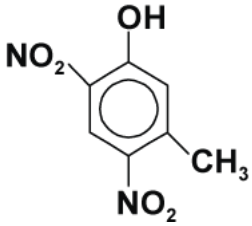
Q6. Give IUPAC name of the following compound:



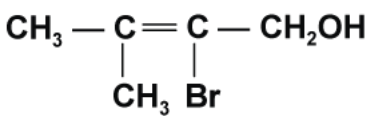
Q7. Give IUPAC name of the following compound:



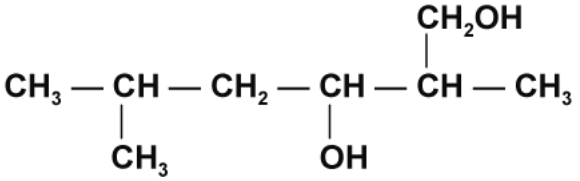
Q8. Give IUPAC name of the following compound:



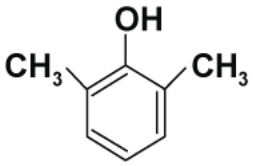
Q9. Give IUPAC name of the following compound:



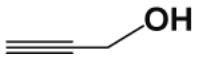
Q10. Give IUPAC name of the following compound:



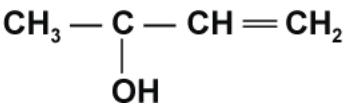
Q11. Give IUPAC name of the following compound:



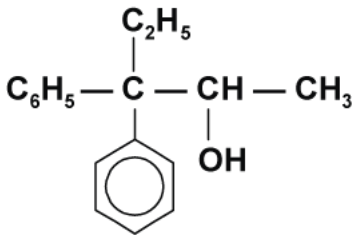
Q12. Give IUPAC name of the following compound:



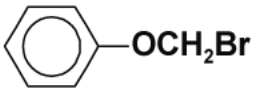
Q13. Give IUPAC name of the following compound:



Q14. Give IUPAC name of the following compound:



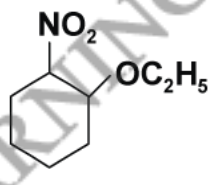
Q15. Give IUPAC name of the following compound:



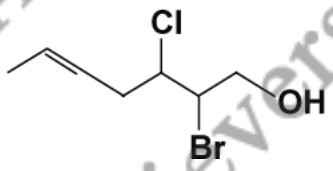
Q16. Give IUPAC name of the following compound: $CH_3 - O - C(CH_3)_3$

Q17. Give IUPAC name of the following compound: $(CH_3)_2CHOCH_3$

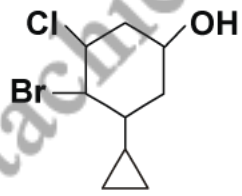
Q18. Give IUPAC name of the following compound:



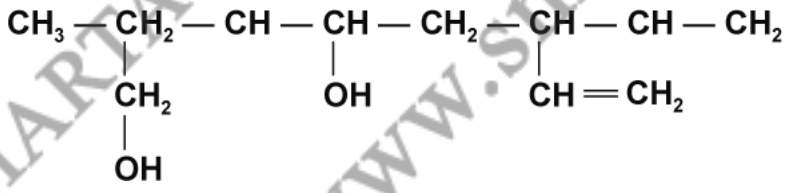
Q19. Give IUPAC name of the following compound:



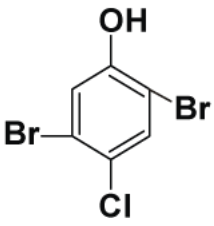
Q20. Give IUPAC name of the following compound:



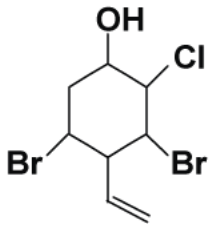
Q21. Give IUPAC name of the following compound:



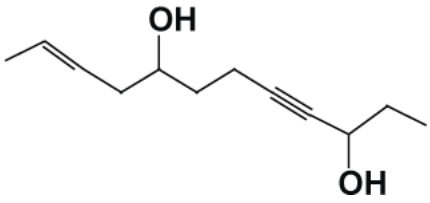
Q22. Give IUPAC name of the following compound:



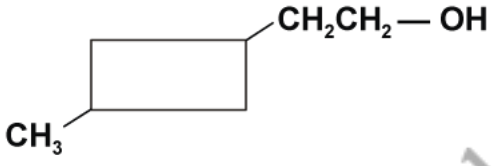
Q23. Give IUPAC name of the following compound:



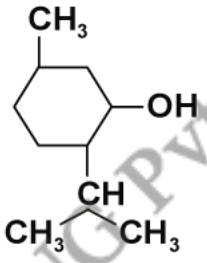
Q24. Give IUPAC name of the following compound:



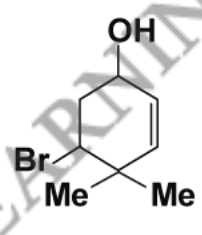
Q25. Give IUPAC name of the following compound:



Q26. Give IUPAC name of the following compound:



Q27. Give IUPAC name of the following compound:



Q28. Give bond notation of phenoxy chloropropan-2-ol.

Q29. Give IUPAC bond notation of 1-Cyclopropylpen-2-enol.

Q30. Give IUPAC structure of 1-Chloro-2,3-epoxypropane.

Q31. Give IUPAC structure of 3-Chloromethyl-pentan-1-ol.

Q32. Give IUPAC structure of 2-phenol sulphonic acid.

Q33. Give IUPAC name of cyclohexyl-*n*-propyl ether.

Q34. Write structure of Salicylic acid:

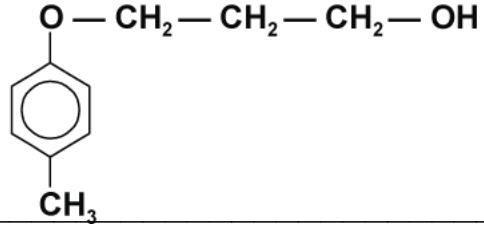
Q35. Give IUPAC name of catechol.

O36. Give IUPAC name of *m*-cresrol.

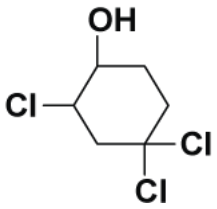
Q37. Give IUPAC name of picric acid.

Q38. Give bond notation of 4-(2-Chloroethyl)-Phenol

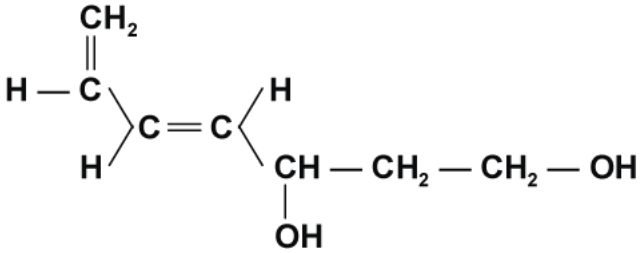
Q39. Give IUPAC name of the following compound:



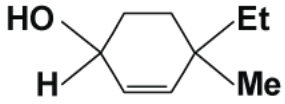
Q40. Give IUPAC name of the following compound:



Q41. Give IUPAC name of the following compound:



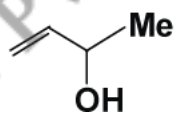
Q42. Write the IUPAC name, as its name and classify it as 1°, 2°, 3°.



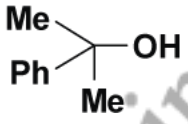
Q43. Write the IUPAC name, as its name and classify it as 1°, 2°, 3°.

Et_3C — OH

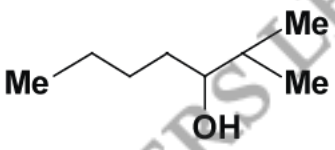
Q44. Write the IUPAC name, as its name and classify it as 1°, 2°, 3°.



Q45. Write the IUPAC name, as its name and classify it as 1°, 2°, 3°.



Q46. Write the IUPAC name, as its name and classify it as 1°, 2°, 3°.



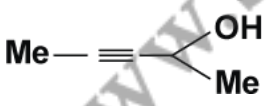
Q47. Give bond notation of 3,4,4,5-tetrachlorohept-6-enol.

Q48. Give bond notation of 3, 4, 4-trichloro-phenoxyhex-2-ene.

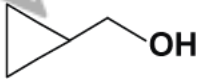
Q49. Give bond notation of trichloro-2,2-diphenylethane.

Q50. Give bond notation of 2-Methyl-4-isobutyloctan-2,3-diol.

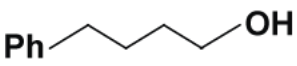
Q51. Write the IUPAC name, as its name and classify it as 1°, 2°, 3°.



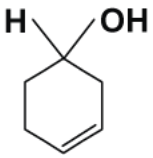
Q52. Write the IUPAC name, as its name and classify it as 1°, 2°, 3°.



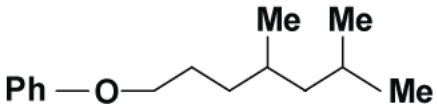
Q53. Write the IUPAC name, as its name and classify it as 1°, 2°, 3°.



Q54. Write the IUPAC name, as its name and classify it as 1°, 2°, 3°.



Q55. Write the IUPAC name of the given compound.



Q56. Write the structure for the given compound: Hexan-1,2,5,6-tetra-ol

Q57. Write the structure for the given compound: 1, 3, 5-Trioxa cyclohexane

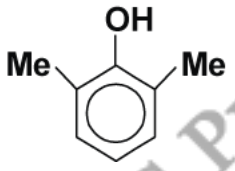
Q58. Write the structure for the given compound: Cyclopentyl-*t*-butyl ether

Q59. Write the structure for the given compound: *m*-Diethoxybenzene

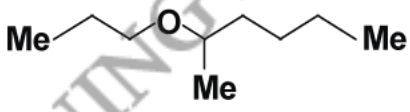
Q60. Write the structure for the given compound: Cyclophex-3-en-1-ol

Q61. Write the structure for the given compound: 2,3-Dimethyl cyclopentanol.

Q62. Write the IUPAC name of following compound:



Q63. Write the IUPAC name of the given compound.



Date: 23/10/2021

S1. 3-Bromo-4-methyl-3-penten-1,2-diol.

S2. 3-chloromethyl-2-isopropylpentanol Or 3-chloromethyl-2-(methylethyl)pentanol.

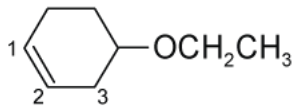
S3. 1-Phenoxyheptane.

S4. 2,6-Dimethylphenol.

S5. 2,2,4-Trimethylpentan-3-ol.

S6. 4-Nitro anisole (OR) 4-Nitromethoxy benzene

S7. 4-Ethoxycylohexene.



S8. 2,4-Dinitro-5-methylphenol.

S9. 2-Bromo-3-methylbut-2-en-1-ol.

