Class: 12th

Subject: Chemistry

Chapter 6: Transition Elements

🩸 Transition Elements & Compounds – Key MCQs

1. Transition elements are defined as elements having:

(a) Fully filled s and p-subshells

(b) Partially filled s or p-subshells

(c) Partially filled d or f-subshells ✅

(d) No unpaired electrons

2. Which groups are referred to as non-typical transition elements?

(a) IIA and IIIB

(b) IIB and IIIB ✅

(c) IB and IIA

(d) IIIA and IVB

3. Which property of transition metals increases with the number of unpaired electrons?

(a) Atomic mass

(b) Melting point ✅

(c) Density

(d) Ionic size

4. Compounds containing complex ions capable of independent existence are called:

(a) Ionic compounds

(b) Molecular compounds

(c) Coordination compounds ✅

(d) Covalent compounds

5. The colour of transition metal complexes arises due to:

(a) Nuclear reactions

(b) Absorption of ultraviolet light

(c) d-d transition of visible light ✅

(d) Loss of electrons from s-orbital

6. Wrought iron contains carbon in the range of:

(a) 0.25% - 2.5%

(b) 0.12% - 0.25% ✅

(c) 2% - 5%

(d) 0.5% - 1%

7. Steel contains carbon in the range of:

(a) 0.12% - 0.25%

(b) 0.25% - 2.25% ✅

(c) 2% - 4%

(d) 0.1% - 0.2%

8. Chromate and dichromate ions in aqueous solution:

(a) React to form water only

(b) Exist in equilibrium ✅

(c) Form a solid precipitate

(d) Oxidize immediately

9. The chemical decay of metals due to the action of surrounding medium is called:

(a) Oxidation

(b) Rusting

(c) Corrosion ✅

(d) Combustion

10. Which of the following methods prevent corrosion of metals?

(a) Tin plating and galvanizing ✅

(b) Heating and cooling

(c) Adding water

(d) Mixing with acids

🩸 Important MCQs:

1. Transition elements are those which have ________.

(a) Completely filled d-subshells

(b) Completely filled f-subshells

(c) Partially filled d or f-subshells ✅

(d) Empty s-subshells

2. Transition elements are located between ________.

(a) s-block and f-block

(b) p-block and f-block

(c) s-block and p-block ✅

(d) p-block and d-block

3. The properties of transition elements are in transition between ________.

(a) Metals and nonmetals ✅

(b) Gases and liquids

(c) Solids and gases

(d) Lanthanides and actinides

4. Chromium and copper show irregular electronic configurations due to ________.

(a) Magnetic effect

(b) Half-filled and fully filled d-subshell stability ✅

(c) Presence of f-electrons

(d) High atomic masses

5. Which of the following groups contain non-typical transition elements?

(a) Group IVB and VB

(b) Group VIB and VIIB

(c) Group IIB and IIIB ✅

(d) Group VIIIB and IB

6. Why are Zn, Cd, and Hg called non-typical transition elements?

(a) They are nonmetals

(b) They do not have partially filled d-subshells ✅

(c) They have high atomic weights

(d) They are radioactive

7. The coinage metals Cu, Ag, and Au are treated as transition metals because ________.

(a) They are good conductors

(b) Their ions have partially filled d-subshells ✅

(c) They are precious metals

(d) They form alloys

8. The f-block elements are also known as ________.

(a) Outer transition elements

(b) Main group elements

(c) Inner transition elements ✅

(d) Alkali metals

9. In Scandium (Sc^{3+}), there are no d-electrons because ________.

(a) All d-electrons are paired

(b) The atom loses its only one d-electron ✅

(c) The d-subshell is overfilled

(d) It gains extra s-electrons

10. The d-block elements are called ________.

(a) Inner transition elements

(b) Outer transition elements ✅

(c) Main group elements

(d) Halogens

11. Transition elements are mostly ________.

(a) Non-metals

(b) Metalloids

(c) Metals in true sense ✅

(d) Radioactive elements

12. Which of the following transition metals are important industrially?

(a) Na, K, Ca

(b) Ti, Fe, Cr, Ni, Cu ✅

(c) B, Si, Ge

(d) He, Ne, Ar

13. Transition metals are generally ________.

(a) Soft and brittle

(b) Hard and strong with high melting points ✅

(c) Low density and weak

(d) Poor conductors of electricity

14. Transition metals show variable valency because ________.

(a) They have only s-electrons

(b) d-electrons also take part in bonding ✅

(c) They are non-metals

(d) They have filled p-orbitals

15. Most transition metal ions and compounds are ________.

(a) Colourless

(b) Coloured ✅

(c) Transparent

(d) White solids

16. The toughness and strength of transition metals are due to ________.

(a) Ionic bonding

(b) Weak metallic bonding

(c) Strong metallic binding involving d-electrons ✅

(d) Hydrogen bonding

17. Binding energy in transition metals is strongest up to ________.

(a) Group IIB

(b) Group VIB ✅

(c) Group IIIB

(d) Group IVB

18. In the first transition series, increase in binding energy ends at ________.

(a) Titanium

(b) Vanadium ✅

(c) Chromium

(d) Manganese

19. Transition metals have high melting and boiling points because ________.

(a) They are gases at room temperature

(b) They have strong metallic bonding ✅

(c) They have weak Van der Waals forces

(d) They are non-conductors

20. Melting points of transition metals ________.

(a) Remain constant

(b) Increase to the middle and then decrease ✅

(c) Decrease continuously

(d) Increase continuously

21. Covalent radii of transition metals ________.

(a) Increase throughout the series

(b) Decrease rapidly, then become constant, then increase ✅

(c) Remain unchanged

(d) Fluctuate randomly

22. The increase in covalent radii at the end of the series is due to ________.

(a) Shielding by 3d electrons ✅

(b) Increase in nuclear charge

(c) Addition of p-electrons

(d) Loss of s-electrons

23. Substances weakly attracted by a magnetic field are called ________.

(a) Diamagnetic

(b) Paramagnetic ✅

(c) Ferromagnetic

(d) Antimagnetic

24. Paramagnetism arises due to the presence of ________.

(a) Paired electrons

(b) Unpaired electrons ✅

(c) Protons in nucleus

(d) Neutrons

25. The strongest paramagnetism is shown by ________.

(a) Cu^{2+} and Zn^{2+}

(b) Fe^{3+} and Mn^{2+} ✅

(c) Co^{2+} and Ni^{2+}

(d) Cr^{3+} and Ti^{3+}

26. Transition elements show variable oxidation states because ________.

(a) They have multiple unpaired d-electrons ✅

(b) They are gases

(c) They have filled d-subshell

(d) They are nonmetals

27. +2 oxidation state in transition elements arises due to _________.

