Chapter: Hydrogen

Exercise

Q9.1

On the basis of its electronic configuration, justify the location of hydrogen in the periodic table.

Answer:

The first element in the periodic table is hydrogen. It has a $1s^1$ electronic configuration. Hydrogen has a dual behavior, resembling both alkali metals and halogens due to the presence of only one electron in its 1s shell.

Resemblance with alkali metals:

1. Hydrogen also contains one electron in its valence shell like alkali metals. So, it can donate that one electron and become a unipositive ion.
2. Hydrogen combines with the electronegative atoms to form oxides, halides, and sulfides like alkali metals.

Resemblance with halogens:

1. To complete their octet, both hydrogen and halogen requires one electron only. So, hydrogen can accept one electron to become a uninegative ion.
2. 2. It forms a diatomic molecule and many covalent compounds, similar to halogens. Though hydrogen shares some properties with alkali metals and halogens, it is distinct in some ways. Hydrogen, unlike alkali metals, does not have metallic properties. It has a high ionization enthalpy, on the other hand. It also has a lower reactivity than halogens.

Hydrogen cannot be mixed with alkali metals (group I) or halogens for these reasons (group VII). It was also established that because H+ ions are so tiny, they cannot exist freely. H+ ions are always found in the presence of other atoms or molecules. As a result, hydrogen should be listed separately in the periodic table.

Q9.2

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

Answer:

There are three isotopes for hydrogen. They are:

1. Protium $_1^1H$
2. Deuterium $_1^2H$ or D
3. Tritium $_1^3H$ or T

The mass ratio of protium, deuterium and tritium are 1:2:3.

Q9.3

Under typical circumstances, why does hydrogen exist in a diatomic form rather than a monoatomic one?

Answer:

The enthalpy of ionisation of a hydrogen atom is quite high. As a result, removing its single electron is extremely difficult. As a result, it has a low tendency to exist in monoatomic form. Instead, hydrogen is a diatomic (H_2) molecule that establishes a covalent link with another hydrogen atom.

Q9.4

How can we enhance the amount of dihydrogen produced by 'coal gasification'?

Answer:

Dihydrogen is produced by coal gasification method as:

$$\underset{\text{(coal)}}{C_{(s)}} + H_2O_{(g)} \xrightarrow{1270\text{ K}} CO_{(g)} + H_{2(g)}$$

By combining carbon monoxide (produced during the reaction) with steam in the presence of iron chromate as a catalyst, the yield of dihydrogen (obtained from coal gasification) can be enhanced. This reaction is called water-gas shift reaction.

Q9.5

Describe the electrolytic process for obtaining dihydrogen in bulk. What role does an electrolyte play in this procedure?

Answer:

The electrolysis of acidified or alkaline water with platinum electrodes produces dihydrogen. In most cases, 15 to 20% of an acid (H_2SO_4) or a basic (NaOH) is used. Because there are no ions in pure water, its electrical conductivity is relatively low. As a result, electrolysis of pure water occurs at a slow rate. The rate of electrolysis rises when an electrolyte, such as an acid or a base, is added to the process. The electrolyte is added to the process to make the ions available for electricity to conduct for electrolysis to take place.

Q9.6

Complete the following reactions:

(i) $H_{2(g)} + M_mO_{o(s)} \xrightarrow{\Delta}$

(ii) $CO_{(g)} + H_{2(g)} \xrightarrow[\text{catalyst}]{\Delta}$

(iii) $C_3H_{8(g)} + 3H_2O_{(g)} \xrightarrow[\text{catalyst}]{\Delta}$

(iv) $Zn_{(s)} + NaOH_{(aq)} \xrightarrow{\text{heat}}$

Answer:

(i) $H_{2(g)} + M_mO_{o(s)} \xrightarrow{\Delta} mM_{(s)} + H_2O_{(l)}$

(ii) $CO_{(g)} + 2H_{2(g)} \xrightarrow[\text{catalyst}]{\Delta} CH_3OH_{(l)}$

(iii) $C_3H_{8(g)} + 3H_2O_{(g)} \xrightarrow[\text{catalyst}]{\Delta} 3CO_{(g)} + 7H_{2(g)}$

(iv) $Zn_{(s)} + 2NaOH_{(aq)} \xrightarrow{\text{heat}} Na_2ZnO_{2(aq)} + H_{2(g)}$

Sodium zincate

Q9.7

Discuss how the high enthalpy of the H-H bond affects dihydrogen's chemical reactivity.