S10. 2, 5-Dimethylhexan-1, 3-diol.

S11. 2, 6-Dimethylphenol.

S12. Prop-2-yn-1-ol

S13. But-3-en-2-ol

S14. 3, 3-Diphenylpentan-2-ol.

S15. (Bromomethoxy) benzene.

S16. 2-Methoxy-2-methylpropane.

S17. 2-Methoxypropane.

S18. 1-Ethoxy-2-nitrocyclohexane.

S19. 2-Bromo-3-chlorohept-5-en-1-ol.

S20. 4-Bromo-3-chloro-5-cyclopropylcyclohexanol.

S21. 2-Ethyl-5-vinylhept-6-en-1,3-diol Or 5-Ethenyl-2-ethylhept-6-en-1,3-diol.

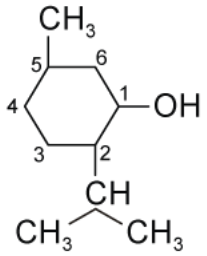
S22. 2,5-Dibromo-4-chlorophenol.

S23. 3,5-Dibromo-2-chloro-4-ethenylcyclohexanol.

S24. Dodec-10-en-4-yne-3, 8-diol.

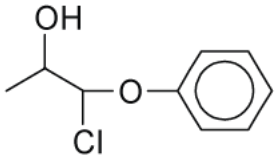
S25. 2-(3-Methylcyclobutyl) ethanol.

S26. 5-Methyl-2-(methylethyl) cyclohexanol Or 5-Methyl-2-isopropylcyclohexanol.

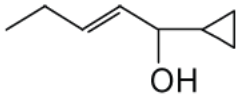


S27. 5-Bromo-4,4-dimethylcyclohex-2enol.

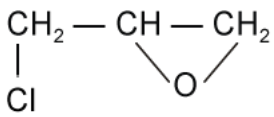
S28.



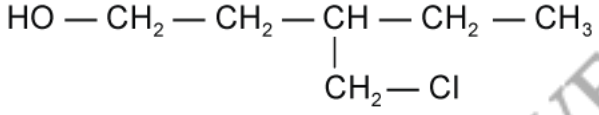
S29.



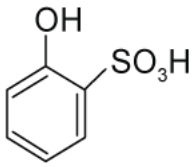
S30.



S31.

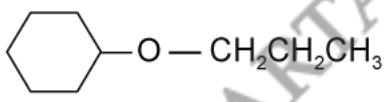


S32.



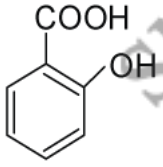
2-Hydroxybenzene-sulphonic acid.

S33.



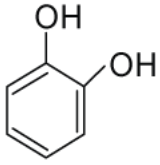
n-Propoxycyclohexane.

S34.

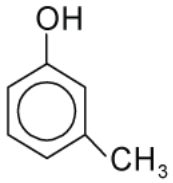


2-Hydroxybenzoic acid

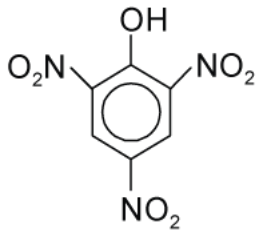
S35.



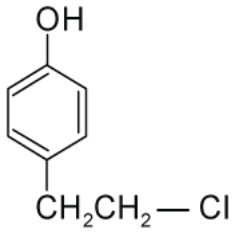
1,2-diHydroxybenzene

S36. 

3-Methylphenol OR *m*-Methylphenol

S37. 

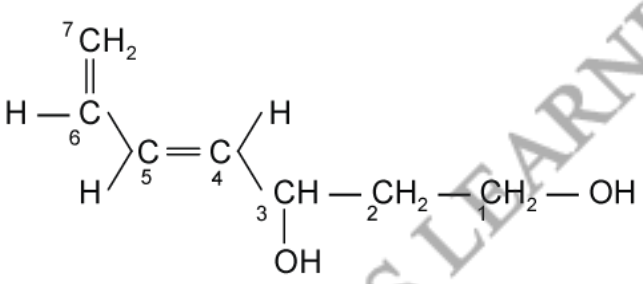
2,4,6-triNitrophenol
(Picric Acid)

S38. 

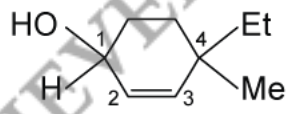
S39. 3-(*p*-Methylphenoxy) propanol.

S40. 2,4,4-trichlorocyclohexanol.

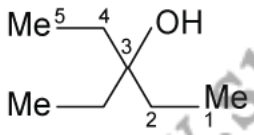
S41. Hept-4, 6-dien-1, 3-diol



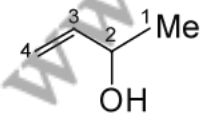
S42. 4-Ethyl-4-methyl cyclohex-2-en-1-ol (2° allylic)



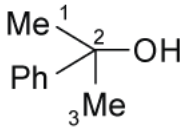
S43. 3-Ehtyl pentan-3-ol (3°)



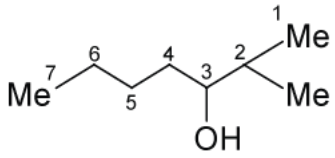
S44. But-3-en-2-ol (2° allylic)



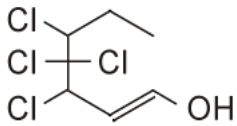
S45. 2-Pheyl propan-2-ol (3°)



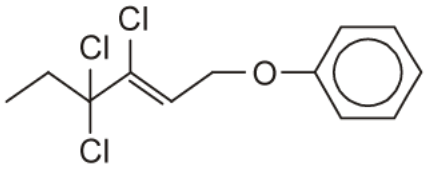
S46. 2-Methyl heptan-3-ol (2°)



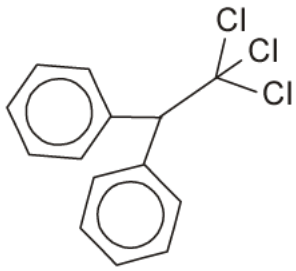
S47.



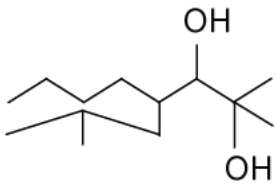
S48.



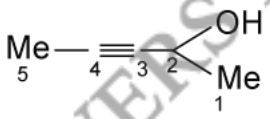
S49.



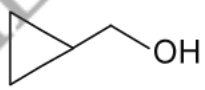
S50.



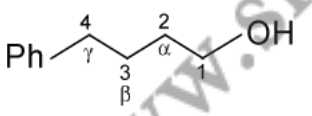
S51. Pent-3-yn-2-ol (2° propargylic)



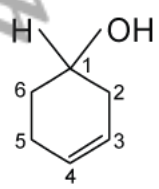
S52. Cyclopropyl methanol (1°)



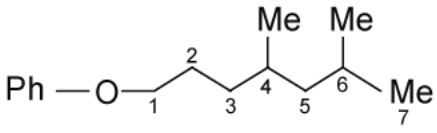
S53. 4-Phenyl butan-1-ol (1°)



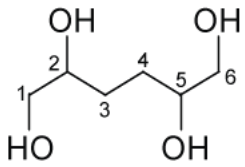
S54. Cyclohex-3-en-1-ol (2°)



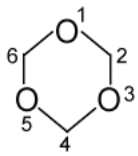
S55. 1-Phenoxy-4,6-dimethyl heptane



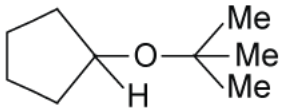
S56.



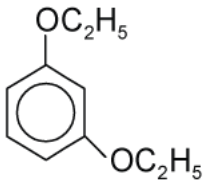
S57.



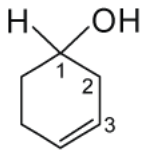
S58.



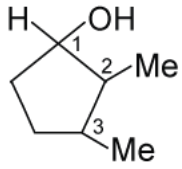
S59.



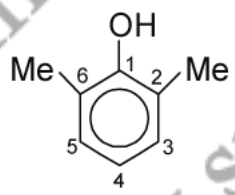
S60.



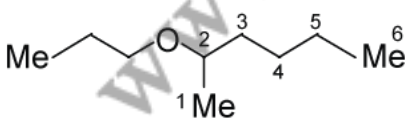
S61.



S62. 2,6-Dimethyl phenol



S63. 2-Propoxy hexane



Date: 23/10/2021

Q1. Draw the structures of the isomers (geometric and optical) of $[CoCl_2(en)_2]^{\oplus}$.

Q2. Draw geometrical isomers of $[CoCl_2(NH_3)_4]^{\oplus}$.

Q3. Draw structures of geometrical isomers of $[Fe(NH_3)_2(CN)_4]^{\ominus}$

Q4. Draw the structures of the isomers (geometric and optical) of $[Co(NH_3)Cl(en)_2]^{2\oplus}$.

Q5. Draw the structures of the isomers (geometric and optical) of $[Co(NH_3)_2Cl_2(en)]^{\oplus}$.

Q6. Write all the geometrical isomers of [Pt (NH_3) (Br) (Cl) (Py)] and how many of these will exhibit isomerism?

Q7. Out of the following two coordination entities, which is chiral (optically active)?

(a) cis-$[CrCl_2(ox_2)^{3\ominus}]$ (b) trans-$[CrCl_2(ox)_2]^{3\ominus}$

Q8. Indicate the types of isomerism exhibited by the following complexes and draw the structures for geometrical and optical isomers.

(a) $[Co(NH_3)_5(NO_2)]\ (NO_3)_2$ (b) $[Pt(NH_3)(H_2O)Cl_2]$

Q9. Indicate the types of isomerism exhibited by the following complexes and draw the structures for geometrical and optical isomers.

(a) $K[Cr(H_2O)_2\ (C_2O_4)_2]$ (b) $[Co(en)_3]Cl_3$

Q10. Illustrate with an example ionisation isomerism in coordination compounds.

Q11. Give evidence that $[Co(NH_3)_5Cl]SO_4$ and $[Co(NH_3)_5SO_4]Cl$ are ionisation isomers.

