Date: 16/10/2021

Q1. Hard water is softened before using in boilers. Why?

Q2. A 5.6 mL of H_2O_2 solution liberates 0.508 g of I_2 from an acidified KI solution. Calculate the volume strength of H_2O_2 solution.

Q3. What is the role of resin in synthetic resin method to soften the water?

Q4. Saline hydrides are known to react with water violently producing fire. Can CO_2 a well known fire extinguisher be used in this case?

Q5. How hydrogen is obtained commercially by electrolysis?

Q6. Ionic hydrides are frequently used to remove traces of water from organic compounds. What is the basis of this process?

Q7. Account for the following:

(a) The bleaching action of H_2O_2. (b) H_2O_2 is better oxzidising agent than water.

Q8. (a) Name the regents used for softening of the temporary hardness of water.

(b) What is the role of calgon in removing hardness of water?

Q9. (a) Why does hydrogen reacts mostly at high temperatures?

(b) The sample of hard water is allowed to pass through an anion exchanger. Will it produce latter with soap easily?

(c) What is hydrolith? How is it prepared?

Q10. Describe the industrial applications of hydrogen depend on

(a) the heat liberated when its atoms are made to combine on the surface of a metal.

(b) its effect on the unsaturated organic systems in the presence of a catalyst.

(c) its ability to combine with nitrogen under specific conditions.

Q11. (a) Why is the ionisation enthalpy of hydrogen higher than that of sodium?

(b) Complete the following reaction:

$$CO\,(g) + 2H_2\,(g) \xrightarrow{\text{Cobalt catalyst}}$$

(c) What is meant by 'demineralised water' and how can it be obtained?

Q12. (a) What happens when aluminium (III) chloride reacts with alkaline water?

(b) Complete the following reaction.

$$2HSO_4^-\,(aq) \xrightarrow{\text{Electrolysis}} A\,(aq) \xrightarrow{\text{Hydrolysis}} B + C + D$$

(c) If same mass of liquid water and a piece of ice is taken, then why is the density of ice less than that of liquid water?

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S1. Hard water on boiling gives precipitates of $MgCO_3$, $CaCO_3$ and $CaSO_4$ which form scales in boilers. The formation of these boiler scales causes deterioration of the boiler due to overheating. Therefore, in order to avoid formation of these scales, hard water is softened before using in boilers.

S2. 0.508 g of $I_2 = \frac{0.508}{127}$ equivalent of $I_2 = \frac{0.508}{127}$ equivalent of H_2O_2 in 5 mL solution

$$\therefore \quad N(H_2O_2) = \frac{0.508}{127} \times \frac{1000}{5} = 0.8\,N$$

$$\text{Volume strength} = N \times 5.6 = 0.8 \times 5.6 = 4.48\,g\,mL^{-1}.$$

S3. In synthetic resin method, cation exchange resins contain large organic molecules with — SO_3H group and are water insoluble. Ion exchange resin (RSO_3H) is changed to RNa by treating it with NaCl. The resin exchanges Na^+ ions with Ca^{2+} and Mg^{2+} ions present in hard water to make the water soft.

S4. Saline hydrides like NaH, CaH_2 react with water violently to form the corresponding metal hydroxides with the evolution of dihydrogen

$$NaH\,(s) + H_2O\,(l) \longrightarrow NaOH\,(aq) + H_2\,(g)$$

These reactions are highly exothermic that the evolved H_2 catches fire. The fire, so produced cannot be extinguished by CO_2 because it gets reduced by the hot metal hydride to form sodium formate.

$$NaH + CO_2 \longrightarrow HCOONa$$

S5. It is obtained as a by-product in the manufacturing of NaOH and chlorine by the electrolysis of brine solution. During electrolysis, the reaction that take place is

$$\underset{\text{Brine solution}}{2Na^+\,(aq) + 2Cl^-\,(aq)} + 2H_2O\,(l) \xrightarrow{\text{Electricity}} Cl_2\,(g) + H_2\,(g) + 2Na^+\,(aq) + 2OH\,(aq)$$

S6. Ionic hydrides like sodium hydride react with traces of water present in organic compound because of the presence of H^- which acts as strong Bronsted base and react with water readilly liberating H_2 gas.

$$NaH\,(s) + H_2O\,(aq) \longrightarrow H_2\,(g) + NaOH\,(aq)$$

S7. (a) H_2O_2 acts as a bleaching agent as it produces nascent oxygen [O].

$$H_2O_2 \longrightarrow H_2O + O$$

$$\text{Coloured matter} + [O] \longrightarrow \text{Colourless matter}$$

It bleaches materials like silk, hair, ivory, cotton, wool etc.

(b) Water does not produce nascent oxygen [O] as H_2O_2 does, hence water has limited oxidising property. In many case water does not oxidise but H_2O_2 do as, discussed below.

H_2O_2 oxidises an acidified solution of KI to give I_2 which gives blue colour with strach solution but H_2O does not

$$2KI + H_2SO_4 + H_2O_2 \longrightarrow K_2SO_4 + 2H_2O + I_2$$

H_2O_2 turns black PbS to white $PbSO_4$ but H_2O does not

$$PbS + 4H_2O_2 \longrightarrow PbSO_4 + 4H_2O$$

S8. (a) Calculated amounts of quicklime, $Ca(OH)_2$ are added to hard water. Quicklime, $Ca(OH)_2$ reacts with bicarbonates of Ca and Mg present in temporary hard water to form the corresponding insoluble carbonates which upon filtration give soft water.

