

Chapter - Hydrogen



Topic-1: Preparation and Properties of Hydrogen and Hydrides



9 Assertion and Reason / Statement Type Questions

Each question contains **STATEMENT-1 (Assertion)** and **STATEMENT-2 (Reason)**. Each question has 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct. Mark your answer as

- (a) If both Statement -1 and Statement -2 are correct, and Statement -2 is the correct explanation of the Statement -2.
(b) If both Statement -1 and Statement -2 are correct, but Statement -2 is not the correct explanation of the Statement -1.

- (c) If Statement -1 is correct but Statement -2 is incorrect.
(d) If Statement -1 is incorrect but Statement -2 is correct.
1. Read the following statement and explanation and answer as per the options given statement below :

Statement - 1 : The alkali metals can form ionic hydrides which contain the hydride ion H^- .

Statement - 2 : The alkali metals have low electronegativity; their hydrides conduct electricity when fused and liberate hydrogen at the anode.

[1994 - 2 Marks]



Topic-2: Preparation and Properties of H_2O and D_2O



1 MCQs with One Correct Answer

1. Polyphosphates are used as water softening agents because they [2002S]
(a) form soluble complexes with anionic species
(b) precipitate anionic species
(c) form soluble complexes with cationic species
(d) precipitate cationic species
2. Heavy water is [1983 - 1 Mark]
(a) H_2^{18}O
(b) water obtained by repeated distillation
(c) D_2O
(d) water at 4°C
3. The temporary hardness of water due to calcium bicarbonate can be removed by adding – [1979]
(a) CaCO_3 (b) Ca(OH)_2 (c) CaCl_2 (d) HCl



6 MCQs with One or More than One Correct Answer

4. The reagent(s) used for softening the temporary hardness of water is (are) [2010]
(a) $\text{Ca}_3(\text{PO}_4)_2$ (b) Ca(OH)_2
(c) Na_2CO_3 (d) NaOCl
5. The species present in solution when CO_2 is dissolved in water are [2006 - 5M, -1]
(a) CO_2 , H_2CO_3 , HCO_3^- , CO_3^{2-}
(b) H_2CO_3 , CO_3^{2-}
(c) CO_3^{2-} , HCO_3^-
(d) CO_2 , H_2CO_3
6. When zeolite, which is hydrated sodium aluminium silicate, is treated with hard water the sodium ions are exchanged with [1990 - 1 Mark]
(a) H^+ ions (b) Ca^{++} ions
(c) SO_4^{--} ions (d) Mg^{++} ions
(e) OH^- ions



Topic-3: Preparation and Properties of H_2O_2



1 MCQs with One Correct Answer

- Hydrogen peroxide in its reaction with KIO_4 and NH_2OH respectively, is acting as a [Adv. 2014]
 - Reducing agent, oxidising agent
 - Reducing agent, reducing agent
 - Oxidising agent, oxidising agent
 - Oxidising agent, reducing agent
- The volume strength of 1.5 N H_2O_2 solution is [1991 - 1 Mark]
 - 4.8
 - 8.4
 - 3.0
 - 8.0



3 Numeric / New Stem Based Questions

- To a 25 mL H_2O_2 solution, excess of acidified solution of potassium iodide was added. The iodine liberated required 20 mL of 0.3 N sodium thiosulphate solution. Calculate the volume strength of H_2O_2 solution. [1997 - 5 Marks]
- A 5.0 cm^3 solution of H_2O_2 liberates 0.508 g of iodine from an acidified KI solution. Calculate the strength of H_2O_2 solution in terms of volume strength at STP. [1995 - 2 Marks]



