Hydrogen

1. Which one of the following statements about water is false? (2016)

(a) Water can act both as an acid and as a base

(b) There is extensive intramolecular hydrogen bonding in the condensed phase

(c) Ice formed by heavy water sinks in normal water

(d) Water is oxidised to oxygen during photosynthesis

2. Hydrogen peroxide in its reaction with KIO_4 and NH_2OH respectively, is acting as a (2014)

(a) reducing agent, oxidising agent

(b) reducing agent, reducing agent

(c) oxidising agent, oxidising agent

(d) oxidising agent, reducing agent

3. In which of the following reactions H_2O_2 acts as a reducing agent? (2014)

I. $H_2O_2 + 2H^+ + 2e^- \longrightarrow 2H_2O$

II. $H_2O_2 - 2e^- \longrightarrow O_2 + 2H^+$

III. $H_2O_2 + 2e^- \longrightarrow 2OH^-$

IV. $H_2O_2 + 2OH^- - 2e^- \longrightarrow O_2 + 2H_2O$

(a) I and II

(b) III and IV

(c) I and III

(d) II and IV

4. The oxide that gives H_2O_2 on treatment with a dilute acid is (1985)

(a) PbO_2

(b) Na_2O_2

(c) MnO_2

(d) TiO_2

5. Which of the following process uses water gas shift reaction?

(a) Merck's process

(b) Lane's process

(c) Permutit process

(d) Bosch's process

6. Ethylene and H_2O_2 react to give

(a) CO_2, H_2O

(b) CO, H_2O

(c) Ethylene oxide

(d) Ethylene glycol

7. In which of the following compounds does hydrogen exhibit a negative oxidation state:

(a) LiH

(b) H_2O

(c) HCl

(d) none of these

8. The number of neutrons in deuterium is

(a) 2

(b) 3

(c) 1

(d) 2

9. Which of the following represents the heavy water?

(a) water at 277 K

(b) water containing large contamination of lead salts

(c) deuterium oxide

(d) protium oxide

10. H_2O_2 cannot act as

(a) oxidising agent

(b) dehydrating agent

(c) reducing agent

(d) acid

11. Hardness of water is due to dissolved impurities of

(a) calcium and magnesium salts

(b) barium and magnesium salts

(c) calcium and strontium salts

(d) sodium and potassium salts

12. H_2O_2 is reduced by

(a) O_3

(b) acidic $KMnO_4$ solution

(c) lead sulphide suspension in water

(d) none of these

13. When water is dropped over sodium peroxide, the colourless gas produced is

(a) dinitrogen

(b) dioxygen

(c) dihydrogen

(d) hydrogen peroxide

14. In which of the following reaction dihydrogen acts as an oxidising agent?

(a) $Ca + H_2 \rightarrow CaH_2$

(b) $2H_2 + O_2 \rightarrow 2H_2O$

(c) $H_2 + F_2 \rightarrow 2HF$

(d) $CuO + H_2 \rightarrow Cu + H_2O$

15. Which of the following metal does not produce dihydrogen gas with dilute hydrochloric acid?

(a) Mg

(b) Zn

(c) Ag

(d) Ba

16. Which oxide cannot be reduced by H_2?

(a) Al_2O_3

(b) CuO

(c) ZnO

(d) All of these

17. Nascent hydrogen consists of

(a) hydrogen ions in the excited state

(b) hydrogen molecules with excess energy

(c) solvated protons

(d) hydrogen atoms with excess energy

18. 30-volume hydrogen peroxide means

(a) 30% of H_2O_2 by volume

(b) 30 g of H_2O_2 solution contains 1 g of H_2O

(c) 1 cm^3 of solution liberates 30 cm^3 of dioxygen gas at STP

(d) 30 cm^3 of the solution contains one mole of H_2O_2

19. The compound which gives H_2O_2 on treatment with dilute acid is

(a) PbO_2

(b) MnO_2

(c) TiO_2

(d) KO_2

20. When a sample of hard water is passed through the layer of sodium zeolite resulting, which of the following ions will not be present in the resulting sample of water obtained?

