

## Q 9.1

Justify the position of hydrogen in the periodic table on the basis of its electronic configuration.

Ans:

The 1<sup>st</sup> element in the periodic table is hydrogen. Hydrogen exhibits dual behaviour because it has only 1 electron on its one 'S' shell.(i.e.,) hydrogen resembles both halogens and alkali metals.

Electronic configuration of hydrogen =  $[1s^1]$

**Hydrogens resemblance with alkali metals:**

Hydrogen has 1 valence electron on its valency shell like alkali metals.

$[He] 2s^1 - Li$

$1s^1 - H$

$[Ne] 3s^1 - Na$

Therefore, to form a uni positive ion, it can lose one of its electron.

To form halides, oxides and sulphides, it combines with electro -ve elements which is the same as alkali metals.

**Hydrogens resemblance with halogens:**

Only 1 electron is required to complete their respective octets for both the halogen and hydrogen.

H :  $1s^1$

F :  $1s^2 2s^2 2p^5$

Cl :  $1s^2 2s^2 2p^6 3s^2 3p^5$

It forms several covalent compounds and diatomic molecules like halogens. Even though hydrogen has a certain similarities among both halogen and alkali metal, it differs from them. Hydrogen won't possess metallic characteristics; it possesses higher ionization enthalpy and reacts less than halogens.

Due to these reasons, hydrogen cant be replaced with alkali metal of 1<sup>st</sup> group or with the halogens of 2<sup>nd</sup> group. Therefore, it is best to place hydrogen separate in the periodic table.

## Q 9.2

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

Ans:

**3 isotopes:**

(i) tritium  ${}^3_1H$  or T

(ii) protium  ${}^1_1H$

(iii) deuterium  ${}^2_1H$  or D

**Mass Ratio:**

Tritium : Protium : deuterium = 1 : 2 : 3

**Q 9.3**

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

**Ans:**

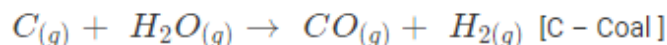
The ionization enthalpy of hydrogen atom is higher. Therefore, it is harder to remove its electron. This results its tendency to exist in the low monoatomic form. Instead of that, covalent bond is formed by hydrogen with another hydrogen atom and exists as diatomic molecule.

**Q 9.4**

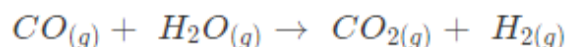
**How can the production of dihydrogen, obtained from 'coal gasification', be increased?**

**Ans:**

By the process of coal gasification, di hydrogen is produced as,



Reaction with carbon monoxide with steam in the presence of a catalyst (iron chromate) results in increase in the yield of di hydrogen.



The above reaction is known as water- gas shift reaction. The carbon dioxide can be removed by scrubbing it with sodium arsenite solution.

**Q 9.5**

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

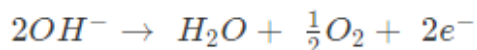
**Ans:**

The preparation of di hydrogen is by the electrolysis of acidified or alkaline water using platinum electrodes. Generally, 15 – 20% of an acid ( $H_2SO_4$ ) or a base (NaOH) is used.

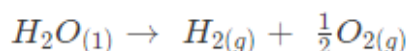
At the cathode, reduction of water occurs as:



At the anode, oxidation of  $OH^-$  ions takes place as:



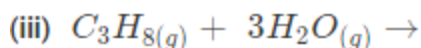
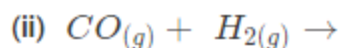
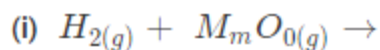
Net reaction is represented as



Due to the absence of ions, the electrical conductivity of pure water is too low. Hence, electrolysis of pure water takes place at a low rate. The rate of electrolysis increases if an electrolyte such as an base or acid is added to the process. The electrolyte is added which makes the ions available in the process for the conduction of electricity and for electrolysis to take place.

