

Class 12 D and F Block Elements Important Questions with Answers

Short Answer Type Questions

Q1. Why does copper not replace hydrogen from acids?

Answer:

Copper does not replace hydrogen from acids because Cu has a positive E[°] value, i.e., it is less reactive than hydrogen, which has an electrode potential of 0.0 V. So, Cu cannot replace hydrogen from acids.

Q2. Why are E- values for Mn, Ni and Zn more negative than expected?

Answer:

The metals will quickly lose their electrons and get oxidized. A negative E value means that the oxidized species is more stable than the reduced species. Here, Mn^{2+} (3d5) and Zn^{2+} (3d10) have half-filled and fully filled d orbitals, giving them stability and, therefore, prefer to stay that way and not get reduced. Ni²⁺ (3d8) has very high negative hydration enthalpy, balanced by first and second ionization enthalpy.

Q3. Why is the first ionisation enthalpy of Cr is lower than that of Zn?

Answer:

lonisation enthalpy of Cr is less than that of Zn because Cr has a stable configuration. In the case of zinc, the electron comes out from wholly filled 4s orbital. So, the removal of an electron from zinc requires more energy as compared to chromium.

Q4. Transition elements show high melting points. Why?

Answer:

The high melting points of transition metals are due to the involvement of a greater number of electrons of (n-1)d in addition to the ns electrons in the interatomic metallic bonding.

Q5. When Cu^{2+} ion is treated with KI, a white precipitate is formed. Explain the reaction with the help of a chemical equation.



When Cu^{2+} ion is treated with KI, it produces Cu_2I_2 white precipitate in the final product. $2Cu^{2+} + 4I^- \rightarrow Cu_2I_2$ (White ppt.) + I_2 (In this reaction, CuI_2 is formed, which, being unstable, dissociates into Cu_2I_2 and I_2).

Q6. Out of Cu_2Cl_2 and $CuCl_2$, which is more stable and why?

Answer:

CuCl₂ is more stable than Cu₂Cl₂. The stability of Cu²⁺ (aq) is more than Cu⁺ (aq) due to the much more negative $\Delta_{hvd}H^{\circ}$ of Cu²⁺ (aq) than Cu⁺ (aq).

Q7. When a brown compound of manganese (A) is treated with HCl it gives a gas (B). The gas taken in excess, reacts with NH to give an explosive compound (C). Identify compounds A, B and C.

Answer:

When brown compound Mn_3O_4 is treated with HCl, it gives chlorine gas.

 $Mn_3O_4 + 8HCI \rightarrow 3MnCl_2 + 4H_2O + Cl_2\uparrow$

Chlorine gas taken in excess reacts with ammonia to give an explosive compound NCI_3 . $NH_3 + 3CI_2$ (excess) $\rightarrow NCI_3 + 3HCI$

The compounds A, B and C are A = Mn_3O_4 , B = Cl_2 gas, C = NCl_3 .

Q8. Although fluorine is more electronegative than oxygen, but the ability of oxygen to stabilise higher oxidation states exceeds that of fluorine. Why?

Answer:

Oxygen can form multiple bonds with metals, while fluorine can't form multiple bonds. Hence, oxygen has more ability to stabilize a higher oxidation state rather than fluorine.

Q9. Although Cr^{3+} and Co^{2+} ions have same number of unpaired electrons but the magnetic the moment of Cr^{3+} is 3.87 B.M. and that of Co^{2+} is 4.87 B.M. Why?

Answer:



Due to symmetrical electronic configuration, there is no orbital contribution in the Cr^{3+} ion. However, appreciable orbital contribution takes place in Co^{2+} ions.

Q10. Ionisation enthalpies of Ce, Pr and Nd are higher than Th, Pa and U. Why?

Answer:

Ce, Pr and Nd are lanthanoid and have an incomplete 4f shell, while Th, Pa and U are actinoid and have an incomplete 5f shell.

When 5f-orbitals begin to be occupied, they will penetrate less into the inner core of electrons. The 5f-electrons will, therefore, be more effectively shielded from the nuclear charge than the 4f electrons of the corresponding lanthanoids.

