46. (b) $2Na + H_2 \rightarrow 2Na^+H^-$

Hydrogen has $-ve$ (–1) oxidation state.

47. (a) $NaH \rightleftharpoons Na^+ + H^-$

At anode : $H^- \rightarrow H + e^-$

$H + H \rightarrow H_2$

48. (a) For example HCl is a protonic acid

$HCl + H_2O \rightleftharpoons [H_3O]^+ + Cl^-$

49. (c) Hydrogen resembles both alkali metals and halogens.

50. (d) Chlorine has lone pair which it can donate to form co-ordinate bond while hydrogen cannot.

51. (c) Actually these exist in the ratio.

Protium	:	Deuterium	:	Tritium
1	:	1.56×10^{-2}	:	1×10^{-17}

52. (d) $SO_3 + D_2O \rightarrow D_2SO_4$ dideutero-sulphuric acid.

53. (b) $H^1H^1, H^1H^2, H^2H^2, H^3H^3, H^2H^3$

54. (d) $\overset{+2}{Ca}\ \overset{x}{H_2}$ *i.e.,* $2 + 2x = 0$, $x = -1$

$2x = -2$ or $x = \frac{-2}{2} = -1$

55. (c) Pure hydrogen is obtained by the electrolysis of $Ba(OH)_2$ solution in a *U*-tube using nickel electrode. The gas is liberated at the cathode and is passed over heated platinum gauze to remove oxygen if present as impurity.

56. (b) $\underbrace{CO + H_2}_{\text{water gas}} + H_2O \xrightarrow{\text{catalyst}} CO_2 + 2H_2$

57. (b) Deuterium (^2_1H) and hydrogen (^1_1H) both have same atomic number but different mass number so they have similar chemical but different physical properties.

58. (b) $^3_1H \rightarrow {}^3_2He + {}^0_{-1}e$

59. (d) $V.\text{oil} + H_2 \xrightarrow[\Delta]{Ni} \text{Fat}$

60. (a) $2H \rightleftharpoons H_2$; $\Delta H = -104.5\, kcal$

61. (b) Lavoisier give the name hydrogen which means water maker.

62. (a) For diatomic gases (*e.g.* H_2) $r = C_p / C_v = 1.40$

For monoatomic gases $r = 1.66$

For triatomic gases $r = 1.33$

63. (b) H_3 is also called Hyzone.

64. (b) $4LiH + AlCl_3 \xrightarrow{\text{Ether}} LiAlH_4 + 3LiCl$

65. (b) Alkali metal hydrides react with water to give metal hydroxide and H_2 *e.g.,*

$NaH + H_2O \rightarrow NaOH + H_2$

Alkali metal hydroxides are strongly basic in nature.

66. (c) Ionic hydrides are good reducing agents.

68. (c) Systematic name of water is oxidane.

69. (c) BeH_2 and MgH_2 have significant covalent character.

70. (a) Limiting composition of *f* block hydrides are MH_2 and MH_3.

71. (d) H_2 does not react with *Au, Cu* or *Ni* with *Ca* it gives CaH_2.

$Ca + H_2 \rightarrow CaH_2$

72. (c) $Ca(OH)_2$ is used for the softening of temporary hard water.

$Ca(OH)_2(aq) + CO_2(g) \rightarrow \underset{\text{cloudiness}}{CaCO_3(s)} + H_2O(l)$

73. (a) $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

$Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$

$\therefore$ Ratio of volumes of H_2 evolved is 1 : 1.

74. (c) Anhydrous $CaCl_2$ is used for fast drying of neutral gases.

75. (d) Hydrogen is the lightest gas.

76. (c) An atom of tritium contains 1 proton, 1 electron and 2 neutrons.

77. (d) Hydrogen is a non-metal while all other members of group 1 (alkali metals) are metals.

78. (b) $\underset{\text{base 1}}{H^-(aq)} + \underset{\text{acid 2}}{H_2O(l)} \rightarrow \underset{\text{base 2}}{OH^-(aq)} + \underset{\text{acid1}}{H_2(g)}$

79. (a) $\underset{1s^1}{H} + e^- \rightarrow \underset{1s^2 \text{ or } [He]^2}{H^-}$

$\underset{[He]^2 2s^2 2p^5}{F} + e^- \rightarrow \underset{[He]^2 2s^2 2p^6 \text{ or } [Ne]^{10}}{F^-}$

80. (a) Hydrogen from bonds in +1 and –1 oxidation state.