Q12. Draw the structures of

(a) *mer*-triamminetrichloridocobalt (III)

(b) *fac*-triaquatrinitrito-N-cobalt (III)

(c) *cis*-dichloridotetracyanachromate (III)

Q13. Name the following coordination entities and draw the structures of their stereoisomers:

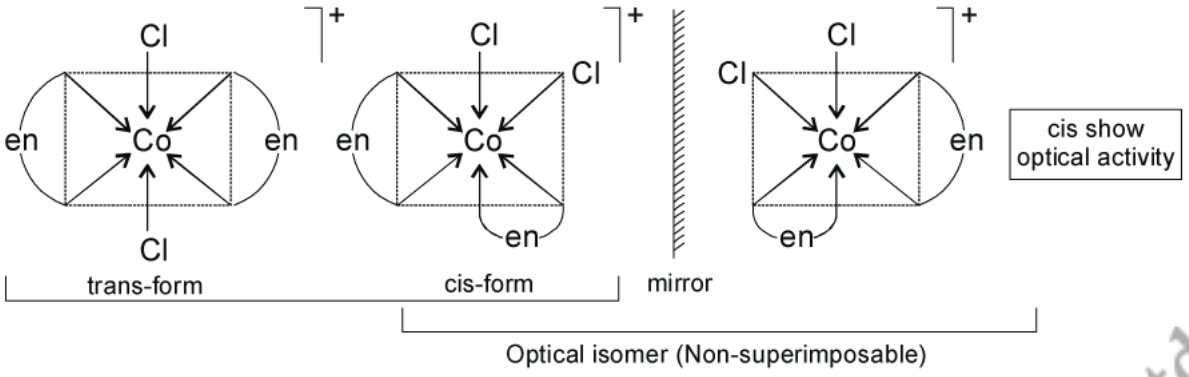
(a) $[Co(en)_2Cl_2]^{\oplus}$ (b) $[Co(NH_3)_3Cl_3]$ (Atomic numbers Co = 27)

Q14. Draw the structures of optical isomers of :

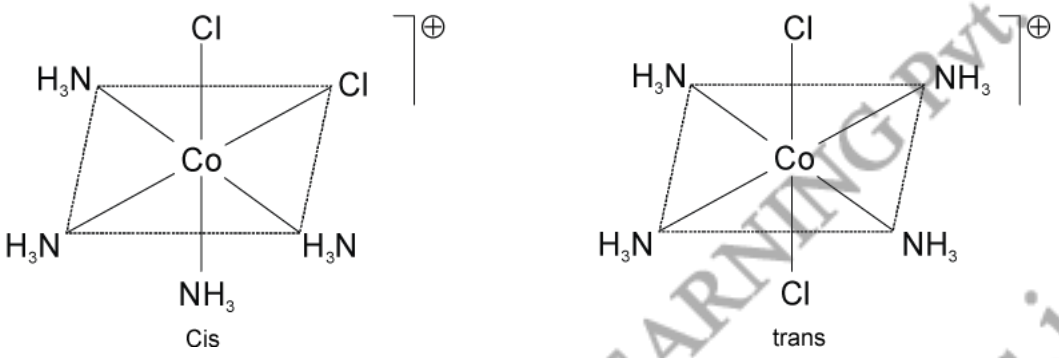
(a) $[Cr(C_2O_4)_3]^{3\ominus}$ (b) $[PtCl_2(en)_2]^{2\oplus}$ (c) $[Cr(NH_3)_2Cl_2(en)]^{\oplus}$

Date: 23/10/2021

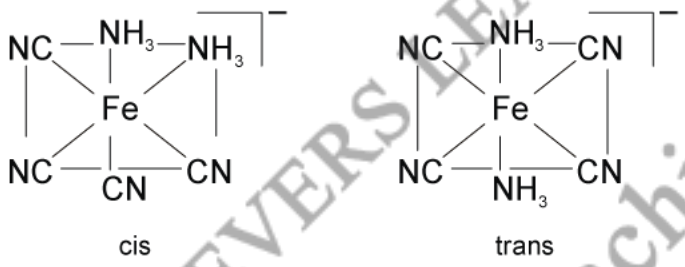
S1. Geometrical and optical isomer of $[CoCl_2(en)_2]^{\oplus}$



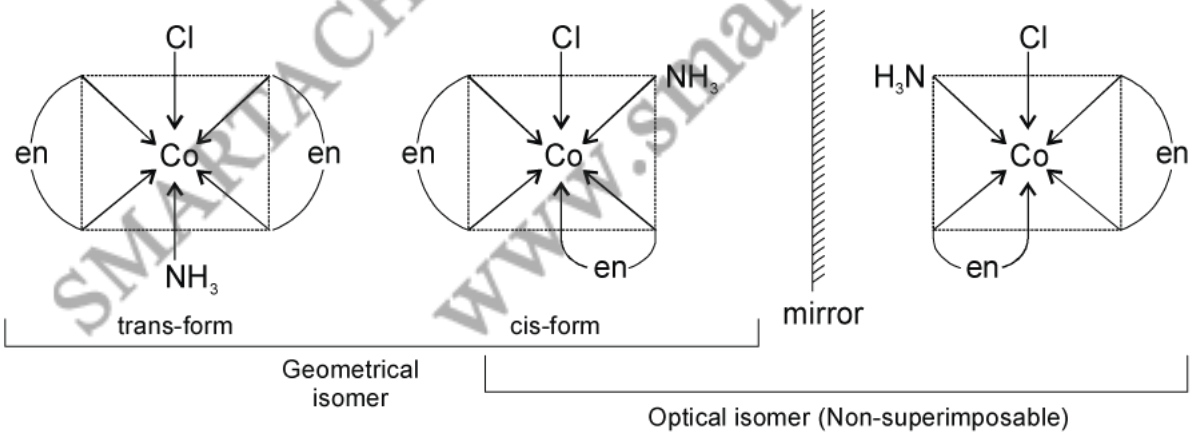
S2. It exists in cis and trans forms as :



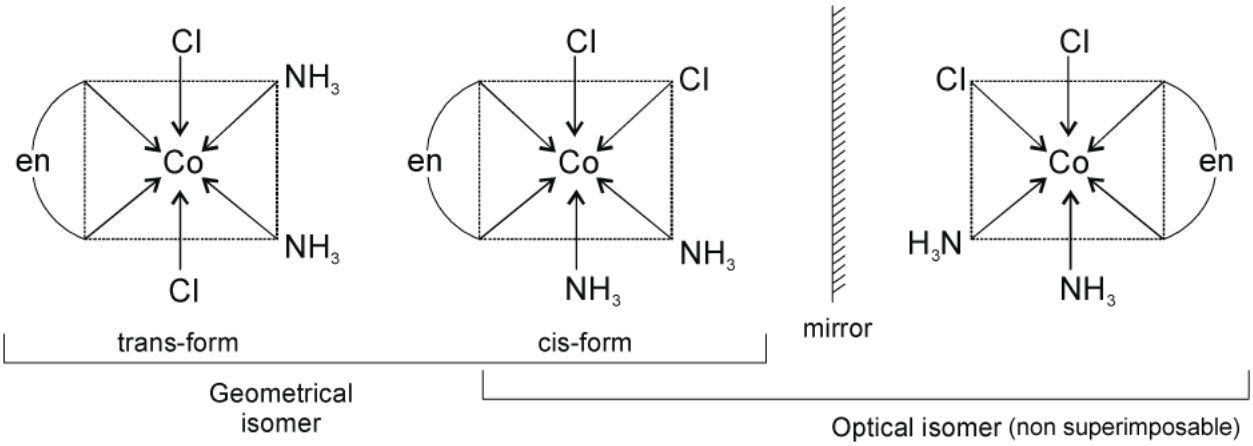
S3.



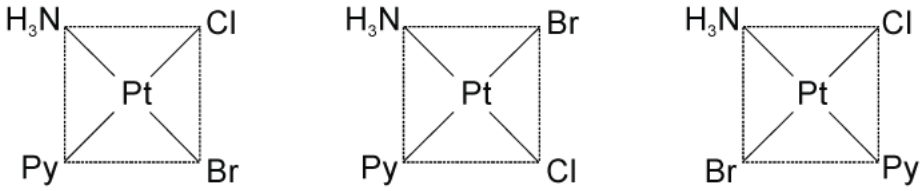
S4. Geometrical and optical isomer of $[Co(NH_3)Cl(en)_2]^{2\oplus}$



S5. Geometrical and optical isomer of $[Co(NH_3)_2Cl_2(en)]^{\oplus}$

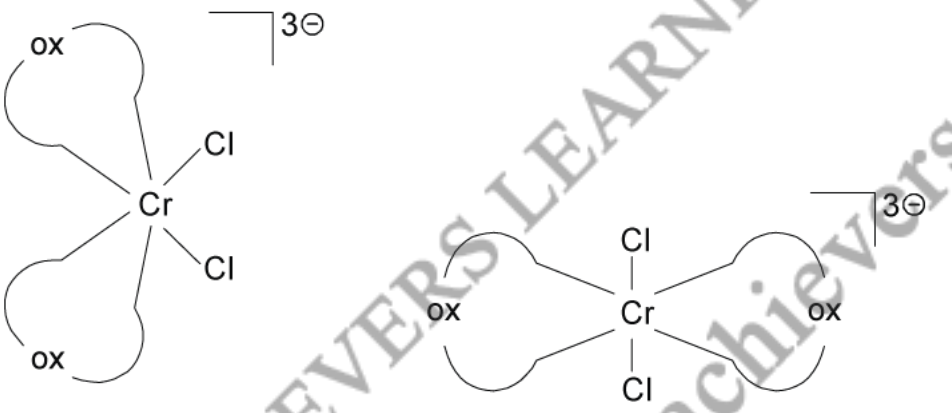


S6. Three isomers are possible as follows:



Isomers of this type do not show any optical isomerism. Optical isomerism only rarely occurs in square-planar when they contain unsymmetrical chelating ligand.

S7. The two entities are represented as



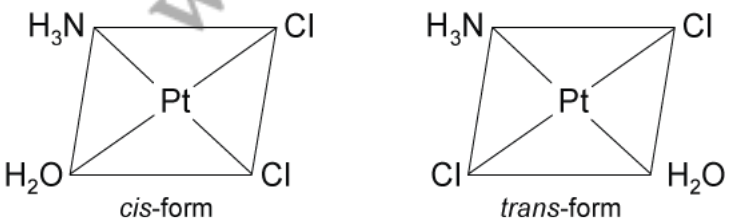
(a) cis-$[CrCl_2(ox)_2]^{3\ominus}$ (b) trans-$[CrCl_2(ox)_2]^{3\ominus}$

S8. (a) The compound will show Ionisations as well as linkage Isomerism.