Answer:

The H–H bond has a relatively high ionisation enthalpy. This means that hydrogen has a low tendency for forming ions. It has an ionisation enthalpy similar to that of halogens. As a result, it produces diatomic molecules ( ), element hydrides, and a huge number of covalent bonds. Because of its high ionisation enthalpy, hydrogen does not have the same metallic properties as metals (lustre, ductility, etc.).

Q9.8

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

Answer:

The presence of a total number of electrons and bonds in a molecular hydride's Lewis structure is used to classify it:

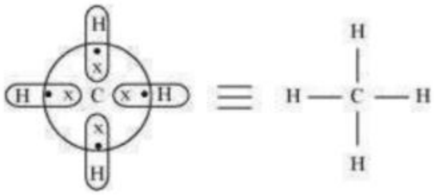
1. Electron-deficient hydrides

2. Electron-precise hydrides

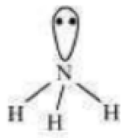
3. Electron rich hydrides

An electron-deficient hydride, such as diborane, has far less electrons than is required to represent the usual Lewis structure (B_2H_6). There are six bonds in total in B_2H_6, but only four of them are normal two-centered-two-electron bonds. The remaining two bonds are three centered-two electron bonds, which means three atoms share two electrons. As a result, the Lewis structure can't be drawn. An electron-precise hydride has a large enough number of electrons to be represented by a Lewis structure. E.g.: CH_4

The Lewis structure can be written as:



Two atoms share two electrons, resulting in four regular bonds. Excess electrons are found as lone pairs in an electron-rich hydride. E.g.: NH_3



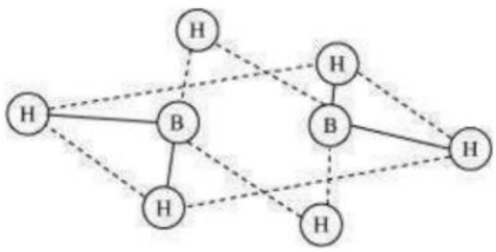
With a lone pair of electrons on the nitrogen atom, there are three normal bonds in total.

Q9.9

In terms of structure and chemical reactions, what properties do you expect from an electron-deficient hydride?

Answer:

An electron-deficient hydride, such as B_2H_6, Al_2H_6, and others, lacks enough electrons to form a normal bond in which two atoms share two electrons. Conventional Lewis structures cannot represent these hydrides. B_2H_6 includes four normal bonds and two three-centered-two-electron bonds, for example. It has the following structure:



These hydrides have a tendency to receive electrons since they are electron deficient. As a result, they function as Lewis acids.

$$B_2H_6 + 2NMe \longrightarrow 2BH_3 \cdot NMe_3$$

$$B_2H_6 + 2CO \longrightarrow 2BH_3 \cdot CO$$

Q9.10

Do you expect the carbon hydrides of the type (C_nH_{2n+2}) to act as 'Lewis' acid or base? Explain your answer.

Answer:

For hydrides, to be act as a Lewis acid, it should be electron deficient. For Lewis base, it should contain lone pair or become an electron rich hydride. In alkanes having general formula (C_nH_{2n+2}) have precise number of electrons. So, they are not Lewis base or Lewis acid. The hydride C_nH_{2n+2} contains enough electrons to be represented by a Lewis structure. As a result, it is an electron-precise hydride, with all atoms having full octets. As a result, it is unable to give or take electrons in order to operate as a Lewis acid or Lewis base.

Q9.11

What exactly do you mean when you say "non-stoichiometric hydrides"? Do you think alkali metals will produce this type of hydride? Justify your response.

Answer:

Dihydrogen reacts with d-block and f-block elements to generate non-Stoichiometric hydrides, which are hydrogen-deficient compounds. The law of constant composition does not apply to these hydrides. Stoichiometric hydrides are formed by alkali metals. The hydrides in question are ionic in nature. Alkali metal ions and hydride ions have similar diameters (208 pm). As a result, the forming metal and the hydride ion have high binding forces. Stoichiometric hydrides are generated as a result. Non-stoichiometric hydrides are unable to produce with alkali metals.