81. (c) Mercury (*Hg*) will not displace hydrogen.

82. (c) Hydrogen is the lightest gas. It is insoluble in water.

83. (b) Hydrogen forms maximum number of compounds in chemistry comparison than carbon.

84. (c) $Zn + H_2O \rightarrow ZnO + H_2$

$Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

$Zn + 2H_2SO_4 \rightarrow ZnSO_4 + SO_2 + 2H_2O$.

Water or hydride of oxygen

4. (b) $Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow \underset{\text{ppt.}}{2CaCO_3\downarrow} + 4H_2O$

5. (c) D_2O in which $D = {}_1H^2$

7. (b) HCO_3^- is main reason of temporary hardness of water.

8. (b) By boiling temporary hardness of water can be removed.

$Ca(HCO_3)_2 \xrightarrow{\text{Boil}} \underset{\text{(insoluble)}}{CaCO_3} + H_2O + CO_2$

9. (c) $\underset{\text{Zeolite}}{Na_2Al_2Si_2O_8}.xH_2O + Ca^{+2} \rightarrow$

$CaAl_2Si_2O_8.xH_2O + 2Na^+$

10. (b) Water has high dielectric constant *i.e.,* 82, high liquid range and can dissolve maximum number of compounds. That is why it is used as universal solvent.

11. (a) Heavy water *i.e.,* D_2O slows down the speed of neutrons in nuclear reactors..

12. (a) Chlorides and sulphates of *Mg* and *Ca* produces permanent hardness and bicarbonates of *Mg* and *Ca* produces temporary hardness.

13. (d) Permanent hardness cannot be removed by boiling of water but temporary hardness can be removed.

14. (d) The density of water is $1\ g\ cm^{-3}$ at $4°C$

so molarity $= \frac{1000}{18} = 55.5\ M$.

15. (d) Water containing Ca^{+2}, Mg^{+2} and $H^+ (> 10^{-7} m)$ is a hard water.

$H^+(aq) + CH_3COONa(aq) \rightleftharpoons CH_3COOH(s) + Na^+(aq)$

16. (c) Heavy water is used as a moderator to slow down the speed of fast moving neutrons and as well as a coolant.

17. (b) Heavy water freezes at a slightly higher temperature than water.

18. (b) *pH* of heavy water is slightly more than seven.

19. (c) D_2O actually has higher freezing point (3.8°*C*) than water H_2O (0°*C*).

20. (d) Colourless anhydrous $CuSO_4$ becomes blue on reaction with water.

21. (c) Due to plumbosolvancy, lead dissolves in water to a small extent to form soluble hydroxide which is poisonous so lead pipe is not used for carrying drinking water.

22. (a) Slaked lime removes temporary hardness of water.

$$\underset{\text{From hard water}}{Ca(OH)_2 + Ca(HCO_3)_2} \rightarrow 2CaCO_3 \downarrow + 2H_2O$$

23. (a) In cation exchange resin Mg^{+2} and Ca^{+2} (cations) are replaced by Na^+ ions.

24. (c) Washing soda removes both the temporary and permanent hardness by converting soluble calcium and magnesium compounds into insoluble carbonates.

$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$

$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 + Na_2SO_4$

$Ca(HCO_3)_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaHCO_3$.

25. (c) It is $Na_2Al_2Si_2O_8.xH_2O$

26. (c) $_1H_2^3O = 16 + 2 \times 3 = 22\,amu$

27. (d) $H_2O(H = {}_1H^2)$

$16 + 2 \times 2 = 20\,amu$

30. (c) $K_2SO_4.Al_2(SO_4)_3.24H_2O$

Potash alum is generally used for purifying water.

31. (c) Copper will not reduce H_2O to H_2 because of low reducing power of copper comparison than hydrogen.

32. (c) Heavy water is formed by the combination of heavier isotope ($_1H^2$ or *D*) with oxygen.

$$2D_2 + O_2 \rightarrow \underset{\text{Heavy water}}{2D_2O}$$

33. (c) Water molecule associate due to inter molecular hydrogen bonding.

34. (d) Heavy water is D_2O $(1-c)$

Temporary hard water contains bicarbonates of Ca^{2+} and $Mg^{2+}(2-a)$

Soft water may have no foreign ions $(3-b)$.