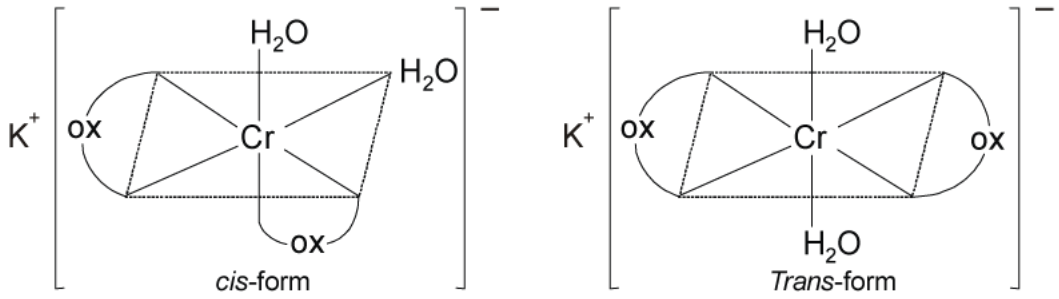
Ionisation Isomers: $[Co(NH_3)_5\ (NO_2)]\ (NO_3)_2$, $[Co(NH_3)_5(NO_3)](NO_2)\ (NO_3)$

Linkage Isomerism: $[Co(NH_3)_5\ (NO_2)]\ (NO_3)_2\ [Co(NH_3)_5\ (ONO)]\ (NO_3)_2$

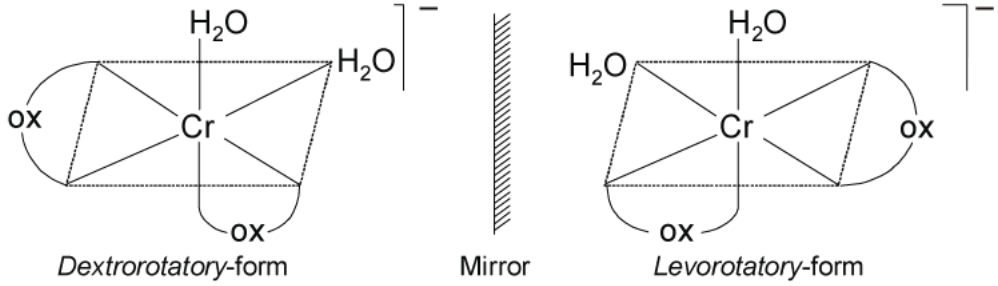
(b) Geometrical Isomerism (*cis* and *trans*)



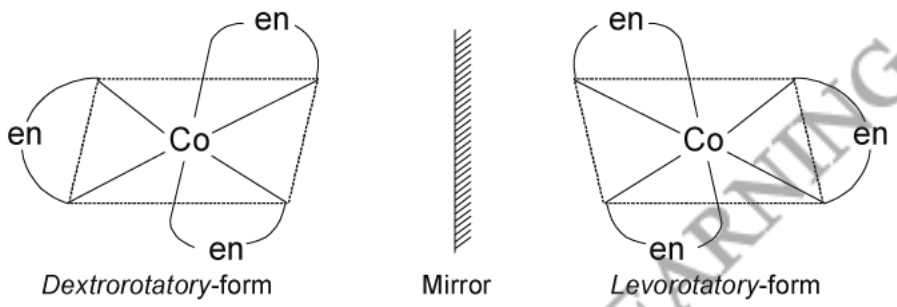
S9. (a) (i) Both geometrical isomer (*cis* and *trans*)



(ii) *Cis*-Isomer of this compound can exist as pair of optical isomer.



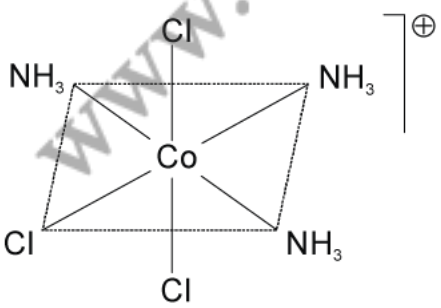
(b) Complex will exist as optical Isomers.



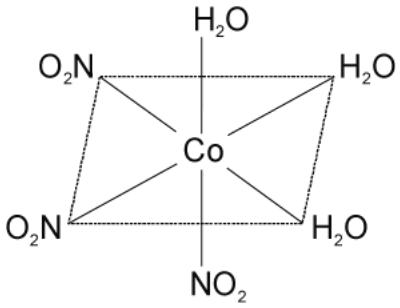
S10. (a) $[Co(NH_3)_5Br]SO_4$ and (b) $[Co(NH_3)_5SO_4]Br$ are example of ionisation isomers because they give different ions in aqueous solution. Complex (a) gives $SO_4^{2\ominus}$ in aqueous solution which will give white precipitate of $BaSO_4$ with barium chloride solution. Complex (b) gives $Br^{\ominus}$ in aqueous solution which gives yellow precipitate of AgBr with silver nitrate solution.

S11. When they are disolved in water, they give different ions in the solution which can be tested by adding $AgNO_3$ solution and $BaCl_2$ solution. Both one by one when Cl^- ions are the counter ions, a white ppt. will be obtained with $AgNO_3$ solution. If SO_4^{2-} ions are the counter ions, a white ppt. will be obtained with $BaCl_2$ solution.

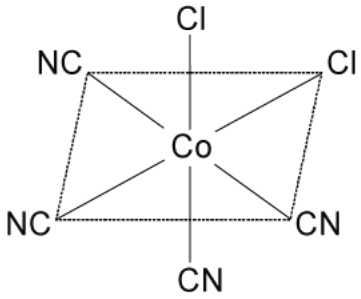
S12. (a) *mer*-triamminetrichloridocobalt (III)



(b) *fac*-triaquatrinitrito-N-cobalt (III)

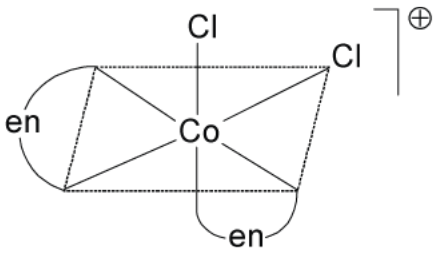


(c) *cis*-dichloridotetracyanachromate (III)

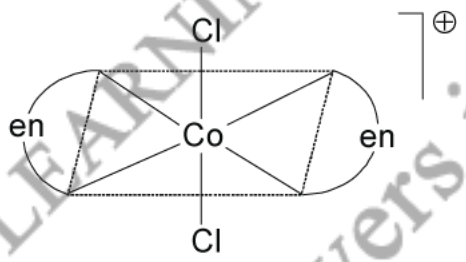


S13. (a) **$[Co(en)_2C_2]^{\oplus}$**

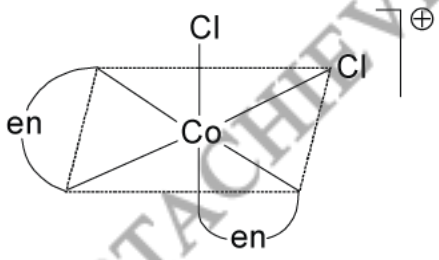
Name: Dichloridobis (ethane-1, 2-diamine) cobalt (III) ion. It shows two geometrical isomers *cis*- and trans.*cis*-shows optical isomerism.

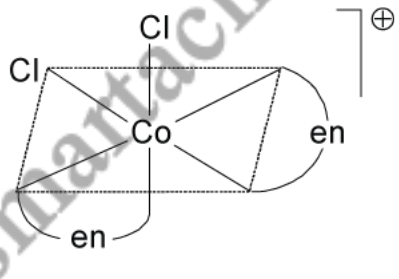


cis-



Trans-



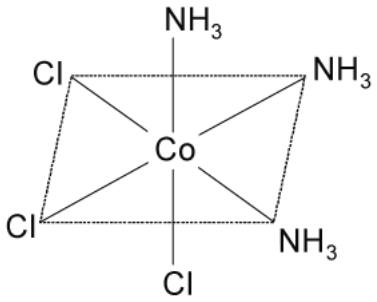


cis-$[Co(en)_2Cl_2]^{\oplus}$ is optically active

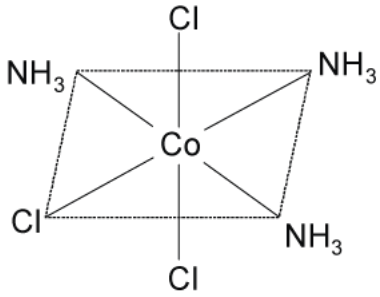
(b) **$[Co(NH_3)_3Cl_3]$**

Name: Triamminetrichloridocobalt (III)

It shows two geometrical isomers known as facial (fac) and meridional (mer) isomers as shown below:

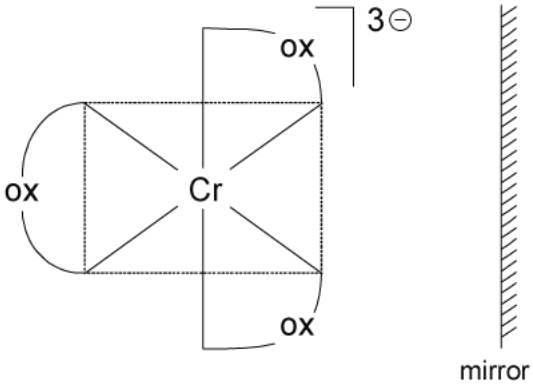


fac-

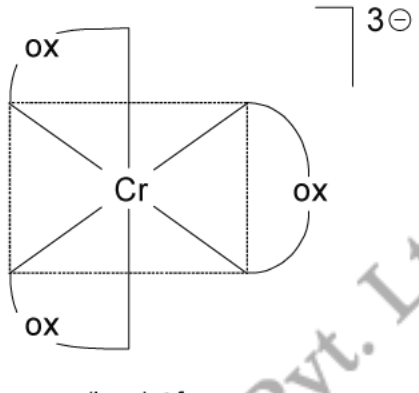


mer-

S14. (a) $[Cr(C_2O_4)_3]^{3\ominus}$

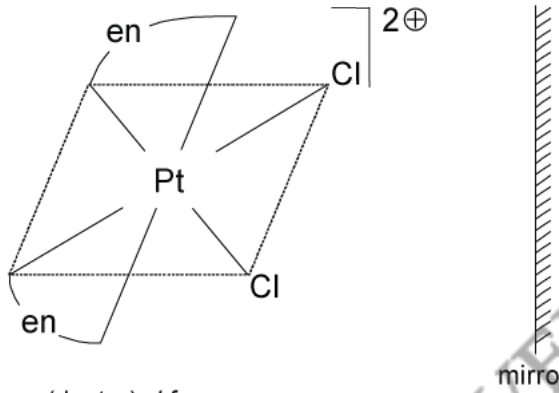


(dextro) *d*-form

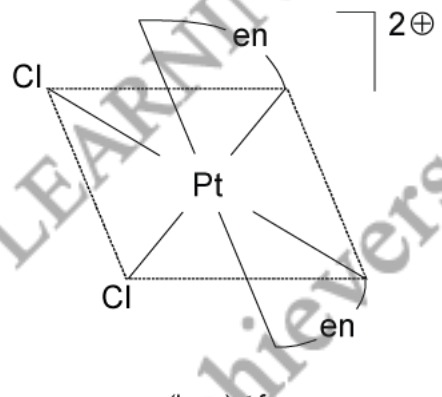


(levo) *l*-form

(b) $[PtCl_2(en)_2]^{2\oplus}$

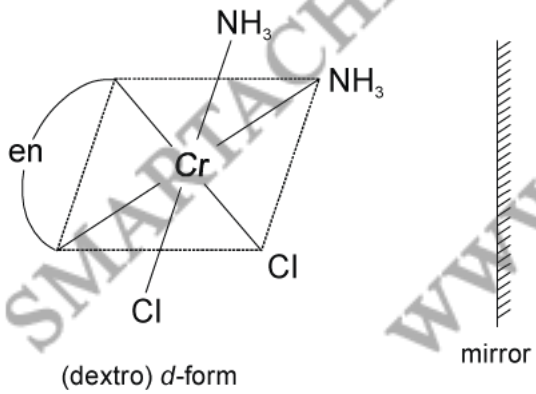


(dextro) *d*-form

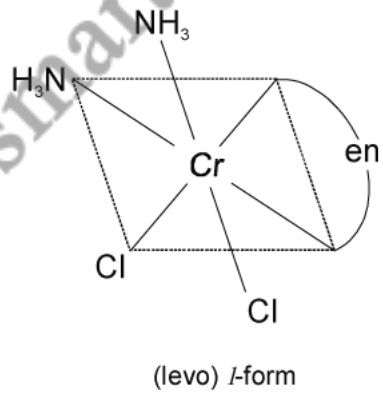


(levo) *l*-form

(c) $[Cr(NH_3)_2Cl_2(en)]^{\oplus}$



(dextro) *d*-form



(levo) *l*-form

Date: 23/10/2021

Q1. What is crystal field, and crystal field splitting?