(a) Involvement of 2s-electrons only ✅

(b) Involvement of d-electrons only

(c) Loss of p-electrons

(d) Gain of electrons

28. The colour in transition metal compounds is due to _________.

(a) Absorption of visible light by d–d transition ✅

(b) Presence of s-electrons

(c) Reflection of UV rays

(d) Formation of ionic bonds

29. In $[Ti(H_2O)_6]^{3+}$ ion, yellow light is absorbed and the solution appears ________.

(a) Blue

(b) Green

(c) Violet ✅

(d) Red

30. Interstitial compounds are formed when ________.

(a) Non-metals enter the interstices of metal lattices ✅

(b) Metals form oxides

(c) Electrons occupy higher orbitals

(d) Alloys are dissolved in acids

31. The compound formed by mixing aqueous solutions of $Fe(CN)_2$ and KCN is ________.

(a) $Fe(CN)_6$

(b) $K_4[Fe(CN)_6]$ ✅

(c) FeK_6CN_6

(d) $[Fe(CN)_4]K_2$

32. Compounds containing complex ions capable of independent existence are called ________.

(a) Double salts

(b) Ionic compounds

(c) Coordination compounds ✅

(d) Molecular compounds

33. In the complex $K_4[Fe(CN)_6]$, Fe^{2+} is the ________.

(a) Ligand

(b) Central metal ion ✅

(c) Coordination sphere

(d) Counter ion

34. Ligands are species that ________.

(a) Accept electrons from central metal ion

(b) Donate electron pairs to the central metal ion ✅

(c) Always carry positive charge

(d) Never form bonds

35. The coordination number of Fe in $K_4[Fe(CN)_6]$ is ________.

(a) 2

(b) 4

(c) 6 ✅

(d) 8

36. The purest form of commercial iron is:

(a) Pig iron

(b) Wrought iron ✅

(c) Cast iron

(d) Steel

37. Wrought iron contains carbon up to:

(a) 0.3% ✅

(b) 1.5%

(c) 2.5%

(d) 4.5%

38. The process used for the manufacture of wrought iron from cast iron is:

(a) Bessemer’s process

(b) Puddling process ✅

(c) Open hearth process

(d) Electrolytic process

39. The furnace used in the puddling process is lined with:

(a) Dolomite

(b) Silica

(c) Haematite ✅

(d) Limestone

40. Steel contains carbon in the range of:

(a) 0.12–0.25%

(b) 0.25–2.5% ✅

(c) 2.5–4.5%

(d) 4.5–6.5%

41. Mild steel is used in making:

(a) Rails and axles

(b) Hammers and dies

(c) Tubes, nuts and bolts ✅

(d) Cutting tools

42. High carbon steel is used in making:

(a) Boiler plates

(b) Cutting tools and machine parts ✅

(c) Axles and rails

(d) Bolts and nuts

43. The most modern method for the manufacture of steel is:

(a) Puddling process

(b) Bessemer’s process

(c) Open hearth process ✅

(d) Blast furnace process

44. The furnace with basic lining (CaO, MgO) is used when impurities are:

(a) Silicon and manganese

(b) Phosphorus and sulphur ✅

(c) Carbon and oxygen

(d) Iron oxides

45. The furnace used in Bessemer's process is called:

(a) Reverberatory furnace

(b) Bessemer's converter ✅

(c) Blast furnace

(d) Cupola furnace

46. The process of chemical decay of metals due to the action of surrounding medium is called:

(a) Reduction

(b) Corrosion ✅

(c) Oxidation

(d) Sublimation

47. According to electrochemical theory, corrosion is promoted by:

(a) Pure metals

(b) Impurities present in metals ✅

(c) Polishing the metal surface

(d) Absence of moisture

48. When aluminium comes in contact with copper, aluminium:

(a) Remains intact

(b) Acts as a cathode

(c) Gets corroded rapidly ✅

(d) Becomes less reactive

49. In tin plating, when the tin coating is damaged, iron:

(a) Remains protected

(b) Gets rusted more rapidly ✅

(c) Becomes passive

(d) Does not react with moisture

50. In galvanizing, zinc acts as:

(a) Cathode

(b) Anode ✅

(c) Neutral metal

(d) Inert coating

51. Chromates and dichromates are salts of which acids respectively?

(a) Chromous acid and dichromous acid

(b) Chromic acid and dichromic acid ✅

(c) Hydrochloric acid and sulphuric acid

(d) Nitric acid and acetic acid

52. The colour of most chromates is:

(a) Green

(b) Blue

(c) Yellow ✅

(d) Red

53. Potassium dichromate ($K_2Cr_2O_7$) is converted from potassium chromate (K_2CrO_4) by adding:

(a) Base

(b) Acid ✅

(c) Salt

(d) Ammonia

54. Potassium dichromate acts as a strong:

(a) Reducing agent

(b) Oxidizing agent ✅

(c) Neutral compound

(d) Complexing agent

55. When potassium dichromate reacts with hydrogen sulphide, sulphur is formed along with:

(a) K_2SO_4

(b) $Cr_2(SO_4)_3$ ✅

(c) $FeSO_4$

(d) Na_2SO_4

56. Chromyl chloride (CrO_2Cl_2) is obtained when $K_2Cr_2O_7$ is heated with:

(a) NaCl and H_2SO_4 ✅

(b) KCl and HNO_3

(c) Na_2SO_4 and HCl

(d) NaOH and H_2O

57. The colour of potassium dichromate crystals is:

(a) Yellow

(b) Orange-red ✅

(c) Purple

(d) Green

58. Potassium permanganate ($KMnO_4$) is prepared by oxidizing potassium manganate (K_2MnO_4) using:

(a) HCl gas

(b) Cl_2 gas ✅

(c) CO_2 gas

(d) NH_3 gas

59. The colour of potassium permanganate crystals is:

(a) Green

(b) Deep purple ✅

(c) Orange

(d) Yellow

60. $KMnO_4$ is used as:

(a) Reducing agent

(b) Disinfectant ✅

(c) Acid-base indicator

(d) Precipitating agent

🩸 Transition Elements & Compounds – Key Short Questions

1. What are transition elements?

Answer:

👉 Transition elements are those elements which have partially filled d or f-subshells in their atomic state or in any of their commonly occurring oxidation states.