(a) Mg^{2+} and Ca^{2+}

(b) Ca^{2+} and $Na^{\oplus}$

(c) Mg^{2+} and CO_3^{2-}

(d) CO_3^{2-} and Cl^{Θ}

21. Hydrolysis of one mole of peroxodisulphuric acid produces

(a) two moles of sulphuric acid and hydrogen peroxide

(b) two moles of peroxomonosulphuric acid

(c) one mole of sulphuric acid, one mole of peroxomonosulphuric acid and one mole of hydrogen peroxide

(d) one mole of sulphuric acid and one mole of peroxomonosulphuric acid

22. Barium peroxide reacts with phosphoric acid to produce barium phosphate along with

(a) water

(b) hydrogen peroxide

(c) dioxygen

(d) phosphine

23. One part of heavy water is present in X parts of ordinary water. Here X is

(a) 10

(b) 60

(c) 6000

(d) 600000

24. The hydride ion $H^{\ominus}$ is a stronger base than hydroxide ion. Which of the following reaction would occur if NaH is dissolved in water?

(a)

$$H^{\ominus}_{(aq)} + H_2O_{(l)} \longrightarrow H_3O^{\oplus}_{(aq)}$$

(b)

$$H^{\ominus}_{(aq)} + H_2O_{(l)} \longrightarrow \overset{\ominus}{O}H_{(aq)} + H_2$$

(c)

$$H^{\ominus} + H_2O \longrightarrow \text{No reaction}$$

(d) None of the above

25. The volume strength of 1.5 N H_2O_2 solution is

(a) 4.8

(b) 5.2

(c) 8.8

(d) 8.4

26. Which of the following pair of substances will not evolve H_2 gas?

(a) Iron and aqueous H_2SO_4

(b) Copper and $HCl_{(aq)}$

(c) Sodium and ethanol

(d) Iron and steam

27. H_2 molecule has two electrons and two nuclei. In which form of hydrogen the spin of electrons and also the spin of nuclei are in opposite directions.

(a) ortho-hydrogen

(b) parahydrogen

(c) metahydrogen

(d) β-hydrogen

28. What is false about Lane's process?

(a) Method is used for manufacture of dihydrogen

(b) It involves the oxidation of iron by steam

(c) It involves the reduction of $H_2O_{(g)}$ by iron

(d) It involves the oxidation of water gas

29. Which of the following hydrides are generally non-stoichiometric in nature?

(a) Ionic hydrogen

(b) Molecular hydrides

(c) Interstitial hydrides

(d) All of these

30. Dihydrogen gas may be prepared by heating caustic soda on

(a) Cu

(b) Zn

(c) Na

(d) Ag

31. The volume of 10 volume H_2O_2 required to liberate 500mL of O_2 at STP is

(a) 25 mL

(b) 50 mL

(c) 100 mL

(d) 125 mL

32. Pure H_2O_2 is

(a) semi-solid

(b) liquid

(c) solid

(d) gas

33. Hydrogen can react with the following even in dark:

(a) I_2

(b) Cl_2

(c) F_2

(d) Br_2

34. 34 g of H_2O_2 is present in 1120 mL of solution. This solution is called

(a) 10 vol solution

(b) 20 vol solution

(c) 34 vol solution

(d) 32 vol solution

35. A 5.0 mL solution of H_2O_2 liberates 1.27 g of iodine from an acidified KI solution. The percentage strength of H_2O_2 is

(a) 11.2

(b) 5.6

(c) 1.7

(d) 3.4

36. A 5.0 mL solution of H_2O_2 liberates 1.27 g of iodine from an acidified KI solution. The strength of H_2O_2 in terms of volume strength is

(a) 11.2

(b) 5.6

(c) 1.7

(d) 3.4

37. 100 mL of ozone at STP was passed through 100 mL of 10 volume H_2O_2 solution. What is the volume strength of H_2O_2 after the reaction?

