I P U C QUESTION BANK

SUBJECT:- CHEMISTRY, UNIT – 9 : HYDROGEN

Questions carrying one mark:

1. Which is the most abundant element in the universe?
2. Name the isotope of hydrogen that do not contain neutron.
3. What is the composition of water gas?
4. What is the chemical used in clarke's process to remove the temporary hardness of water?
5. What volume of oxygen is produced by one litre of "10 volume" H_2O_2 at STP?
6. Name the isotope of hydrogen containing two neutrons.
7. What is the role of heavy water in a nuclear reactor?
8. What is a "syn gas"?
9. Give an example of an ionic hydride.
10. Give an example of a covalent hydride.
11. What is "demineralised water "?
12. Arrange LiH, NaH, and CsH in the increasing order of ionic character.
13. Arrange H_2, D_2, T_2 in the increasing order of their boiling points.
14. Which isotope of hydrogen is radioactive?
15. What causes temporary hardness of water?
16. What causes permanent hardness of water?
17. Why H_2O has higher boiling point compared to H_2S?
18. What are Non-stoichiometric hydrides?
19. Why is H_2O_2 not stored in glass containers?
20. What is "calgon"?
21. What is the chemical name of zeolite used in softening of hard water?
22. Out of ice and water, which has low density?

23. What is the bond angle in H_2O molecule?

24. Name the gas liberated by the reaction of zinc with aqueous NaOH solution.

25. Complete the following reaction

$Mg(HCO_3)_2$ (aq) $\xrightarrow{Boil}$ _____ + 2 CO_2.

Questions carrying Two / Three marks:

26. Justify the position of hydrogen in the periodic table.

27. Write the names of isotopes of hydrogen. What is the mass ratio of these isotopes?

28. Why does hydrogen occur in a diatomic form rather than in a monoatomic form under normal conditions?

29. How can the production of dihydrogen obtained from 'coal gasification' be increased?

30. Describe the bulk preparation of dihydrogen by electrolytic method. What is the role of electrolyte in this process?

31. Complete the following reactions:

i) $H_2(g) + M_mO_o(s) \xrightarrow{\Delta}$

ii) $CO(g) + H_2(g) \xrightarrow[Catalyst]{\Delta}$

iii) $C_3H_8(g) + 3\ H_2O(g) \xrightarrow[Catalyst]{\Delta}$

iv) $Zn(s) + NaOH\ (aq) \xrightarrow{Heat}$

32. Discuss the consequences of high enthalpy of H-H bond in terms of chemical reactivity of dihydrogen.

33. What do you understand by (i) electron- deficient (ii) electron-precise (iii) electron-rich compounds of hydrogen? Provide justification with suitable examples.

34. How do you expect the metallic hydrides to be useful for hydrogen storage? Explain.

35. How does the atomic hydrogen or oxy hydrogen torch function for cutting and welding purposes? Explain.

36. Among NH_3, H_2O, and HF, which has highest magnitude of hydrogen bonding and why?

37. What is "auto-protolysis "of water? Mention its significance.

38. Consider the reaction of water with F_2 and suggest, in terms of oxidation and reduction, which species are oxidized/reduced?

39. Complete the following chemical reactions:

i) $PbS\ (s) + H_2O_2\ (aq) \rightarrow$

ii) $Mn O_4^-\ (aq) + H_2O(aq) \rightarrow$

iii) $CaO\ (s) + H_2O\ (g) \rightarrow$

iv) $AlCl_3(s) + H_2O\ (l) \rightarrow$

v) $Ca_3N_2\ (s) + H_2O \rightarrow$

40. Write the chemical reactions to show amphoteric nature of water.

41. Discuss the principle and method of softening of hard water by synthetic ion exchange resins.

42. Write chemical reactions to justify that H_2O_2 can function as an oxidizing as well as reducing agent?

43. What properties of water make it useful as a solvent? What type of compounds can it (i) dissolve and (ii) hydrolyse?

44. How can saline hydrides remove traces of water from organic compounds?

45. What is the difference between the terms hydrolysis and hydration?

46. Mention any two uses of dihydrogen.

47. Calculate the strength of '10 volume' solution of hydrogen peroxide.

48. With an example explain the oxidizing property of water.

49. Explain the reducing property of water with an example.

50. With equations explain the action of washing soda on hard water in removing it's permanent hardness.

UNIT-9. HYDROGEN. Model answers.