2. Which elements are called non-typical transition elements?

Answer:

👉 Group IIB and IIIB elements are called non-typical transition elements as they do not show all typical properties of transition elements.

3. How do binding energies, melting points, and paramagnetism vary in transition metals?

Answer:

👉 Binding energies, melting points, paramagnetism, and oxidation states of transition metals increase with the number of unpaired electrons.

4. What are coordination compounds?

Answer:

👉 Compounds containing complex molecules or complex ions capable of independent existence are called coordination compounds or complex compounds.

5. How do transition metal complexes show colour?

Answer:

👉 When a complex ion absorbs a wavelength of visible light, it transmits the remaining radiation, which imparts colour to the complex.

6. What is the carbon content of wrought iron and steel?

Answer:

👉 Wrought iron contains 0.12% - 0.25% carbon, while steel contains 0.25% - 2.25% carbon.

7. What is the relationship between chromate and dichromate ions in solution?

Answer:

👉 Chromate and dichromate ions exist in equilibrium in an aqueous solution, and the equilibrium shifts with changes in acidity.

8. What is corrosion and how can it be prevented?

Answer:

👉 Corrosion is the chemical decay of metals due to their surrounding medium. It can be prevented by tin plating or galvanizing.

🩸 Important Short Questions:

1. Define transition elements.

Answer:

👉 Transition elements are those elements which have partially filled d or f-subshells in atomic state or in any of their commonly occurring oxidation states.

2. Why are d-block and f-block elements called transition elements?

Answer:

👉 They are located between s and p-block elements, and their properties are intermediate (in transition) between metallic elements of the s-block and nonmetallic elements of the p-block.

3. What is the electronic configuration exception in chromium and copper?

Answer:

👉 In chromium, one electron from s-subshell moves to half-fill the d-subshell; in copper, one electron from s-subshell moves to fully fill the d-subshell, giving extra stability.

4. Which groups of elements are called non-typical transition elements?

Answer:

👉 Group IIB (Zn, Cd, Hg) and group IIIB (Sc, Y, La) elements, as they do not show most properties of typical transition elements.

5. Why are Cu, Ag, and Au considered transition metals despite exceptions?

Answer:

👉 Because Cu^{2+} has 3d configuration, Ag^{+} has 4d, and Au^{3+} has 5d configuration, allowing them to show typical transition metal properties.

6. Why do transition metals show high melting and boiling points?

Answer:

👉 Due to strong metallic binding between atoms involving outer s-electrons and unpaired d-electrons.

7. Explain the trend of binding energies in transition metals.

Answer:

👉 Binding energies increase up to group VIB due to more unpaired electrons, then decrease towards group IIB as electrons pair up.

8. How do covalent and ionic radii change across the transition series?

Answer:

👉 Covalent radii decrease at the start, become constant, then slightly increase at the end. Ionic radii changes are less regular.

9. Define paramagnetism and diamagnetism in transition metals.

Answer:

👉 **Paramagnetism:** Attraction by magnetic field due to unpaired electrons.

👉 **Diamagnetism:** Repulsion by magnetic field due to all electrons being paired.

10. Which ions show the strongest paramagnetic behavior in the first transition series?

Answer:

👉 Fe^{3+} and Mn^{2+} ions, each having 5 unpaired electrons.

11. Why do transition metals exhibit variable oxidation states?

Answer:

👉 Unpaired d-electrons, along with s-electrons, participate in bonding, leading to multiple oxidation states.

12. Explain the role of d-d transitions in the color of transition metal compounds.

Answer:

👉 d-orbitals split into two energy levels; electrons absorb specific wavelengths of visible light and jump to higher levels, transmitting the rest, which gives color.

13. What are interstitial compounds?

Answer:

👉 Compounds formed when small non-metal atoms (H, B, C, N) occupy interstices of transition metals, enhancing properties like hardness and strength.

14. How do transition metals form alloys? Give examples.

Answer:

👉 Similar-sized atoms replace one another in metallic lattices, forming substitutional alloys. Examples: alloy steels, brass, bronze, coinage alloys.

15. Why are transition metals generally hard and strong?

Answer:

👉 Strong metallic bonding from s and unpaired d electrons makes them tough, malleable, and ductile.

16. Define a complex compound.

Answer:

👉 Compounds containing complex molecules or complex ions capable of independent existence are called coordination compounds or complexes.

17. What is a central metal ion in a complex compound?

Answer:

👉 A metal atom or ion (usually a transition element) surrounded by ligands is called a central metal ion, e.g., Fe^{2+} in $K_4[Fe(CN)_6]$.

18. Define ligand and give examples.

Answer:

👉 Ligands are atoms, ions, or neutral molecules that donate electron pairs to the central metal ion. Examples: CN^- (anionic ligand), NH_3 (neutral ligand).

19. What is the coordination number?

Answer:

👉 The number of lone electron pairs donated by ligands to the central metal ion is called the coordination number, e.g., 6 for Fe in $K_4[Fe(CN)_6]$.

20. What are chelates and why are they more stable?

Answer:

👉 Chelates are complexes in which polydentate ligands form one or more rings with the central metal ion. They are more stable due to ring formation.

21. Name the important ores of iron.

Answer:

👉 The important ores of iron are magnetite (Fe_3O_4), haematite (Fe_2O_3), and limonite ($Fe_2O_3{\cdot}3H_2O$).

22. What are the commercial forms of iron? Give their carbon contents.

Answer:

👉 **Commercial forms of iron:**

1. Pig iron or cast iron ⟶ 2.5–4.5% C

2. Wrought iron ⟶ 0.12–0.25% C

3. Steel ⟶ 0.25–2.5% C

23. Describe wrought iron and its manufacture.

Answer:

👉 **Wrought iron** is the purest form of commercial iron with low carbon (0.12–0.25%) and minor impurities.

👉 **Manufactured** from cast iron by puddling in a reverberatory furnace. Impurities are oxidized and removed as slag. The semi-solid metal is hammered to remove slag completely.

24. Classify steel and mention their uses.

Answer:

👉 **Mild steel** (0.1–0.2% C): soft, malleable ⟶ tubes, bolts, bars.

👉 **Medium carbon steel** (0.2–0.7% C): harder → rails, axles, castings.

👉 **High carbon steel** (0.7–1.5% C): hard, used for cutting tools, hammers, machine parts.