Q9.12

What role do you think metallic hydrides will play in hydrogen storage? Explain.

Answer:

Metallic hydrides are hydrogen-deficient, which means they defy the law of constant composition. It has been demonstrated that hydrogen occupies the interstitial position in the lattices of Ni, Pd, Ce, and Ac hydrides, allowing for further hydrogen absorption on these metals. Pd, Pt, and other metals have the ability to hold a considerable amount of hydrogen. As a result, they are used for hydrogen storage and as a source of energy.

Q9.13

For cutting and welding, how does the atomic hydrogen or oxy-hydrogen torch work? Explain.

Answer:

The breakdown of dihydrogen with the help of an electric arc produces atomic hydrogen atoms. This produces a significant quantity of energy (435.88 kJ). This energy can be used to generate a 4000 K temperature, which is perfect for welding and metal cutting. For these applications, atomic hydrogen or oxy-hydrogen torches are used. As a result, atomic hydrogen is allowed to recombine on the welding surface to produce the desired temperature.

Q9.14

Which of NH_3, H_2O, and HF would you expect to have the most hydrogen bonding, and why?

Answer:

Electronegativity and the number of hydrogen atoms available for bonding determine the extent of hydrogen bonding. Among nitrogen, fluorine, and oxygen, the increasing order of their electronegativities are N < O < F.

As a result, the expected order of hydrogen bonding extent is HF > H2O > NH3. However, the correct order is H_2O > HF > NH_3. Despite the fact that fluorine is more electronegative than oxygen, water has a greater amount of hydrogen bonding. In HF, there is a deficiency of hydrogens, whereas water has exactly the proper quantity of hydrogens. As a result, straight chain bonding is the only option. By virtue of its great hydrogen bonding ability, oxygen, on the other hand, creates a massive ring-like structure. Because nitrogen has only one lone pair, the degree of hydrogen bonding in ammonia is limited. As a result, it is unable to satisfy all hydrogens.

Q9.15

Saline hydrides are known to react aggressively with water, causing fire. Is it possible to use CO_2, a well-known fire extinguisher, in this situation? Explain.

Answer:

CO_2 is heavier than dioxygen. It is employed as a fire extinguisher because it blankets the fire and prevents the flow of dioxygen, effectively putting out the fire.

CO2 can also be employed in this situation. It's heavier than dihydrogen, therefore it'll keep dihydrogen and dioxygen away from the burning surface.

Q9.16

Arrange the following:

(i) CaH_2, BeH_2 and TiH_2 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_2 and H_2O in order of increasing reducing property.

Answer:

(i) The ionic or covalent constitution of a molecule determines its electrical conductivity. Covalent chemicals do not carry electricity, whereas ionic compounds do. BeH_2 is a covalent hydride. As a result, it does not conduct electricity. In the molten form, CaH_2 is an ionic hydride that conducts electricity. TiH_2 (titanium hydride) is a metal that conducts electricity at room temperature. Hence the increasing order of electrical conductance is in the order: $BeH_2 < CaH_2 < TiH_2$

(ii) The electronegativities of the atoms involved determine the ionic character of a bond. The ionic character is lesser the greater the difference between the electronegativities of atoms. From Lithium to Caesium, the electronegativity drops. Hence, the ionic character of their hydrides will increase as:

LiH < NaH < CsH

(iii) The bond dissociation enthalpy depends on the strength of the bond. Higher the bond strength, higher will be the bond dissociation enthalpy. In case of H-H and D-D bond, there is strong attraction between the D-D bond due to the higher mass of the D nucleus. So, the bond dissociation enthalpy is higher for D-D than H-H.

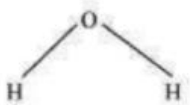
But in case of F-F, it will have least bond dissociation enthalpy. It is due to the small size of fluorine, and more number of electrons, it experiences higher repulsion of electrons and thus the bond become weaker. So, the bond dissociation enthalpy of F-F will be least.

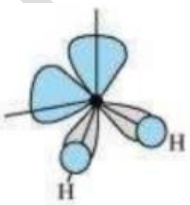
Q9.17

Compare the structures of H_2O and H_2O_2.