Therefore, outer electrons are less firmly held and are available for bonding in the actinoids.

Q11. Although Zr belongs to 4d and Hf belongs to 5d transition series but it is quite difficult to separate them. Why?

Answer:

Separation of Zr and Hf are pretty tricky because of lanthanoid contraction. Due to lanthanoid contraction, they have almost identical sizes (Zr = 160 pm and Hf = 159 pm) and, thus, similar chemical properties. That's why it is tough to separate them by chemical methods.

Q12. Although +3 oxidation states is the characteristic oxidation state of lanthanides but cerium shows +4 oxidation state also. Why?

Answer:

After losing one more electron, Ce³⁺ acquires a stable 4f⁰ electronic configuration. Thus, although the +3 oxidation state is the characteristic oxidation state of lanthanoids, cerium shows a +4 oxidation state.

Q13. Explain why does colour of KMnO₄, disappear when oxalic acid is added to its solution in acidic medium.

Answer:

 $KMnO_4$ acts as an oxidising agent. It oxidises oxalic acid to CO_2 and changes to Mn^{2+} ion, which is colourless.

Q14. When orange solution containing $Cr_2O_7^{2-}$ ion is treated with an alkali, a yellow solution is



formed and when H⁺ ions are added to yellow solution, an orange solution is obtained. Explain why does this happen?

Answer:

The following reaction takes place when $Cr_2O_7^{2-}$ is treated with an alkali, (orange) $Cr_2O_7^{2-} + OH^- \rightarrow 2CrO_4^{2-}$ (yellow)

When the yellow solution is treated with an acid, we get back the orange solution (yellow) $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-}$ (orange) + H₂O

This reaction is reversible under proper conditions.

Q15. A solution of $KMnO_4$ on reduction yields either a colourless solution or a brown precipitate or a green solution depending on pH of the solution. What different stages of the reduction do these represent and how are they carried out?

Answer:

Oxidising behaviour of KMnO₄ depends on the pH of the solution.

In an acidic medium (pH < 7), $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

In an alkaline medium (pH > 7), MnO₄⁻ + e⁻ \rightarrow MnO₄²⁻

In a neutral medium (pH = 7), MnO₄⁻ + 2H₂O+ 3e⁻ \rightarrow MnO₂ + 4OH⁻

Q16. The second and third rows of transition elements resemble each other much more than they resemble the first row. Explain why?

Answer:

Due to lanthanoid contraction, the atomic radii of the second and third-row transition elements are almost identical. So, they resemble each other much more than first-row elements.

Q17. E^0 of Cu is + 0.34V while that of Zn is - 0.76V. Explain.

Answer:



High ionisation enthalpy to transform Cu(s) to Cu^{2+} (aq) is not balanced by its hydration enthalpy. However, in Zn's case, after removing electrons from 4s-orbital, a stable $3d_{10}$ configuration is acquired. Thus, the value of E⁰ of Cu is + 0.34V while that of Zn is - 0.76V.

Q18. The halides of transition elements become more covalent with increasing oxidation state of the metal. Why?

Answer:

As the oxidation state increases, the size of the ion of the transition element decreases. As per Fajan's rule, as the size of metal ions decreases, the covalent character of the bond formed increases. Therefore, the halide of transition elements become more covalent with the increasing oxidation state of the metal.

Q19. While filling up of electrons in the atomic orbitals, the 4s orbital is filled before the 3d orbital but reverse happens during the ionisation of the atom. Explain why?

Answer:

Atomic orbitals are filled in order of increasing energies. Since the energy of 3d orbital is more than 4s orbital, based on the (n+l) rule, it is filled after 4s orbital. But during ionization, electrons in the outermost orbital are lost. Since 4s will be the outermost orbital, in this case, electrons from this orbital will be ionized first.

Q20. Reactivity of transition elements decreases almost regularly from Sc to Cu. Explain.

Answer:

Reactivity of transition elements decreases almost regularly from Sc to Cu due to the regular increase in ionization enthalpy.

Long Answer Type Questions

Q1. Identify A to E and also explain the reactions involved.