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3\downarrow + 2H_2O$$
$$Mg(HCO_3)_2 + Ca(OH)_2 \longrightarrow CaCO_3\downarrow + MgCO_3\downarrow + 2H_2O$$

(b) When calgon, i.e., sodium hexametaphosphate is added to hard water, the Ca^{2+} and Mg^{2+} ions present in hard water combine with it to form soluble complex of calcium and magnesium salts.

$$\underset{\text{(From hard water)}}{2CaCl_2} + \underset{\text{Sodium hexametaphosphate (calgon)}}{Na_2[Na_4(PO_3)_6]} \longrightarrow \underset{\text{Complex salt (soluble)}}{Na_2[Ca_2(PO_3)_6]} + 4NaCl$$

$$\underset{\text{(From hard water)}}{2MgSO_4} + \underset{\text{Sodium hexametaphosphate}}{Na_2[Na_4(PO_3)_6]} \longrightarrow \underset{\text{Complex salt (soluble)}}{Na_2[Mg_2(PO_3)_6]} + 2Na_2SO_4$$

The complex of calcium and magnesium ions do not form any precipitate with soap and hence, water readily produces lather with soap.

S9. (a) Due to high bond dissociation enthalpy of H — H bond, hydrogen is relatively unreactive at room temperature. It dissociates into its atoms only at high temperatures.

$$H_2(g) \xrightarrow{\text{High temperature}} 2H(g)$$

Hence, most of the reactions of hydrogen occur at high temperatures.

(b) No, Ca^{2+} and Mg^{2+} ions are still present and they will interact with soap to form curdy white ppt. because the anion exchanger only exchanges Cl^- and SO_4^{2-} present in hard water with OH^- of the resins. Therefore, water will not produce lather with soap easily.

(c) Calcium hydride is also known as hydrolith. It is obtained by treating calcium with hydrogen.

$$Ca + H_2 \xrightarrow{\Delta} CaH_2 \text{ (hydrolith)}$$

S10. (a) Due to this property, hydrogen is used as atomic hydrogen in welding/cutting torch.

(b) Due to this property, hydrogen is used for the manufacturing of vanaspati ghee from edible oils such as cotton-seed oil, soyabean oil, corn oil etc.

$$\text{Unsaturated oil} + H_2(g) \xrightarrow{\text{Ni - catalyst}} \text{Vanaspati ghee}$$

(c) Due to this property, dihydrogen is used for the manufacturing of ammonia.

$$N_2(g) + 3H_2(g) \xrightarrow[Fe,\ Mo]{673\ K,\ 200\ atm} 2NH_3(g)$$

This process is known as Haber's process.

S11. (a) Both H and Na contain one electron in the valence shell. But the size of H is much smaller as compared to that of a, therefore it is difficult to remove an electron from H-atom as it is tightly bounded to the nucleus of H in comparison to Na-atom where it is loosely held due to their large size. Hence, the ionisation enthalpy of hydrogen is much higher (1312 kJ mol^{-1}) than that of Na (496 kJ mol^{-1}).

(b) $$CO(g) + 2H_2(g) \xrightarrow{\text{Cobalt catalyst}} CH_3OH(l)$$

(c) Water which is free from all soluble mineral salts is called demineralised water. It is obtained by passing water successively through a cation exchange and an anion exchange resings. In cation exchanger, Ca^{2+}, Mg^{2+}, Na^+ and other cations present in water are removed by exchanging them with H^+ ions while in anion exchanger, Cl^-, HCO_3^-, SO_4^{2-}, etc. present in water are removed by exchanging them with OH^- ions.

$$\underset{\text{(Released in cation exchanger)}}{H^+} + \underset{\text{(Released in anion exchanger)}}{OH^-} \longrightarrow H_2O$$

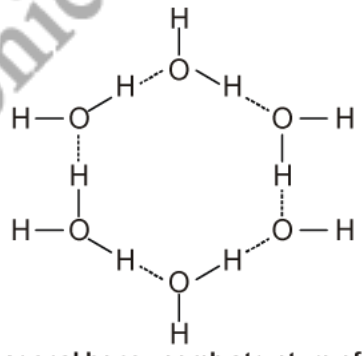
S12. (a) In alkaline water, $AlCl_3$ yields following products:

$$AlCl_3(s) \xrightarrow{\text{Alk. water}} [Al(OH)_4^-](aq) + 3Cl^-(aq)$$

$$[Al(OH)_4^-] \longrightarrow [AlO_2^-](aq) + 2H_2O(l)$$

(b) $$\underset{}{2HSO_4^-(aq)} \xrightarrow{\text{Electrolysis}} \underset{(A)}{HO_3SOOSO_3(aq)} \xrightarrow{\text{Hydrolysis}} \underset{(B)}{2HSO_4^-(aq)} + \underset{(C)}{2H^+(aq)} + \underset{(D)}{H_2O_2(aq)}$$

(c) In ice, the hydrogen bonding gives rise to a cage like structure of water molecules. Each water molecule is linked tetrahedrally to four water molecules. Thus, in ice, molecules of H_2O are not as closely packed as in liquid water. When ice melts, the cage like vacant spaces reduces. Thus, for the same mass of water, the volume decreases hence, density increases. In other words, density of ice is lower than liquid water and hence, ice floats on water.



Hexagonal honey comb structure of ice