SOLVED PROBLEMS OF TRANSITION ELEMENTS

Board Level Questions

Problem 1: The chemical reactivity of lanthanides resemble to which other elements of the periodic table?

Solution: The chemical reactivity of the starting lanthanides resemble calcium due to similar first and second ionization energy. But latter lanthanides resemble Al due to ability of showing +3 oxidation state and similarity in I.E.

Problem 2: Enthalpies of atomization of transition elements are higher than those of alkali and alkaline earth metals. Explain.

Solution: The number of unpaired electrons in transition elements are more when compared to these in alkali and alkaline earth metals. As a result, the metallic bonds in transition metals are stronger and enthalpies of atomization are higher than those of alkali and alkaline earth metals.

Problem 3: Explain the following:

(a) Chromium is a typical metal while mercury is a liquid metal.

(b) Zinc readily liberates H_2 from cold dil. H_2SO_4 but not form cold conc. H_2SO_4.

Solution:
(a) Chromium has five unpaired electrons in its d-orbitals which make its metallic bond very strong, whereas in mercury there is no unpaired d-electrons so its metallic bond is very weak, hence it is a liquid.

(b) Since, conc. H_2SO_4 act as an oxidizing agent hence does not evolve H_2 when it reacts with zinc.

$$Zn + 2H_2SO_4 \longrightarrow ZnSO_4 + SO_2 + H_2O$$

Problem 4: Compare thermal stability of ZnO, CdO and HgO.

Solution: ZnO > CdO > HgO

Problem 5: Cu^+ ion has $3d^{10}4s^0$ configuration and colourless but Cu_2O is red and Cu_2S is black. Explain.

Solution: Cu^+ ion has $3d^{10}4s^0$ configuration, i.e. it has no unpaired electron hence there is no d-d transition possible and it is colourless. But Cu_2O and Cu_2S are coloured due to charge transfer of electrons from O^{2-} or S^{2-} to the vacant orbital of Cu^+ ion.

Problem 6: While Cu, Ag and Au are considered as transition elements but Zn, Cd and Hg are not considered as transition elements although all the mentioned elements have complete d-orbitals. Explain.

Solution: Although Cu, Ag and Au have their d – orbitals complete in the elemental state. They do have incomplete d orbitals in their compound state. So they are included in the transition elements.

$Cu^{+2} = 3d^9$

$Au^{+3} = 5d^8$

Zn, Cd and Ag have their d-orbitals complete in their elemental state as well as compound state. So they are not included in the transition elements.

$Zn^{+2} = 3d^{10}$

$Hg^{+2} = 5d^{10}$

Problem 7:

(i) CrO_3 is an acid anhydride. Explain.

(ii) Between Na^+ and Ag^+ which is a stronger Lewis acid and why?

Solution:

(i) $CrO_3 + H_2O \longrightarrow H_2CrO_4$, i.e CrO_3 is formed by loss of one H_2O molecule from chromic acid.

(ii) Between Na^+ and Ag^+, Ag^+ is stronger Lewis acid. Because Ag^+ has pseudo noble gas configuration which makes it more polarizing.

Problem 8: **It is well known that alkali and alkaline earth metals displace hydrogen from dilute acids. But most of the transition elements do not behave so. Explain**.

Solution: Alkali and alkaline earth metals have positive oxidation potential. But most of the transition elements have negative oxidation potentials. So they are not as good oxidizing agents as the alkali and alkaline earth metal are.

Problem 9: In the melting point curves of transition metals, one observes a dip in the curves at the end i.e. Cu, Ag & Au and Zn, Cd & Hg have lower melting points when compared to other transition metals. Explain.

Solution: In the last two groups of transition elements i.e. Cu, Ag, Au, Zn, Cd and Hg all the electrons are paired which can not take part in metallic bonding. As a result, metallic bond in these elements is weak resulting in the lower melting points of these metals.

Problem 10: Enthalpies of atomization of transition elements are higher than those of alkali and alkaline earth metals. Explain.

Solution: The number of unpaired electrons in transition elements are more when compared to those in alkali and alkaline earth metals. As a result, the metallic bonds in transition metals are stronger and enthalpies of atomization are higher than those of alkali and alkaline earth metals.

Problem 11: Explain the following:

(a) Scandium forms no coloured ions, yet it is regarded as a transition element.

(b) Transition elements have many irregularities in electronic configurations.

Solution:

(a) Scandium in the ground state has one d electron. Hence it is regarded as transition element.

(b) In the transition elements, the (n – 1)d subshell and ns subshell have very small difference in energy. The incoming electron may enter into either ns or (n-1)d subshell. Hence they show irregularities in their electronic configurations.

Problem 12: Explain the following

(a) Chromium is a typical metal while mercury is a liquid metal.

(b) Cobalt (II) is stable in aqueous solution but in the presence of strong ligands, it is a easily oxidised to cobalt (III).

Solution:

(a) chromium has 5 unpaired electrons in its d – orbitals which make its metallic bond very stronger. Whereas in mercury there are no unpaired d electrons, so its metallic bond is very weak.

(b) CO(III) has greater tendency to form complex than CO(II) hence in the presence of ligands CO(II) changes to CO(III).

Problem 13: Write down the products of the following reactions.

(a) $CuSO_4$ solution is treated with KI solution.

(b) $AgNO_3$ solution is added to $Na_2S_2O_3$ solution.

Solution:

(a) Free iodine is liberated along with the formation of a white precipitate of cupric iodide.

$$CuSO_4 + 2KI \longrightarrow CuI_2 + K_2SO_4$$

$$2CuI_2 \longrightarrow 2CuI + I_2$$

(b) A white precipitate of $Ag_2S_2O_3$ is obtained which turns yellow, brown and finally black on keeping.

$$2AgNO_3 + Na_2S_2O_3 \longrightarrow Ag_2S_2O_3 + 2NaNO_3$$

$$Ag_2S_2O_3 + H_2O \longrightarrow \underset{\text{black ppt.}}{Ag_2S} + H_2SO_4$$

Problem 14: Explain the following

(a) Zinc readily liberates H_2 form cold dil.H_2SO_4 but not from cold conc. H_2SO_4.

(b) Blue colour of the $CuSO_4$ solution is discharged slowly when an iron rod is dipped into it.

Solution:

(a) Conc. H_2SO_4 is a covalent compound. Hence does not contain H^+ ions. Dilute H_2SO_4 contains H_3O^+ which reacts with Zn and liberates H_2.

$$H_2SO_4 + H_2O \longrightarrow 2H_3O^+ + SO_4^{2-}$$

$$Zn + 2H_3O^+ \longrightarrow Zn^{2+} + 2H_2O + H_2O \uparrow$$

(b) Fe is more electropositive than Cu, hence it displaces copper form $CuSO_4$ solution.

$$Fe_{(s)} + CuSO_{(aq)} \longrightarrow FeSO_{4(aq)} + Cu_{(s)}$$

Problem 15: An aqueous solution containing one mole of HgI_2 and two moles of NaI is orange in colour. On addition of excess NaI the solution becomes colourless. The orange colour reappears on subsequent addition of NaOCl. Explain with equations.

Solution:

$$Hgl_2 + 2Nal \longrightarrow Na_2[Hgl_4]$$

(orange) coloured due to residual Hgl2)

$$Hgl_2 + Nal(excess) \longrightarrow Na_2[Hgl_4]$$

(orange) (colourless because there is no residual Hgl2)

$$2Na_2[Hgl_4] + 2NaOCl + H_2O \longrightarrow 2Hgl_2 + NaCl + 4NaOH + 2Nal_3$$

(orange)