Questions carrying one mark

1. Hydrogen

2. Protium—$_1H^1$

3. A mixture of carbon monoxide and hydrogen or $CO + H_2$

4. Lime or $Ca(OH)_2$ or Calcium hydroxide.

5. 10 litres.

6. Tritium—$_1T^3$

7. As a moderator or to slow down fast moving neutrons.

8. A mixture of carbon monoxide and hydrogen $(CO+H_2)$

9. LiH, BeH_2, or MgH_2

10. CH_4, NH_3, H_2O, HF etc.

11. Water which does not contain cations and anions is called demineralised water.

12. LiH < NaH < CsH.

13. $H_2 < D_2 < T_2$.

14. Tritium.

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

16. Permanent hardness is due to the presence of chlorides and sulphates of calcium and magnesium.

17. H_2O molecules associate due to intermolecular hydrogen bonding.

18. Non-stoichiometric hydrides are hydrogen deficient compounds formed by the reaction of dihydrogen with d and f block elements.

19. Alkali metal oxides present in glass catalyse the decomposition of H_2O_2.

20. Sodium hexa metaphosphate or $Na_6P_6O_{18}$.

21. Sodium Aluminium silicate-$(NaAlSiO_4)$

22. Ice has low density.

23. 104.5^0

24. Hydrogen gas

25. $Mg(OH)_2$

Model answers for questions carrying two or three marks.

26. Resemblance of hydrogen with alkali metals:

i) Hydrogen has $1S^1$ configuration in it's valence shell and has a tendency to lose electron to form H^+ ion.

ii) Similar to alkali metals hydrogen forms oxides, halides, and sulphides.

Resemblance of hydrogen with halogens:

i) Similar to halogens it can gain one electron and form hydride (H^{--}) ion.

ii) It also forms covalent compounds and exists as a diatomic molecule "H_2"

27. I) Protium- $_1H^1$ ii) Deuterium- $_1D^2$ iii) Tritium- $_1T^3$.

28. Hydrogen molecule has a very high bond dissociation enthalpy . It forms a covalent bond with another H-atom and exists as a diatomic molecule.

29. By reacting CO with steam in presence of iron chromate catalyst.

$CO(g) + H_2O(g) \xrightarrow[\text{Catalyst}]{673K} CO_2(g) + H_2(g)$

This is called water gas-shift reaction.

30. Hydrogen is prepared by the electrolysis of acidified water using platinum.

$2H_2O \xrightarrow[\text{Traces of acid/base}]{\text{Electrolysis}} 2H_2(g) + O_2(g)$electrodes.

Pure water is not an electrolyte. Addition of electrolyte makes the ions available for electrolysis.

31. I) $H_2(g) + M_mO_o(s) \xrightarrow{\Delta} mM(s) + 0\ H_2O(l)$.

ii) $CO(g) + H_2(g) \xrightarrow[Catalyst]{\Delta} CH_3OH(l)$

iii) $C_3H_8(g) + 3\ H_2O(g) \xrightarrow[Catalyst]{\Delta} 3CO(g) + 7\ H_2(g)$

iv) $Zn(s) + 2\,NaOH\,(aq) \xrightarrow{Heat} Na_2znO_2(aq) + H_2(g)$.

32.Dihydrogen is chemically inert at room temperature due to it's high H-H bond dissociation enthalpy. At high temperature it accomplishes the reactions in which it is converted to H^+ or OH^-ions and formation of covalent bond by sharing electrons.

33.I) An electron deficient hydride has less number of electrons for writing it's conventional lewis structure. Example: diborane-B_2H_6.

ii)An electron precise hydride has the required number of electrons to write the conventional lewis structure. Example: methane-CH_4.

iii)Electron rich hydrides have excess of electrons which are present as lone pairs.Example: ammonia-NH_3.

34. Metallic hydrides of Ni, Pd, Ce, Ac etc. have the property of absorption of dihydrogen. The property of absorption of large volume of hydrogen on transition metals like Pd and Pt is widely used in catalytic reduction / hydrogenation. This property has high potential for hydrogen storage and as source of energy.

35. Atomic hydrogen produced by the dissociation of dihydrogen with the help of an electric arc is made is made to combine on the surface to be welded which produces a very high temperature of 4000k.

Oxy-hydrogen flame generates a high temperature used for cutting and welding purposes.

36. Fluorine is the most electronegative atom and H-F bond is highly polar leading to strong intermolecular bonding in H-F.

37. $H_2O(l) + H_2O(l) \rightarrow H_3O^+(aq) + OH^-(aq)$

Auto-protolysis or self ionization of water is a chemical reaction in which two water molecules react to produce a hydroxide ion(OH^{--}) and hydronium ion.(H_3O^+). This indicates the amphoteric nature or acid base behavior of water.