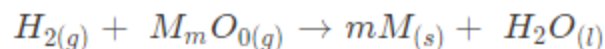
#### Q 9.6

Complete the following reactions:

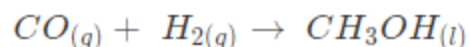


Ans :

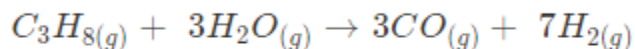
(i)



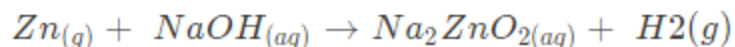
(ii)



(iii)



(iv)

**Q 9.7**

**Discuss the consequences of high enthalpy of H–H bond in terms of chemical reactivity of dihydrogen**

**Ans:**

The ionization enthalpy of H–H bond is higher (1312 kJ mol<sup>–1</sup>) which shows that hydrogen has a low tendency to form H<sup>+</sup> ions. Its ionization enthalpy value is comparable to that of halogens. Hence, it forms

→ a large number of covalent bonds

→ diatomic molecules (H<sub>2</sub>)

→ hydrides with element

Hydrogen does not possess metallic characteristics (lustre, ductility, etc.) like metals because ionization enthalpy is very high.

**Q 9.8**

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

**Ans:**

Molecular hydride is classified on the basis of the presence of the bonds and total number of electrons in their Lewis structures as:

1. Electron-deficient hydrides
2. Electron-precise hydrides
3. Electron-rich hydrides

An electron-deficient hydride has very less electrons, less than that required for representing its conventional Lewis structure.

**E.g**

Diborane (B<sub>2</sub> H<sub>6</sub>)

In  $B_2H_6$ , there are 6 bonds in all, out of which only 4 bonds are regular 2 centered-2 electron bonds.

The remaining 2 bonds are 3 centered-2 electron bonds i.e., 2 electrons are shared by 3 atoms. Hence, its conventional Lewis structure cannot be drawn.

By conventional Lewis structure, an electron-precise hydride has a sufficient number of electrons to be represented.

e.g.  $CH_4$

The Lewis structure can be written as:

4 regular bonds are formed where 2 electrons are shared by 2 atoms. An electron-rich hydride contains excess electrons as lone pairs.

e.g.  $NH_3$

There are 3 regular bonds in all with a lone pair of electrons on the nitrogen atom.

### Q 9.9

**What characteristics do you expect from an electron-deficient hydride with respect to its structure and chemical reactions?**

**Ans:**

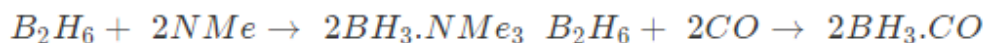
To form a regular bond, an electron-deficient hydride does not have sufficient electrons in which 2 electrons are shared by 2 atoms.

e.g.,  $B_2H_6$ ,

$Al_2H_6$  etc.

Conventional Lewis structures cannot be able to represent these hydrides.  $B_2H_6$ , for example, contains 4 regular bonds and 2 3centered-2 electron bond.

They have a tendency to accept electrons because, these hydrides are electron-deficient. Hence, they act as Lewis acids.



### Q 9.10

**Do you expect the carbon hydrides of the type  $(C_n H_{2n+2})$  to act as 'Lewis' base or acid? Justify.**

**Ans:**

For carbon hydrides which belong to type  $(C_n H_{2n+2})$ , the following hydrides are possible for





For a hydride to act as a Lewis acid, it should be electron deficient.

Lewis acid = electron accepting

Also, for a hydride to act as a Lewis base, it should be electron rich.

Lewis base = electron donating

Taking  $C_2H_6$  as an example, the total number of electrons are 14 and the total covalent bonds are 7. Hence, the bonds are regular  $2e^-$ -2centered bonds.

Hence, hydride  $C_2H_6$  has sufficient electrons to be represented by a conventional Lewis structure. Therefore, it is an electron-precise hydride, having all atoms with octets. Thus, it can neither accept nor donate electrons to act as a Lewis base or Lewis acid.