Permanent hard water contains sulphates and chlorides of Ca^{+2} and $Mg^{2+}(4-d)$

35. (d) The $H-O-H$ angle in water molecule is about 105° (due to two lone pair of electron).

36. (a) Two ice cubes when pressed over each other unite due to hydrogen bond formation.

37. (a) $CaC_2 + 2D_2O \rightarrow C_2D_2 + Ca(OD)_2$

38. (c) Pure water can be obtained from sea water by reverse osmosis.

39. (c) Action of water on dil. Mineral acids (HCl, H_2SO_4) can give dihydrogen.

40. (d) Iron (*Fe*) does not react with cold water to give H_2. However, iron reacts with steam to give H_2.

41. (c) *pH* of neutral water at room temperature is seven.

43. (c) The low density of ice compared to water is due to hydrogen bonding interactions.

44. (b) Silicon tetra fluoride on hydrolysis furnish ortho silicic acid and hydrogen silicofluoride.

$$\underset{\text{(Silicon tetra Fluoride)}}{3SiF_4} + \underset{\text{(Water)}}{4H_2O} \longrightarrow \underset{\text{(Ortho Silicic acid)}}{H_2SiO_4} + \underset{\text{(Hydrogen Silico Fluoride)}}{2H_2SiF_4}$$

45. (a) The triple point of any substance is that temperature and pressure at which the material can exist in all three phases (Solid, liquid and gas) in equilibrium specifically the triple point of water is $273.16K$ at $611.2\,Pa$.

46. (b) Hardness of water is due to the presence of bicarbonates, chlorides and sulphates of Ca and Mg on it. These Ca^{2+} and Mg^{2+} ions react with the anions of fatty acids present in soaps to form curdy white precipitates. As a result, hard water does not produce lather with soap immediately.

Hydrogen peroxide

1. (b) $\underset{0}{Cl_2} + H_2O_2 \rightarrow 2\underset{-1}{HCl} + O_2$

In this reaction H_2O_2 works as reducing agent

2. (d) $[H_2O_2 \rightarrow H_2O + \frac{1}{2}O_2] \times 2$

$\underset{68\,g}{2H_2O_2} \rightarrow 2H_2O + O_2$ 22.4 *litre* at N.T.P.

$\because$ 22.4 *litre* O_2 at N.T.P. obtained by 68 *gm* of H_2O_2

$\therefore$ 10 *litre* O_2 at N.T.P. obtained by

$\frac{68}{22.4} \times 10 = 30.35\,gm/litre$

$\therefore$ 1000 *ml* O_2 at N.T.P. obtained by = 30.35 *gm*

$\therefore$ 100 *ml* O_2 at N.T.P. obtained by

$= \frac{30.35}{1000} \times 100 = 3.035\%$

3. (a) $H_2SO_4 + BaO_2 \rightarrow BaSO_4 + H_2O_2$

5. (c) $BaO_2 + 2HCl \rightarrow BaCl_2 + H_2O_2$

6. (c) $Na_2O_2 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O_2$

7. (d) $PbS + 4H_2O_2 \rightarrow PbSO_4 + 4H_2O$

8. (c) $\underset{-2}{H_2S} + H_2O_2 \rightarrow \underset{0}{S} + 2H_2O$

In this reaction H_2O_2 shows oxidising nature.

9. (b) $H_2O_2 + Cl_2 \rightarrow 2HCl + O_2$

13. (a) Volume strength $= 5.6 \times \text{Normality}$

$= 5.6 \times 1.5 = 8.4\ litre$

14. (b) Quantity of $H_2O_2 = 15\ ml$ and volume of $H_2O_2 = 20$

We know that 20 volume of H_2O_2 means 1 *litre* of this solution will give 20 *litre* of oxygen at N.T.P.

Since, oxygen liberated from 1000 *ml* (1 *litre*) of $H_2O_2 = 20\ litre$, therefore oxygen liberate from 15 *ml* of

$H_2O_2 = \frac{20}{1000} \times 15 = 0.3\ litre = 300\ ml$

15. (a) E.W. of $H_2O_2 = 17$

$N = \frac{30.36}{17} = 1.78\ N$

Volume strength $= 5.6 \times$ Normality

$= 5.6 \times 1.78 = 10\ litre$

17. (a) Equivalent weight of H_2O_2 is 17.