(a) 9.5

(b) 9.0

(c) 4.75

(d) 4.5

38. 25 mL samples of distilled water, tap water and boiled water required, respectively, 1 mL, 13 mL and 5 mL of soap solution to form a permanent lather. The ratio of temporary to permanent hardness in the tap water is

(a) 3:2

(b) 2:3

(c) 1:2

(d) 2:1

39. 3.4 g sample of H_2O_2 solution containing x% H_2O_2 by weight requires *x* mL of a $KMnO_4$ solution for complete oxidation under acidic condition. The normality of $KMnO_4$ solution is

(a) 1N

(b) 2N

(c) 3N

(d) 0.5N

40. If 100 mL of acidified 2 N H_2O_2 is allowed to react with $KMnO_4$ solution till there is a light tinge of purple colour. The volume of oxygen produced at STP is

(a) 2.24 L

(b) 1.12 L

(c) 3.36 L

(d) 4.48 L

41. 100 mL of 0.01 M $KMnO_4$ oxidises 100 mL HiO_2 in acidic medium. Volume of the same $KMnO_4$ required in alkaline medium to oxidise 100 mL of the same H_2O_2 will be ($MnO_4^{\ominus}$changes to Mn^{2+} in acidic medium and to MnO_2 in alkaline medium)

(a) $\frac{100}{3}\text{mL}$

(b) $\frac{500}{3}\text{mL}$

(c) $\frac{300}{5}\text{mL}$

(d) None

42. 10 mL of H_2O_2 solution (volume strength= *x*) requires 10 mL of N/0.56 $MnO_4^{\ominus}$ solution in acidic medium. Hence *x* is

(a) 0.56

(b) 5.6

(c) 0.1

(d) 10

43. The normality and volume strength of a solution made by mixing 1.0 L each of 5.6 volume and 11.2 volume H_2O_2 solution are:

(a) 1N, 5.6 vol

(b) 1.5N, 5.6 vol

(c) 1.5N, 8.4 vol

(d) 1N, 8.4 vol

44. 100 mL of H_2O_2 is oxidised by 100 mL of 0.01 M $KMnO_4$ in acidic medium ($MnO_4^{\ominus}$ reduced to Mn^{2+}). 100 mL of the same H_2O_2 is oxidised by V mL of 0.01 M $KMnO_4$ in basic medium. Hence V is

(a) 500

(b) 100

(c) $\frac{100}{3}$

(d) $\frac{500}{3}$

45. The purity of H_2O_2 in a given sample is 85%. Calculate the weight of impure sample of H_2O_2 which requires 1O mL of M/5 $KMnO_4$ solution in a titration in acidic medium

(a) 2g

(b) 0.2g

(c) 0.17g

(d) 0.15g

46. 10 L of hard water required 0.56 g of lime (CaO) for removing hardness. Hence, temporary hardness in ppm (part per million, 10^6) of $CaCO_3$ is

(a) 100

(b) 200

(c) 10

(d) 20

47. Hydrogen has the tendency to gain one electron to acquire helium configuration, in this respect, it resembles:

(a) alkali metals

(b) carbon

(c) alkaline earth metals

(d) halogens

48. Heavy water is qualified as heavy liquid as it is:

(a) a heavy liquid

(b) an oxide of heavier isotope of oxygen

(c) an oxide of deuterium

(d) denser than water

49. Which of the following is used as rocket fuel?

(a) Liquid O_2

(b) Liquid NH_3

(c) Liquid N_2

(d) Liquid H_2

50. On burning hydrogen in air the colour of flame is

(a) green

(b) light bluish

(c) yellow

(d) none of these

Answer Keys:

1. b	2. a	3. d	4. b	5. d	6. d	7. a	8. c	9. c	10. b
11. a	12. c	13. b	14. a	15. c	16. a	17. d	18. c	19. d	20. a
21. a	22. b	23. c	24. b	25. d	26. b	27. b	28. d	29. c	30. b
31. b	32. b	33. c	34. a	35. d	36. a	37. a	38. d	39. b	40. a
41. b	42. d	43. c	44. d	45. b	46. d	47. d	48. c	49. d	50. b

Solutions:

1. There is extensive intermolecular H-bonding in the condensed phase.

2.

