CHAPTER – 2

ACIDS, BASES AND SALTS

ACIDS

Acid is a substance which furnishes H^+ ions or H_3O^+ ions when dissolved in water. Acids have one or more replaceable hydrogen atoms. The word acid is derived from the Latin name ' acidus ' which means sour taste. Substances with ' sour taste ' are acids. Lemon juice, vinegar and grape juice have sour taste, so they are acidic. They change blue litmus to red. They are colourless with phenolphthalein and pink with methyl orange. There are many substances which contain acid and hence taste sour, such as curd, tamarind, lemon, etc.

CLASSIFICATION OF ACIDS

1. **Based on their sources :** Acids are classified into two types namely organic acids and inorganic acids.

   Organic acids:- Acids present in plants and animals (living beings) are **organic acids** eg. HCOOH, CH_3COOH (Weak acids).

   Inorganic acids:- Acids from rocks and minerals are **inorganic acids** or mineral acids eg. HCl, HNO_3, H_2SO_4 (Strong acids).

2. **Based on their basicity**
   Monobasic acid: - It is an acid which gives one hydrogen ion per molecule of the acid in solution eg. HCl, HNO_3.
   Dibasic acid:- It is an acid which gives two hydrogen ions per molecule of the acid in solution e.g., H_2SO_4, H_2CO_3.
   Tribasic acid:- It is an acid which gives three hydrogen ions per molecule of the acid in solution. e.g.,H_3PO_4,

3. **Based on ionisation**
   Acids are classified into two types based on ionisation.
   Strong acids:- These are acids which ionise completely in water eg.HCl
   Weak acids:-These are acids which ionise partially in water eg. CH_3COOH

4. **Based on concentration:-** Depending on the percentage or amount of acid dissolved in water acids are classified into concentrated acid and dilute acid.
   Concentrated acid:- It is an acid having a relatively high percentage of acid in its aqueous solution.
   Dilute acid:- It is an acid having a relatively low percentage of acid in aqueous solution.

INTEXT QUESTIONS PAGE NO. 18

Question 1: You have been provided with three test tubes. One of them contains distilled water and the other two contain an acidic solution and a basic solution, respectively. If you are given only red litmus paper, how will you identify the contents of each test tube?
Answer : If the colour of red litmus paper gets changed to blue, then it is a base and if there is no colour change, then it is either acidic or neutral. Thus, basic solution can be easily identified.

Let us mark the three test tubes as A, B, and C. A drop of the solution in A is put on the red litmus paper. Same is repeated with solution B and C. If either of them changes colour to blue, then it is basic. Therefore, out of three, one is eliminated. Out of the remaining two, any one can be acidic or neutral. Now a drop of basic solution is mixed with a drop of each of the remaining two solutions separately and then the nature of the drops of the mixtures is checked. If the colour of red litmus turns blue, then the second solution is neutral and if there is no change in colour, then the second solution is acidic. This is because acidic and basic solutions neutralize each other. Hence, we can distinguish between the three types of solutions.

CHEMICAL PROPERTIES OF ACIDS

REACTION OF ACIDS WITH METAL:

Acids give hydrogen gas along with respective salt when they react with a metal.

Metal + Acid → Salt + Hydrogen

Example:

- Hydrogen gas and zinc chloride are formed when hydrochloric acid reacts with zinc metal.

  $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
- Hydrogen gas and sodium chloride are formed when hydrochloric acid reacts with sodium metal.

  $2Na + 2HCl \rightarrow 2NaCl + H_2$
- Hydrogen gas and iron chloride are formed when hydrochloric acid reacts with iron.

  $Fe + 2HCl \rightarrow FeCl_2 + H_2$
- Hydrogen gas and zinc sulphate are formed when zinc metal reacts with sulphuric acid

  $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

REACTION OF ACIDS WITH METAL CARBONATE:

Acids give carbon dioxide gas and respective salts along with water when they react with metal carbonates.

Metal carbonate + Acid → Salt + Carbon dioxide + Water

Examples:

- Sulphuric acid gives calcium sulphate, carbon dioxide gas, calcium sulphate and water when it reacts with calcium carbonate.

  $CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O$
- Sulphuric acid gives sodium sulphate, carbon dioxide gas and water when it reacts with sodium carbonate.

  $Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + CO_2 + H_2O$
- Hydrochloric acid gives carbon dioxide gas, calcium chloride and water when it reacts with calcium carbonate.

  $CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$
- Hydrochloric acid gives carbon dioxide gas, sodium chloride along with water when reacts with sodium carbonate.

  $Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$
- Hydrochloric acid gives carbon dioxide, magnesium chloride and water when it reacts with magnesium carbonate.

  $MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$
- Nitric acid gives sodium nitrate, water and carbon dioxide gas when it reacts with sodium carbonate.

  $2HNO_3 + Na_2CO_3 \rightarrow NaNO_3 + 2H_2O + CO_2$

REACTION OF ACID WITH HYDROGEN CARBONATES (BICARBONATES):

Acids give carbon dioxide gas, respective salt and water when they react with metal hydrogen carbonate.

Acid + Metal hydrogen carbonate → Salt + Carbon dioxide + Water

Examples:

- Hydrochloric acid gives carbon dioxide, sodium chloride and water when it reacts with sodium bicarbonate.

  $NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$

- Sulphuric acid gives sodium sulphate, carbon dioxide gas and water when it reacts with sodium bicarbonate.

  $2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2CO_2 + 2H_2O$

- Sodium bicarbonate is also known as sodium hydrogen carbonate, baking soda, baking powder, bread soda and bicarbonate of soda.
  The gas evolved because of reaction of acid with metal carbonate or metal hydrogen carbonate turns lime water milky. This shows that the gas is carbon dioxide gas. This happens because of formation of white precipitate of calcium carbonate.

  $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

  $CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$

  But when excess of carbon dioxide is passed through lime water, it makes milky colour of lime water disappear. This happens because of formation of calcium hydrogen carbonate. As calcium hydrogen carbonate is soluble in water, thus the milky colour of solution mixture disappears.

REACTION OF ACID WITH MARBLE AND EGG SHELL:

Since, marble and egg shell are made of calcium carbonate, hence when acid is poured over marble or egg shell, bubbles of carbon dioxide are formed.

