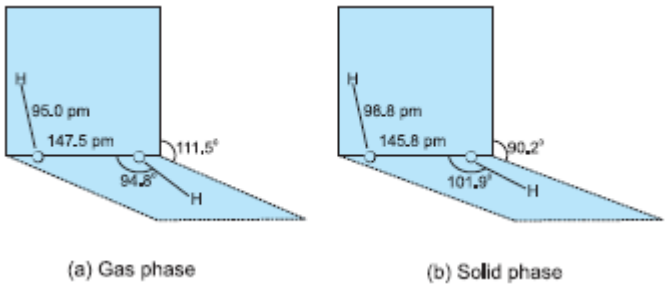
PREVIOUS HSE QUESTIONS AND ANSWERS OF THE CHAPTER "HYDROGEN"

1. (i) Which of the following mixture is known as 'syn gas' ?
   (A) CO and H_2O (B) CO and N_2 (C) CO and H_2 (D) CO_2 and H_2O (1)
   (ii) Explain the production of dihydrogen gas by water gas shift reaction. (2)
   Ans: (i) (C) CO and H_2
   *(ii) When steam is passed over syngas mixture in the presence of iron chromate as catalyst, we get more amount of H_2. This is called **water-gas shift reaction**.*
   $CO(g) + H_2O(g) \xrightarrow{673K,\ catalyst} CO_2(g) + H_2(g)$
2. (i) Give any one disadvantage of hardness of water. (1)
   (ii) Hydrogen peroxide is stored in wax-lined glass or plastic vessels in dark. Why? (2) [December 2021]
   Ans: Hard water is not suitable for laundry purpose. Also it reduces the efficiency of boilers and results in boiler explosion.
3. (i) Syn gas is a mixture of:
   (A) $CO + H_2$ (B) $CO_2 + H_2$ (C) $CO + N_2$ (D) $CO_2 + N_2$ (1)
   (ii) Write the difference between hard water and soft water. (1)
   (iii) Why Hydrogen peroxide is stored in wax lined glass vessels in dark? (1)
   Ans: (i) (A) $CO + H_2$
   (ii) Hard water do not readily forms lather with soap solution, while soft water readily forms lather.
   (iii) In presence of light, H_2O_2 decomposes slowly and forms water and dioxygen.
   $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$
   Presence of metal surfaces or traces of alkali catalyze the above reaction. SO H_2O_2 is stored in wax-lined glass vessels in dark.
4. (i) What are molecular hydrides? (1)
   (ii) Classify the following molecular hydrides into electron deficient, electron precise and electron rich hydrides:
   NH_3, CH_4, B_2H_6, HF (2) [September 2021]
   Ans: (i) These are the hydrides of p-block elements. Examples are CH_4, NH_3, H_2O and HF.
   (ii) Electron deficient hydrides: B_2H_6
   Electron precise hydrides: CH_4
   Electron rich hydrides: NH_3, HF
5. (a) Write any one method for the laboratory preparation of hydrogen. (1)
   (b) Write any 2 uses of hydrogen gas. (1)
   Ans: (a) In the laboratory H_2 gas is prepared by the reaction between granulated zinc and dilute HCl.
   $Zn + HCl \rightarrow ZnCl_2 + H_2$
   (b) It is used as (i) a rocket fuel in space research and (ii) in fuel cells for generating electrical energy.
6. (a) Perhydrol is used as an antiseptic. Give the chemical name of perhydrol. (1)
   (b) Explain the structure of ice. (1)
   (c) Name any two methods for the removal of permanent hardness of water. (1) [December 2020]
   Ans: (a) Hydrogen peroxide (H_2O_2)
   (b) Ice has a highly ordered three dimensional hydrogen bonded structure (open type structure). Each oxygen atom is tetrahedrally surrounded by four other oxygen atoms.