10 Subjective Problems

- Hydrogen peroxide acts both as an oxidising and as a reducing agent in alkaline solution towards certain first row transition metal ions. Illustrate both these properties of H_2O_2 using chemical equations. [1998 - 4 Marks]
- Give reactions for the oxidation of hydrogen peroxide with potassium permanganate in acidic medium. [1997 - 1 Mark]
- Give reasons for the following :
 - Hydrogen peroxide acts as an oxidising as well as a reducing agent. [1992 - 1 Mark]
 - Hydrogen peroxide is a better oxidising agent than water. [1986 - 1 Mark]
- The mixture of hydrazine and hydrogen peroxide with a copper(II) catalyst is used as a rocket propellant. [1987 - 1 Mark]
- Write down the balanced equations for the reactions when: An alkaline solution of potassium ferricyanide is reacted with hydrogen peroxide. [1982 - 1 Mark]



Answer Key

Topic-1 : Preparation and Properties of Hydrogen and Hydrides

1. (a)

Topic-2 : Preparation and Properties of H_2O and D_2O

1. (c)

2. (c)

3. (b)

4. (b, c, d)

5. (a)

6. (b, d)

Topic-3 : Preparation and Properties of H_2O_2

1. (a)

2. (b)

3. (1.344)

4. (4.48)

Hints & Solutions



Topic-1: Preparation and Properties of Hydrogen and Hydrides

1. (a) The alkali metals are highly electropositive elements, hence, the hydrides, hydrogen exist as hydride ion H^- . This is the reason why hydrogen liberate at anode.



Topic-2: Preparation and Properties of H_2O and D_2O

1. (c) $2Ca^{2+} + Na_2[Na_4(PO_3)_6] \longrightarrow 4Na^+ + Na_2[Ca_2(PO_3)_6]$
water soluble
2. (c) Heavy water is D_2O , deuterium oxide.
3. (b) Temporary hardness of water is due to presence of bicarbonates of Ca and Mg and it is removed by adding $Ca(OH)_2$ to hard water and precipitating these soluble bicarbonates in the form of insoluble salts.
 $Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow CaCO_3 \downarrow + 2H_2O$
 $Mg(HCO_3)_2 + 2Ca(OH)_2 \longrightarrow 2CaCO_3 \downarrow + Mg(OH)_2 \downarrow + 2H_2O$
4. (b, c, d) Temporary hardness is due to bicarbonates of calcium and magnesium. Temporary hardness can be removed by Clark's process, which involves the addition of slaked lime, $Ca(OH)_2$. Washing soda (Na_2CO_3) removes both the temporary and permanent hardness by converting soluble calcium and magnesium compounds into insoluble carbonates.
 $Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3 \downarrow + 2H_2O$
 $Ca(HCO_3)_2 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + 2NaHCO_3$
 NaOCl can remove the hardness as :
 $2OCl^- + 2H_2O \rightleftharpoons 2HOCl + 2OH^-$
 $Ca(HCO_3)_2 + 2OH^- \longrightarrow CaCO_3 \downarrow + CO_3^{2-} + 2H_2O$
5. (a) $CO_2 + H_2O \rightleftharpoons H_2CO_3$
 $\rightleftharpoons H^+ + HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$
6. (b, d) $Na_2Al_2Si_2O_8 \cdot xH_2O + Ca^{2+} \longrightarrow CaAl_2Si_2O_8 \cdot xH_2O + 2Na^+$
 $Na_2Al_2Si_2O_8 \cdot xH_2O + Mg^{2+} \longrightarrow MgAl_2Si_2O_8 \cdot xH_2O + 2Na^+$



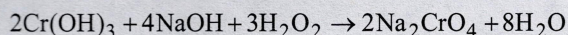
Topic-3: Preparation and Properties of H_2O_2