Q2. Explain term complex ion.

Q3. The values of dissociation constants of $[Cu(NH_3)_4]^{2\oplus}$ and $[Co(NH_3)_6]^{3\oplus}$ are 1.0×10^{-12} and 6.2×10^{-36} respectively. Which complex would be more stable and why?

Q4. $[CoF_6]^{-3}$ is a high spin complex. Why?

Q5. Using valence bond theory explain the geometry and magnetic behaviour of pentacarbonyl iron (0).

Q6. With the help of crystal field theory, calculate the number of unpaired electrons in octahedral complexes of $Fe^{3\oplus}$ in the presence of (i) weak field ligand (ii) strong field ligand.

Q7. With the help of crystal field theory, predict the number of unpaired electrons in $[Fe(CN)_6]^{4\ominus}$ and $[Fe(H_2O)_6]^{2\oplus}$ complexes.

Q8. Predict the number of unpaired electrons in the square planar $(Pt(CN)_4)^{2\ominus}$ ion.

Q9. Account for the different magnetic behaviour of hexacyanoferrate (III) and hexafluoroferrate (III).

Q10. What is crystal field splitting energy? How does the magnitude of Δ_0 decide the actual configuration of *d*-orbitals in a co-ordination entity?

Q11. What is spectrochemical series? Explain the difference between a weak field ligand and a strong field ligand.

Q12. Draw a sketch to show the splitting of *d*-orbitals in an octahedral crystal field. State for a d_6 ion how the actual configuration of the split d-orbitals in an octahedral crystal field is decided by the relative values of Δ_0 and P.

Date: 23/10/2021

S1. The ligands especially anionic (or polar neutral ligands) has negatively charged field around them because of which they are called ***crystal field***. In a free transition metal ion, all the five *d*-orbitals are degenerate but when it is involved in a complex, the degeneracy is split. Due to ligands such type of splitting is known as ***crystal field splitting***.

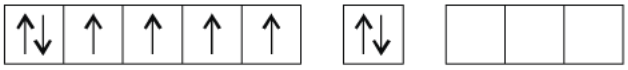
S2. Complex ion is electrically charged species formed by co-ordination of a simple cation with a number of neutral or charged ligands.

For example: Hexacyanoferrate $Fe(CN_6)^{-3}$.

S3. Smaller the value of the dissociation constant, more stable is the complex in the solution. Thus, $[Co(NH_3)_6]^{3\oplus}$ is more stable than $[Cu(NH_3)_4]^{2\oplus}$ ion.

S4. In the formation of $[CoF_6]^{-3}$ *d*-orbitals are involved of outershell which give a high spin complex.

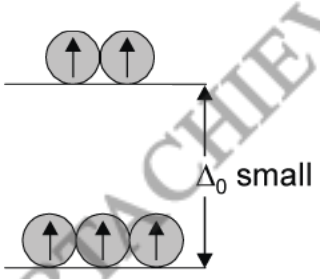
S5. It this case, iron is in 0 oxidation state and has the configuration $3d^6\ 4s^2$.

Fe(Z = 26) 

The two electrons from 4*s*-orbital shift to 3*d*-orbitals. In $Fe(CO)_5$ all the d-electrons get paired up leaving one empty orbital. The molecule involves dsp^3 hybridisation resulting trigonal bipyramidal goemetry and the molecule is diamagnetic.

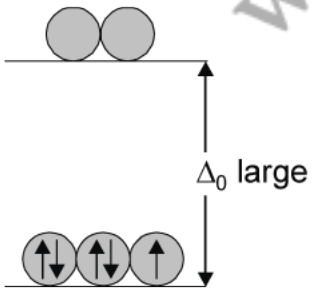
S6. $Fe^{3\oplus}$ has $3d^5$ configuration.

(i) In the presence of weak field ligand, Δ_0 will be small. As a result, electrons can fill lower as well as upper set of orbitals as :



No. of unpaired electrons = 5

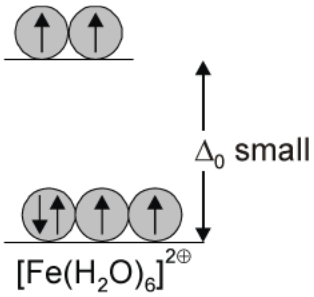
(ii) In the presence of strong field ligand, Δ_0 will be large. As a result, electrons will try to remain only in the lower set of orbitals and will therefore, pair up.



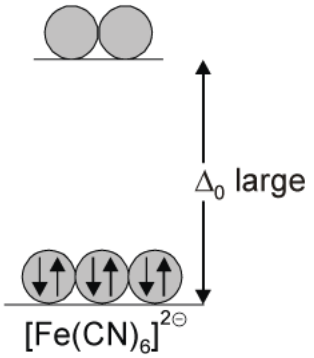
No. of unpaired electrons = 1

S7. H_2O is a weak field ligand and it will have low value of Δ_0. As a result, the electrons can fill lower set of *d*-orbitals as well as upper set as : $t_{2g}^4 e_g^2$.

On the other hand, $CN^{\ominus}$ is a strong field ligand, so that Δ_0 will be high. As a result, electron will try to remain only in the lower set and will therefore pair up i.e. t_{2g}^6.

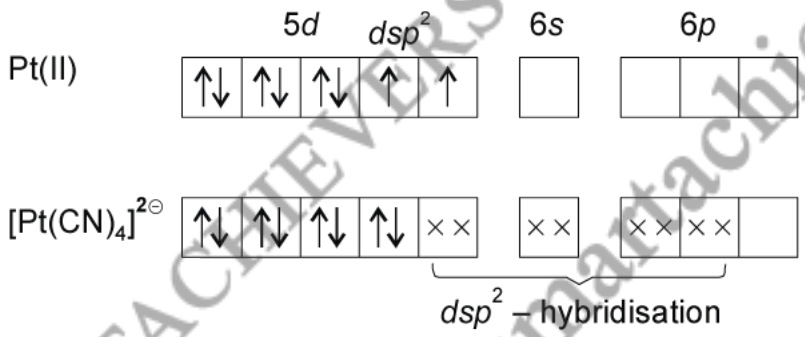


Since it contains 4 unpaired electrons, it will be paramagnetic

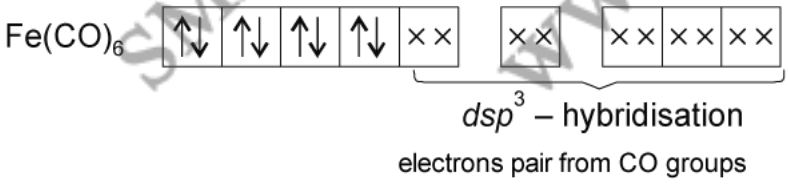


Since it has no unpaired electron, it will be diamagnetic

S8. The Pt (II) ion has $5d^8$ electronic configuration. For square planar geometry dsp^4 hybridisation is involved. For this, one empty *d*-orbital is needed for hybridisation. Therefore, pairing of electrons takes place in the remaining *d*-orbitals. Hence, there are no unpaired electrons in $[Pt(CN)_4]^{2\ominus}$ ion and it is **diamagnetic**.



S9. In $[Fe(CN)_6]^{3\ominus}$ is a strong field ligand and therefore, electrons pair up in *d*-subshell leaving one unpaired electron. The complex is inner orbital complex.



On the other hand, in $FeF_6^{3\ominus}$, $F^{\ominus}$ is a weak field ligand and therefore, electrons in 3*d*-subshell do not get pair up. It is outer orbital complex and has 5 unpaired electrons. Thus, $[FeF_6]^{3\ominus}$ has greater magnetic moment than $[Fe(CN)_6]^{3\ominus}$.

S10. When ligands approach a transition metal ion, the *d*-orbitals split into two sets, one with lower energy and the other with higher energy. The difference of energy between the two sets of orbitals is called ***crystal field splitting energy*** (Δ_0 for octahedral). If $\Delta_0 < P$ (Pairing energy), the 4th electron enters one of the e_g orbitals giving the configuration t_{2g}^3, e_g^1, thus, forming high spin complexes such ligands for which $\Delta_0 < P$ are called weak field ligands.

If $\Delta_0 > P$, the 4th electron pair up in one of the t_{2g} orbitals giving the configuration t_{2g}^4, e_g^0 therby forming low spin complexes. Such ligands for which $\Delta_0 > P$ are called ***strong field ligands***.

S11. **Spectrochemical series:** The arrangement of ligands in order of their increasing crystal field splitting energy [CFSE] values is called spectrochemical series.

$I^- < Br^- < SCN < Cl^- < S^{2-} < F^- < OH^- < C_2O_4^{2-}$ weak field ligand $< H_2O < NCS^- < EDTA^{4-} < NH_3 < en < CN < CO$ ⟵ Strong field ligand.

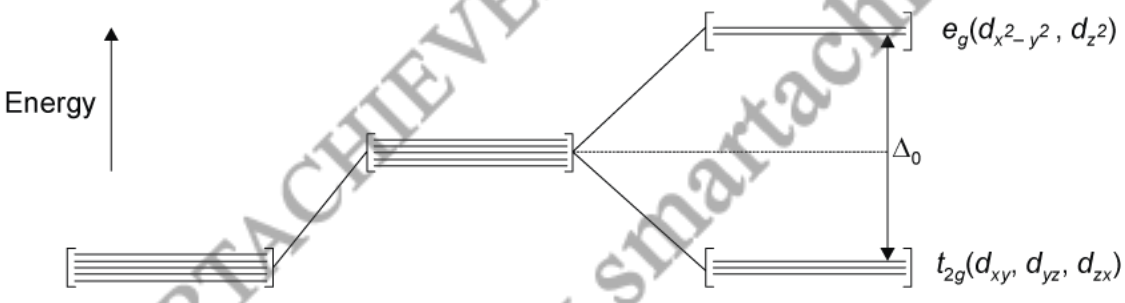
Difference between weak field ligand and a strong field ligand: The ligands with small value of CFSE (Δ_0) are called weak field ligands whereas those with large value of CFSE are called strong field ligands.