7. (a) What are saline hydrides? (1)
   (b) Why hard water is unsuitable for laundry purpose? (1)
   Ans: (a) These are hydrides formed ny s-block elements. They are also known as ionic hydrides. E.g. NaH
   (b) Hard water does not readily form lather with soap. So it results in wastage of soap and hence unsuitable for laundry purpose.
8. (a) What is calogen ? (1)
   (b) Explain the methods used for the removal of temporary hardness of water. (2) [March 2020]
   Ans: (a) Calgon is sodium hexametaphosphate ($Na_6P_6O_{18}$).
   *(b) **Boiling**: During boiling, the soluble $Mg(HCO_3)_2$ is converted into insoluble $Mg(OH)_2$ and $Ca(HCO_3)_2$ is changed to insoluble $CaCO_3$, which can be removed by filtration.*
   $Mg(HCO_3)_2 \longrightarrow Mg(OH)_2 \downarrow + 2CO_2 \uparrow$
   $Ca(HCO_3)_2 \longrightarrow CaCO_3 \downarrow + H_2O + CO_2 \uparrow$
   ***Clark's method**: In this method, calculated amount of lime is added to hard water. Calcium carbonate or magnesium hydroxide gets precipitated and can be filtered out.*
   $Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 \downarrow + 2H_2O$
9. Name the compound used in Clark's method for the removal of hardness of water. (1)
   Ans: Slaked lime [$Ca(OH)_2$]
10. (a) Substantiate the amphoteric nature of water with suitable chemical equations. (2)
    (b) What is meant by 100 volume H_2O_2? (1) [July 2019]

    Ans: (a) Water can act both as acid and base. So it is an amphoteric substance.
    e.g. $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$
    acid
    $HNO_3 + H_2O \rightleftharpoons H_3O^+ + NO_3^-$
    Base
    (b) 30% solution of hydrogen peroxide is called 100 volume H_2O_2. i.e. 1 mL of 30% H_2O_2 solution will give 100V of oxygen at STP.

11. Which among the following is a molecular hydride?
    a) LiH b) NH_3 c) CrH d) $LaH_{2.87}$ (1)
    Ans: b) NH_3
12. Give the structure, preparation and a chemical reaction of H_2O_2. (3) [March 2019]
    Ans: Structure of H_2O_2.



(a) Gas phase (b) Solid phase

Preparation: It is prepared by acidifying barium peroxide and removing excess water by evaporation under reduced pressure. $BaO_2.8H_2O(s) + H_2SO_4(aq) \rightarrow BaSO_4(s) + H_2O_2(aq) + 8H_2O(l)$

***OR**, By the auto-oxidation of 2-alklylanthraquinols.*

2 ethylanthraquinol $\rightleftharpoons$ H_2O_2 *+ oxidised product*

Chemical reaction: When exposed to sunlight, it decomposes slowly and forms O_2.

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

13. Briefly explain the different types of hydrides. (3) [August 2018]

Ans: Hydrides are classified into three:

***i) Ionic or saline or salt-like hydrides**:*

These are stoichiometric compounds of H_2 *with s-block elements. They are crystalline, non-volatile solids and conduct electricity in the molten state or in aqueous solution state.*

e.g. NaH, KH, CaH_2, BaH_2 *etc.*

***ii) Covalent or Molecular Hydrides**:*

These are the hydrides of p-block elements. Examples are CH_4, NH_3, H_2O *and HF. Being covalent, they are volatile compounds. Molecular hydrides are further classified into 3 according to the relative numbers of electrons and bonds in their Lewis structure - (i) electron-deficient, (ii) electron-precise and (iii) electron-rich hydrides.*

***iii) Metallic or interstitial Hydrides**: These are formed by d-block and f-block elements. However, the metals of group 7, 8 and 9 do not form this hydride. They are almost always nonstoichiometric, being deficient in hydrogen.*

They conduct heat and electricity.

e.g. $LaH_{2.87}$, $YbH_{2.55}$, $TiH_{1.5–1.8}$, $ZrH_{1.3–1.75}$, $VH_{0.56}$, $NiH_{0.6–0.7}$, $PdH_{0.6–0.8}$ *etc.*

14. Give a reason for the following :

a) H_2O_2 is stored in wax-lined glass or plastic vessels in dark. (2)

b) Hard water is not suitable for laundry. (1) [March 2018]

Ans: a) This is because in presence of light, H_2O_2 *decomposes slowly and forms water and dioxygen.*

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

b) Hard water does not readily form lather with soap. So it is not suitable for laundry.