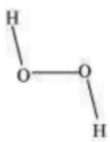
Answer:

The geometry of water molecule is sp3 having bond angle of 104.5 degrees. The shape of water molecules is bent in gaseous phase. The bond length of O-H bond is 95.7 pm. The structure is:





In both gaseous and solid phase, hydrogen peroxide has a non-planar structure. It is like an open book shape. The dihedral angle in gas and solid phase is 111.5° and 90.2° respectively. The structure is as follows:



Q9.18

What do you mean when you say, "water auto-protolysis"? What is the importance of this?

Answer:

In protolysis, two water molecules react to form hydroxyl ion and hydronium ion. It is also called self-ionization of water. The reaction of auto-protolysis is given as:

This auto-protolysis shows the amphoteric nature of water. It can act as both acid and base at same time.

Q9.19

Consider the reaction of water with F_2 and determine which species are oxidised or reduced in terms of oxidation and reduction.

Answer:

The reaction between fluorine and water can be given as:

$$2F_{2(g)} + 2H_2O_{(l)} \longrightarrow 4H^+_{(aq)} + 4F^-_{(aq)} + O_{2(g)}$$

Water is oxidised to oxygen, while fluorine is reduced to fluoride ion, which is an example of a redox reaction.

Q9.20

Complete the following chemical reactions.

(i) $PbS_{(s)} + H_2O_{2(aq)} \rightarrow$

(ii) $MnO^-_{4(aq)} + H_2O_{(g)} \rightarrow$

(iii) $CaO_{(s)} + H_2O_{(g)} \rightarrow$

(iv) $AlCl_{3(g)} + H_2O_{(l)} \rightarrow$

(v) $Ca_3N_{2(s)} + H_2O_{(l)} \rightarrow$

Classify the above into (a) hydrolysis, (b) redox and (c) hydration reactions.

Answer:

(i)

$$PbS_{(s)} + H_2O_{2(aq)} \rightarrow PbSO_{4(s)} + H_2O_{(l)}$$

It is redox reaction. Since H_2O_2 acts as a oxidising agent here.

(ii)

$$2MnO_{4(aq)}^{-} + 5H_2O_{2(g)} \rightarrow 6H^{+}_{(aq)} \rightarrow 2Mn^{2+}_{(aq)} + 8H_2O_{(l)} + 5O_{2(g)}$$

This is also a redox reaction. Since, H_2O_2 acts as a reducing agent in acidic medium.

(iii)

$$CaO_{(s)} + H_2O_{(g)} \rightarrow Ca(OH)_{2(aq)}$$

Hydrolysis reactions are those in which a chemical combine with water to form other compounds. The above given reaction is a hydrolysis reaction.

(iv)

$$2AlCl_{3(g)} + 3H_2O_{(l)} \rightarrow Al_2O_{3(s)} + 6HCl_{(aq)}$$

Hydrolysis reactions are those in which a chemical combine with water to form other compounds. $AlCl_3$ hydrolysis is represented by the given reaction.

(v)

$$Ca_3N_{2(s)} + 6H_2O_{(l)} \rightarrow 3Ca(OH)_{2(aq)} + 2NH_{3(g)}$$

Hydrolysis reactions are those in which a chemical combine with water to form other compounds. Ca_3N_2 hydrolysis is represented by the given reaction.

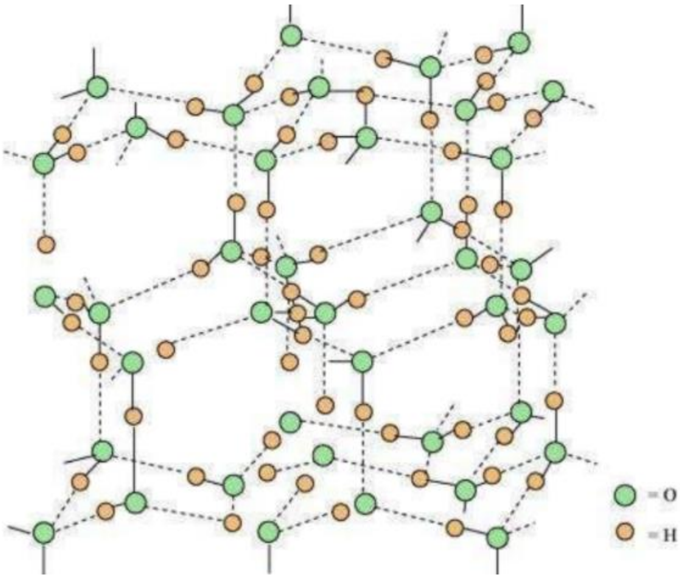
Q9.21

Explain the structure of the most common form of ice.