18. (b) $\because$ 22.4 *litre* O_2 at N.T.P. obtained by 68 *gm* of H_2O_2

$\therefore$ 1 *litre* O_2 at N.T.P. obtained by $\frac{68}{22.4}$ *gm* of H_2O_2

$\therefore$ 20 *litre* O_2 at N.T.P. obtained by

$\frac{68}{22.4} \times 20$ *gm* of $H_2O_2 = 60.71\ gm$ of H_2O_2

$\therefore$ 1000 *ml* O_2 at N.T.P. obtained by = 60.71 *gm* of H_2O_2

$\therefore$ 100 *ml* O_2 at N.T.P. obtained by

$= \frac{60.71}{1000} \times 100 = 6.71\%$

19. (c) Electrolysis of 50% sulphuric acid gives per disulphuric acid $(H_2S_2O_8)$ which on distillation yields 30% solution of hydrogen peroxide.

20. (c) Due to $O - O$ bond.

21. (a) 10 volume of H_2O_2 means 10 *ml* of O_2 is obtained from 1 *ml* of H_2O_2.

22. (a) Glycerol, phosphoric acid or acetanilide is added to H_2O_2 to check its decomposition.

23. (a) H_2O_2 reduces O_3 to O_2

$O_3 + H_2O_2 \rightarrow H_2O + 2O_2$

24. (d) Fe^{+3} cannot be reduced by H_2O_2 while all other get reduced.

25. (d) Hydrogen peroxide does not show basic properties.

26. (d) Although H_2O_2 is a better polar solvent than H_2O. However it cannot be used as such because of the strong autooxidation ability.

27. (d) H_2O_2 is used as an oxidant for rocket fuel and has 90% concentration to be used in rockets.

28. (a) $\underset{\text{weak acid}}{H_2O_2} \rightarrow H_2O + [O]$

29. (a) Lattice energy of all metal nitrate are less than that of their solvation energy so nitrates of metals soluble in water.

31. (c) H_2O_2 is unstable liquid and decomposes into water and oxygen either on standing or on heating.

32. (c) $\begin{matrix} CH_2 \\ \| \\ CH_2 \end{matrix} + H_2O_2 \rightarrow \begin{matrix} CH_2OH \\ | \\ CH_2OH \end{matrix}$

33. (d) H_2O_2 show all these properties.

34. (a) As H_2O_2 is loosing electrons so it is acting as reducing agent.

36. (c) This is due to the formation of CrO_5.

$K_2Cr_2O_7 + H_2SO_4 + 4H_2O_2 \rightarrow K_2SO_4 + \underset{\text{Blue}}{2CrO_5} + 5H_2O$

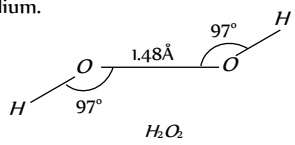
37. (a) K of $H_2O_2 = 1.55 \times 10^{-12}$

38. (a) In the following reaction H_2O_2 acts as a reducing agent.

$PbO_2(s) + H_2O_2(aq) \rightarrow PbO(s) + H_2O(l) + O_2(g)$

39. (e) H_2O_2 acts as an oxidising agent in acidic and alkaline medium.

40. (e)



H_2O_2

41. (b) We know that

$2H_2O_2 \longrightarrow 2H_2O + O_2$

$2 \times 34g \qquad 22400\ ml$

$\because$ $2 \times 34\ gm = 68\ gm$ of H_2O_2 liberates

$22400\ ml$ O_2 at STP

$\therefore$ $.68\ gm$ of H_2O_2 liberates

$= \frac{.68 \times 22400}{68} = 224\ ml$

Critical Thinking Questions

1. (c) Polyphosphates (sodium hexametaphosphates, sodium tripolyphosphate or STPP) from soluble complexes with Ca^{+2}, Mg^{+2} present in hard water.

2. (d) Critical temperature of water is more than O_2 due to its dipole moment (Dipole moment of water = 1.84 *D*; Dipole moment of O_2 = zero *D*).

3. (c) $\underset{\substack{\text{(Cal. phosphide)} \\ \text{1 mole}}}{Ca_3P_2} + 6H_2O \rightarrow \underset{\substack{\text{phosphene} \\ \text{(2 moles)}}}{2PH_3} + 3Ca(OH)_2$

4. (d) Zeolite when treated with hard water exchange Cu^{+2} and Mg^{+2} ions (present in hard water) with Na^+ ions.