25. Mention two methods of steel manufacture.

Answer:

👉 **1. Open hearth process:** uses cast iron, scrap steel, quick lime; removes impurities via oxidation and forms steel.

👉 **2. Bessemer's process:** uses molten pig iron in a converter; hot air oxidizes C, Si, Mn; ferromanganese is added to adjust carbon content.

26. Define corrosion.

Answer:

👉 Corrosion is the chemical decay of metals due to the action of their surrounding medium.

27. What is the simplest case of corrosion?

Answer:

👉 When metals come in contact with atmospheric gases, their surfaces form oxides, sulphides, or carbonates. These may form a protective layer, preventing further corrosion.

28. Explain the electrochemical theory of corrosion.

Answer:

👉 Impurities accelerate corrosion. When two different metals (e.g., Al and Cu) are in moist air, a galvanic cell is formed. The more active metal (Al) acts as anode, loses electrons, and corrodes. The less active metal (Cu) acts as cathode and remains intact.

29. Mention some methods to prevent corrosion.

Answer:

👉 **Corrosion can be prevented by:**

1. Coating the metal with oil, paint, varnish, or enamel.

2. Alloying the metals.

3. Coating the metal with a thin layer of another metal (e.g., tin or zinc).

30. Differentiate between tin plating and galvanizing.

Answer:

👉 **Tin plating (cathode coating):** Iron is coated with molten tin; tin protects iron as long as coating is intact.

👉 **Galvanizing (anode coating):** Iron is coated with zinc; zinc acts as sacrificial anode, protecting iron even if coating is damaged.

31. Define chromates and dichromates.

Answer:

👉 Chromates are salts of chromic acid (H_2CrO_4), and dichromates are salts of dichromic acid ($H_2Cr_2O_7$). Both acids exist only in aqueous solution, but their salts are stable.

32. How is potassium chromate (K_2CrO_4) prepared?

Answer:

👉 By oxidizing trivalent chromium compounds in the presence of an alkali, or by fusing Cr_2O_3 with alkali and an oxidizing agent, or from chromite ore using potassium carbonate and oxygen.

33. Explain the equilibrium between chromate and dichromate ions.

Answer:

👉 In aqueous solution, CrO_4^{2-} (yellow) and $Cr_2O_7^{2-}$ (orange-red) ions exist in equilibrium. Adding acid shifts the equilibrium to form dichromate ions, while adding alkali shifts it to chromate ions.

34. How is potassium dichromate ($K_2Cr_2O_7$) prepared?

Answer:

👉 By acidifying potassium chromate solution, which converts chromate ions into dichromate ions. It can also be prepared by reacting sodium dichromate with KCl.

35. Mention some important properties of potassium dichromate.

Answer:

👉 Orange-red crystalline solid, soluble in water, powerful oxidizing agent, oxidizes H_2S, $FeSO_4$, and KI, and forms chromyl chloride with metal chlorides.

36. What are the uses of potassium dichromate?

Answer:

👉 Used in dyeing, leather industry for chrome tanning, and as an oxidizing agent.

37. How is potassium permanganate ($KMnO_4$) prepared on a large scale?

Answer:

👉 By fusing MnO_2 with KOH in the presence of air or an oxidizing agent to form K_2MnO_4, then converting it to $KMnO_4$ using Stadeler's process, CO_2 oxidation, or electrolytic oxidation.

38. Describe some physical properties of potassium permanganate.

Answer:

👉 Dark purple lustrous crystals, deep pink solution, soluble in water (7% at 20°C, 25% at 63°C), powerful oxidizing agent.

39. Write reactions of $KMnO_4$ with H_2S, $FeSO_4$, and oxalic acid.

Answer:

👉 **With H_2S:** Oxidizes H_2S to S.

With $FeSO_4$: Oxidizes Fe^{2+} to Fe^{3+}.

With oxalic acid: Oxidizes $C_2O_4^{2-}$ to CO_2.

40. Mention the uses of potassium permanganate.

Answer:

👉 Used as an oxidizing agent, disinfectant, germicide, and in the manufacture of many organic compounds.

🩸 Exercise

Q1. Fill in the blanks:

(i) The property of paramagnetism is due to the presence of ______ electrons.

Answer: unpaired ✅

(ii) MnO_4^- ion has ______ colour and $Cr_2O_7^{2-}$ has ______ colour.

Answer: purple, orange ✅

(iii) When potassium chromate is treated with an acid ______ is produced.

Answer: potassium dichromate ✅

(iv) The d-block elements are located between ______ and ______ block elements.

Answer: s-block, p-block ✅

(v) Oxidation number of Fe in $K_4[Fe(CN)_6]$ is ______ while in $K_3[Fe(CN)_6]$ it is ______

Answer: +2, +3 ✅

(vi) The presence of ______ in a metal promotes corrosion.

Answer: impurities ✅

(vii) If copper is in contact with aluminium ______ gets corroded.

Answer: aluminium ✅

(viii) Complexes having sp^3d^2 hybridization have ______ shape.

Answer: octahedral ✅

(ix) In naming the complexes, all the ligands are named in ______

Answer: alphabetical order ✅

(x) In an aqueous solution, CrO_4^{2-} and $Cr_2O_7^{2-}$ exist in the form of ______

Answer: equilibrium mixture ✅

Q2. Indicate True or False:

(i) A substance which is attracted into a magnetic field is said to be diamagnetic.

Answer: False ❌ (It is paramagnetic)

(ii) Compounds of the transition elements are mostly coloured.

Answer: True ✅

(iii) Fe^{3+} ions are blue when hydrated.

Answer: False ❌ (They are yellow or brownish)

(iv) An extreme case of paramagnetism is called diamagnetism.

Answer: False ❌ (They are opposite phenomena)

(v) Tin plating is used to protect iron sheets from corrosion.

Answer: True ✅

(vi) In galvanizing, zinc prevents corrosion of iron.

Answer: True ✅

(vii) Tin plated iron gets rusted more rapidly when the protective coating is damaged than the unplated iron.

Answer: True ✅

(viii) The name of anionic ligands in a complex ends in suffix 'O'.

Answer: True ✅

(ix) Pig iron contains greater percentage of carbon than steel.

Answer: True ✅

(x) Complex compounds having dsp^2 hybridization have tetrahedral geometry.

Answer: False ❌ (They have square planar geometry)

🩸 Q 3. Multiple choice questions. Encircle the correct answer.