S12. In d^1 coordination entity, d^1 electron occupies t_{2g} orbitals. In d^2 and d^3 also, electrons occupy t_{2g} orbitals singly in accordance with the Hund's rule. For d^4 ions there are two possibilities. If Δ_0 is less than P (energy required for electron pairing in a single orbital) *i.e.*, in a weak field, the fourth electron enters one of the e_g orbitals giving $t_{2g}^3\, e_g^1$. Fifth electron also enters eg orbitals, *i.e.*, $t^3_{2g}\, e^2_g$.

When $\Delta_0 > P$, i.e., in strong field, low spin situation, pairing will occur in the t_{2g} level with e_g orbitals remaining unoccupied in d^1 to d^6 ions. Greater the Δ_0 value, greater the chances of pairing.

If $\Delta_0 > P$, the Electronic configuration is : $t_{2g}^6\, e_g^0$

If $\Delta_0 < P$, the Electronic configuration is : $t_{2g}^4\, e_g^2$



d-orbital splitting in an octahedral crystal field

Date: 23/10/2021

Q1. Among $[Ag(NH_3)_2]Cl$, $[Ni(CN)_4]^{2\ominus}$ and $[CuCl_4]^{2\ominus}$ which
(a) has square planar geometry?
(b) remains colourless in aqueous solutions and why?
[Atomic number of Ag = 47, Ni = 28, Cu = 29]

Q2. Deduce the shape and magnetic behaviour of the complex ion $[Co(NH_3)_5NO_2]^{2\oplus}$.
[Atomic number of Co = 27]

Q3. Using the valence bond approach, deduce the shape and magnetic behaviour of $[Cr(NH_3)_6]^{3\oplus}$ ion. [Atomic number of Cr = 24]

Q4. Using valence bond approach, deduce the shape and magnetic behaviour of $[Fe(CN)_6]^{4\ominus}$.
[Atomic number of Fe = 26]

Q5. Using the valence bond approach, predict the shape and magnetic behaviour of $[CoCl_4]^{2\ominus}$.
[Given atomic number of Co = 27]

Q6. Using the valence bond approach, deduce the shape and magnetic character of $[Co(NH_3)_6]^{3\oplus}$. [Atomic number of Co = 27]

Q7. Using the valence bond approach, predict the shape and magnetic character of $[Fe(CN)_6]^{3\ominus}$ ion. [Atomic number of Fe = 26]

Q8. The spin only magnetic moment of $[MnBr_4]^{2\ominus}$ is 5.9 BM. Predict the geometry of the complex ion.

Q9. Using valence bond approach, explain the shape and magnetic behaviour of $[Ni(NH_3)_6]^{2\oplus}$.
[Given atomic number of Ni = 28]

Q10. Using valence bond approach, predict the shape and magnetic character of:
(a) $[Ni(CO)_4]$ (b) $[NiCl_4]^{2\ominus}$ [Atomic number of Pt = 28]

Q11. Draw the structures and write the hybridised state of the central atom of each of the following species:
(a) $Fe(CO)_5$ (b) trans-$[Co(NH_3)_4Cl_2]^{\oplus}$ [Atomic number of Fe = 26, Co = 27]

Q12. Explain the following:
(a) $[Co(NH_3)_6]^{3\oplus}$ is diamagnetic, whereas $[CoF_6]^{3\ominus}$ is paramagnetic.
(b) $[Fe(H_2O)_6]$ is more paramagnetic than $[Fe(CN)_6]^{3\ominus}$.

Q13. Write the limitations of valence bond theory.

Q14. A solution of $[Ni(H_2O)_6]^{2+}$ is green but a solution of $[Ni(CN)_4]^{2-}$ is colourless. Explain.

Q15. Predict the number of unpaired electrons in the square-planar $[Pt(CN)_4]^{2-}$ ion.

Q16. Explain $[Co(NH_3)_6]^{3+}$ is an inner orbital complex whereas $[Ni(NH_3)_6]^{2+}$ is an outer orbital complex.

Q17. $[Fe(H_2O)_6]^{3+}$ **is strongly paramagnetic whereas** $[Fe(CN)_6]^{3-}$ **is weakly paramagnetic. Explain.**

Q18. $[NiCl_4]^{2-}$ **is paramagnetic while** $[Ni(CO)_4]$ **is diamagnetic through both are tetrahedral. Why?**

Date: 23/10/2021

S1. (a) $[Ni(CN)_4]^{2\ominus}$ has square planar geometry.

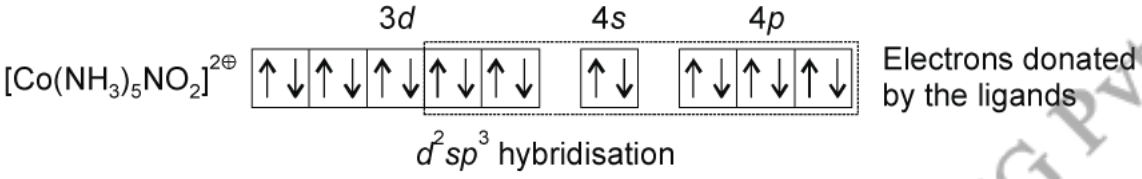
(b) $[Ag(NH_3)_2]Cl$ remains colourless in aqueous solution because $Ag^{\oplus}$ has not unpaired electron, therefore, it cannot undergo *d-d* transition.

$[Ni(CN)_4]^{2\ominus}$ also remains colourless as it does not have unpaired electrons.

S2. Co : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^7$.

$Co^{3\oplus}$ ion has outer electronic configuration : $4s^0\ 3d^6$.

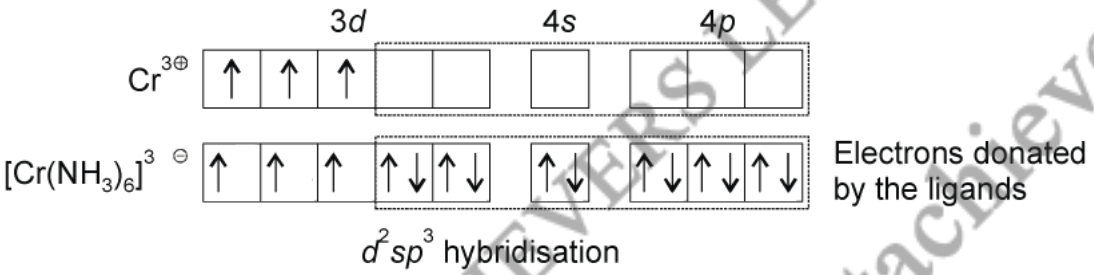
NH_3 causes pairing of electrons in d-orbital as shown below :



It has octahedral shape. It is diamagnetic because it does not have unpaired electrons.

S3. Cr has electronic configuration [Ar] $4s^1\ 3d^5$.

$Cr^{3\oplus}$ has electronic configuration [Ar] $4s^0\ 3d^3$.

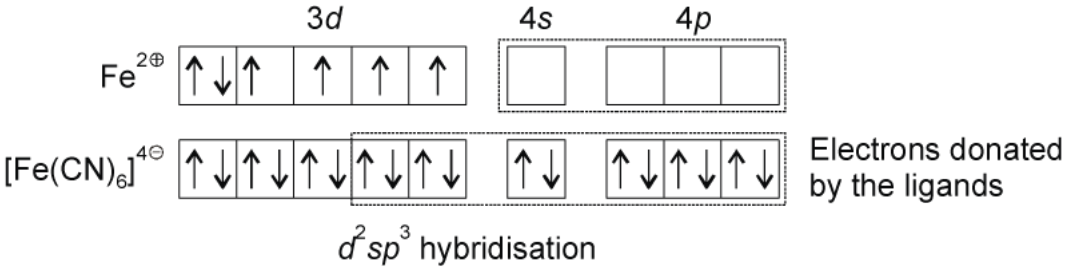


d^2sp^3 hybridisation gives octahedral shape. The complex is paramagnetic due to presence of unpaired electrons.

S4. Fe has electronic configuration [Ar] $4s^2\ 3d^6$.

'$Fe^{2\oplus}$ has electronic configuration $4s^0\ 3d^6$.

$CN^{\ominus}$ ion causes pairing of electrons because it is a strong field ligand. Hence,

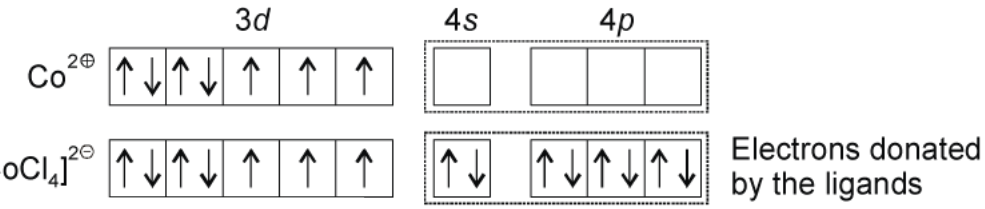


It has octahedral shape and is diamagnetic due to absence of unpaired electrons.

S5. Electronic configuration of Co: [Ar] $4s^2\,3d^7$.

Electronic configuration of $Co^{2\oplus}$: [Ar] $4s^0\,3d^7$.

$Cl^{\ominus}$ does not cause pairing of electrons because it is weak field ligand. Hence,

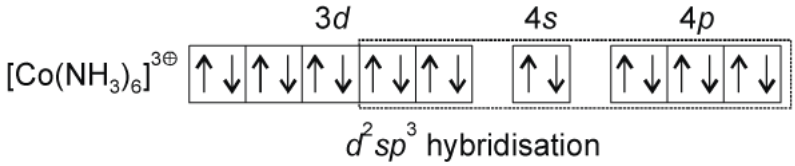


It has tetrahedral shape and is paramagnetic due to presence of three unpaired electrons.

S6. Electronic configuration of Co : [Ar] $4s^2\,3d^7$.

Electronic configuration of $Co^{3\oplus}$: [Ar] $4s^0\,3d^6$.

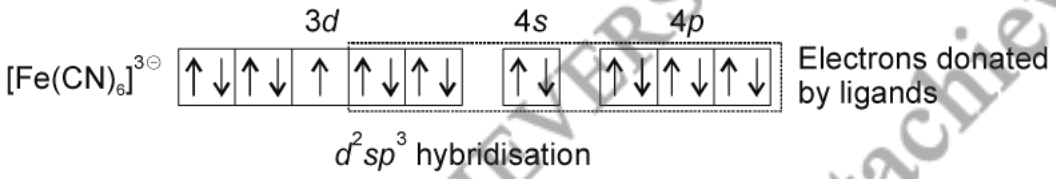
NH_3 is a strong field ligand, it will cause pairing of electrons. Hence,



It has octahedral shape and is diamagnetic due to the absence of unpaired electrons.