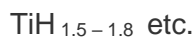
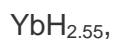
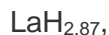
### Q 9.11

**What do you understand by the term “non-stoichiometric hydrides”? Do you expect this type of the hydrides to be formed by alkali metals? Justify your answer.**

**Ans:**

Non-Stoichiometric hydrides are hydrogen-deficient compounds which is formed by the reaction of dihydrogen with d- block and f- block elements. These hydrides do not follow the law of constant composition.

**Eg:**



Alkali metals form stoichiometric hydrides which are naturally ionic. Hydride ions have comparable sizes (208 pm) with alkali metal ion. This results in strong binding force between the constituting metal and hydroxide ion. As a result, stoichiometric hydrides are formed.

Alkali metals will not form non-stoichiometric hydrides.

### Q 9.12

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

**Ans:**

Metallic hydrides are hydrogen deficient. They don't follow the law of constant composition.

It has been established that in the hydrides of Pd, Ac, Ni, and Ce, hydrogen occupies the interstitial position in lattices which allow further absorption of hydrogen on these metals.

Metals like Pt and Pd have the capacity to accommodate a large volume of hydrogen. Hence, metallic hydrides serve as a source of energy and used for the storage of hydrogen.

**Q 9.13**

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

**Ans:**

The atomic hydrogen torch is also known as oxy- hydrogen torch. These atoms are produced through dihydrogen dissociation with the help of an electric arc which results in huge amount of energy.

Energy released =  $435.88 \text{ kJ mol}^{-1}$

This energy is used in generation of 4000 K temperature which is used in cutting and welding of metals.

Therefore, atomic hydrogen torches are used for this purpose i.e., it allows to recombine on the particular surface to be welded for the generation of particular temperature.

**Q 9.14**

**Among  $\text{NH}_3$ ,  $\text{H}_2\text{O}$  and  $\text{HF}$ , which would you expect to have highest magnitude of hydrogen bonding and why?**

**Ans:**

The extent of hydrogen bonding mainly depends on

- (i) Electronegativity
- (ii) Number of hydrogen atoms available for bonding.

Among oxygen, fluorine and nitrogen, the increasing order of their electro negativities are  $\text{N} < \text{O} < \text{F}$ .

Therefore, the expected order of the extent of hydrogen bonding is  $\text{HF} > \text{H}_2\text{O} > \text{NH}_3$ .

But, the actual order is  $\text{H}_2\text{O} > \text{HF} > \text{NH}_3$ .

Even though fluorine is more electronegative than oxygen, the extent of hydrogen bonding is high in water.

There is a shortage of hydrogens in HF, whereas there are exactly the right numbers of hydrogens in water. As a result, only straight chain bonding takes place.

On the other hand, oxygen forms a huge ring-like structure through its high ability of hydrogen bonding.

The extent of hydrogen bonding is limited in case of ammonia, because nitrogen has only 1 lone pair. Therefore, it cannot satisfy all hydrogens.

**Q 9.15**

**Saline hydrides are known to react with water violently producing fire. Can  $\text{CO}_2$ , a well known fire extinguisher, be used in this case? Explain.**

**Ans:**

Saline hydrides [i.e., LiH, NaH etc.] react with water to form hydrogen gas

And a base. The chemical equation to represent this reaction is



This reaction behaves violent and also fire is produced from this.

Dioxygen weights lighter than CO<sub>2</sub>. CO<sub>2</sub> is commonly used as fire extinguisher as it covers the fire like blanket and inhibits the dioxygen supply, thereby dousing the fire.

It can be used in this scenario also. It weights higher than di hydrogen and effective in isolating the burning surface from dioxygen and dihydrogen.