1. Which of the following is a non-typical transition element?

(a) Cr

(b) Mn

(c) Zn ✅

(d) Fe

2. Which of the following is a typical transition metal?

(a) Sc

(b) Y

(c) Ra

(d) Co ✅

3. f-block elements are also called:

(a) Non-typical transition elements

(b) Outer transition elements ✅

(c) Normal transition elements

(d) None is true

4. The strength of binding energy of transition elements depends upon:

(a) Number of electron pairs

(b) Number of unpaired electrons ✅

(c) Number of neutrons

(d) Number of protons

5. Group VIB of transition elements contains:

(a) Zn, Cd, Hg

(b) Fe, Ru, Os

(c) Cr, Mo, W ✅

(d) Mn, Tc, Re

6. The formula of tetraammine chloro-nitro-platinum (IV) sulphate is:

(a) $[Pt(NH_3)_4(NO_2)]SO_4$

(b) $[Pt(NO_2)_2Cl(NH_3)_4]SO_4$

(c) $[PtCl(NO_2)(NH_3)_5]SO_4$

(d) $[Pt(NH_3)_4(NO_2)Cl]SO_4$ ✅

7. The percentage of carbon in different types of iron products is in the order of:

(a) Cast iron > Wrought iron > Steel

(b) Wrought iron > Steel > Cast iron

(c) Cast iron > Steel > Wrought iron ✅

(d) Cast iron steel > Wrought iron

8. The colour of transition metal complexes is due to:

(a) d–d transition of electrons ✅

(b) Paramagnetic nature of transition elements

(c) Ionization

(d) Loss of s-electrons

9. Coordination number of Pt in $[PtCl(NO_2)(NH_3)_2]$ is:

(a) 2

(b) 4 ✅

(c) 1

(d) 6

10. The total number of transition elements is:

(a) 10

(b) 14

(c) 40 ✅

(d) 58

🌟 Q4. How does the electronic configuration of valence shell affect the following properties of the transition elements?

❖ Introduction:

- **Transition elements** are those which have partially filled d-orbitals in their atoms or ions.
- **Their general electronic** configuration is $(n-1)d^{1-10}\ ns^{0-2}$.
- **This special arrangement** of electrons in both d and s orbitals of the valence shell is responsible for their characteristic properties such as strong metallic bonding, paramagnetism, high melting points, and variable oxidation states.

(a) Binding Energy

- **The binding energy** of a metal refers to the strength with which its atoms are held together in the metallic crystal.
- **In transition metals**, the number of unpaired d-electrons determines the strength of metallic bonding.

- **When there** are more **unpaired electrons,** stronger d–d overlap occurs between neighboring atoms, resulting in greater cohesive force and higher binding energy.

For example, elements like chromium ($3d^5$ $4s^1$) and manganese ($3d^5$ $4s^2$) have high binding energy because they possess several unpaired d-electrons.

On the other hand, zinc ($3d^{10}$ $4s^2$), which has completely filled orbitals, has weak metallic bonds and thus low binding energy.

(b) Paramagnetism

- **Paramagnetism** is the property of being attracted by a magnetic field and is due to the presence of unpaired electrons in the d-orbitals of transition elements.
- **Each unpaired electron** possesses a magnetic moment due to its spin. The total magnetic moment of an atom or ion is determined by the number of unpaired electrons (n) using the formula:

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

For instance, Fe^{2+} ($3d^6$) has four unpaired electrons and is strongly paramagnetic, while Zn^{2+} ($3d^{10}$) has no unpaired electrons and is therefore diamagnetic (repelled by a magnetic field).

(c) Melting Points

- **Transition metals** generally have high melting and boiling points compared to s-block elements.
- **This is because** of strong **metallic bonding** caused by the presence of **unpaired d-electrons**, which form a “sea of delocalized electrons.”
- **As the number** of unpaired electrons increases, the strength of metallic bonding also increases, resulting in higher melting points.
- The **melting points** of transition elements first increase up to the middle of the d-series and then decrease toward the end, as the d-orbitals gradually become filled and metallic bonding weakens.

For example, chromium (Cr) and tungsten (W) have some of the highest melting points among all transition metals due to maximum unpaired electrons and strongest metallic bonds.

(d) Oxidation States

- **One of the most** important characteristics of transition elements is their ability to show variable oxidation states.
- **This is due** to the small energy difference between (n–1)d and ns orbitals, which allows electrons from both shells to take part in bonding.

As a result, transition metals can lose different numbers of electrons to form ions with different oxidation numbers.

For example, iron (Fe) shows both +2 and +3 oxidation states, while manganese (Mn) can exhibit oxidation states from +2 to +7.

However, zinc (Zn), with a completely filled $3d^{10}$ configuration, shows only one oxidation state (+2) because its d-orbitals are stable and do not easily lose electrons.

✦ **Summary:**

- **In summary,** the valence shell electronic configuration plays a crucial role in determining the physical and chemical properties of transition elements.
- A **greater number of** unpaired d-electrons leads to higher binding energy, stronger metallic bonds, greater paramagnetism, and higher melting points.
- The **small energy gap** between ns and (n−1)d orbitals allows these elements to show variable oxidation states.

Thus, most of the unique behaviors of transition metals arise directly from the structure and arrangement of electrons in their valence shells.

🌟 Q5. Explain the following terms giving examples.

(a) Ligands

❖ Definition:

- **Ligands are** ions or neutral molecules that surround the central metal atom or ion and donate a pair of electrons to it for bond formation.
- **Ligands act** as Lewis bases (electron pair donors), while the central metal atom/ion acts as a Lewis acid (electron pair acceptor).

Examples:

In the complex $K[Fe(CN)_6]$, the CN^- ions act as ligands.

In $[Ag(NH_3)_2]Cl$, the NH_3 molecules act as ligands.

Types of Ligands:

1. Monodentate (Unidentate) — Donate one lone pair (e.g., Cl^-, H_2O, NH_3).

2. Bidentate (Didentate) — Donate two lone pairs (e.g., $C_2O_4^{2-}$, ethylenediamine).

3. Polydentate — Donate more than two lone pairs (e.g., $EDTA^{4-}$).

(b) Coordination Sphere

❖ **Definition:**

- **The coordination** sphere consists of the central metal atom or ion and the ligands directly attached to it.
- **It represents** the portion of a complex compound enclosed within square brackets [ ].

Explanation:

- **Atoms or** ions inside the brackets are tightly bound and behave as a single unit, while those outside the brackets are ionic counterparts.