USES OF ACIDS

- Sulphuric acid (King of chemicals) is used in car battery and in the preparation of many other compounds.
- Nitric acid is used in the production of ammonium nitrate which is used as fertilizer in agriculture.
- Hydrochloric acid is used as cleansing agent in toilet.
- Tartaric acid is a constituent of baking powder.
- Salt of benzoic acid (sodium benzoate) is used in food preservation.
- Carbonic acid is used in aerated drinks.

BASES

Base is a substance which releases hydroxide ions when dissolved in water. It is a substance which is bitter in taste and soapy to touch (e.g. Washing soda, caustic soda and caustic potash). They change red litmus to blue. They are pink with phenolphthalein and yellow with methyl orange.

CLASSIFICATION OF BASES

1. **Based on ionisation**
   Strong bases:- These are bases which ionise completely in aqueous solution eg.NaOH, KOH.

Weak bases:- These are bases which ionise partially in aqueous solution eg. NH_4OH, $Ca(OH)_2$.

2. **Based on their acidity**

Monoacidic base:- It is a base which ionises in water to give one hydroxide ion per molecule eg.NaOH, KOH.

Diacidic base:- It is a base which ionises in water to give two hydroxide ions per molecule eg. $Ca(OH)_2$, $Mg(OH)_2$.

Triacidic base:- It is a base which ionises in water to give three hydroxide ions per molecule eg. $Al(OH)_3$, $Fe(OH)_3$.

3. **Based on the concentration:**

Depending on the percentage or amount of base dissolved in water, bases are classified as concentrated alkali and dilute alkali.

Concentrated alkali:- It is an alkali having a relatively high percentage of alkali in its aqueous solution.

Dilute alkali:- It is an alkali having a relatively low percentage of alkali in its aqueous solution.

REACTION OF BASE WITH METALS:

When alkali (base) reacts with metal, it produces salt and hydrogen gas.

Alkali + Metal $\rightarrow$ Salt + Hydrogen

Example:

- Sodium aluminate and hydrogen gas are formed when sodium hydroxide reacts with aluminium metal.

  $2NaOH + 2Al + 2H_2O \rightarrow 2NaAlO_2 + 2H_2$

- Sodium hydroxide gives hydrogen gas and sodium zincate when reacts with zinc metal.

  $2NaOH + Zn \rightarrow Na_2ZnO_2 + H_2$

REACTION OF BASE WITH OXIDES OF NON-METALS:

Non-metal oxides are acidic in nature. For example; carbon dioxide is a non-metal oxide. When carbon dioxide is dissolved in water it produces carbonic acid.

Therefore, when a base reacts with non-metal oxide both neutralize each other resulting respective salt and water are produced.

Base + Non-metal oxide $\rightarrow$ Salt + Water

Example:

- Calcium hydroxide gives calcium carbonate and water when it reacts with carbon dioxide.

  $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

- Sodium hydroxide gives sodium carbonate and water when it reacts with carbon dioxide.

  $2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$

USES OF BASES

- Sodium hydroxide is used in the manufacture of soap.
- Calcium hydroxide is used in white washing the buildings.

- Magnesium hydroxide is used as a medicine for stomach troubles.
- Ammonium hydroxide is used to remove grease stains from clothes.

NEUTRALISATION REACTION:

An acid neutralizes a base when they react with each other and respective salt and water are formed.

Acid + Base → Salt + Water

Since in the reaction between acid and base both neutralize each other, hence it is also known as neutralization reaction.

Example:

- Sodium sulphate and water are formed when sulphuric acid reacts with sodium hydroxide (a base).

  $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

- In similar way, when nitric acid reacts with sodium hydroxide, sodium nitrate and water are formed.

  $HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$

- Sodium chloride and water are formed when hydrochloric acid reacts with sodium hydroxide (a strong base).

  $HCl + NaOH \rightarrow NaCl + H_2O$

- In similar way, calcium chloride is formed along with water when hydrochloric acid reacts with calcium hydroxide (a base).

  $2HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O$

REACTION OF ACID WITH METAL OXIDES:

Metal oxides are basic in nature. Thus, when an acid reacts with a metal oxide both neutralize each other. In this reaction, respective salt and water are formed.

Acid + Metal Oxide □ Salt + Water

Example:

- Calcium is a metal, thus calcium oxide is a metallic oxide which is basic in nature. When an acid; such as hydrochloric acid; reacts with calcium oxide, neutralization reaction takes place and calcium chloride; along with water; is formed.

  $2HCl + CaO \rightarrow CaCl_2 + H_2O$

- Similarly, when sulphuric acid reacts with zinc oxide, zinc sulphate and water are formed.

  $H_2SO_4 + ZnO \rightarrow ZnCl_2 + H_2O$

- When hydrochloric acid reacts with aluminium oxide, aluminium chloride and water are formed.

  $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$

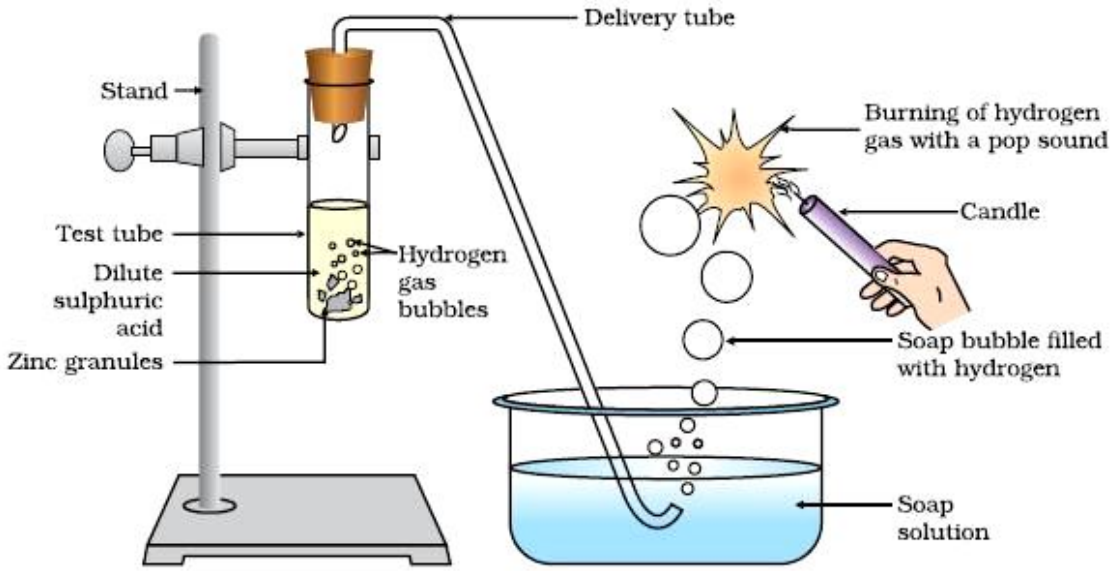
INTEXT QUESTIONS PAGE NO. 22

Question 1: Why should curd and sour substances not be kept in brass and copper vessels?