PLAN This problem can be solved by using concept of oxidant and reductant.

Oxidant Oxidant increases the oxidation number of the species with which it is reacted.

Reductant Reductant decreases the oxidation number of the species with which it is reacted.

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 gets reduced hence, H_2O_2 is a reducing agent here.

With NH_2OH, it given following reaction:

$$\overset{-1}{N}H_2OH + H_2O_2 \longrightarrow \overset{+3}{N_2}O_3 + H_2O$$

In the above reaction, oxidation state of N varies from –1 to +3. Here, oxidation number increases, hence H_2O_2 is acting as an oxidising agent here.

Hence, (a) is the correct choice.

3.

Release of electron is known as reduction. So, H_2O_2 acts as reducing agent when it releases electrons.

Here, in reaction (II) and (IV), H_2O_2 releases two electron, hence reaction (II) and (IV) is known as **reduction**.

In reaction (I) and (III), two electrons are being added, so (I) and (III) represents **oxidation.**

4. Sodium peroxide on treatment with dilute acid gives H_2O_2

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

5. Factual statement

6.

$$H_2C = CH_2 + H_2O_2 \longrightarrow \underset{\underset{OH}{|}}{H_2C} - \underset{\underset{OH}{|}}{CH_2}$$

Ethylene glycol

7. LiH is an ionic hydride, in which an electron is transferred from Li hence $Li^{\oplus}$ and $H^{\oplus}$ are formed.

8. Deuterium is $^{2}_{1}\mathrm{H}$

Number of neutrons = Atomic mass – Atomic number

= 2 –1 = 1

9. Deuterium oxide is D_2O

10. Factual statement.

11. Factual statement.

12. $\mathrm{PbS} + 4\mathrm{H_2O_2} \rightarrow \mathrm{PbSO_4} + 4\mathrm{H_2O}$

13. $2\mathrm{NaO_2} + 2\mathrm{H_2O} \rightarrow 2\mathrm{NaOH} + \mathrm{H_2O} + \frac{3}{2}\mathrm{O_2}$

14. $\overset{(0)}{\mathrm{Ca}} + \mathrm{H_2} \rightarrow \overset{(2+)}{\mathrm{Ca}}\mathrm{H_2}$

15. Factual statement.

16. Factual statement

17. Factual statement.

18. Factual statement.

19. $2KO_2 + H_2SO_4 \rightarrow \underset{\text{dil}}{K_2SO_4} + H_2O_2$

20. As $Na^{\oplus}$ ions in sodium zeolite are replaced by Ca^{2+} and Mg^{2+} ions present in hard water, these two ions will not be present.

21.

$$\underset{\text{Peroxodi-sulphuric acid}}{H_2S_2O_8} + H_2O \longrightarrow 2H_2SO_4 + H_2O_2$$

22.

$$\underset{\text{Barium peroxide}}{3BaO_2} + \underset{\text{Phosphoric acid}}{2H_3PO_4} \longrightarrow Ba_3(PO_4)_2 + 3H_2O_2$$

23. Factual statement

24. Factual statement

25.

Strength = Normality × EW of H_2O_2

$= 1.5N \times 17\ g\ L^{-1} = 25.5\ g\ L^{-1}$

$$\underset{68\ g}{2H_2O_2} \longrightarrow 2H_2O + \underset{22400\ mL\ at\ STP}{O_2}$$

68 g of H_2O_2 gives = 22400 mL of O_2 at STP

25.5 g H_2O_2 gives $= \frac{22400}{68} \times 25.5 = 8400$ mL of O_2 at STP

25.5 g of H_2O_2 is present in 1000 mL of H_2O_2 solution.

1000 mL of H_2O_2 gives 8400 mL of O_2 at STP.

1 mL of H_2O_2 gives $\frac{8400}{1000}$ mL of O_2 at STP

$= 8.4$ mL of O_2

Hence, volume strength of 1.5 N $H_2O_2 = 8.4$ volume.