Examples:

- In $K[Fe(CN)_6]$, the coordination sphere is $[Fe(CN)_6]^{4-}$.
- In $[Cu(NH_3)_4]SO_4$, the coordination sphere is $[Cu(NH_3)_4]^{2+}$.

(c) Substitutional Alloy

❖ **Definition:**

- A substitutional alloy is formed when atoms of one metal replace the atoms of another metal in its crystal lattice.
- This happens when both metals have similar atomic sizes and crystal structures.

Explanation:

- The metal atoms mix uniformly and occupy the same positions in the metallic structure, resulting in a homogeneous solid solution.

Examples:

- Brass (Cu + Zn)
- Bronze (Cu + Sn)
- German silver (Cu + Zn + Ni)

These alloys are harder, more corrosion-resistant, and stronger than pure metals.

(d) Central Metal Atom (or Ion)

❖ Definition:

The central metal atom or ion is the main component of a coordination compound around which ligands are arranged.

Explanation:

- It acts as a Lewis acid by accepting electron pairs from ligands. Usually, transition metals serve as central atoms because they have vacant d-orbitals to accept electrons.

Examples:

In $K[Fe(CN)_6]$, Fe^{2+} is the central metal ion.

In $[Ag(NH_3)_2]Cl$, Ag^+ is the central metal ion.

✦ Summary:

In complex compounds:

- Ligands donate electron pairs to form bonds.
- **Central metal** atom/ion accepts these pairs to form the coordination entity.

- The **Coordination** sphere represents the metal with all attached ligands as one unit.
- **Substitutional** alloys are metallic mixtures where atoms replace each other in the crystal structure.

🌟 Q6. Describe the rules for naming the coordination complexes and give examples.

❖ **Answer:**

Coordination compounds are chemical compounds in which a central metal atom or ion is surrounded by ligands (atoms, ions, or neutral molecules that donate electron pairs). To give a unique systematic name to these complexes, IUPAC rules are followed.

Rules for Naming Coordination Complexes

1. Cation is named before anion

When the complex contains both a cation and an anion, the cation is always named first, followed by the anion.

Example:

$K_4[Fe(CN)_6]$ ⟶ Potassium hexacyanoferrate(II)

K^+ = cation ⟶ “Potassium”

$[Fe(CN)_6]^{4-}$ = anionic complex ⟶ “hexacyanoferrate(II)”

2. Ligands are named alphabetically

- In the **coordination sphere**, ligands are listed in alphabetical order, ignoring their multiplicity.
- **Use prefixes** to indicate the number of ligands: di, tri, tetra, penta, hexa.

Example:

$[Co(NH_3)_4Cl_2]Cl$ ⟶ Tetraammine dichlorocobalt(III) chloride

Ligands: NH_3 ⟶ ammine, Cl^- ⟶ chloro

Alphabetical order: ammine first, chloro next

Oxidation state of Co = +3 ⟶ III

3. Anionic ligands end with suffix -o

Examples of anionic ligands:

OH^- ⟶ hydroxo

CN^- ⟶ cyano

CO_3^{2-} ⟶ carbonato

4. Neutral ligands are usually unchanged

Common neutral ligands:

NH_3 ⟶ ammine

H_2O ⟶ aqua

CO ⟶ carbonyl

5. Metal name ends with -ate if complex is anionic

If the complex ion has a negative charge, the metal's name gets the suffix -ate.

Example: $[Fe(CN)_6]^{4-}$ ⟶ ferrate(II)

If the complex is neutral or cationic, the metal name remains unchanged.

6. Oxidation number of central metal in Roman numerals

The oxidation number of the central metal is shown in parentheses in Roman numerals.

Example: Fe^{2+} in $[Fe(CN)_6]^{4-}$ ⟶ ferrate(II)

Examples of Named Complexes

1. $K_4[Fe(CN)_6]$ ⟶ Potassium hexacyanoferrate(II)

2. $[Pt(NH_3)_4Cl(NO_2)]SO_4$ ⟶ Tetraammine chloronitroplatinum(IV) sulfate

3. $[Co(NH_3)_6]Cl_3$ ⟶ Hexaamminecobalt(III) chloride

4. $[Cu(H_2O)_4]SO_4$ ⟶ Tetraaquacopper(II) sulfate

✦ **Summary:**

- Cation ⟶ Anion
- Ligands alphabetically

- Anionic ligands ⟶ -o
- Neutral ligands ⟶ unchanged
- Anionic complex ⟶ metal name ends with -ate
- Metal oxidation number ⟶ Roman numerals

🌟 Q7. Difference between Wrought Iron and Steel and Bessemer’s Process of Steel Manufacture

1. Wrought Iron

❖ Definition:

- Wrought iron is the purest form of commercial iron with very low carbon content.

Characteristics and Composition:

- **Carbon content**: 0.12% – 0.25%
- **Impurities**: S, P, Si, Mn ≤ 0.3%

Soft, malleable, and ductile

Can be easily forged and shaped

Uses:

- Wires, nails, chains
- Decorative iron work and household items

2. Steel

❖ Definition:

Steel is an alloy of iron containing 0.25% – 2.5% carbon and traces of other elements.

Characteristics and Composition:

- **Carbon content**: 0.25% – 2.5%
- Contains traces of S, P, Si, Mn
- Harder and stronger than wrought iron

Malleable and ductile, but hardness increases with carbon content

Uses:

- Rails, axles, boiler plates
- Cutting tools, hammers, machine parts
- Engines and structural applications

Difference between Wrought Iron and Steel:

Wrought iron: low carbon, soft, pure

Steel: moderate carbon, harder, strong, industrial applications

3. Bessemer Process for Steel Manufacture

❖ Definition:

- Bessemer process is a method of producing steel from molten cast iron by blowing air through it to remove impurities.

Equipment:

Bessemer Converter: pear-shaped steel vessel

- Holes at bottom for hot air blast
- Converter mounted on central axis for tilting

Stepwise Procedure:

1. Charging the Converter:

- Molten cast iron is poured into the converter

2. Blowing Air:

- Hot air is passed through molten iron
- **Carbon**, **silicon**, manganese, phosphorus, and sulfur oxidize

3. Slag Formation:

- **Oxides formed** react with added lime to produce slag
- **Slag floats** on molten steel surface and removes impurities

4. Adjusting Carbon Content:

- **Carbon** in steel is too low after oxidation
- **Ferromanganese** is added to increase carbon and remove sulfur

5. Pouring Steel:

- Molten steel is poured into molds
- Steel solidifies into ingots ready for industrial use

Key Points:

- Process takes 10–15 minutes
- Produces large-scale steel efficiently
- Final carbon content can be controlled precisely

✦ Summary:

Wrought Iron: Soft, low carbon, pure, used for decorative and light construction work.