Answer : Curd and other sour substances contain acids. Therefore, when they are kept in brass and copper vessels, the metal reacts with the acid to liberate hydrogen gas and harmful products, thereby spoiling the food.

Question 2: Which gas is usually liberated when an acid reacts with a metal? Illustrate with an example. How will you test for the presence of this gas?

Answer : Hydrogen gas is usually liberated when an acid reacts with a metal.



Take few pieces of zinc granules and add 5 ml of dilute H2SO4. Shake it and pass the gas produced into a soap solution. The bubbles of the soap solution are formed. These soap bubbles contain hydrogen gas.

$$H_2SO_4 + Zn \rightarrow ZnSO_4 + H_2 \uparrow$$

We can test the evolved hydrogen gas by its burning with a pop sound when a candle is brought near the soap bubbles.

Question 3: Metal compound A reacts with dilute hydrochloric acid to produce effervescence. The gas evolved extinguishes a burning candle. Write a balanced chemical equation for the reaction if one of the compounds formed is calcium chloride.

Answer :

$$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$$

Calcium carbonate	Hydrochloric acid	Calcium chloride	Carbon dioxide	Water

COMMON IN ACID AND BASE

Acids give hydrogen gas when they react with metal. This shows that all acids contain hydrogen. For example: Hydrochloric acid (HCl), sulphuric acid (H_2SO_4), nitric acid (HNO_3), etc.

When an acid is dissolved in water, it dissociates hydrogen. The dissociation of hydrogen ion in aqueous solution is the common property in all acids. Because of dissociation of hydrogen ion in aqueous solution, an acid shows acidic behavior.

Example:

- Hydrochloric acid (HCl) gives hydrogen ion (H^+) and chloride ion (Cl^-) when it is dissolved in water.

  $HCl\ (aq) \rightarrow H^+ + Cl^-$

- Sulphuric acid (H_2SO_4) gives hydrogen ion (H^+) and sulphate ion (SO_4^{--}) in water.

  $H_2SO_4\ (aq) \rightarrow H^+ + SO_4^{--}$

- Nitric acid (HNO_3) gives hydrogen ion (H^+) and nitrate ion (NO_3^-) in water.

  $HNO_3\ (aq) \rightarrow H^+ + NO_3^-$

- Acetic acid (CH_3COOH) gives acetate ion (CH_3COO^-) and hydrogen ion (H^+).

$$CH_3COOH\ (aq) \rightarrow\ CH_3COO^- H^+$$

- Hydrogen ion which is produced by acid (when acid is combined with water molecule), exists in the form of hydronium ion (H_3O^-) in aqueous solution. That's why hydrogen ion is always written with suffix (aq), such as H^+ (aq).

$$HCl + H_2O \rightarrow\ H_3O^- + Cl^-$$

$$H_2SO_4 + H_2O \rightarrow\ H_3O^- + SO_4^{--}$$

Thus, because of dissociation of hydrogen ions; acid shows its acidic behavior.

Acids conduct electricity in their aqueous solution because of dissociation of hydrogen ion. Hydrogen ion in aqueous solution conducts electricity.

A dry acid, such as dry hydrochloric acid does not change the colour of blue litmus paper to red because a dry acid does not dissociate hydrogen ion. This is the cause that a moist litmus paper is used to check the acidic or basic character of a gas.

Acidic behavior of carbon dioxide gas:
Carbon dioxide gas produces carbonic acid when dissolved in water. This carbonic acid dissociates hydrogen ion and carbonate ion in the aqueous solution.

$$CO_2 + H_2O \rightarrow\ H_2CO_3 \rightarrow\ H^+ + CO_3^{--}$$

Are all compounds which contain hydrogen, necessarily acids?
No, all compounds which contain hydrogen are not acid. For example; glucose ($C_6H_{12}O_6$), methyl alcohol (CH_3OH), etc. are not acid in spite of the fact that they contain hydrogen. This is because these compounds do not dissociate hydrogen ion in their aqueous solution.

Common in all Base:
A base dissociates hydroxide ion in water, which is responsible for the basic behavior of a compound. Example:
When sodium hydroxide is dissolved in water, it dissociates hydroxide ion and sodium ion.

$$NaOH\ (aq) \rightarrow\ Na^+ + OH^-$$

Similarly, when potassium hydroxide is dissolved in water, it dissociates hydroxide ion and potassium ion.

$$KOH\ (aq) \rightarrow\ K^+ + OH^-$$

Thus, base shows its basic character because of dissociation of hydroxide ion.

NEUTRALISATION REACTION:

When an acid reacts with a base, the hydrogen ion of acid combines with the hydroxide ion of base and forms water. As these ions combine together and form water; instead of remaining free, thus both neutralize each other.

$$OH^- + H^+ \rightarrow\ H_2O$$

Example:

- When sodium hydroxide (a base) reacts with hydrochloric acid, sodium hydroxide breaks into sodium ion and hydroxide ion and hydrochloric acid breaks into hydrogen ion and chloride ion. Hydrogen ion and hydroxide ion combine together and form water, while sodium ion and chloride ion combine together and form sodium chloride.

$$NaOH + HCl \rightarrow\ OH^- + Na^+ + H^+ + Cl^- \rightarrow\ NaCl + H_2O$$

DILUTION OF ACID AND BASE:

The concentration of hydrogen ion in an acid and hydroxide ion in a base; per unit volume; shows the concentration of acid or base.

By mixing of acid to water, the concentration of hydrogen ion per unit volume decreases. Similarly, by addition of base to water the concentration of hydroxide ion per unit volume decreases. This process of addition of acid or base to water is called dilution and the acid or base is called diluted.