Compound A to D are, $A = Cu \quad B = Cu(NO_3)_2 \quad C = [Cu(NH_3)_4] \quad D = CO_2$

 $CuCO_3 \rightarrow CuO + CO_2$

 $2CuO + CuS \rightarrow 3Cu + SO_2$

 $Cu + 4HNO_3(conc) \rightarrow Cu(NO_3)_2 + 2NO + 2H_2O$

 $Cu^{2+} + NH_3 \rightarrow [Cu(NH_3)_4]$

 $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

 $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$

Q2. When a chromite ore (A) is fused with sodium carbonate in free excess of air and the product is dissolved in water, a yellow solution of compound (B) is obtained. After treatment of this yellow solution with sulphuric acid, compound (C) can be crystallised from the solution. When compound (C) is treated with KCI, orange crystals of compound (D) crystallise out. Identify A to D and also explain the reactions.



Compound A to D are, A = FeCr₂O₄ B = Na₂CrO₄ C = Na₂Cr₂O₇.2H₂O D = K₂Cr₂O₇

 $4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$

 $2Na_2CrO_4 + 2H^{\scriptscriptstyle +} \rightarrow Na_2Cr_2O_7 + 2Na^{\scriptscriptstyle +} + H_2O$

 $Na_2Cr_2O_7 + 2KCI \rightarrow K_2Cr_2O_7 + 2NaCI$

Q3. When an oxide of manganese (A) is fused with KOH in the presence of an oxidising agent and dissolved in water, it gives a dark green solution of compound (B). Compound (B) disproportionates in neutral or acidic solution to give purple compound (C). An alkaline solution of compound (C) oxidises potassium iodide solution to a compound (D) and compound (A) is also formed. Identify compounds A to D and also explain the reactions involved.

Answer:

Compound A to D are, A = MnO_2 , B = K_2MnO_4 , C = $KMnO_4$, D = KIO_3

When Manganese dioxide (A) is fused with KOH, it gives a green solution of potassium manganate (B).

 $2MnO_2(A) + 4KOH + O_2 \rightarrow 2K_2MnO_4(B) + 2H_2O$

Potassium manganate disproportionates to give purple potassium permanganate (C).

 $3MnO_4^{2-} + H^+ \rightarrow 2MnO_4^{-}(C) + MnO_2 + 2H_2O$

Potassium permanganate reacts with KI to give potassium iodate (D) and manganese dioxide.

 $2MnO_4^- + H_2O + KI \rightarrow 2MnO_2 + 2OH^- + KIO_3(D)$

Q4. On the basis of Lanthanoid contraction, explain the following

(i) Nature of bonding in Lu₂O₃ and La₂O₃

- (ii) Trends in the stability of oxo salts of lanthanides from La to Lu.
- (iii) Stability of the complexes of lanthanides.
- (iv) Radii of 4d and 5d block elements
- (v) Trends in acidic character of lanthanide oxides.



(i) Due to lanthanide contraction, size reduces. With the size reduction, the covalent character increases. Therefore, Lu_2O_3 is more covalent than La_2O_3 .

(ii) Oxosalts contain oxygen as an anion. As the size of the cation reduces from La to Lu, according to Fajan's rules, the polarizing power of the cation will increase, and it will distort the cloud of oxygen(anion) significantly. Thus the bond weakens, and the stability also reduces.

(iii)As the size of the central atom reduces, the stability of the complex increases. A small metal ion with a greater charge attracts the ligands better.

(iv) In 5d block elements, the effective nuclear charge increases due to poor shielding of f orbitals, thereby reducing the size. This is called lanthanide contraction. So, the radii of 4d and 5d block elements end up being very similar.

(v) From La to Lu, the acidic character increases. As the size reduces from La to Lu, the ability to lose electrons(Lewis base character) reduces, so the acidity increases.

Q5. (a) Answer the following questions:

(i) Which element of the first transition series has highest second ionisation enthalpy?

- (ii) Which element of the first transition series has highest third ionisation enthalpy?
- (iii) Which element of the first transition series has lowest enthalpy of atomisation?
- (b) Identify the metal and justify your answer.