S7. Fe(26) : [Ar]$4s^2\,3d^6$, $Fe^{3\oplus}$: [Ar]$4s^0 3d^5$.

$CN^{\ominus}$ is strong field ligand, it will cause pairing of electrons.



It has octahedral shape and is paramagnetic in nature due to presence of one unpaired electrons.

S8. The coordination number of $Mn^{2\oplus}$ ion in the complex ion is 4. Therefore, it will be either tetrahedral (involving sp^3 hybridisation) or square planar (involving dsp^2 hybridisation).

Magnetic moment is 59.

$$\sqrt{n(n+2)} = 5.9$$

$$n(n+2) = 34.81$$

$$n^2 + 2n = 34.81$$

$$n^2 + 2n - 34.81 = 0$$

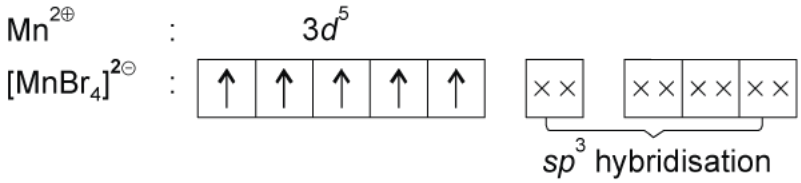
$$n = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$n = \frac{-2 \pm \sqrt{2^2 + 4 \times 1 \times 34.81}}{2 \times 1}$$

$$= \frac{\sqrt{-2 \pm (4 + 4 \times 34.81)}}{2}$$

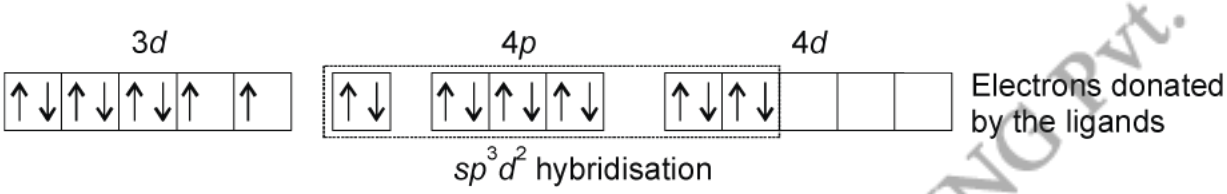
= 4.99 approx.

Since it has 5 unpaired electrons, this means that the 3*d* orbitals are not disturbed are sp^3 hybridisation occurs resulting tetrahedral structure of the complex.



S9. Electronic configuration of Ni: $4s^2\ 3d^8$.

Electronic configuration of $Ni^{2\oplus}$: $4s^0\ 3d^8$.



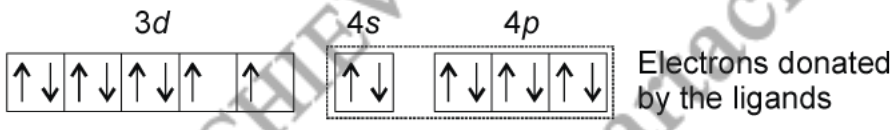
It has octahedral shape. It is paramagnetic due to the presence of two unpaired electrons.

S10. (a) **$[Ni(CO)_4]$**

Ni(28) : $4s^2\ 3d^8$, Ni(0) $3d^{10}$, CO is a strong field ligand, therefore, two 4*s* electrons are paired with 3*d* electrons, sp^3 hybridsation takes place

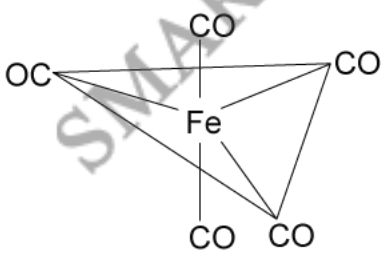
It has tetrahedral shape and is diamagnetic in nature.

(b) **$[NiCl_4]^{2\ominus}$:** $Ni^{2\oplus} : 4s^0\ 3d^8$



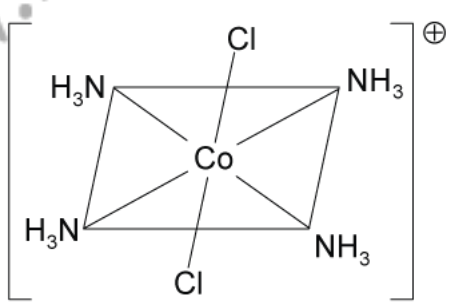
It is tetrahedral in shape and paramagnetic in nature due to the presence of two unpaired electrons.

S11. (a)



Trigonal bipyramidal
(dsp^3 hybridisation)

(b)



trans-$[Co(NH_3)_4Cl_2]^{\oplus}$
(d^2sp^3 hybridisation)

S12. (a) $[Co(NH_3)_6]$ is diamagnetic because NH_3 is strong field ligand. It causes pairing of electrons and no unpaired electrons are left. $[CoF_6]^{3\ominus}$ is paramagnetic because $F^{\ominus}$ is weak field ligand. It does not cause pairing of electrons and there are unpaired electrons left.

(b) $[Fe(H_2O)_6]^{3\oplus}$ has 5 unpaired electrons while $[Fe(CN)_6]^{3\ominus}$ has one unpaired electron. Therefore, $[Fe(H_2O)_6]$ is more paramagnetic than $[Fe(CN)_6]^{3\ominus}$.

S13. Valence bond theory suffers from the following shortcomings:

(a) It does not give quantitative interpretation of magnetic data.

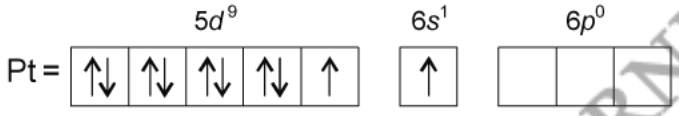
(b) It does not explain the colour shown by co-ordination compound.

(c) It does not give a quantitative interpretation of the thermodynamic or kinetic stabilities of co-ordination compound.

(d) It does not distinguish between weak and strong ligands.

S14. In both the complexes, Ni is in +2 state with the configuration $3d^8$, it has 2 unpaired electrons. In presence of the weak H_2O ligand, they do not pair up. These electrons undergoes *d-d* transition and shows colour. In presence of strong CN^- ligand, they pair up leaving no unpaired electron. Due to absence of unpaired electron complex is colourless.

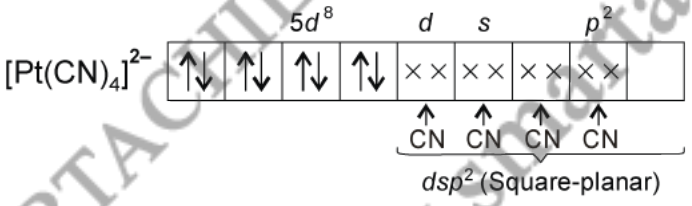
S15. $_{78}Pt$ lies in group 10 with the configuration $5d^9\,6s^1$.



In $[Pt(CN)_4]^{2-}$, the oxidation state of Pt = +2

Hence Pt^{2+} has the configuration d^8

Due to presence of CN (Strong ligand) the electrons of *d*-orbital start pairing.



For square-planar shape, the hybridisation is dsp^2. Hence, the unpaired electrons in 5*d* pair up to make one *d*-orbital empty for dsp^2 hybridisation. Thus, there is no unpaired electron. It has diamagnetic character.

S16. In $[Co(NH_3)_6]^{3+}$ Co is in +3 state with the configuration $3d^6$, In presence of NH_3, 3*d* electrons pair up leaving 3*d*-orbitals empty. Hence, the hybridisation is d^2sp^3 forming an inner orbital complex. In $[Ni(NH_3)_6]^{2+}$, Ni is in +2 state with configuration $3d^8$. In presence of NH_3, the 3*d* electron do not pair up. The hybridisation involved sp^3d^2 forming an outer orbital complex.

S17. In both the complexes, Fe is in +3 oxidation state with the configuration $3d^5$. CN^- is a strong ligand. In its presence, 3*d* electrons pair up leaving only one unpaired electron the hybridisation is d^2sp^3 forming inner orbital complex. H_2O is a weak ligand. In its presence 3*d* electrons do not pair up. The hybridisation is sp^3d^2 forming an outer orbital complex containing five unpaired electrons. Hence it is strongly paramagnetic.

S18. In $[NiCl_4]^{2-}$, Ni +2 oxidation state with the configuration $3d^8 4s^0$. We know that Cl^- is weak ligand. It cannot pair up the electrons in 3*d* orbital's. Hence it is paramagnetic. In $[Ni(CO)_4]$, Ni is in zero oxidation state with the configuration $3d^8 4s^2$. In the presence of CO ligand the 4*s* electrons shifts to 3*d* to pair up 3*d* electrons. Thus there is no unpaired electron present. Hence it is diamagnetic.

Date: 22/10/2021

Q1. $E^{\ominus}$ of some elements are given as:

$I_2 + 2e^- \longrightarrow 2I^{\ominus}$ $\quad E^{\ominus} = 0.54$ V

$MnO^{4\ominus} + 8H^{\oplus} + 5e^- \longrightarrow Mn^{2\oplus} + 4H_2O$, $\quad E^{\ominus} = 1.52$ V

$Fe^{3\oplus} + e^- \longrightarrow Fe^{2\oplus}$ $\quad E^{\ominus} = 0.77$ V

$Sn^{4\oplus} + 2e^- \longrightarrow Sn^{2\oplus}$ $\quad E^{\ominus} = 0.1$ V

(a) Select the strongest reductant and weakest oxidant among these elements.

(b) Select the weakest reductant and strongest oxidant among these elements.

Q2. The standard reduction potential of the reaction:

$$2H_2O + 2e^- \rightleftharpoons H_2(g) + 2OH^- \text{ is } -0.8277 \text{ V}$$

Calculate equilibrium constant for the reaction

$$2H_2O \rightleftharpoons H_2O^+ + OH^- \text{ at } 25^\circ C.$$

Q3. (a) Draw a neat diagram of standard hydrogen electrode.

(b) Describe the electrochemical phenomenon of rusting of iron.

Q4. (a) How long will it take an electric current of 0.15 A to deposit all the copper from 500 ml of 0.15 M copper sulphate solution?

(b) What is corrosion? What are the factors which affect corrosion? CO_2 is always present in natural water. Explain its effect (increases, stops or no effect) on rusting of Fe.

Q5. (a) What are secondary cells? Give the anode and cathode reaction of Nickel-Cadmium storage cell.

(b) What is disproportionation reaction? Calculate the equilibrium constant for the disproportionation of copper (I) ion in aqueous solution.

[Given $E^\circ_{Cu^{2+}/Cu} = +0.34$ V and $E^\circ_{Cu^+/Cu} = +0.52$ V]

Q6. (a) For the cell, $Mg|Mg^{2+}(aq)||Ag^+(aq)|Ag$, calculate the equilibrium constant at 25 °C and also the maximum work that can be obtained by operating the cell.

$$E^{\ominus}(Mg^{2+} | Mg) = -2.37 \text{ V and } E^{\ominus}(Ag^+ | Ag) = +0.80 \text{ V.}$$

(b) Explain the following in brief.