Answer:

The crystalline form of water is ice. If crystallised at atmospheric pressure, it takes a hexagonal shape, but if the temperature is sufficiently low, it condenses into a cubic shape.

The three-dimensional structure of ice is represented as:



Hydrogen bonding is present in the structure, which is highly organised. At a distance of 276 pm, each oxygen atom is surrounded tetrahedrally by four other oxygen atoms. Wide gaps in the structure allow for the interstitial storage of molecules of appropriate sizes.

Q9.22

What causes temporary and permanent water hardness?

Answer:

The presence of soluble magnesium and calcium salts in the form of hydrogen carbonates in water causes temporary hardness. The presence of soluble calcium and magnesium salts in the form of chlorides in water causes permanent hardness.

Q9.23

Discuss the theory and approach of using synthetic ion-exchange resins to soften hard water.

Answer:

The exchange of cations and anions present in water by H^+ and OH^- ions, respectively, is the basis for treating permanent hardness of water with synthetic resins.

Synthetic resins are of two types:

1) Cation exchange resins

2) Anion exchange resins

The $-SO_3H$ group is found in cation exchange resins, which are massive organic compounds. The resin is initially converted to RNa (from $-RSO_3H$) by adding NaCl to it. After that, the resin exchanges Na^+ ions for Ca^{2+} and Mg^{2+} ions, softening the water.

Water first goes through the cation exchange process before moving on to the next step. This procedure produces water that is free of mineral cations and acidic in character. The acidic water is subsequently de-ionized using the anion exchange process, which uses OH^- ions to neutralise the H^+ ions and de-ionize the water.

Q9.24

Write chemical reactions to show the amphoteric nature of water.

Answer:

The following reactions can be used to describe the amphoteric nature of water:

1) Reaction with H_2S

$$\underset{\text{Base}}{H_2O_{(l)}} + \underset{\text{Acid}}{H_2S_{(aq)}} \rightleftharpoons \underset{\text{Conjugate acid}}{H_3O^+_{(aq)}} + \underset{\text{Conjugate base}}{HS^-_{(aq)}}$$

In the forward reaction, water molecule accepts a proton. So, it is acts as a Lewis base.

2) Reaction with NH_3:

$$H_2O_{(l)} + NH_{3(aq)} \rightleftharpoons OH^-_{(aq)} + NH^+_{4(aq)}$$

In the forward reaction, water molecule donates its proton to ammonia. So, it acts as a Lewis acid.

3) Self ionization of water:

$$\underset{\text{Acid}}{H_2O_{(l)}} + \underset{\text{Base}}{H_2O_{(l)}} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

Water molecule acts as a Lewis acid and base simultaneously.

Q9.25

Give chemical reactions to demonstrate that hydrogen peroxide may serve as both an oxidising and a reducing agent.

Answer:

In both acidic and alkaline medium, hydrogen peroxide acts as both oxidising agent and reducing agent.

The reactions which show the reducing character of hydrogen peroxide are:

1) $2MnO_4^- + 6H^+ + 5H_2O_2 \longrightarrow 2Mn^{2+} + 8H_2O + 5O_2$

2) $I_2 + H_2O_2 + 2OH^- \longrightarrow 2I^- + 2H_2O + O_2$

3) $HOCl + H_2O_2 \longrightarrow H_3O^+ + Cl^- + O_2$

4) $2MnO_4^- + 3H_2O_2 \longrightarrow 2MnO_2 + 3O_2 + 2H_2O + 2OH^-$

The reactions which show the oxidising character of hydrogen peroxide are:

1) $2Fe^{2+} + 2H^+ + H_2O_2 \longrightarrow 2Fe^{3+} + 2H_2O$

2) $Mn^{2+} + H_2O_2 \longrightarrow Mn^{4+} + 2OH^-$

3) $PbS + 4H_2O_2 \longrightarrow PbSO_4 + 4H_2O$

4) $2Fe^{2+} + H_2O_2 \longrightarrow 2Fe^{3+} + 2OH^-$

Q9.26

What does it mean to have 'demineralized' water, and how do you get it?

Answer:

All soluble mineral salts are removed from demineralized water. There are no anions or cations in it. Water is demineralized by passing it through a cation exchange resin (in the H^+ form) and an anion exchange resin (in the OH^- form) in that order. H^+ exchanges for Na^+, Mg^{2+}, Ca^{2+}, and other cations in water during the cation exchange process.

Q9.27

Is it possible to consume demineralized or distilled water? How can it be useful if it isn't?

Answer:

Water is an essential component of life. It contains various dissolved nutrients that humans, plants, and animals require to survive. All soluble minerals are removed from demineralized water. As a result, it is unfit for consumption. It can only be used after specific minerals in specific amounts, which are necessary for growth, have been added.

Q9.28

Describe how water is useful in the biosphere and biological processes.

Answer:

All types of life require water to survive. It makes up approximately 65 percent of the human body and 95 percent of all plants. Because of its high specific heat, thermal conductivity, surface tension, dipole moment, and dielectric constant, water plays a vital role in the biosphere. Water's high heat of vaporisation and heat of capacity aid in the regulation of climate and body temperature in all living things. It transports various nutrients that plants and animals require for various metabolic activities.

Q9.29

What characteristics of water make it a good solvent? What types of compound can it (i) dissolve, and (ii) hydrolyse?

Answer:

Water is a universal solvent due to its high dielectric constants and dipole moment. Most ionic and covalent substances can be dissolved in water. Because of the ion-dipole interaction, ionic compounds dissolve in water, whereas covalent molecules form hydrogen bonds and dissolve in water. Metallic and non-metallic oxides, hydrides, carbides, phosphides, nitrides, and a variety of other salts can all be hydrolysed by water. Water ions H^+ and OH^- interact with the reactive molecule during hydrolysis.

Q9.30

Do you think D_2O may be utilised for drinking purposes, knowing the qualities of H_2O and D_2O?

Answer:

D_2O, or heavy water, works as a moderator, slowing down the rate of a process. Because of this feature, D_2O cannot be used for drinking because it will slow down anabolic and catabolic responses in the body, resulting in a casualty.

Q9.31

What's the difference between hydration and hydrolysis?

Answer:

Hydrolysis is a chemical reaction in which water molecules' hydrogen and hydroxide ions (H^+ and OH^- ions) combine with a substance to produce products. For e.g.:

$$NaH + H_2O \longrightarrow NaOH + H_2$$

The addition of one or more water molecules to ions or molecules to generate hydrated compounds is known as hydration. For e.g.:

$$CuSO_4 + 5H_2O \longrightarrow CuSO_4 \cdot 5H_2O$$

Q9.32

What makes saline hydrides so effective at removing water from organic compounds?

Answer:

In nature, saline hydrides are ionic. They react with water to generate a metal hydroxide, releasing hydrogen gas in the process. The reaction of saline hydrides with water is given as:

$$AH_{(s)} + H_2O_{(l)} \longrightarrow AOH_{(aq)} + H_{2(g)}$$

(Where, A= Na, Ca,)

When they're mixed with water in an organic solvent, they react. The metallic hydroxide is left behind as hydrogen escapes into the environment. The dry organic solvent evaporates.

Q9.33

What do you think the nature of hydrides will be if they are created by dihydrogen and elements with atomic numbers 15, 19, 23, and 44? Compare and contrast their attitudes about water.

Answer:

The elements of atomic numbers 15, 19, 23, and 44 are nitrogen, potassium, vanadium,

and ruthenium respectively.

1) Hydrides of Nitrogen

The nitrogen hydride (NH_3) is a covalent molecule. Due to the existence of excess electrons as a lone pair on nitrogen, it is an electron-rich hydride.

2) Hydrides of potassium

Due of potassium's high electropositive character, dihydrogen forms an ionic hydride with it. It is non-volatile and crystalline in nature.

3) Hydrides of Vanadium and Ruthenium

The periodic table's d–block contains both vanadium and ruthenium. Metallic or non–stoichiometric hydrides are formed by the metals of the d–block. Vanadium and ruthenium hydrides are so metallic in character and have a hydrogen shortage.