15. a) There are two types of hardness of water – temporary hardness and permanent hardness.

i) Give the reason for temporary hardness. (1)

ii) Suggest one method to remove permanent hardness. (1)

b) H_2O_2 is an important chemical.

i) Write a method to prepare H_2O_2. (1)

ii) Represent the structure of H_2O_2. (1) [July 2017]

Ans: a) i) Temporary hardness is due to the presence of dissolved bicarbonates of Ca^{2+} *and* Mg^{2+} *in water.*

ii) By treating with washing soda: Washing soda reacts with soluble calcium and magnesium chlorides and sulphates in hard water to form insoluble carbonates.

$CaCl_2 + 2Na_2CO_3 \rightarrow CaCO_3 \downarrow + 2NaCl$

$MgCl_2 + 2Na_2CO_3 \rightarrow MgCO_3 \downarrow + 2NaCl$

b) Refer the Ans. of the qn. No. 4.

16. Hydrogen is the most abundant element in the universe. But in free state it is almost not found in earth's atmosphere.

a) Suggest any three methods for the preparation of H_2 gas by selecting suitable substance given below.

Na, Zn, CaH_2, H_2O, Al, NaOH, HCl (3)

b) Do you expect carbon hydrides of the type C_nH_{2n+2} to act as Lewis acid or base? Why? (1) [March 2017]

Ans: a) $2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$

$Zn + HCl \rightarrow ZnCl_2 + H_2$

$CaH_2 + HCl \rightarrow CaCl_2 + H_2$

b) They cannot act as Lewis acid or Lewis base because they do not contain vacant orbitals or lone pairs of electrons. They are electron precise hydrides.

17. a) Discuss the position of hydrogen in the periodic table. (2)

b) Account for the following:

i) H_2O_2 is a bleaching agent.

ii) Density of ice is lower than that of water. (2) [September 2016]

Ans: a) Hydrogen shows resemblance with both Alkali metals of the first group and halogens of the 17th group. Like alkali metals it has one electron in the outer most shell and forms unipositive ions.
Like halogens, it requires only one electron to complete the valence shell configuration and form uninegative ion. It exists as diatomic molecule and combines with metals.
At the same time it shows some differences from alkali metals and halogens. So it is placed separately in the periodic table.

b) i) H_2O_2 decomposes to form nascent hydrogen which is responsible for its bleaching action.

$H_2O_2 \longrightarrow H_2O + [O]$

ii) Due to the presence of hydrogen bonding, there is a large no. of vacant spaces in ice. So it has lower density than water.

18. a) Hydrogen peroxide restores the colour of lead paintings. Give a reason. (2)

b) How does the atomic hydrogen torch function for cutting and welding purposes? (2) [March 2016]

Ans: a) It is due to the oxidising action of H_2O_2. It oxidises black PbS to white $PbSO_4$ as follows:

$PbS + 4H_2O_2 \rightarrow PbSO_4 + 4H_2O$

b) Here H atoms are allowed to recombine on the surface to be welded to generate the temperature of 4000K.

19. Hydrogen reacts with most of the metals and nonmetals to form hydrides.

a) Elements in which one of the following group/groups of the periodic table do not form hydrides?

i) Groups I5, 16, 17 ii) Group 18 iii) Groups 7, 8, 9 iv) Group 14 (1)

b) Explain the different types of covalent hydrides with suitable examples. (3) [October 2015]

Ans: a) (iii) Groups 7, 8, 9

*b) Covalent hydrides are of three types - electron-deficient, electron-precise and electron-rich hydrides. An **electron-deficient hydride** has very few electrons for writing its Lewis structure. E.g. Diborane (B_2H_6). All elements of group 13 will form electron-deficient compounds. They act as Lewis acids (i.e. they accept electron pairs). **Electron-precise hydrides** have the required number of electrons to write their Lewis structures. All elements of group 14 form such compounds (e.g., CH_4,*

SiH_4 etc.) ***Electron-rich hydrides*** *have excess electrons which are present as lone pairs. Elements of group 15 to 17 form such compounds. They behave as Lewis bases (i.e., electron donors).*

20. a) 'Syn gas' is a mixture of ……..

i) CO and H_2O ii) CO and H_2 C) CO_2 and H_2 iv) CH_4 and CO (1)

b) i) A sample of river water does not give lather with soap easily when it is cold, but on heating gives ready lather with soap. Why? (2)

ii) Draw the structure of a hydrogen peroxide molecule. (1) [March 2015]

Ans: a) CO and H_2

b) i) It is due to temporary hardness. Bicarbonate of calcium or magnesium is dissolved in this water. On heating the bicarbonates decomposes and form insoluble carbonates.

ii) See the Answer of the qn. No 12.