Steel: Harder, stronger, moderate carbon, used in heavy machinery, rails, and engines.

Bessemer Process: Efficient industrial method of converting molten cast iron to steel by oxidation of impurities, slag removal, and carbon adjustment using ferromanganese.

🌟 Q8. Explanation of Corrosion-related Phenomena

(a) Why does damaged tin-plated iron get rusted quickly?

Explanation:

- **Tin plating** is applied on iron to protect it from corrosion. Tin acts as a stable, unreactive coating.
- **When** the tin coating is intact, iron does not come in contact with moisture or air, so it remains protected.
- If the tin coating is damaged, the exposed iron comes into contact with water and oxygen.
- **A galvanic cell** is formed between tin (cathode) and iron (anode).
- **Electrons flow** from iron to tin, leading to the formation of Fe^{2+} ions, which react with water to form $Fe(OH)_2$, eventually leading to rust.

Reason:

- The presence of tin accelerates corrosion of exposed iron because iron acts as the anode in the galvanic couple.

(b) Under what conditions does aluminium corrode?

Explanation:

- **Aluminium** is normally resistant to corrosion due to the formation of a protective oxide layer (Al_2O_3) on its surface.
- **Corrosion** occurs when aluminium is in contact with:

1. Moist air containing salts (e.g., coastal areas)

2. Strong acids or alkalis

3. Other metals forming a galvanic cell (e.g., aluminium in contact with copper in moist air)

Reason:

- In **galvanic action,** aluminium (more reactive) acts as the anode, loses electrons, and forms Al^{3+} ions, leading to corrosion.
- The **oxide layer** protects only under normal conditions; damage or extreme environments break this protection.

(c) How does the process of galvanizing protect iron from rusting?

Explanation:

- **Galvanizing** involves coating iron with a thin layer of zinc.
- **Zinc** serves as an anode and iron as cathode in a galvanic cell.
- **Even** if the zinc layer is scratched, zinc corrodes preferentially, protecting the iron.

Zinc also forms a protective oxide layer on its surface, reducing direct exposure to air and water.

Reason:

- This is called sacrificial corrosion, where the more reactive zinc sacrifices itself to protect the less reactive iron.
- **Used in water pipes,** roofing sheets, and iron fences.

✦ Summary / Key Points:

Tin-plated iron: Rusts faster if coating damaged → galvanic cells → iron corrodes.

Aluminium: Corrodes only when protective oxide layer is damaged or in presence of galvanic action / acidic or basic environment.

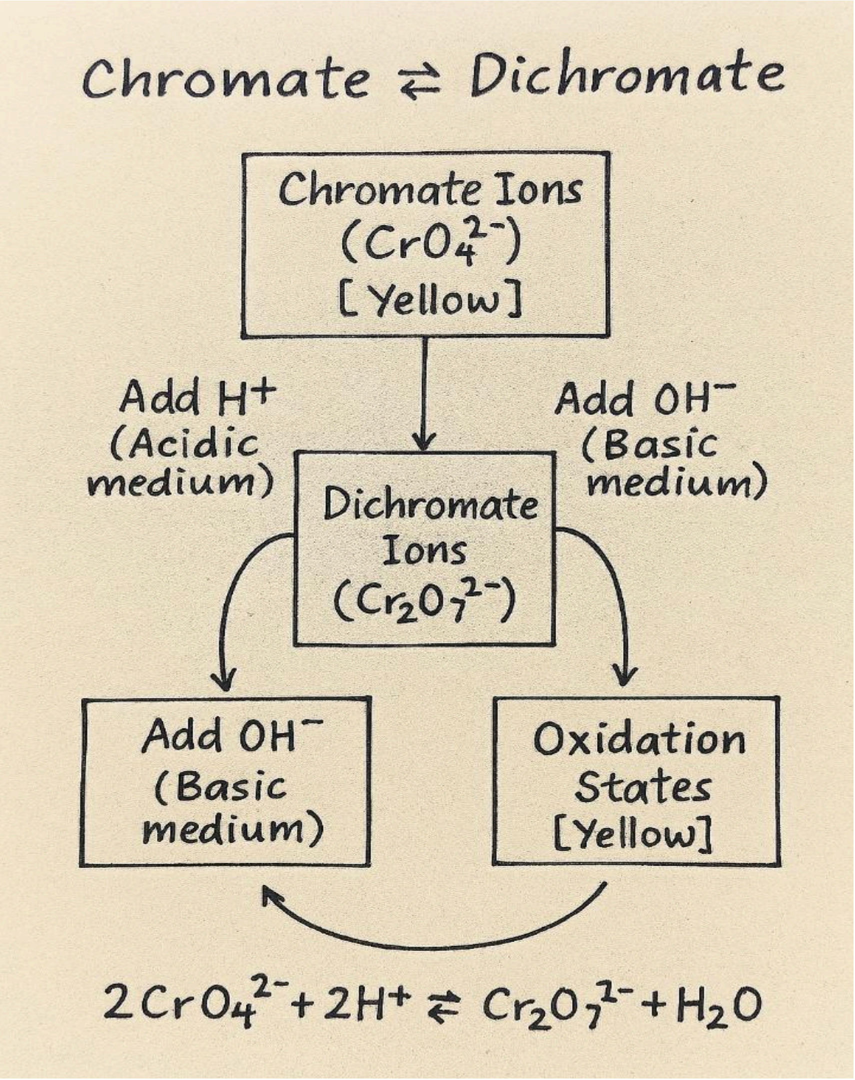
Galvanized iron: Zinc coating protects iron → sacrificial anode → iron remains intact.

🌟 Q9. How Chromate Ions Are Converted into Dichromate Ions

❖ Introduction:

- **Chromates** (CrO_4^{2-}) and dichromates ($Cr_2O_7^{2-}$) are interconvertible ions in aqueous solution.
- This **conversion** depends on the pH of the solution (acidic or basic medium).

✦ Digram:



🔹 Stepwise Explanation

1. Chromate in Basic or Neutral Solution

- In neutral or slightly basic solutions, chromium exists as chromate ions (CrO_4^{2-}).
- These ions give a yellow color to the solution.