**Q 9.16**

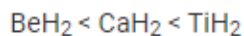
**Arrange the following**

- (i) CaH<sub>2</sub>, BeH<sub>2</sub> and TiH<sub>2</sub> in order of increasing electrical conductance.
- (ii) LiH, NaH and CsH in order of increasing ionic character.
- (iii) H–H, D–D and F–F in order of increasing bond dissociation enthalpy.
- (iv) NaH, MgH<sub>2</sub> and H<sub>2</sub>O in order of increasing reducing property.

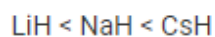
**Ans:**

(i) The electrical conductance of a molecule mainly depends on its covalent or ionic nature. CaH<sub>2</sub> is an ionic hydride, which conducts electricity in the molten state. Titanium hydride, TiH<sub>2</sub> is metallic in nature and conducts electricity at room temperature. Covalent compounds do not conduct, whereas ionic compounds conduct. BeH<sub>2</sub> is a covalent hydride. Hence, it does not conduct.

Hence, the increasing order of electrical conductance is as follows:



(ii) The ionic character of a bond is dependent on the electro negativities of the atoms involved. The higher the difference between the electro negativities of atoms, the smaller is the ionic character. Electronegativity decreases down the group from Lithium to Caesium. Hence, the ionic character of their hydrides will increase (as shown below).



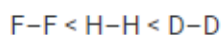
(iii) The bond pair in D–D bond is more strongly attracted by the nucleus than the bond pair in H–H bond. This is because of the higher nuclear mass of D<sub>2</sub>. The stronger the attraction the greater will be the bond strength and the higher is the bond dissociation enthalpy.



Bond dissociation energy depends upon the bond strength of a molecule, which in turn depends upon the repulsive and attractive forces present in a molecule.

Hence, the bond dissociation enthalpy of D–D is higher than H–H. However, bond dissociation enthalpy is the minimum in the case of F–F. The bond pair experiences strong repulsion from the lone pairs present on each F-centre.

Therefore, the increasing order of bond dissociation enthalpy is as follows:



(iv) Ionic hydrides are strong reducing agents. NaH can easily donate its electrons. Hence, it is most reducing in nature. Both,  $MgH_2$  and  $H_2O$  are covalent hydrides.  $H_2O$  is less reducing than  $MgH_2$  since the bond dissociation energy of  $H_2O$  is higher than  $MgH_2$ . Hence, the increasing order of the reducing property is  $H_2O < MgH_2 < NaH$ .

### Q 9.17

Compare the structures of  $H_2O$  and  $H_2O_2$ .

Ans:

The water molecule will be displayed with a bond angle of  $104.5^\circ$  has a bent form in gaseous phase. The O-H bond length is 95.7 pm.

Structure:

Hydrogen peroxide has a non-planar structure both in solid and gas phase.

The dihedral angle in gas and solid phase is  $90.2^\circ$  and  $111.5^\circ$ .

### Q 9.18

What do you understand by the term 'auto-protolysis' of water? What is its significance?

Ans:

Auto-protolysis (self-ionization) of water is a chemical reaction in which 2 water molecules react to produce a hydroxide ion ( $OH^-$ ) and a hydronium ion ( $H_3O^+$ ).

The reaction involved can be represented as:



Auto-protolysis of water indicates its amphoteric nature i.e., its ability to act as an acid as well as a base.

The acid-base reaction can be written as :



Q 9.19

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

Ans:

The reaction between water and fluorine can be represented as:



This is an example of redox reaction



Water is getting oxidized to oxygen and fluorine is being reduced to fluoride ion.

The oxidation number of various species can be represented as:

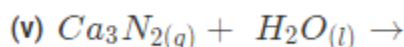
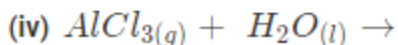
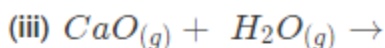
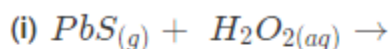


Water is oxidized from  $(-2)$  to zero oxidation state. An increase in oxidation state indicates oxidation of water.

Fluorine is reduced from zero to  $(-1)$  oxidation state. A decrease in oxidation state indicates the reduction of fluorine.