4) Behaviour of hydrides towards water:

Potassium hydride reacts violently with water as:

$$KH_{(s)} + H_2O_{(aq)} \longrightarrow KOH_{(aq)} + H_{2(g)}$$

Ammonia (NH_3) behaves as a Lewis base and reacts with water as:

$$H_2O_{(l)} + NH_{3(aq)} \longleftrightarrow OH^-_{(aq)} + NH^+_{4(aq)}$$

Vanadium and Ruthenium hydrides do not react with water. As a result, the hydrides' reactivity increases in the following order: (V, Ru) H < NH_3 < KH.

Q9.34

When Aluminium (III) Chloride and Potassium Chloride are treated individually with (i) normal water, (ii) acidified water, and (iii) alkaline water, do you expect different products in Answer? Wherever equations are required, write them down.

Answer:

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:

$$KCl_{(s)} \xrightarrow{\text{water}} K^+_{(aq)} + Cl^-_{(aq)}$$

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 $[Al(OH)_3]$.

Hence, it undergoes hydrolysis in normal water.

$$AlCl_{3(s)} + 3H_2O_{(l)} \xrightarrow[\text{Water}]{\text{Normal}} Al(OH)_{3(s)} + 3H^+_{(aq)} + 3Cl^-_{(aq)}$$

In acidified water, H^+ ions react with $Al(OH)_3$ forming water and giving Al^{3+} ions. Hence, in acidified water, $AlCl_3$ will exist as Al^{3+} and Cl^- ions.

In alkaline water, the following reaction takes place:

$$Al(OH)_{3(s)} + \underbrace{OH^-_{(aq)}}_{\text{from alkaline water}} \longrightarrow [Al(OH)_4]^-_{(aq)} + 2H_2O_{(l)}$$

9.35

What is the effect of H2O2 as a bleaching agent?

Answer:

In both acidic and basic conditions, H_2O_2 or hydrogen peroxide works as a potent oxidising agent. It disrupts the chemical bonds of the chromophores (colour-producing substances) when applied to a textile. As a result, no visible light is absorbed, and the cloth whitens.

Q9.36

What do you understand by the terms:

(i) hydrogen economy (ii) hydrogenation (iii) ‘syngas’ (iv) water-gas shift reaction (v) fuel-cell?

Answer:

(i) Hydrogen economy

Hydrogen economy is a method of utilising dihydrogen in a cost-effective manner. It entails the transportation and storage of dihydrogen in liquid or gas form. Dihydrogen produces more energy and is more environmentally friendly than gasoline. As a result, it can be utilised to create electricity in fuel cells. The conveyance of this energy in the form of dihydrogen is the focus of the hydrogen economy.

(ii) Hydrogenation

The addition of dihydrogen to another reactant is known as hydrogenation. In the presence of a suitable catalyst, this procedure is used to decrease a chemical. For example, utilising nickel as a catalyst to hydrogenate vegetable oil produces edible fats like vanaspati and ghee.

(iii) Syngas

Carbon monoxide and dihydrogen are mixed together to make syngas. Syngas, synthesis gas, or water gas is the name given to the mixture of the two gases utilised in the synthesis of methanol. Steam reacts with hydrocarbons or coke at a high temperature in the presence of a catalyst to produce syngas.

$$CnH_{2n+2} + nH_2O \xrightarrow[\text{Ni}]{1270\text{K}} nCO + (3n+1)H_2$$

For example,

$$CH_{4(g)} + H_2O_{(g)} \xrightarrow[\text{Ni}]{1270\text{K}} \underbrace{CO_{(g)} + 3H_{2(g)}}_{\text{Syngas}}$$

(iv) Water shift reaction

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

$$CO_{(g)} + H_2O_{(g)} \xrightarrow[\text{Catalyst}]{673\text{K}} CO_{2(g)} + H_{2(g)}$$

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

$$C_{(s)} + H_2O_{(g)} \longrightarrow CO_{(g)} + H_{2(g)}$$

(v) Fuel cells

Fuel cells are devices that use an electrolyte to generate energy from fuel. In these cells, dihydrogen can be employed as a fuel. It is preferred over other fuels because it is environmentally benign and produces more energy per unit mass of fuel than gasoline and other fuels.