(i) Carbonyl M(CO)₅

(ii) MO₃F

Answer:

(a) (i) Cu, because the electronic configuration of Cu is 3d¹⁰. So, the second electron needs to be removed from the completely filled d-orbital, which is very difficult.

(ii) Zinc, because of the electronic configuration of $Zn = 3d^{10}4s^2$ and $Zn2+=3d^{10}$, which is fully filled and is very stable. Removal of the third electron requires very high energy.

(iii) Zinc, as it has completely filled 3d subshell, and no unpaired electron is available for metallic bonding.

(b) (i) It is $Fe(CO)_5$ by EAN rule.

According to the EAN rule, the effective number of metal in a metal carbonyl is equal to the atomic number of nearest inert gas EAN is calculated as

EAN = number of electrons of meta $^{(+2)}$ × (CO)

= atomic number of nearest inert gas



In $M(CO)_5 = x + 2 \times (5) = 36$ (Kr is the nearest inert gas) x = 26 (atomic number of metal) So, the metal is Fe (iron).

(ii) MO_3F is MnO_3F In MO_3F , let us assume M=x. $x + 3 \times (-2) + (-1)$ x = +7M is in a +7 oxidation state so that the given compound is MnO_3F .

Q6. Mention the type of compounds formed when small atoms like H, C and N get trapped inside the crystal lattice of transition metals. Also give physical and Chemical characteristics of these compounds.

Answer:

The compounds formed when tiny atoms of H, C or N get trapped inside the crystal lattice of metals is known as interstitial compounds. The transition metals form several interstitial compounds. Transition metals react with hydrogen, carbon, nitrogen, boron etc., to form interstitial compounds. Physical and Chemical properties of Interstitial Compounds

- 1. These compounds have very high melting points, higher than the parent transition metals.
- 2. These compounds are very hard. The hardness of some borides is comparable to that of a diamond.
- 3. The conductivity exhibited by them is similar to their parent metal.
- 4. These compounds are chemically inert.

Q7. (a) Transition metals can act as catalysts because these can change their oxidation state.How does Fe(III) catalyse the reaction between iodide and persulphate ions?(b) Mention any three processes where transition metals act as catalysts.

Answer:

(a) The reaction between iodide and persulphate ions. $2I^- + S_2O_8^{2^-} \rightarrow I_2 + 2SO_4^{2^-}$ We can explain this catalytic action as: $2Fe^{3^+} + 2I^- \rightarrow 2Fe^{2^+} + I_2$ $2Fe^{2^+} + S_2O_8^{2^-} \rightarrow 2Fe^{3^+} + 2SO_4^{2^-}$

(b) (i) Vanadium (V) oxide in the contact process for the oxidation of SO₂ to SO₃.

- (ii) Finely divided iron in Haber's process in converting N_2 and H_2 to NH_3 .
- (iii) MnO_2 in preparation of oxygen from $KClO_3$.



Q8. A violet compound of manganese (A) decomposes on heating to liberate oxygen and compounds (B) and (C) of manganese are formed. Compound (C) reacts with KOH in the presence of potassium nitrate to give compound (B). On heating compound (C) with conc. H_2SO_4 and NaCl, chlorine gas is liberated and a compound (D) of manganese along with other products is formed. Identify compounds A to D and also explain the reactions involved.

Answer:

Here,

 $A = KMnO_4$ $B = K_2MnO_4$ $C = MnO_2$ $D = MnCl_2$

$$\begin{split} &\mathsf{KMnO_4} \rightarrow \mathsf{K_2MnO_4} + \mathsf{MnO_2} + \mathsf{O_2} \\ &\mathsf{MnO_2} + \mathsf{KOH} + \mathsf{O_2} \rightarrow 2\mathsf{K_2MnO_4} + 2\mathsf{H_2O} \\ &\mathsf{MnO_2} + \mathsf{NaCl} + \mathsf{H_2SO_4} \rightarrow \mathsf{MnCl_2} + 2\mathsf{NaHSO_4} + 2\mathsf{H_2O} + \mathsf{Cl_2} \end{split}$$