Q 9.20

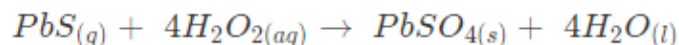
Complete the following chemical reactions.



Classify the above into (a) Hydrolysis, (b) Redox and (c) Hydration reactions.

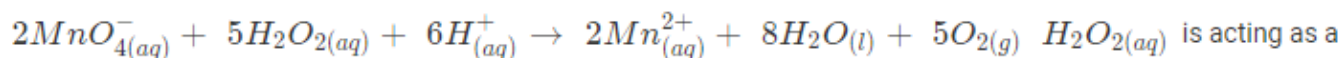
Ans:

(i)



$H_2O_2$  is acting as an oxidizing agent in the reaction. Hence, it is a redox reaction

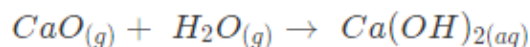
(ii)



reducing agent in the acidic medium, thereby oxidizing  $MnO_4^-(aq)$

Hence, the given reaction is a redox reaction.

(iii)



The reactions in which a compound reacts with water to produce other compounds are called hydrolysis reactions. The given reaction is hydrolysis.

(iv)



The reactions in which a compound reacts with water to produce other compounds are called hydrolysis reactions. The given reaction represents hydrolysis of  $AlCl_3$ .

(v)



The reactions in which a compound reacts with water to produce other compounds are called hydrolysis reactions. The given reaction represents hydrolysis of  $Ca_3N_2$ .

Q 9.21

Describe the structure of the common form of ice.

**Ans:**

Generally, ice is the crystalline form of water. It is visible in a hexagonal form if it is crystallized at atmospheric pressure. When the temperature is very low, it condenses to cubic form.

### 3 – D structure of ice:

It has hydrogen bonding and highly ordered structure. Each of the oxygen atoms is surrounded tetrahedrally by 4 other oxygen atoms at a distance of 276 pm. The structure of ice also contains wide holes that can hold molecules of particular sizes.

### Q 9.22

**What causes the temporary and permanent hardness of water?**

**Ans:**

Due to the presence of soluble salts of magnesium and calcium in the form of chlorides in water, hardness remains permanent in water.

Due to the presence of soluble salts of calcium and magnesium in the form of hydrogen carbonates in water, hardness remains temporary in water.

### Q 9.23

**Discuss the principle and method of softening of hard water by synthetic ionexchange resins.**

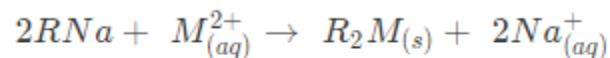
**Ans:**

The process of treating permanent hardness of water using synthetic resins generally based on exchange of anions and cations present in water by  $\text{OH}^-$  and  $\text{H}^+$  ions, respectively.

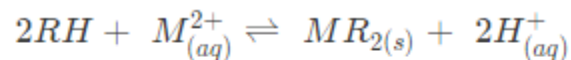
Two types of synthetic resins are

1. Anion exchange resins
2. Cation exchange resins

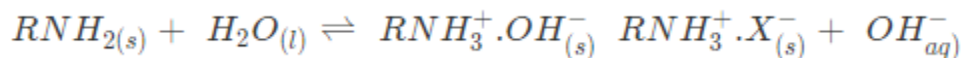
Cation exchange resins are large organic molecules that contain the  $-\text{SO}_3\text{H}$  group. Firstly the resin gets changed into  $\text{RNa}$  by treating it with  $\text{NaCl}$ . This resin exchanges  $\text{Na}^+$  ions with  $\text{Ca}^{2+}$  ions and  $\text{Mg}^{2+}$  ions, thereby making the water soft.



There are cation exchange resins in  $\text{H}^+$  form. The resins exchange  $\text{H}^+$  ions for  $\text{Na}^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Mg}^{2+}$  ions.