38. $2F_2(g) + 2H_2O(l) \rightarrow 4H^+(aq) + 4\,F^-(aq) + O_2(g)$.

H_2O is oxidized to O_2. (oxidation number of oxygen increases from –2 to 0)

F_2 is reduced to F^-or HF.(oxidation number of fluorine decreases from 0 to –1)

39. I) $PbS(s) + 4H_2O_2(l) \rightarrow 4H_2O(l) + PbSO_4$ (Redox reaction)

ii) $2MnO_4^-(aq) + 5\ H_2O_2(aq) + 6\ H^+(aq) \rightarrow 2\ Mn^{2+}(aq) + 5O_2(g) + 8\ H_2O(l)$(Redox reaction)

iii) $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2$ (Hydration reaction)

iv) $AlCl_3(s) + 3\ H_2O(i) \rightarrow Al(OH)_3(aq) + 3HCl(aq)$. (Hydrolysis)

v) $Ca_3N_2(s) + 6\ H_2O\ (l) \rightarrow 3\ Ca(OH)_2(s) + 2\ NH_3(g)$ (Hydrolysis)

40 i) $H_2O(l) + NH_3(aq) \Leftrightarrow NH_4^+(aq) + OH^-(aq)$

In this reaction water acts as Bronsted acid.

ii) $H_2O(l) + H_2S(aq) \Leftrightarrow H_3O^+(aq) + HS^-(aq)$

In this reaction H_2O acts as a Bronsted base. Hence H_2O is amphoteric.

41.Cation exchange resins contain large organic molecules like $R—SO_3H$ which are water soluble. Ion exchange resin ($R—SO_3H$) is changed to R—Na by treating with NaCl. The resin exchanges Na^+ ions with Ca^{2+} and Mg^{2+} ions present in hard water and make it soft. Here R is anion.

$2R—Na(s) + M^{2+}(aq) \rightarrow R_2M(s) + 2Na^+(aq)$

The resin can be regenerated by adding aqueous NaCl solution.

42.H_2O_2 oxidises PbS to $PbSO_4$

$PbS(s) + 4\ H_2O_2(l) \rightarrow PbSO_4(s) + 4\ H_2O(l)$

Example of a reaction for reducing action of H_2O_2 in acidic medium

$2MnO_4^{--} + 6\ H^+ + 5\ H_2O_2 \rightarrow 2Mn^{2+} + 8\ H_2O + 5O_2$.

43. Water is a universal solvent due to high value of dielectric constant and dipole moment.

i) water can dissolve many ionic compounds because of ion—dipole interaction.

Ii) water can hydrolyse metallic and non-metallic oxides , hydrides ,carbides etc.

44. Saline hydrides are ionic and contain H^-ion which react with water liberating H_2 gas.

For example: $NaH + H_2O \rightarrow NaOH + H_2$.

45. Hydrolysis is reaction in which H^+ and OH^-ions of water react with a compound to form products.Hydration is association of one or more molecules of water to form hydrated compounds.

46.Dihydrogen is used i) in the synthesis of ammonia ii) in the manufacture of vanaspathi by hydrogenation of oils. Iii) as a rocket fuel iv) in the manufacture of metal hydrides, methanol etc. v) in metallurgical reduction of metal oxides vi) in fuel cells for generating electrical energy.

47.$2H_2O_2(l) \rightarrow H_2O(l) + O_2(g)$

2x34=68g 22.7 L at STP

22.7 litres of $O_2$is produced from 68 g of H_2O_2 at STP

10 litres of O_2 is produced from 68x10/22.7=29.9g or 30 g of H_2O_2

Strength of H_2O_2 in 10volume solution= 30 g/litre= 3% H_2O_2 solution.

48. Highly electropositive metals like Na reacts with H_2O and reduces H_2O to dihydrogen.

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

49. Water is oxidized to O_2 during photosynthesis.

$6CO_2(g) + 12\ H_2O(i) \rightarrow C_6H_{12}O_6(aq) + 6H_2O(l) + 6\ O_2(g)$.

50.Washing soda converts soluble chlorides and sulphates of Ca/Mg to insoluble carbonates and reduces the permanent hardness of water.

$MCl_2 + Na_2CO_3 \rightarrow MCO_3 + 2NaCl$

$MSO_4 + Na_2CO_3 \rightarrow MCO_3 + Na_2SO_4$. (where M= Ca/Mg)

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