2. Effect of Acidic Medium

- When an acid (like H_2SO_4) is added, hydrogen ions (H^+) react with chromate ions.
- This shifts the equilibrium to form dichromate ions ($Cr_2O_7^{2-}$).
- **Reaction in words**: 2 chromate ions + 2 $H^+ \longrightarrow$ 1 dichromate ion + H_2O
- The **solution changes** from yellow (chromate) to orange-red (dichromate).

3. Reversibility

- If the solution becomes basic again, dichromate ions are converted back to chromate ions.

This is an example of a dynamic equilibrium:

$2\,CrO_4^{2-} + 2H^+ \rightleftharpoons Cr_2O_7^{2-} + H_2O$

Reason for Conversion

The equilibrium shifts according to Le Chatelier's principle:

- Adding acid → shifts right → forms dichromate
- Adding alkali → shifts left → forms chromate

Uses / Importance

- This reaction is important in analytical chemistry for oxidation reactions.
- The color change from yellow to orange-red is used as a visual indicator.

✦ Summary:

- Chromate ions (CrO_4^{2-}) are yellow.
- Adding acid converts them to dichromate ions ($Cr_2O_7^{2-}$), orange-red.
- The reaction is reversible, depending on solution pH.

🌟 Q10. Describe the preparation of $KMnO_4$ and K_2CrO_4.

❖ **Answer:**

1. From Potassium Manganate (K_2MnO_4) – Acidification Method

- $KMnO_4$ is prepared by treating a solution of K_2MnO_4 with sulfuric acid (H_2SO_4).
- Reaction converts green manganate solution to purple permanganate solution.

Concept: Acid oxidizes manganate (Mn^{6+}) to permanganate (Mn^{7+}).

2. From Pyrolusite (MnO_2) – Fusion Method

- **Mineral MnO_2** is fused with KOH in the presence of air or oxidizing agents (e.g., KNO_3).
- This **forms green** K_2MnO_4 (manganate).
- The **green solution** is then converted to $KMnO_4$ by oxidation (e.g., Cl_2 gas or CO_2 in some processes).

Concept: MnO_2 is first oxidized to manganate, then further oxidized to permanganate.

3. Electrolytic Oxidation

- Aqueous K_2MnO_4 solution undergoes electrolysis.
- Oxygen at the anode oxidizes manganate ions to permanganate ions.
- Hydrogen is released at the cathode.

Key Concept:

- **$KMnO_4$** is a powerful oxidizing agent.
- The **deep purple** color indicates formation of permanganate ions.

Preparation of Potassium Chromate (K_2CrO_4)

1. By Oxidation of Trivalent Chromium

- Trivalent chromium compounds (Cr^{3+}) are treated with an oxidizing agent in the presence of alkali (KOH).

Example: Oxidation of $KCrO_2$ gives K_2CrO_4.

2. Fusion Method

- **Chromite** ore ($FeO \cdot Cr_2O_3$) is strongly heated with potassium carbonate (K_2CO_3) in the presence of oxygen.

- **K_2CrO_4** is extracted by dissolving the fused mass in water.

Concept: Chromite is oxidized by air to produce soluble potassium chromate.

3. Equilibrium Concept (Conversion to Dichromate)

- K_2CrO_4 can later be converted to $K_2Cr_2O_7$ in acidic solution.

🌟 Q 11. Give systematic names to following complexes.

Rules Recap for Naming Complexes:

1. Cations are named before anions.

2. Ligands are named in alphabetical order regardless of their number.

3. Use prefixes di, tri, tetra... to indicate the number of each ligand.

4. Anionic ligands end with 'o' (e.g., chloro, cyano, hydroxo).

5. Neutral ligands are usually unchanged (e.g., NH_3 → ammine, H_2O → aqua, CO → carbonyl).

6. The name of metal comes after ligands; if the complex is anionic, metal ends with '-ate'.

7. The oxidation state of the central metal is given in Roman numerals in parentheses.

🔹 Systematic Names of Given Complexes

(a) $[Fe(CO)_5]$

- **CO** = carbonyl (neutral ligand)
- **5 ligands** = pentacarbonyl
- **Metal** = Fe (neutral complex)

✅ **Name**: Pentacarbonyl iron

(b) $[Co(NH_3)_6]Cl$

- **NH_3** = ammine (neutral ligand)
- **6 ligands** = hexaammine
- **Metal** = Co^{3+} (oxidation state III)

Anion = Cl^-

✅ **Name**: Hexaammine cobalt(III) chloride

(c) $[Fe(H_2O)_6]^{2+}$

- **H_2O** = aqua (neutral ligand)
- **6 ligands** = hexaqua
- **Metal** = Fe^{2+} (oxidation state II)

✅ **Name**: Hexaaqua iron(II) ion

(d) $Na_3[CoF_6]$

- **F^-** = fluoro (anionic ligand)
- **6 ligands** = hexafluoro
- **Metal** = cobalt (anion ⟶ cobaltate)
- **Oxidation state** = III
- **Na_3** = cation

✅ **Name**: Sodium hexafluorocobaltate(III)

(e) $K_2[Cu(CN)_4]$

- **CN^-** = cyano (anionic ligand)
- **4 ligands** = tetracyano
- **Metal** = Cu (anion ⟶ cuprate)
- **Oxidation state** = I
- **K_2** = cation

✅ **Name**: Potassium tetracyanocuprate(I)

(f) $K_2[PtCl_6]$

- **Cl^-** = chloro (anionic ligand)
- **6 ligands** = hexachloro
- **Metal** = Pt ⟶ platinate
- **Oxidation state** = IV

✅ **Name**: Potassium hexachloroplatinate(IV)

(g) $[Pt(OH)_2(NH_3)_4]SO_4$

- **OH^-** = hydroxo (anionic)
- **NH_3** = ammine (neutral)
- 2 hydroxy + 4 ammine
- **Metal** = Pt (oxidation state IV)
- **Anion** = SO_4^{2-}

✅ **Name**: Dihydroxo tetraammine platinum(IV) sulphate

(h) $[Cr(OH)_3(H_2O)_3]$

- **OH^-** = hydroxo (anionic)
- **H_2O** = aqua (neutral)

- 3 hydroxo + 3 aqua
- **Metal** = Cr^{3+}

✅ **Name**: Trihydroxo triaqua chromium(III) ion

Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

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Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.

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