Anion exchange resins exchange  $\text{OH}^-$  ions for anions like  $\text{Cl}^-$ ,  $\text{HCO}_3^-$  and  $\text{SO}_4^{2-}$  present in water.



During the whole process, first the water passes through the cation exchange process. The water which is obtained after this process is free from mineral cations and naturally acidic. This acidic water is then passed through the anion exchange process where  $OH^-$  ions neutralize the  $H^+$  ions and de-ionize the water obtained.

#### Q 9.24

Write chemical reactions to show the amphoteric nature of water

Ans:

The amphoteric nature of water can be described on the basis of the following reactions:

##### 1) Reaction with $H_2S$

The reaction takes place as:



In the forward reaction,  $H_2O_{(l)}$  accepts a proton from  $H_2S_{(aq)}$ . Therefore, it acts as a lewis base.

##### 2) Reaction with $NH_3$

The reaction takes place as:



In the forward reaction,  $H_2O_{(l)}$  donates its proton to  $NH_{3(aq)}$ . Therefore, it acts as lewis acid.

##### 3) Self-ionization of water

2 water molecules reacts in this reaction as,



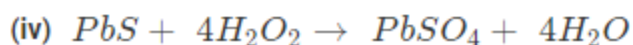
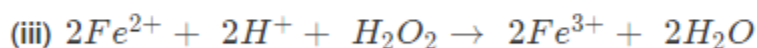
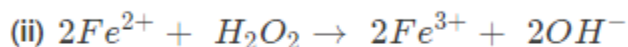
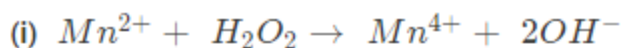
#### Q 9.25

Write chemical reactions to justify that hydrogen peroxide can function as an oxidising as well as reducing agent.

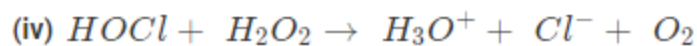
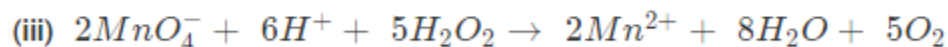
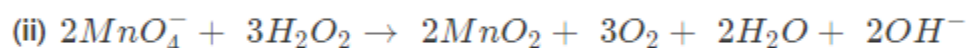
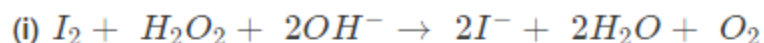
Ans:

Hydrogen peroxide acts as an oxidizing agent as well as reducing agent in both alkaline medium and acidic medium.

The reaction which are involved in oxidizing actions are:



The reaction which are involved in reduction actions are:



Q 9.26

What is meant by 'demineralised' water and how can it be obtained?

Ans:

This water is free from all the soluble mineral salts and it doesn't contain any cation or anion. It is obtained successively by passing the water through anion exchange and cation exchange resin.

During the cation exchange process,  $\text{H}^+$  exchanges for



→  $\text{Mg}^{2+}$

and other cations present in the water.

**Q 9.27**

**Is demineralised or distilled water useful for drinking purposes? If not, how can it be made useful?**

**Ans:**

Water is very essential for our life. It consists of many dissolved nutrients that are required for us and also for plants and animals. Demineralised water is free from all soluble minerals and so it cannot be used for drinking purpose.

After adding desired minerals in specific amounts that are required for growth, this water can be made useful.

**Q 9.28**

**Describe the usefulness of water in biosphere and biological systems.**

**Ans:**

Water is very necessary for all forms of life which constitute 65% of human body and 95% of plants. It plays a vital role in the biosphere due to its

→ Thermal conductivity

→ Dipole moment

→ Specific heat

→ Dielectric constant and

→ Surface tension.

For moderating the human body temperature of all the living beings and the atmospheric climate,

(i) The heat capacity and

(ii) The heat of vapourization helps a lot.

It acts as a carrier of different nutrients which are required by animals and plants for various metabolic reactions.