Or mass of H_2O_2 in 1.5 N solution

= EW of $H_2O_2 \times 1.5$ N

$= 17 \times 1.5 = 25.5$ g /L

Hence, volume strength of 1.5 N H_2O_2 solution

$= \frac{22.4 \times 25.5}{68} = 8.4$

26. Factual statement

27. Factual statement

28. Factual statement

29. Factual statement

30. $Zn + 2NaOH \xrightarrow{\Delta} Na_2ZnO_2 + H_2$

31.

10 volume H_2O_2 means 10 mL of O_2 is produced at STP from 1 mL of 10 vol H_2O_2.

Hence 500 mL of O_2 is produced at STP from

$\frac{500}{10}$ = 50 mL of 10 vol H_2O_2

32. Factual statement

33. Factual statement

34.

$$N = \frac{W_2 \times 1000}{EW_2 \times VmL}$$

$$= \frac{34 \times 1000}{17 \times 1120} = \frac{200}{12}$$

1 N of H_2O_2 = 5.6 vol strength

$\frac{200}{12}$ N of $H_2O_2 = 5.6 \times \frac{200}{12}$ = 10 vol strength

35.

$H_2O_2 \equiv KI \equiv I_2$

mEq of $H_2O_2 = 5 \times N$

$$\text{mEq of } I_2 = \frac{\text{Weight}}{\text{EW}} \times 1000$$

$$= \frac{1.27}{127} \times 1000 = 10 \text{ mEq}$$

$I_2 = MW = 254$

$$EW = \frac{MW}{2} = \frac{254}{2} = 127$$

$\therefore$ mEq of H_2O_2 = mEq of I_2

$5 \times N = 10 \quad \therefore N = 2$

1 N of H_2O_2 = 1.7% of H_2O_2

2 N of H_2O_2 = 3.4 % H_2O_2

36. In Question 35, *N* of H_2O_2 = 2

$\because$ 1 N of H_2O_2 = 5.6 vol strength

2 N of H_2O_2 = 11.2 vol strength.

37.

$$O_3 \longrightarrow O_2 + O \quad \text{...(i)}$$

$$H_2O_2 \longrightarrow H_2O + O \quad \text{...(ii)}$$

$$O + O \longrightarrow O_2 \quad \text{...(iii)}$$

1/2 vol 1/2 vol 1 vol

From Eqs. (i) and (ii), we infer that 100 mL of O_3 at STP will produce 100 mL of O_3 as such and 100 mL of O_2 molecule after reaction with H_2O_2.

This new volume of 100 mL of molecular oxygen after reaction with H_2O_2 is contributed equally by O_3 and H_2O_2. Thus, 50 mL of oxygen has been contributed by H_2O_2.

Again, we know that

Volume of H_2O_2 × vol strength of H_2O_2 = vol of O_2 at STP

After utilisation of 50 mL of O_2, according to Eq. (iii), the balance (1000 – 50) = 950 mL of O_2 at STP are still retainable by 100 mL of H_2O_2. Hence vol strength of H_2O_2 after reaction

$$= \frac{\text{Volume of } O_2 \text{ at STP}}{\text{Volume of } H_2O_2}$$

$$= \frac{950}{100} = 9.5 \text{ V}$$

∴ Volume strength = 9.5

	Distilled H_2O [No hardness]	Tap H_2O [Temporary + Permanent hardness]	Boiled H_2O [Permanent hardness only]
Volume of soaps solution	1 mL	13 mL	5 mL

Volume of soap solution used effectively in tap water

$= 13 - 1 = 12$ mL

$\therefore$ Temporary + Permanent hardness = 12 mL

Volume of soap solution used effectively in boiled water $= 5 - 1 = 4$ mL

$\therefore$ Temporary + Permanent hardness = 12 mL

Permanent hardness = 4 mL

Temporary hardness = 8 mL

$$\therefore \frac{\text{Temporary hardness}}{\text{Permanent hardness}} = \frac{8}{4} = 2:1$$

39.