1. (a) $KIO_4 + H_2O_2 \rightarrow KIO_3 + H_2O + O_2$
 Thus, H_2O_2 is acting as a reducing agent
 $2NH_2OH + H_2O_2 \rightarrow N_2 + 4H_2O$
 Here H_2O_2 is acting as an oxidising agent
2. (b) Volume strength = Normality $\times 5.6 = 1.5 \times 5.6 = 8.4$ L
3. (1.344) By law of equivalence:
 Meq. of H_2O_2 = Meq. of $Na_2S_2O_3$ = Meq. of I_2 = Meq. of KI
 $\frac{w}{17} \times 1000 = 20 \times 0.3$
 $\therefore w = 0.102$ g (equating Meq. in 25 mL solution)
 $H_2O_2 \rightarrow H_2O + \frac{1}{2}O_2$
 $\therefore \text{Volume of } O_2 = \frac{11200 \times 0.102}{34} = 33.6$ mL
 $\therefore \text{Volume strength} = \frac{33.6}{25} = 1.344$
4. (4.48)

$$\begin{array}{ccccccc} H_2O_2 & + & H_2SO_4 & + & 2KI & \longrightarrow & K_2SO_4 + I_2 + 2H_2O \\ 34 \text{ g} & & & & \text{Acidified} & & 254 \text{ g} \\ 5 \text{ cm}^3 \text{ or mL} & & & & \text{KI sol} & & 0.508 \text{ g} \end{array}$$

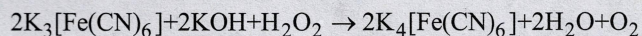
i.e. 254 g of I_2 is released by 34 g H_2O_2
 $\therefore 0.508$ g of I_2 will be released by
 $= \frac{34}{254} \times 0.508 = 0.068$ g
 5 mL of H_2O_2 sol. contains 0.068 g of H_2O_2 .
 $\therefore 1$ mL of H_2O_2 sol contains $\frac{0.068}{5}$ g H_2O_2
 The strength of H_2O_2 is generally calculated in terms of **volume strength**. According to which, 10 volume of H_2O_2 means that 1 mL of H_2O_2 sol gives 10 mL of O_2 at STP.
 $2H_2O_2 \longrightarrow 2H_2O + O_2$
 $\begin{array}{ccc} 2 \times 34 \text{ g} & & 32 \text{ g or} \\ & & 22,400 \text{ mL at STP} \end{array}$
i.e., 68 g of H_2O_2 gives 22,400 mL of O_2 at STP
 or 1 mL of H_2O_2 sol
 or $\frac{0.068}{5}$ g of H_2O_2 gives $\frac{22,400}{68} \times \frac{0.068}{5} = 4.48$ mL
 or 1 mL of H_2O_2 sol gives 4.48 mL of O_2 *i.e.* strength of H_2O_2 sol is **4.48 volumes**.

5. Example of oxidising character of H_2O_2 in alkaline medium



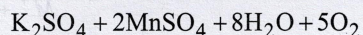
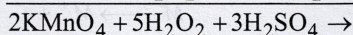
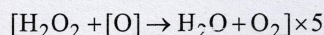
Here, Cr^{3+} (Cr is a first row transition metal) is oxidised to Cr^{6+} .

Example of reducing character of H_2O_2 in alkaline medium:



Here, Fe^{3+} (Fe is a first row transition metal) is reduced to Fe^{2+} .

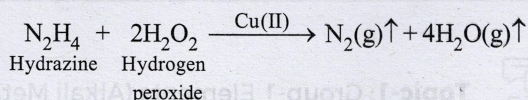
6. $2\text{KMnO}_4 + 3\text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2\text{MnSO}_4 + 3\text{H}_2\text{O} + 5[\text{O}]$



7. (i) The oxidation state of oxygen in H_2O_2 (i.e. -1) can be changed to 0 or -2 i.e. oxygen in H_2O_2 exists in an intermediate oxidation state with respect to O_2 and O^{2-} . Hence, it acts both as an oxidising and reducing agent.

(ii) H_2O_2 is a better oxidising agent than H_2O because oxidation number of oxygen in H_2O_2 is -1 and that in water it is -2. So, H_2O_2 easily reduces to -2 oxidation number.

8. The mixture of N_2H_4 and H_2O_2 (in presence of Cu (II) catalyst) is used as a rocket propellant because the reaction is highly exothermic and large volume of gases are evolved, which can propel a rocket.



9. Ferricyanide is oxidised to ferrocyanide on treatment with alkali:

