HYDROGEN [JEE ADVANCED PREVIOUS YEAR SOLVED PAPERS]

JEE Advanced

Single Correct Answer Type

1. The temporary hardness of water due to calcium bicarbonate can be removed by adding
   a. $Ca_3(PO_4)_2$ **b.** $Ca(OH)_2$
   c. Na_2CO_3 **d.** NaOCl **(IIT-JEE 1979)**
2. Heavy water is
   a. H_2O^{18}
   b. water obtained by repeated distillation
   c. D_2O
   d. water at 4°C **(IIT-JEE 1983)**
3. The oxide that gives H_2O_2 on treatment with a dilute acid is
   a. PbO_2 **b.** Na_2O_2 **c.** MnO_2 **d.** TiO_2
   (IIT-JEE 1985)
4. The species that do not contain peroxide ions is
   a. PbO_2 **b.** H_2O_2 **c.** SrO_2 **d.** BaO_2
   (IIT-JEE 1992)
5. Complete hydrolysis of 1 mol of peroxodisulphuric acid produces
   a. 2 mol of sulphuric acid
   b. 2 mol of peroxomonosulphuric acid
   c. 1 mol of H_2SO_4 and 1 mol of peroxomonosulphuric acid
   d. 2 mol of H_2SO_4 and 1 mol of H_2O_2 **(IIT-JEE 1996)**
6. Polyphosphates are used as water softening agents because they
   a. form soluble complexes with anionic species
   b. precipitate anionic species
   c. form soluble complexes with cationic species
   d. precipitate cationic species. **(IIT-JEE 2002)**

Multiple Correct Answers Type

1. When zeolite, which is hydrated sodium aluminium silicate, is treated with hard water, the sodium ions are exchanged with

a. $H^{\oplus}$ ions
b. Ca^{2+} ions
c. SO_4^{2-} ions
d. Mg^{2+} ions

(IIT-JEE 1990)

2. The reagent used for softening the temporary hardness of water is/are
   a. $Ca_3(PO_4)_2$
   b. $Ca(OH)_2$
   c. Na_2CO_3
   d. NaOCl **(IIT-JEE 2010)**
3. Hydrogen peroxide in its reaction with KIO_4 and NH_2OH respectively, is acting as a
   a. reducing agent, oxidising agent
   b. reducing agent, reducing agent
   c. oxidising agent, oxidising agent
   d. oxidising agent, reducing agent

(JEE Advanced 2014)

4. Fe^{3+} is reduced to Fe^{2+} by using
   a. H_2O_2 in presence of NaOH
   b. Na_2O_2 in water
   c. H_2O_2 in presence of H_2SO_4
   d. Na_2O_2 in presence of H_2SO_4 **(JEE Advanced 2015)**

Fill in the Blanks Type

1. The adsorption of hydrogen by palladium is commonly known as _____. **(IIT-JEE 1983)**
2. Hydrogen gas is liberated the action of aluminium with concentrated solution of _____. **(IIT-JEE 1987)**

Subjective Type

Give reasons in one or two sentences for the following:

1. 'H_2O_2 is a better oxidizing agent than water'. **(IIT-JEE 1986)**
2. The mixture of hydrazine and hydrogen peroxides with a copper (II) catalyst is used as a rocket propellant. **(IIT-JEE 1987)**
3. Hydrogen peroxide acts both as an oxidizing 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. **(IIT-JEE 1998)**

Answer Key

JEE Advanced

Single Correct Answer Type

1. b. **2.** c. **3.** b. **4.** a. **5.** d.
6. c.

Multiple Correct Answers Type

1. b., d. **2.** b., c., d. **3.** a. **4.** c., d.

Fill in the Blanks Type

1. occlusion **2.** sodium hydroxide

Hints and Solutions

JEE Advanced

Single Correct Answer Type

1. b. Temporary hardness of water is due to the presence of bicarbonates of calcium and magnesium.

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

The temporary hardness of water can be removed by the addition of calculated quantity of milk of lime which converts soluble bicarbonates into insoluble carbonates which can be removed.

2. c. Heavy water is an oxide of heavy hydrogen, which is called deuterium oxide. It is D_2O.

3. b. Only the true peroxides which have —O—O— bond give H_2O_2 with dilute acids as in Na_2O_2 oxidation state of 'O' is –1 so it is peroxide $^{-}O—O^{-}$.

$$Na_2O_2 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O_2$$

4. a. Only true peroxide which have –O – O – bond give H_2O_2 with dilute acids. PbO_2 does not give H_2O_2 with dilute acids. So it is not a true peroxide.

b. $H—\underbrace{O—O}_{\text{Peroxy linkage}}—H \quad \Rightarrow \quad O_2^{2-}$ i.e., Peroxide

c. SrO_2

$2 + 2x = 0 \quad \Rightarrow \quad 2x = -2$

$\Rightarrow \quad x = -1$

d. BaO_2 same as C as Sr and Ba both are of group 2. So, oxidation state is +2.

5. d. Peroxodisulphuric acid ($H_2S_2O_8$) or Marshall's acid on complete hydrolysis gives 2 mol by H_2SO_4 and 1 mol of H_2O_2

$H_2S_2O_8 + 2H_2O \longrightarrow 2H_2SO_4 + H_2O_2$

But partial hydrolysis of $H_2S_2O_8$ gives 1 mol of H_2SO_4 and 1 mol of H_2SO_5 (Caro's acid or peroxomonosulphuric acid).

$$H_2SO_4 + 2H_2O \longrightarrow H_2SO_4 + H_2SO_5$$

6. c. Polyphosphates are used as water softening agents because they form soluble complexes with cations responsible for the hardness of water. These polyphosphates are represented as $Na_2[Na_4(PO_3)_6]$ known as calgon.

$2CaSO_4 + Na_2[Na_4(PO_3)_6] \longrightarrow Na_2[Ca_2(PO_3)_6] + 2Na_2SO_4$

$2MgSO_4 + Na_2[Na_4(PO_3)_6] \longrightarrow Na_2[Mg_2(PO_3)_6] + 2Na_2SO_4$

Note: This method is basically used for softening water for boiler use.

Multiple Correct Answers Type

1. b., d.

When zeolite, which is hydrated sodium aluminium silicate, is treated with hard water, the sodium ions are exchanged with both Ca^{2+} and Mg^{2+} ions.

$$Na_2Z + Ca^{2+} \text{ or } Mg^{2+} \longrightarrow CaZ \text{ or } MgZ + 2Na^{+}$$

2. b., c., d.

Temporary hardness of water is due to the presence of bicarbonates of calcium and magnesium.

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow \underset{\text{Insoluble}}{2CaCO_3} + 2H_2O$$

$$Mg(HCO_3)_2 + 2Ca(OH)_2 \longrightarrow \underset{\text{Insoluble}}{2CaCO_3} + \underset{\text{Insoluble}}{Mg(OH)_2} + 2H_2O$$

This is known as Clark's method.

It is essential to add only the calculated amount of $Ca(OH)_2$.

$$NaOCl + H_2O \rightleftharpoons HOCl + NaOH$$

$$OH^- + HCO_3^- \longrightarrow CO_3^{2-} + H_2O$$

$$Ca(HCO_3)_2 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + 2NaHCO_3$$

3. a.

H_2O_2 reacts with KIO_4 in the following manner:

$$\overset{+7}{KIO_4} + H_2O_2 \longrightarrow \overset{+5}{KIO_3} + H_2O + O_2$$

on reaction of KIO_4 with H_2O_2, oxidation state of I varies from +7 to +5, i.e., decreases. Thus KIO_4 get reduced hence, H_2O_2 is reducing agent here.

H_2O_2 reacts with NH_2OH in the following manner:

$$\overset{-1}{NH_2OH} + H_2O_2 \longrightarrow \overset{+3}{N_2O_3} + H_2O$$

In this reaction, oxidation state of N varies from –1 to +3 i.e., increases, hence H_2O_2 is acting on an oxidising agent here.

4. c., d.

Fe^{3+} is reduced to Fe^{2+} by H_2O_2 and Na_2O_2 in acidic medium.

Fill in the Blanks Type

1. The adsorption of hydrogen by palladium is commonly known as occlusion. Occlusion is general term for adsorption of gases on solid surface.
2. Hydrogen gas is liberated the action of aluminium with concentrated solution of sodium hydroxide.

$$2Al + 2NaOH + 2H_2O \longrightarrow 2NaAlO_2 + 3H_2$$

This liberated hydrogen is used to Clean drains.

Subjective Type

1. H_2O_2 is a better oxidizing agent than water because it can provide nascent oxygen easily.

$$H_2O_2 \longrightarrow H_2O + [O]$$

2. $N_2H_4 + 2H_2O_2 \longrightarrow N_2 + 4H_2O$

The mixture of N_2H_4 and H_2O_2 (in the presence of Cu(II) catalyst) is used as a rocket propellant because of two reasons:

a. The reaction is highly exothermic.

b. Large volume of gases are evolved.

3. Oxidizing action of H_2O_2 in alkaline medium

$$H_2O_2 + {}^-OH + 2e^- \longrightarrow 3\ {}^-OH \qquad \text{(i)}$$

In alkaline medium it converts manganous salts to Mn^{4+} (converts $MnSO_4$ to MnO_2).

i.e., $Mn^{2+} \longrightarrow Mn^{4+} + 4e^-$ (ii)

Add Eqs. (i) and (ii).

$$H_2O_2 + Mn^{2+} \longrightarrow Mn^{4+} + 3\ {}^-OH$$

Reducing action of H_2O_2 in alkaline medium

$$H_2O_2 + 2\ {}^-OH \longrightarrow 2H_2O + O_2 + 2e^- \qquad \text{(iii)}$$

In alkaline medium it converts

$KMnO_4$ to MnO_2 i.e., MnO_4^- to MnO_2

Step 1 : $\overset{+7}{MnO_4^-} + 3e^- \longrightarrow \overset{+4}{MnO_2}$

Step 2 : Charges

L.H.S = – 4 R.H.S = 0

$MnO_4^- + 3e^- \longrightarrow MnO_2 + 4\ {}^-OH$

Step 3 : Balance 'O'

L.H.S = 4 R.H.S = 6

$$MnO_4^- + 3e^- + 2H_2O \longrightarrow MnO_2 + 4\ {}^-OH \qquad \text{(iv)}$$

Multiply Eqs. (iii) × 3 and (iv) × 2 and add.

$$2MnO_4^- + 3\ H_2O_2 \longrightarrow 2\ MnO_2 + 2\ {}^-OH + 2H_2O + 3O_2$$