The dilution of acid or base is exothermic. Thus, acid or base is always added to water and water is never added to acid or base. If water is added to a concentrated acid or base a lot of heat is generated, which may cause splashing out of acid or base and may cause severe damage as concentrated acid and base are highly corrosive.

INTEXT QUESTIONS PAGE NO. 25

Question 1: Why do HCl, HNO_3, etc., show acidic characters in aqueous solutions while solutions of compounds like alcohol and glucose do not show acidic character?
Answer : The dissociation of HCl or HNO_3 to form hydrogen ions always occurs in the presence of water. Hydrogen ions (H^+) combine with H_2O to form hydronium ions (H_3O^+).
The reaction is as follows:

$$HCl_{(aq)} \longrightarrow H^+ + Cl^-$$

$$H^+ + H_2O \longrightarrow H_3O^+$$

Although aqueous solutions of glucose and alcohol contain hydrogen, these cannot dissociate in water to form hydrogen ions. Hence, they do not show acidic character.

Question 2: Why does an aqueous solution of an acid conduct electricity?
Answer : Acids dissociate in aqueous solutions to form ions. These ions are responsible for conduction of electricity.

Question 3: Why does dry HCl gas not change the colour of the dry litmus paper?
Answer : Colour of the litmus paper is changed by the hydrogen ions. Dry HCl gas does not contain H^+ ions. It is only in the aqueous solution that an acid dissociates to give ions. Since in this case, neither HCl is in the aqueous form nor the litmus paper is wet, therefore, the colour of the litmus paper does not change.

Question 4: While diluting an acid, why is it recommended that the acid should be added to water and not water to the acid?
Answer : Since the process of dissolving an acid in water is exothermic, it is always recommended that acid should be added to water. If it is done the other way, then it is possible that because of the large amount of heat generated, the mixture splashes out and causes burns.

Question 5: How is the concentration of hydronium ions (H_3O^+) affected when a solution of an acid is diluted?
Answer : When an acid is diluted, the concentration of hydronium ions (H_3O^+) per unit volume decreases. This means that the strength of the acid decreases.

Question 6: How is the concentration of hydroxide ions (OH^-) affected when excess base is dissolved in a solution of sodium hydroxide?
Answer : The concentration of hydroxide ions (OH^-) would increase when excess base is dissolved in a solution of sodium hydroxide.

STRENGTH OF ACID AND BASE

Acids in which complete dissociation of hydrogen ion takes place are called strong acid. Similarly, bases in which complete dissociation of hydroxide ion takes place are called strong base.

In mineral acids, such as hydrochloric acid, sulphuric acid, nitric acid, etc. hydrogen ion dissociates completely and hence they are considered as strong acid. Since, in organic acids hydrogen ions do not dissociate completely, so they are weak acid.

Alkalis are water soluble base, thus in alkali; complete dissociation of hydroxide ions takes place and they are considered as strong base.

The complete dissociation of hydrogen ions or hydroxide ions is shown by a single arrow. The incomplete dissociation of hydrogen ions or hydroxide ions is denoted by double arrow.

Example of complete dissociation:

$NaOH\ (aq) \rightarrow Na^{+} + OH^{-}$

$HCl \rightarrow H^{+} + Cl^{-}$

Example of incomplete dissociation:

$Mg(OH)2 \rightarrow Mg^{+\,+} + OH^{-\,-}$

$CH_3COOH \rightarrow CH_3COO^{-} + H^{+}$

Although acetic acid being an organic acid is a weak acid, but concentrated acetic acid is corrosive and can damage the skin if poured over it.

pH – MEASUREMENT OF STRENGTH OF ACID AND BASE

pH stands for the power of hydrogen ion concentration in a solution. pH values decide whether a solution is acidic or basic or neutral. pH scale was introduced by S.P.L. Sorenson. It is mathematically expressed as

$$\mathbf{pH = -\log_{10}[H^{+}]}$$

For neutral solution $[H^{+}] = 10^{-7}M$; pH = 7

For acidic solution $[H^{+}] > 10^{-7}M$; pH < 7

For basic solution $[H^{+}] < 10^{-7}M$; pH > 7

When OH^{-} ions are taken into account the pH expression is replaced by pOH

$$\mathbf{pOH = -\log_{10}[OH^{-}]}$$

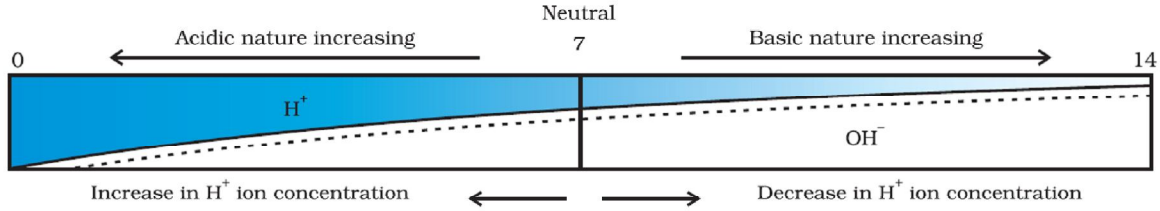
The strength of acid or base depends upon the hydrogen ion concentration. If the concentration of hydrogen ion is greater than hydroxide ion, the solution is called acidic. If the concentration of hydrogen ion is smaller than the hydroxide ion, the solution is called basic. If the concentration of hydrogen ion is equal to the concentration of hydroxide ion, the solution is called neutral solution.

pH is a scale which quantifies the concentration of hydrogen ion in a solution. The range of pH scale is between 0 to 14.

The pH value decreases with increase in hydrogen ion concentration. If the value of pH is 0, this shows maximum hydrogen ion concentration. pH value equal to 14 shows lowest hydrogen ion concentration. pH value equal to 7 shows the hydrogen ion concentration is equal to hydroxide ion concentration.

A neutral solution, such as distilled water has value of hydrogen ion concentration equal to 7 on pH scale. The acidic solution has value of hydrogen ion concentration less than 7 on pH scale. The basic solution has value of hydrogen ion concentration greater than 7 on pH scale.

In pH scale 'p' stands for 'potenz'. Potenz is a German word which means 'power' or 'potential'. Here; 'H' stands for hydrogen ion. Thus, pH means the potential of hydrogen or power of hydrogen.