(i) What is the use of platinum foil in hydrogen electrode?

(ii) Electrolysis of fused KHF_2 gives fluorine at anode but hydrogen at cathode.

Q7. (a) How many coulombs of electricity are required for

(i) oxidation of 1 mol of H_2O to O_2 (ii) Oxidation of 1 mol of FeO to Fe_2O_3

(b) An aqueous sloution of an unknown salt of palladium is electrolysed by a current of 3.0 A passing for 1 hr. During electrolysis, 2.977 g of a palladium ions are reduced at the cathode. What is the charge on the palladium ions in solutions?

Date: 22/10/2021

S1. (a) Higher the positive value for oxidation potential, more is the tendency for oxidation and the element will act as a stronger reductant.

or

Lower the value for reduction potential, more is the tendency for oxidation and the element will act as a stronger reductant.

Maximum $E^{\ominus}_{oxid}$ (–0.1 V) or minimum $E^{\ominus}_{red}$(0.1 V) for $Sn^{2\oplus}$ to $Sn^{4\oplus}$.

Strongest reductant: $Sn^{2\oplus}$

Weakest oxidant: $Sn^{4\oplus}$

(b) $E^{\ominus}_{red}$ value (1.52 V) is highest for $MnO^{4\ominus}$ to $Mn^{2\oplus}$. More the tendency to undergo reduction and more the element will act as a stronger oxidant.

$\therefore$ Strongest oxidant: $MnO_4^{\ominus}$

Weakest reductant: $Mn^{2\oplus}$

S2. Consider the given reaction as the net cell reaction. Let us split it into two half cell reaction.

Oxidation half:

$$H_2O + \frac{1}{2}H_2(g) \longrightarrow H_3O^+ + e^-;\quad E^{\ominus}_{axi} = 0.00\,V \qquad \ldots (i)$$

(it refers to SHE)

Reduction half:

$$H_2O + e^- \longrightarrow \frac{1}{2}H_2(g) + OH^-;\quad E^{\ominus}_{Red} = -0.8277\,V \qquad \ldots (ii)$$

Add the two to get the net reaction:

Net cell reaction:

$$2H_2O \longrightarrow H_3O^+ + OH^-;\quad E^{\ominus}_{cell} = -0.8277\,V$$

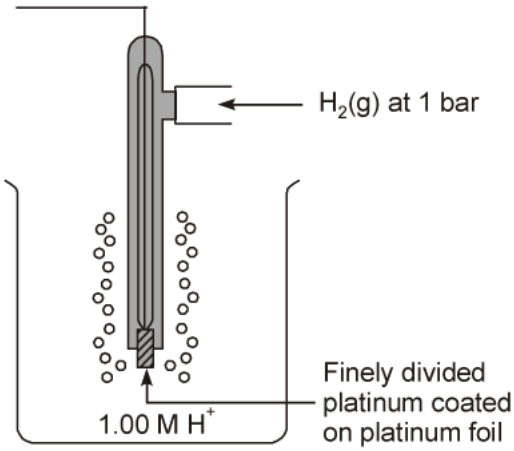
It is the evident from the cell reaction that it involve the transfer of one e^- so that $n = 1$.

Now, $$\log K_e = \frac{n}{0.059}E^{\ominus}_{cell} = \frac{1}{0.059}(-0.8277)$$

$$= -14.028$$

$$K_e = \text{antilog}\,(-14.028) = \mathbf{9.376 \times 10^{-15}}.$$

S3. (a)



(b) It is the process in which metal is oxidised by loss of electrons to other electronegative elements like oxygen, sulphur, etc., to form metal oxide and metal sulphide, respectively. Corrosion of iron occurs in presence of moisture and oxygen. It is an electrochemical phenomenon.

Oxidation: $Fe(s) \longrightarrow Fe^{2+}(aq) + 2e^-$

Reduction: $O_2(g) + 4H^+(aq) + 4e^- \longrightarrow 2H_2O(l)$

Atmospheric oxidation: $2Fe^{2+}(aq) + 2H_2O + \frac{1}{2}O_2(g) \longrightarrow Fe_2O_3(s) + 4H^+(aq)$

S4. (a) 500 mL of 0.15 M $CuSO_4$ solution contains $\frac{500 \times 0.15}{1000}$ = 0.075 mole of Cu

$$\text{Mass of Cu} = 0.075 \times 63.5 = 4.7625\,\text{g}$$

or $$\text{Eq. wt. of } Cu^{2+} = \frac{63.5}{2} = 31.75$$

Applying the following relation to calculate time

$$m = Z \times I \times t$$

or $$4.7625 = \frac{31.75}{96500} \times 0.15 \times t$$

or $$t = \frac{4.7625 \times 96500}{31.75 \times 0.15}$$

$$= 96500 \text{ seconds} = \frac{96500}{60 \times 60} = 26.80 \text{ hours.}$$

(b) Corrosion is a process in which metal reacts with substances present in atmosphere to form surface compounds. Air, moisture, presence of CO_2 are factors which affect corrosion. CO_2 increases rusting of iron because of the following reactions.

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

$$H_2CO_3 \longrightarrow 2H^+ + CO_3^{2-}$$

With increase in concentration of H^+, rusting increases.

S5. (a) Secondary cells are those cells which can be recharged by passing a direct current through them and can be used again as a source of electric current.

Nickel-Cadmium storage cell:

At anode

$$Cd(s) + 2OH^-(aq) \longrightarrow Cd(OH)_2(s) + 2e^- \quad \text{(Oxidation)}$$

At cathode

$$NiO_2(s) + 2H_2O(l) + 2e^- \longrightarrow Ni(OH)_2(s) + 2OH^- \quad \text{(Reduction)}$$

$$\text{overall} \quad Cd(s) + NiO_2(s) + 2H_2O(l) \longrightarrow Cd(OH)_2(s) + Ni(OH)_2(s)$$

(b) A process in which same substance undergoes oxidation as well as reduction process is called ***disproportionation reaction***.

The disproportionation of Cu^+ in aqueous solution can be represented as

$$Cu^+(aq) \rightleftharpoons Cu(s) + Cu^{2+}(aq) \quad E^\circ_{Cell} = ?$$

According to above date

$$2Cu^+(aq) + 2e^- \longrightarrow 2Cu(s) \qquad E^\circ_1 = 0.52\ V \qquad \ldots (i)$$

$$Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s) \qquad E^\circ_2 = 0.34\ V \qquad \ldots (ii)$$

The approximate value of E°_{Cell} can be obtained by subtracting Eq. (ii) from Eq. (i)

So
$$E^\circ_{Cell} = E^\circ_1 - E^\circ_2$$
$$= 0.52 - 0.34$$
$$= 0.18\,V$$

$$E^\circ_{Cell} = \frac{0.059}{n} \log K_C$$

$$\log K_C = \frac{2 \times 0.18}{0.059} \qquad (n = 2)$$

$$\log K_C = 6.10$$
$$K_C = \text{Antilog } (6.10)$$
$$= 1.23 \times 10^6.$$

S6. (a) The cell is:

$$Mg \mid Mg^{2+}(aq) \mid\mid Ag^+(aq) \mid Ag$$

The cell reaction is:

$$Mg(s) + 2Ag^+(aq) \longrightarrow Mg^{2+}(aq) + 2Ag(s)$$

Calculation of $E^{-\ominus}_{cell}$

$$E^{-\ominus}_{cell} = E^{-\ominus}\text{ (cathode)} - E^{-\ominus}\text{ (anode)}$$
$$= E^{-\ominus}\,(Ag^{+}\,|\,Ag) - E^{-\ominus}\,(Mg^{2+}\,|\,Mg)$$
$$= 0.80 - (-2.37) = \mathbf{3.17\,V}.$$

Calculation of equilibrium constant

$$\log K_c = \frac{nE_{cell}}{0.059} \text{ at } 298\text{ K}$$
$$n = 2, \quad E^{-\ominus}_{cell} = 3.17\text{ V}$$

$$\log K_c = \frac{2 \times 3.17}{0.059} = 107.457$$

$$\therefore \quad K_c = 2.56 \times 10^{107}$$

Calculation of maximum work that can be obtained from the cell. The maximum work obtained is equal to $\Delta G^{-\ominus}$ so that

$$\Delta G^{-\ominus} = -nF\,E^{-\ominus}_{cell}$$
$$n = 2, \quad F = 96500\,C, \quad E^{-\ominus}_{cell} = 3.17\text{ V}$$

$$\therefore \quad \Delta G^{-\ominus} = -2\ (96500\,C) \times (3.17\,V)$$
$$= -611810\,CV = -611810\,J \qquad (1\,CV = 1\,J)$$

$\therefore$ Maximum work obtained = **611.8 KJ**.

(b) (i) Pt absorb H_2 where it remains in contact with H^+ and thus, it provides surface at which exchange of electrons occurs.

(ii) $$KHF_2 \rightleftharpoons K^+ + F^- + HF$$

At cathode: $2K^+ + 2e^- \longrightarrow 2K$

$2K + 2HF \longrightarrow 2KF + H_2$

At anode: $2F^- \longrightarrow F_2 + 2e^-$.

S7. (a) (i) **Oxidation of H_2O to O_2**

$$2H_2O \rightleftharpoons 4H^+ + O_2 + 4e^-$$

Oxidation of 2 mol of H_2O require $= 4 \times 96500\,C$

Oxidation of 1 mol of H_2O requires $= 2 \times 96500\,C$

$= \mathbf{1.93 \times 10^5\,C}$.

(ii) **Oxidation of 1 mol of FeO to Fe_2O_3**

$$Fe^{2+} \longrightarrow Fe^{3+} + e^-$$

Oxidation of 1 mol of Fe^{2+} require $= 1 \times 96500\,C$

$= \mathbf{96500\,C}$.

(b) Quantity of electricity passed,

$$Q = I \times t$$

$$= 3.0 \times 1.0 \times 60 \times 60 = 10800\,C$$

Now, palladium ions are reduced at cathode as

Pd^{n+}	+	ne^-	$\longrightarrow$	Pd
1 mol		n-mol		1 mol (106.4 g)

n mol of electrons or $n \times 96500$ C produce 106.4 g of palladium. 96500 nC of current reduce palladium ions = 106.4 g

10800 C of current reduce palladium ions

$$= \frac{106.4\ g}{96500\ n} \times 10800$$

But amount of palladium ions reduced = 2.977 g

$$\therefore \quad \frac{106.4}{96500} \times \frac{10800}{n} = 2.977$$

or $$n = \frac{106.4 \times 10800}{96500 \times 2.977} = 4.0$$

$\therefore$ Palladium ions are Pd^{4+} or charge on palladium is + 4.