**Q 9.29**

**What properties of water make it useful as a solvent? What types of compound can it (i) dissolve, and (ii) hydrolyse?**

**Ans:**

A high value of dipole moment and dielectric constants ( $78.39 \text{ C}^2/\text{Nm}^2$ ) makes water a universal solvent. Water is able to dissolve most covalent and ionic compounds. Owing to the ion-dipole

interaction, ionic compounds dissolve in water, whereas covalent compounds form hydrogen bonding and dissolve in water. Water can hydrolyze

→ metallic and non-metallic oxides

→, nitrides

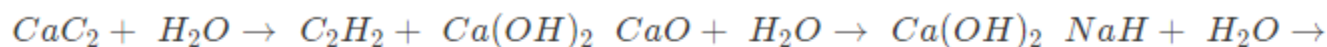
→ phosphides

→ carbides

→ hydrides

and various other salts. During hydrolysis,  $H^+$  and  $OH^-$  ions of water interact with the reacting molecule.

Certain reactions are:



### Q 9.30

Knowing the properties of  $H_2O$  and  $D_2O$ , do you think that  $D_2O$  can be used for drinking purposes?

Ans:

$D_2O$  is known as heavy water which acts as a moderator (slows down the rate of reaction). Due to this property, it cannot be used for drinking purpose because it slows down

(i) catabolic reaction and

(ii) anabolic reaction

That takes place in the body which leads to casualty.

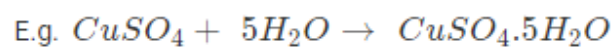
### Q 9.31

What is the difference between the terms 'hydrolysis' and 'hydration'?

Ans:

**Hydration:**

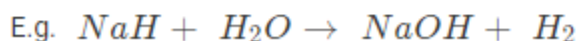
The addition of 1 or more molecules to a molecule or ion which results in the formation of hydrated compounds is known as hydration.





**Hydrolysis:**

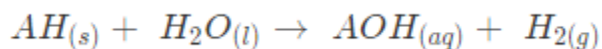
Chemical reaction in which hydroxide ions and hydrogen of water molecules react with a compound to form products is called hydrolysis.

**Q 9.32**

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

**Ans:**

Naturally, saline hydrides are ionic. Saline hydrides reacts with water which results in the formation of metal hydroxide along with hydrogen gas liberation. It is represented as,



When added to an organic solvent, they react with water present in it. Hydrogen escapes into the atmosphere leaving behind the metallic hydroxide. The dry organic solvent distills over.

**Q 9.33**

**What do you expect the nature of hydrides is, if formed by elements of atomic numbers 15, 19, 23 and 44 with dihydrogen? Compare their behaviour with water.**

**Ans:**

The elements of atomic numbers 15 is phosphorus, 19 potassium, 23 is vanadium and 44 is ruthenium.

**Hydride of Phosphorus**

Hydride of phosphorus ( $\text{PH}_3$ ) is covalent in nature. Due to the presence of excess electrons as a lone pair on Phosphorus, it is electron rich.

**Hydride of potassium**

Due to high electropositive nature of potassium, the dihydrogen forms ionic hydrides along with potassium. Naturally it is non – volatile and crystalline.

**Hydrides of Vanadium**

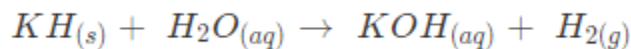
Vanadium belong to d- block in periodic table. The metals of d- block forms non- stoichiometric or metallic hydrides. Hydrides of vanadium are naturally metallic and have deficiency of hydrogen.

**Hydrides of Ruthenium**

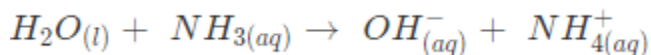
Ruthenium belongs to d- block in the periodic table. The metals of d- block forms non- stoichiometric or metallic hydrides. Hydrides of ruthenium are naturally metallic and have deficiency of hydrogen.

**Behaviour of hydrides towards water**

Potassium hydride reacts violently with water as:



Ammonia (NH<sub>3</sub>) behaves as a Lewis base and reacts with water as:



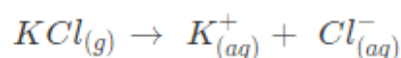
Hydrides of vanadium and Ruthenium do not react with water. Hence, the increasing order of reactivity of the hydrides is (V, Ru) H < PH<sub>3</sub> < KH.

#### Q 9.34

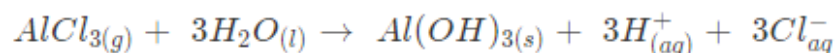
Do you expect different products in solution when aluminium (III) chloride and potassium chloride treated separately with (i) alkaline water (ii) acidified water, and (iii) normal water. Write equations wherever necessary.

**Ans:**

Potassium chloride (KCl) is the salt of a strong acid (HCl) and strong base (KOH). Hence, it is neutral in nature and does not undergo hydrolysis in normal water. It dissociates into ions as follows:



In acidified and alkaline water, the ions do not react and remain as such. Aluminium (III) chloride is the salt of a strong acid (HCl) and weak base [Al(OH)<sub>3</sub>]. Hence, it undergoes hydrolysis in normal water.



In acidified water, H<sup>+</sup> ions react with Al(OH)<sub>3</sub> forming water and giving Al<sup>3+</sup> ions. Hence, in acidified water, AlCl<sub>3</sub> will exist as  $Al_{(aq)}^{3+}$  and  $Cl_{(aq)}^-$

#### Q 9.35

How does H<sub>2</sub>O<sub>2</sub> behave as a bleaching agent?

**Ans:**

Hydrogen peroxide acts as a strong oxidizing agent both in basic and acidic media. When added to a cloth, it breaks the chemical bonds of the chromophores (colour producing agents). Hence, the visible light is not absorbed and the cloth gets whitened.

#### Q 9.36

What do you understand by the terms:

(i) Hydrogen economy (ii) Hydrogenation (iii) 'syngas' (iv) Water-gas shift reaction (v) Fuel cell?

Ans:

**(i) Hydrogen economy**

Dihydrogen releases more energy than petrol and is more eco-friendly. Hence, it can be used in fuel cells to generate electric power. Hydrogen economy is a technique of using dihydrogen in an efficient way. It involves transportation and storage of dihydrogen in the form of liquid or gas. It is about the transmission of this energy in the form of dihydrogen.

**(ii) Hydrogenation**

The process of adding dihydrogen to another reactant is known as hydrogenation. It is used to reduce a compound in the presence of suitable catalyst.

E.g. Hydrogenation of vegetable oil using nickel as a catalyst gives edible fats such as ghee and vanaspathi.

**(iii) 'syngas'**

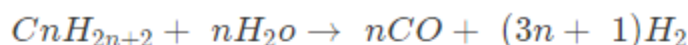
Syngas is a mixture of carbon monoxide and dihydrogen. Since the mixture of the two gases is used for the synthesis of methanol, it is called

syngas

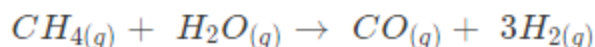
synthesis gas, or

water gas

Syngas is produced on the action of steam with hydrocarbons or coke at a high temperature in the presence of a catalyst.

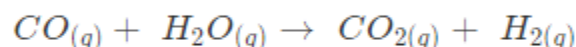


E.g.



**(iv) Water-gas shift reaction**

It is a reaction of carbon monoxide of syngas mixture with steam in the presence of a catalyst as:



This reaction is used to increase the yield of dihydrogen obtained from the coal gasification reaction as:



**(v) Fuel cell**

Fuel cells are devices for producing electricity from fuel in the presence of an electrolyte. Dihydrogen can be used as a fuel in these cells. It is preferred over other fuels because it is eco-friendly and releases greater energy per unit mass of fuel as compared to gasoline and other fuels.