IMPORTANCE OF pH IN EVERYDAY LIFE

1. **pH in human body**
   - Using pH factor the healthiness of our body is predicted. At pH level 6.9, the body becomes prone to viral infections like colds, cough and flu. Cancer cells thrive inside the body at a pH of 5.5.
   - The pH of a normal, healthy human skin is 4.5 to 6. Proper skin pH is essential for a healthy complexion.
   - pH of stomach fluid is approximately 2.0. This fluid is essential for the digestion of food.
   - Human blood pH range is 7.35 to 7.45. Any increase or decrease in this value, leads to diseases. The ideal pH for blood is 7.4.
   - pH of normal saliva ranges between 6.5 to 7.5.
   - White enamel coating in our teeth is calcium phosphate, hardest substance in our body. It does not dissolve in water. If pH of mouth falls below 5.5, the enamel gets corroded. Toothpastes are generally basic, and is used for cleaning the teeth, can neutralize the excess acid and prevent tooth decay.

2. **pH in soil**
   - In agriculture, the pH of soil is very important. Citrus fruits require slightly alkaline soil, while rice requires acidic soil and sugar cane requires neutral soil.

3. **pH in rain water**
   - pH of rain water is approximately 7 showing high level of its purity and neutrality. If rain water is polluted by SO_2 and NO_2, acid rain occurs, bringing the pH value less than 7.

INDICATOR:

Substances which show the acidic or basic behavior of other substance by change in colour are known as indicator.

Type of Indicator: There are many types of indicators. Some common types of indicators are

- Natural
- Olfactory Indicator
- Synthetic Indicator
- Universal Indicator

NATURAL INDICATOR

Indicators obtained from natural sources are called natural indicators. Litmus, turmeric, red cabbage, China rose, etc. are some common natural indicators used widely to show the acidic or basic character of substances.

LITMUS

Litmus is obtained from lichens. The solution of litmus is purple in colour. Litmus paper comes in two colour – blue and red.

- An acid turns blue litmus paper red.
- A base turns red litmus paper blue.

TURMERIC

Turmeric is another natural indicator. Turmeric is yellow in colour. Turmeric solution or paper turns reddish brown with base. Turmeric does not change colour with acid.

RED CABBAGE

The juice of red cabbage is originally purple in colour. Juice of red cabbage turns reddish with acid and turns greenish with base.

OLFACTORY INDICATORS

Substances which change their smell when mixed with acid or base are known as olfactory indicators. For example onion, vanilla, clove, etc.

ONION

Paste or juice of onion loses its smell when added with base. It does not change its smell with acid.

VANILLA

The smell of vanilla vanishes with base, but it’s smell does not vanishes with an acid. Olfactory indicators are used to ensure the participation of visually impaired students in laboratory.

SYNTHETIC INDICATOR

Indicators that are synthesized in laboratory are known as synthetic indicators. For example; phenolphthalein, methyl orange, etc.

Phenolphthalein is a colourless liquid. It remains colourless with acid but turns into pink with a base.

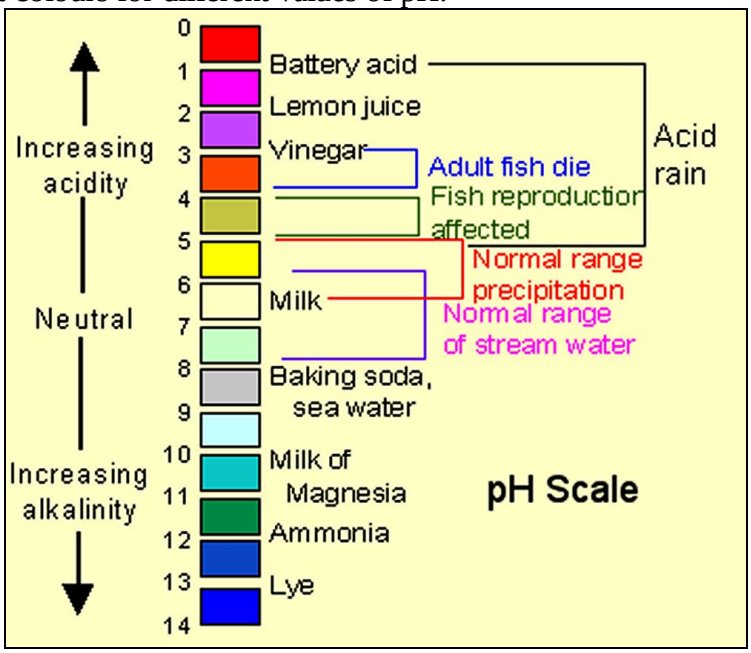
Methyl orange is originally orange in colour. It turns into red with acid and turns into yellow with base.

Indicator	Original colour	Acid	Base
Red litmus	Red	No change	Blue
Blue litmus	Blue	Red	No change
Turmeric	Yellow	No change	Reddish brown
Red cabbage juice	Purple	Reddish	Greenish yellow
Phenolphthalein	Colourless	Colourless	Pink
Methyl orange	Orange	Red	Yellow
Onion	n/a	No change	Smell vanishes
Vanilla	n/a	No change	Smell vanishes

UNIVERSAL INDICATOR:

Using a litmus paper, phelophthalein, methyl orange, etc. only the acidic or basic character of a solution can be determined, but use of these indicators does not give the idea about the strength of acid or base. So, to get the strength as well as acidic and basic nature of a given solution universal indicator is used.

Universal indicator shows different colour over the range of pH value from 1 to 14 for a given solution. Universal indicator is available both in the form of strips and solution. Universal indicator is the combination of many indicators, such as water, propanol, phelophthalein, sodium salt, sodium hydroxide, methyl red, bromothymol blue monosodium salt, and thymol blue monosodium salt. The colour matching chart is supplied with universal indicator which shows the different colours for different values of pH.



INTEXT QUESTIONS PAGE NO. 28

Question 1: You have two solutions, A and B. The pH of solution A is 6 and pH of solution B is 8. Which solution has more hydrogen ion concentration? Which of this is acidic and which one is basic?

Answer : A pH value of less than 7 indicates an acidic solution, while greater than 7 indicates a basic solution. Therefore, the solution with pH = 6 is acidic and has more hydrogen ion concentration than the solution of pH = 8 which is basic.

Question 2: What effect does the concentration of $H^+_{(aq)}$ ions have on the nature of the solution?

Answer : Concentration of $H^+_{(aq)}$ can have a varied effect on the nature of the solution. With an increase in H^+ ion concentration, the solution becomes more acidic, while a decrease of H^+ ion causes an increase in the basicity of the solution.