21. a) Give one reaction supporting the amphoteric nature of water. (2)

b) Write the names of any two electron-rich hydrides. (1)

c) Complete the following reaction

$Ca(HCO_3)_2 \xrightarrow{\text{heating}}$ …… + H_2O + ……. (1) [August 2014]

Ans: a) Refer the answer of the question no. 10 (a)

b) NH_3, H_2O

c) $Ca(HCO_3)_2 \xrightarrow{\text{heating}} CaCO_3 + H_2O + CO_2$

22. a) H_2O_2 is a bleaching agent. Why? (1)

b) Complete the following reaction.

$Zn(s) + NaOH(aq) \xrightarrow{\text{heat}}$ ……. (1)

c) In a seminar, if you are asked to present a paper on hydrogen economy, write any two points you are going to include in your paper. (2) [March 2014]

Ans:

a) H_2O_2 decomposes to form nascent hydrogen which is responsible for its bleaching action.

$H_2O_2 \longrightarrow H_2O + [O]$

b) $Zn(s) + NaOH(aq) \xrightarrow{\text{heat}} Na_2ZnO_2 + H_2$

c) The basic principle of hydrogen economy is the transportation and storage of energy in the form of liquid or gaseous dihydrogen. Advantage of hydrogen economy is that energy is transmitted in the form of dihydrogen and not as electric power. Dihydrogen is also used in fuel cells for generation of electric power.

23. a) Water is an amphoteric substance. Justify. (2)

b) Hydrides are binary compounds of hydrogen with other elements. Give one example each for electron deficient and electron rich hydrides. (2) [September 2013]

Ans:

a) Refer the answer of the question no. 10 (a)

b) Electron deficient hydride: B_2H_6

Electron rich hydride: NH_3

24. About 18% of the total production of dihydrogen is from coal.

a) What is 'coal gasification'? (1)

b) How is dihydrogen produced by 'water gas shift reaction'? (2)

c) Write any two uses of dihydrogen. (1) [March 2013]

Ans:

*a) The process of producing 'syngas' from coal is called **'coal gasification'**.*

$C(s) + H_2O(g) \xrightarrow{1270K} CO(g) + H_2(g)$

*b) When steam is passed over syngas mixture in the presence of iron chromate as catalyst, we get more amount of H_2. This is called **water-gas shift reaction**.*

$CO(g) + H_2O(g) \xrightarrow{673K,\ catalyst} CO_2(g) + H_2(g)$

c) Dihydrogen is mainly used for the synthesis of ammonia.
It is also used in the manufacture of vanaspathi fat.

25. a) Hard water contains calcium and magnesium salts. Therefore it does not lather with soap.

i) Hard water is harmful for boilers. Why? (1)

ii) How will you remove the hardness from water by using washing soda? (1)

iii) Which method is more suitable to get pure demineralised water? (1)

b) Hydrogen peroxide is stored in plastic vessels in dark. Why? (1) [September 2012]

Ans: a) i) Hard water results in scale formation in boilers, which leads to boiler explosion.

ii) Washing soda reacts with soluble calcium and magnesium chlorides and sulphates in hard water to form insoluble carbonates.

$CaCl_2 + 2Na_2CO_3 \rightarrow CaCO_3 \downarrow + 2NaCl$

$MgCl_2 + 2Na_2CO_3 \rightarrow MgCO_3 \downarrow + 2NaCl$

iii) Synthetic resins method.

b) This is because in presence of light, H_2O_2 decomposes slowly and forms water and dioxygen.

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

26. Permanent hardness of water can be removed only by chemical methods.

a) Write the name of any one salt responsible for the permanent hardness of water. (1)

b) Sodium hexametaphosphate is commercially called …….. (1)

c) How is sodium hexametaphosphate useful in removing the permanent hardness of water? (1)

d) Suggest a disadvantage of hard water. (1) [March 2012]

Ans: a) $CaCl_2$

b) Calgon

c) When calgon is added to hard water, the Ca and Mg ions in hard water are replaced by Na^+ ions

$Na_6P_6O_{18} \rightarrow 2Na^+ + Na_4P_6O_{18}^{2-}$

$M^{2+} + Na_4P_6O_{18}^{2-} \rightarrow [Na_2MP_6O_{18}]^{2-} + 2Na^+$ *[Where $M^{2+} = Ca^{2+}$ or Mg^{2+}]*

d) It is not suitable for laundry. Also it reduces the efficiency of boilers.

27. a) Vegetable oil is converted into vanaspathi fat by …….. process. (½)

b) D_2O is generally called …… (½)

c) Hydrogen peroxide is an important chemical used in pollution control treatment of domestic and industrial effluents.

i) Write the formula of hydrogen peroxide. (½)

ii) Draw the structure of hydrogen peroxide (1)

iii) Explain with suitable chemical equation, why hydrogen peroxide is stored in wax-lined glass or plastic vessel in dark. (1½) [October 2011]

Ans: a) Hydrogenation

b) Heavy water

i) H_2O_2

ii) and iii) Refer the answer of the question no. 12

28. a) Account for the following observations:

i) The density of ice is lower than that of water. (1)

ii) Hard water does not give ready lather with soap. (1)

b) Justify the position of hydrogen in the periodic table. (2) [March 2011]

Ans: a) i) Due to the presence of hydrogen bonding, there is a large no. of vacant spaces in ice. So it has lower density than water.

ii) Hard water does not readily form lather with soap. So it is not suitable for laundry.

b) Refer the answer of the question no. 17 (a)

29. The efficiency of a boiler is found to decrease when boiler scales are formed.

a) Which are the possible compounds present in water for scale formation? (1)

b) Write the chemistry of scale formation. (1)

c) Suggest a suitable chemical method to prevent the scale formation. (2) [September 2010]

Ans: a) $Ca(HCO_3)_2$ or $Mg(HCO_3)_2$

b) On heating the bicarbonates decomposes to form carbonates, which are responsible for scale formation.

$Mg(HCO_3)_2 \longrightarrow Mg(OH)_2 \downarrow + 2CO_2 \uparrow$

$Ca(HCO_3)_2 \longrightarrow CaCO_3 \downarrow + H_2O + CO_2 \uparrow$

c) Clark's method: In this method calculated amount of lime is added to hard water. It precipitates out calcium carbonate and magnesium hydroxide.

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

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

30. Match the following by selecting the items from columns B and C which are most suitable to those in A.

A	B	C
a) Protium, Tritium	1) Hard water	i) Fertilizer
b) Ca^{2+}, Mg^{2+}	2) Heavy water	ii) Hydrogen
c) H_2O_2	3) Isotopes	iii) Moderator in nuclear reactor
d) D_2O	4) Perhydrol	iv) No lather with soap
	5) Phenol	v) Antiseptic

(4) [March 2010]

Ans:

A	B	C
a) Protium, Tritium	*3) Isotopes*	*ii) Hydrogen*
b) Ca^{2+}, Mg^{2+}	*1) Hard water*	*iv) No lather with soap*
c) H_2O_2	*4) Perhydrol*	*v) Antiseptic*
d) D_2O	*2) Heavy water*	*iii) Moderator in nuclear reactor*

31. a) What is heavy water? Mention one of its uses? (2)
    b) Explain why hydrogen peroxide is not stored in glass vessels. (1)
    c) What is calgon? What is its use? (1) [March 2009]

Ans: a) D_2O is called heavy water. It is used as moderator in Nuclear reactors.

b) Refer the answer of the question no. 3 (iii)

c) Calgon is sodium hexametaphosphate. It is used for removing permanent hardness of water.

32. a) Name the isotopes of hydrogen. (1)
    b) What is heavy water? (1)
    c) What is a moderator? (1) [June 2008]

Ans: a) Protium, Deuterium and Tritium

b) D_2O is called heavy water.

c) They slow down the speed of neutrons.

33. Hard water does not give ready lather with soap.
    a) What is the reason for hardness? (1)
    b) What are the two types of hardness? (1)
    c) Suggest one method to remove hardness. (1) [February 2008]

Ans: a) Presence of dissolved chlorides, sulphates and bicarbonates of calcium and magnesium.

b) Temporary hardness and permanent hardness

c) Addition of washing soda.