6. (c,d) $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2 \uparrow$

$LiH + H_2O \rightarrow LiOH + H_2 \uparrow$

7. (a,b,d) Water containing any cation other than NH_4^+ and alkali metal is a hard water.

8. (b) Reaction of $NaBH_4$ with cold water is very slow. All other statements except (b) are correct.

9. (b,d) $CaH_2 + 2H_2O \rightarrow Ca(OH)_2 + 2H_2 \uparrow$

$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2 \uparrow$

10. (c,d) Ice is a poor conductor of heat (a good thermal insulator) and its density is less than water.

11. (d) H_2 will not reduce heated Al_2O_3.

12. (d) MnO_2, PbO_2 and *BaO* will not give H_2O_2 with HCl. MnO_2 and PbO_2 will give Cl_2 and *BaO* will react with *HCl* to give $BaCl_2$ and water.

13. (a) *Cu* and dil. *HCl* will not produce H_2.

14. (b) Strength = Normality × Eq. mass

$= 1.5 \times 17$ (eq. mass of H_2O_2)

$= 25.5\ gL^{-1}$

15. (b) $Mn + 2HNO_3(dil.) \rightarrow Mn(NO_3)_2 + H_2$

16. (c) Hydrogen behaves as a metal at very high pressure.

17. (d) H_2O absorbs neutrons more than D_2O and this decreases the number of neutrons for the fission process.

18. (c) The para form of H_2 has lesser energy than the ortho form.

19. (c) Fire due to action of water on saline hydrides cannot be extinguished with water or CO_2. These hydrides can reduce CO_2 at high temperature to produce O_2.

21. (c) $Mg(OH)_2$ is less soluble than $MgCO_3$. On boiling temporary hard water containing Mg^{+2} ions, the ppt. obtained is of $Mg(OH)_2$ are not that of $MgCO_3$.

22. (c) $Ca(OH)_2$ removes the permanent hardness due to Mg^{2+} ion, but it produces Ca^{2+} ions which are removed by Na_2CO_3.

$Mg^{2+} + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + Ca^{2+}$

$Ca^{2+} + Na_2CO_3 \rightarrow CaCO_3 \downarrow + 2Na^+$

$Ca(OH)_2$ or Na_2CO_3 alone cannot remove the permanent hardness.

25. (b) $\underset{\text{Sod. formate}}{2HCOONa(s)} \xrightarrow{\Delta} H_2(g) \uparrow + \underset{\text{Sod. oxalate}}{\begin{matrix} COONa \\ | \\ COONa \end{matrix}}(s)$

26. (b) Presence of CO_3^{2-} and SO_4^{2-} ions in water reduced the tendency of dissolution of *Pb* in water as $Pb(OH)_2$.

27. (b) *NaCl* does not make water hard.

28. (b) Solubility of $CaSO_4$ in water decreases with increase in temperature.

29. (b) Organic ion exchange resins can remove only ionic impurities.

30. (d) Water obtained from organic ion-exchange resins is free from all ionic impurities.

31. (a) Soap can remove all types of hardness of water as it converts the hardness producing cations into insoluble ppt.

32. (b) 10 volume solution of H_2O_2 is 3.035% solution

i.e., 3.035 *g* of H_2O_2 is present in $100ml$ of the solution.

Assertion & Reason

2. (d) Both assertion (*A*) and reason (*R*) are not true.

Correct Assertion : Calgon mask the properties of Ca^{2+} and Mg^{2+} ions present in water without removing them as ppt.

Correct Reason : Calgon forms soluble complexes with Ca^{2+} and Mg^{2+} in which properties of these ions are masked.

3. (a) Both assertion (*A*) and reason (*R*) are true and *R* is the correct explanation of *A*.

Correct Reason : H_2O_2 is a strong reducing agent.

4. (c) Assertion (*A*) is correct but reason (*R*) is not the correct explanation of *A*.

10. (d) Both assertion (*A*) and reason (*R*) are not true.

Correct Assertion : Hydrogen peroxide forms two series of salts called hydroperoxides and peroxides.

Correct Reason : Hydrogen peroxide molecule has two replaceable hydrogen atoms.