Question 3: Do basic solutions also have $H^+_{(aq)}$ ions? If yes, then why are these basic?

Answer : Yes, basic solution also has $H^+_{(aq)}$ ions. However, their concentration is less as compared to the concentration of OH^- ions that makes the solution basic.

Question 4: Under what soil condition do you think a farmer would treat the soil of his fields with quick lime (calcium oxide) or slaked lime (calcium hydroxide) or chalk (calcium carbonate)?

Answer : If the soil is acidic and improper for cultivation, then to increase the basicity of soil, the farmer would treat the soil with quick lime or slaked lime or chalk.

SALT

Salts are the ionic compounds which are produced after the neutralization reaction between acid and base. Salts are electrically neutral. There are number of salts but sodium chloride is the most common among them. Sodium chloride is also known as table salt or common salt. Sodium chloride is used to enhance the taste of food.

CHARACTERISTICS OF SALT:

- Most of the salts are crystalline solid
- Salts may be transparent or opaque
- Most of the salts are soluble in water
- Solution of salts conducts electricity. Salts conduct electricity in their molten state also
- The salt may be salty, sour, sweet, bitter and umami (savoury)
- Neutral salts are odourless
- Salts can be colourless or coloured

Classification of salts

1. **Normal salts**
   A normal salt is obtained by complete neutralization of an acid by a base
   $NaOH + HCl \rightarrow NaCl + H_2O$

2. **Acid salts**
   Acid salts are derived by the partial replacement of hydrogen ions of an acid by a metal. When a calculated amount of a base is added to a polybasic acid, acid salt is obtained, as follows.
   $NaOH + H_2SO_4 \rightarrow NaHSO_4 + H_2O$

3. **Basic salts**
   Basic salts are formed by the partial replacement of hydroxide ions of a diacidic or triacidic base by an acid radical. A basic salt may further reacts with an acid to give a normal salt.
   $Pb(OH)_2 + HCl \rightarrow Pb(OH)Cl + H_2O$
   Diacidic base Basic salt

4. **Double salts**
   Double salts are formed by the combination of saturated solution of two simple salts in equimolar ratio followed by crystallization. e.g. potash alum

FAMILY OF SALT:

Salts having common acidic or basic radicals are said to belong to same family.

Example

- Sodium chloride (NaCl) and Calcium chloride ($CaCl_2$) belong to chloride family.
- Calcium chloride ($CaCl_2$) and calcium sulphate ($CaSO_4$) belong to calcium family.
- Zinc chloride ($ZnCl_2$) and Zinc sulphate ($ZnSO_4$) belong to zinc family.

ACIDIC, BASIC AND NEUTRAL SALTS

NEUTRAL SALT

Salts produced because of reaction between strong acid and strong base are neutral in nature. The pH of value of such salts is equal to 7, i.e. neutral. Example; Sodium chloride, sodium sulphate, potassium chloride, etc.

Sodium chloride (NaCl) is formed after the reaction between hydrochloric acid (a strong acid) and sodium hydroxide (a strong base).

$NaOH + HCl \rightarrow NaCl + H_2O$

SODIUM SULPHATE (Na_2SO_4)
It is formed after the reaction between sodium hydroxide (a strong base) and sulphuric acid (a strong acid).
$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

Potassium chloride (KCl): It is formed after the reaction between potassium hydroxide (a strong base) and hydrochloric acid (a strong acid).
$KOH + HCl \rightarrow KCl + H_2O$

ACIDIC SALT
Salts which are formed after the reaction between a strong acid and weak base are called acidic salt. The pH value of acidic salt is lower than 7. Example: ammonium sulphate, ammonium chloride, etc.

Ammonium chloride is formed after reaction between hydrochloric acid (a strong acid) and ammonium hydroxide (a weak base).
$NH_4OH + HCl \rightarrow NH_4Cl + H_2O$

Ammonium sulphate is formed after reaction between ammonium hydroxide (weak base) and sulphuric acid (a strong acid).
$2NH_4OH + H_2SO_4 \rightarrow (NH_4)_2SO_4 + 2H_2O$

BASIC SALT
Salts which are formed after the reaction between weak acid and strong base are called basic salt. For example; sodium carbonate, sodium acetate, etc.

Sodium carbonate is formed after the reaction between sodium hydroxide (a strong base) and carbonic acid (a weak base).
$H_2CO_3 + 2NaOH \rightarrow Na_2CO_3 + 2H_2O$

Sodium acetate is formed after the reaction between a strong base, sodium hydroxide and a weak acid, acetic acid.
$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

CAUSE OF FORMATION OF ACIDIC, BASIC AND NEUTRAL SALT:

When a strong acid reacts with a weak base, the base is unable to fully neutralize the acid. Due to this an acidic salt is formed in this case.
When a strong base reacts with a weak acid, the acid is unable to fully neutralize the base. Due to this a basic salt is formed in this case.
When equally strong acid and base react they fully neutralize each other. Due to this a neutral salt is formed in this case.

pH Value Of Salt:

- Neutral salt: The pH value of a neutral salt is almost equal to 7.
- Acidic salt: The pH value of an acidic salt is less than 7.
- Basic salt: The pH value of a basic salt is more than 7.

COMMON SALT (SODIUM CHLORIDE)

Sodium chloride (NaCl) is also known as common or table salt. It is formed after the reaction between sodium hydroxide and hydrochloric acid. It is a neutral salt. The pH value of sodium

chloride is about 7. Sodium chloride is used to enhance the taste of food. Sodium chloride is used in manufacturing of many chemicals.

IMPORTANT CHEMICALS FROM SODIUM CHLORIDE:

SODIUM HYDROXIDE (NaOH)

Sodium hydroxide is a strong base. It is also known as caustic soda or Iye. It is obtained by the electrolytic decomposition of solution of sodium chloride (brine). In the process of electrolytic decomposition of brine (aqueous solution of sodium chloride), brine decomposes to form sodium hydroxide. In this process, chlorine is obtained at anode and hydrogen gas is obtained at cathode as byproducts. This whole process is known as Chlor-Alkali process.