100 g of H_2O_2 sample solution contains = x g of H_2O_2

3.4 g of H_2O_2 sample solution contains = $\frac{x}{100} \times 3.4$

Weight of $H_2O_2 = \frac{3.4\,x}{100}$

Eq of $H_2O_2 = \frac{3.4\,x}{100} \times \frac{1}{17}$

mEq of $H_2O_2 = \frac{3.4x}{100 \times 17} \times 1000 = \frac{34\,x}{17} = 2x$

mEq of $KMnO_4 = x \times N$

$x \times N = 2x$

$N = 2$

40.

Volume of O_2 at STP

= 100 mL × 11.2 mL volume strength

= 1120 mL of O_2 at STP

Since 1 N = 5.6 volume strength of H_2O_2

2N = 11.2 volume strength of H_2O_2

Volume of O_2 produced by H_2O_2 = 1120 mL

Same volume of O_2 will be produced by $KMnO_4$, i.e. 1120 mL

Total volume of O_2 produced = 2240 mL = 2.24 L

41.

$MnO_4^{\ominus} + 5e^{\ominus} \longrightarrow Mn^{2+}$ (acidic)

$MnO_4^{\ominus} + 3e^{\ominus} \longrightarrow MnO_2$ (basic)

100 mL $H_2O_2 \equiv 100 \times 5N\ MnO_4^{\ominus} \equiv V \times 3N\ MnO_2$

$$N = \frac{500}{3}\ mL$$

42.

N of H_2O_2 = Volume strength/5.6 = $x/5.6$

mEq. of $H_2O_2 \equiv$ mEq. of $MnO_4^{\ominus}$

$\therefore N_1V_1 \equiv N_2V_2$

$$\frac{x}{5.6} \times 10\ mL \equiv \frac{1}{0.56} \times 10\ mL$$

$\therefore\ x =$ '10' volume strength

43.

1N = 5.6 vol

$\Rightarrow$ Normalities of two solutions are 1 N and 2N

$$\text{Normality of mixture} = \frac{1\times1+1\times2}{1+1} = \frac{3}{2} = 1.5\ N$$

$$\text{Volume strength} = \frac{3}{2} \times 5.6 = \frac{16.8}{2} = 8.4\ mol$$

44.

$100 \times 5N\ (MnO_4^{\ominus}) \equiv V \times 3N\ (MnO_4^{\ominus})$

$$V = \frac{500}{3} mL$$

45.

$$\text{mEq of } MnO_4^{\ominus} \equiv \text{mEq of } H_2O_2$$

$$10 \times \frac{M}{5} \times 5 \equiv \text{mEq of } H_2O_2$$

$$\Rightarrow 10 \text{ mEq} \equiv \text{mEq of } H_2O_2$$

$$\text{Weight of } H_2O_2 = 10 \times 10^{-3} \times \frac{34}{2} \times 0.17 = 0.2 \text{ g}$$

$$\text{Weight of impure } H_2O_2 = \frac{100}{85} \times 0.17 = 0.2 \text{ g}$$

46.

Temporary hardness is due to $HCO_3^{\ominus}$ of Ca^{2+} and Mg^{2+}

$$\underset{56 \text{ g}}{Ca(HCO_3)_2 + CaO} \longrightarrow \underset{(2 \times 100) \text{ g}}{2CaCO_3 + H_2O}$$

$$0.56 \text{ g } CaO \equiv 2 \text{ g } CaCO_3 \text{ in } 10 \text{ L } H_2O$$

$$= 2 \text{ g } CaCO_3 \text{ in } 10^4 \text{ mL } H_2O$$

$$= 20 \text{ g } CaCO_3 \text{ in } 10^6 \text{ mL } H_2O$$

$$= 20 \text{ ppm of } CaCO_3$$

47. General electronic configuration of halogen is ns^2, np^5 i.e. they are short of one electron to acquire noble gas configuration.

48. Factual statement.

49. Factual statement.

50. Factual statement.