$2NaCl + 2H_2O \rightarrow 2NaOH + Cl_2 + H_2$

USE OF PRODUCTS AFTER THE ELECTROLYSIS OF BRINE:

- Hydrogen gas is used as fuel, margarine, in making of ammonia for fertilizer, etc.
- Chlorine gas is used in water treatment, manufacturing of PVC, disinfectants, CFC, pesticides. It is also used in manufacturing of bleaching powder and hydrochloric acid.
- Sodium hydroxide is used for de-greasing of metals, manufacturing of paper, soap, detergents, artificial fibres, bleach, etc.

BLEACHING POWDER ($CaOCl_2$):

Bleaching powder is also known as chloride of lime. It is a solid and yellowish white in colour. Bleaching powder can be easily identified by the strong smell of chlorine.

When calcium hydroxide (slaked lime) reacts with chlorine, it gives calcium oxychloride (bleaching powder) and water is formed.

$Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$

Aqueous solution of bleaching powder is basic in nature. The term bleach means removal of colour. Bleaching powder is often used as bleaching agent. It works because of oxidation. Chlorine in the bleaching powder is responsible for bleaching effect.

USE OF BLEACHING POWDER:

- Bleaching powder is used as disinfectant to clean water, moss remover, weed killers, etc.
- Bleaching powder is used for bleaching of cotton in textile industry, bleaching of wood pulp in paper industry.
- Bleaching powder is used as oxidizing agent in many industries, such as textiles industry, paper industry, etc.

BAKING SODA ($NaHCO_3$)

Baking soda is another important product which can be obtained using byproducts of chlor-alkali process. The chemical name of baking soda is sodium hydrogen carbonate ($NaHCO_3$) or sodium bicarbonate. Bread soda, cooking soda, bicarbonate of soda, sodium bicarb, bicarb of soda or simply bicarb, etc. are some other names of baking soda.

Baking soda is obtained by the reaction of brine with carbon dioxide and ammonia. This is known as Solvay process.

$$NaCl + CO_2 + NH_3 + H_2O \rightarrow NH_4Cl + NaHCO_3$$

In this process, calcium carbonate is used as the source of CO_2 and the resultant calcium oxide is used to recover ammonia from ammonium chloride.

PROPERTIES OF SODIUM BICARBONATE:

- Sodium bicarbonate is white crystalline solid, but it appears as fine powder.

- Sodium hydrogen carbonate is amphoteric in nature.
- Sodium hydrogen carbonate is sparingly soluble in water.
- Thermal decomposition of sodium hydrogen carbonate (baking soda).
- When baking soda is heated, it decomposes into sodium carbonate, carbon dioxide and water.

$$2NaHCO_3 + \text{heat} \rightarrow \quad Na_2CO_3 + CO_2 + H_2O$$

Sodium carbonate formed after thermal decomposition of sodium hydrogen carbonate; decomposes into sodium oxide and carbon dioxide on further heating.

$$Na_2CO_3 \rightarrow \quad Na_2O + CO_2$$

This reaction is known as dehydration reaction.

USE OF BAKING SODA:

- Baking soda is used in making of baking powder, which is used in cooking as it produces carbon dioxide which makes the batter soft and spongy.
- Baking soda is used as antacid.
- Baking soda is used in toothpaste which makes the teeth white and plaque free.
- Baking soda is used in cleansing of ornaments made of sliver.
- Since, sodium hydrogen carbonate gives carbon dioxide and sodium oxide on strong heating, thus it is used as fire extinguisher.

BAKING POWDER:

Baking powder produces carbon dioxide on heating, so it is used in cooking to make the batter spongy. Although baking soda also produces carbon dioxide on heating, but it is not used in cooking because on heating; baking soda produces sodium carbonate along with carbon dioxide. The sodium carbonate; thus produced; makes the taste bitter.

$$2NaHCO_3 + \text{heat} \rightarrow \quad Na_2CO_3 + CO_2 + H_2O$$

Baking powder is the mixture of baking soda and a mild edible acid. Generally, tartaric acid is mixed with baking soda to make baking powder.

$$NaHCO_3 + C_4H_6O_6 \rightarrow \quad CO_2 + H_2O + Na_2C_4H_4O_6$$

When baking powder (mixture of baking soda and an edible acid) is heated, the sodium carbonate formed because of heating of baking soda neutralizes after reacting with tartaric acid and sodium tartarate salt is formed. The smell of sodium tartarate is pleasant and taste is good. This makes the cake or any other food tasty.

WASHING SODA (SODIUM CARBONATE)

Sodium carbonate is manufactured by the thermal decomposition of sodium hydrogen carbonate obtained by Solvay process.

$$NaCl + CO_2 + NH_3 + H_2O \rightarrow \quad NH_4Cl + NaHCO_3$$

$$NaHCO_3 + C_4H_6O_6 \rightarrow \quad CO_2 + H_2O + Na_2C_4H_4O_6$$

The sodium carbonate obtained in this process is dry. It is called soda ash or anhydrous sodium carbonate. Washing soda is obtained by rehydration of anhydrous sodium carbonate.

$$Na_2CO_3 + 10H_2O \rightarrow \quad Na_2CO_3.10H_2O$$

Since there are 10 water molecules in washing soda, hence it is known as Sodium bicarbonate decahydrate.

Sodium carbonate is a crystalline solid and it is soluble in water when most of the carbonates are insoluble in water.

USE OF SODIUM CARBONATE:

- It is used in cleaning of cloths; especially in rural areas.
- In making of detergent cake and powder.

- In removing permanent hardness of water.
- It is used in glass and paper industries.

Water of crystallization: Many salts contain water molecule and are known as hydrated salts. The water molecule present in salt is known as water of crystallization.

Examples:

COPPER SULPHATE PENTAHYDRATE ($CuSO_4.5H_2O$)

Blue colour of copper sulphate is due to presence of 5 molecules of water. When copper sulphate is heated, it loses water molecules and turns into grey-white colour, which is known as anhydrous copper sulphate. After adding water; anhydrous copper sulphate becomes blue again.

$CuSO_4.5H_2O + \text{heat} \rightarrow CuSO_4$

FERROUS SULPHATE HEPTAHYDRATE (FeSO4.7H2O)

The green colour of Ferrous sulphate heptahydrate; commonly known as ferrous sulphate; is due to the presence of 7 molecules of water in it.

PLASTER OF PARIS

Plaster of Paris is obtained by heating of gypsum, a hydrated salt of calcium.

$$CaSO_4.2H_2O + \text{Heat} \rightarrow CaSO_4.\frac{1}{2}H_2O + \frac{3}{2}H_2O$$

After addition of water Plaster of Paris is again converted into gypsum.

$$CaSO_4.\frac{1}{2}H_2O + \frac{3}{2}H_2O \rightarrow CaSO_4.2H_2O$$

Plaster of Paris is used in making of toys, designer false ceiling, etc. Doctors use Plaster of Paris to set the fractured bone.

<u>INTEXT QUESTIONS PAGE NO. 33</u>

Question 1: What is the common name of the compound $CaOCl_2$?

Answer : The common name of the compound $CaOCl_2$ is bleaching powder.

Question 2: Name the substance which on treatment with chlorine yields bleaching powder?

Answer : Calcium hydroxide [Ca (OH)2], on treatment with chlorine, yields bleaching powder.

Question 3: Name the sodium compound which is used for softening hard water.

Answer : Washing soda (Na2CO3.10H2O) is used for softening hard water.

Question 4: What will happen if a solution of sodium hydrocarbonate is heated? Give the equation of the reaction involved.

Answer : When a solution of sodium hydrocarbonate (sodium hydrogencarbonate) is heated, sodium carbonate and water are formed with the evolution of carbon dioxide gas.

$$\underset{\text{Sodium hydrogencarbonate}}{2NaHCO_3} \xrightarrow{\Delta} \underset{\text{Sodium carbonate}}{Na_2CO_3} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon dioxide}}{CO_2\uparrow}$$

Question 5: Write an equation to show the reaction between Plaster of Paris and water.

Answer : The chemical equation for the reaction of Plaster of Paris and water can be represented as

$$CaSO_4 \cdot \frac{1}{2}H_2O + 1\frac{1}{2}H_2O \longrightarrow CaSO_4.2H_2O$$

Plaster of Paris Water Gypsum

EXERCISE QUESTIONS PAGE NO. 34 and 35

Question 1: A solution turns red litmus blue, its pH is likely to be
(a) 1 (b) 4 (c) 5 (d) 10
Answer : (d) Bases turn red litmus blue and acids turn blue litmus red. Basic solution has a pH value more than 7. Since the solution turns red litmus blue, its pH is likely to be 10.

Question 2: A solution reacts with crushed egg-shells to give a gas that turns lime-water milky. The solution contains
(a) NaCl (b) HCl (c) LiCl (d) KCl
Answer : (b) The solution contains HCl.

Question 3: 10 mL of a solution of NaOH is found to be completely neutralised by 8 mL of a given solution of HCl. If we take 20 mL of the same solution of NaOH, the amount of HCl solution (the same solution as before) required to neutralise it will be
(a) 4 mL (b) 8mL (c) 12 mL (d) 16 mL
Answer : (d) 16 mL of HCl solution will be required.

Question 4: Which one of the following types of medicines is used for treating indigestion?
(a) Antibiotic (b) Analgesic (c) Antacid (d) Antiseptic
Answer : (c) Antacid is used for treating indigestion.

Question 5: Write word equations and then balanced equations for the reaction taking place when −
(a) dilute sulphuric acid reacts with zinc granules.
(b) dilute hydrochloric acid reacts with magnesium ribbon.
(c) dilute sulphuric acid reacts with aluminium powder.
(d) dilute hydrochloric acid reacts with iron filings.
Answer : (a) Sulphuric acid + Zinc → Zinc sulphate + Hydrogen

$$H_2SO_{4(aq)} + Zn_{(s)} \longrightarrow ZnSO_{4(aq)} + H_{2(g)}$$

(b) Hydrochloric acid + Magnesium → Magnesium chloride + Hydrogen

$$2HCl_{(aq)} + Mg_{(s)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$$

(c) Sulphuric acid + Aluminium → Aluminium sulphate + Hydrogen

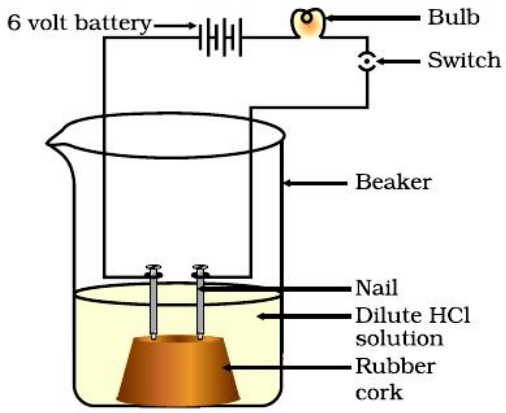
$$3H_2SO_{4(aq)} + 2Al_{(s)} \longrightarrow Al_2(SO_4)_{3(aq)} + 3H_{2(g)}$$

(d) Hydrochloric acid + Iron → Ferric chloride + Hydrogen

$$6HCl_{(aq)} + 2Fe_{(s)} \longrightarrow 2FeCl_{3(aq)} + 3H_{2(g)}$$

Question 6: Compounds such as alcohols and glucose also contain hydrogen but are not categorized as acids. Describe an activity to prove it.
Answer : Two nails are fitted on a cork and are kept it in a 100 mL beaker. The nails are then connected to the two terminals of a 6-volt battery through a bulb and a switch. Some dilute HCl is poured in the beaker and the current is switched on. The same experiment is then performed with glucose solution and alcohol solution.

Observations:



Result:
HCl dissociates into H+ and Cl− ions. These ions conduct electricity in the solution resulting in the glowing of the bulb. On the other hand, the glucose solution does not dissociate into ions. Therefore, it does not conduct electricity.

Conclusion:
From this activity, it can be concluded that all acids contain hydrogen but not all compounds containing hydrogen are acids.

That is why, though alcohols and glucose contain hydrogen, they are not categorised as acids.

Question 7: Why does distilled water not conduct electricity, whereas rain water does?
Answer : Distilled water is a pure form of water and is devoid of any ionic species. Therefore, it does not conduct electricity. Rain water, being an impure form of water, contains many ionic species such as acids and therefore it conducts electricity.

Question 8: Why do acids not show acidic behaviour in the absence of water?
Answer : Acids do not show acidic behaviour in the absence of water because the dissociation of hydrogen ions from an acid occurs in the presence of water only. It is the hydrogen ions that are responsible for the acidic behaviour.

Question 9: Five solutions A, B, C, D and E when tested with universal indicator showed pH as 4, 1, 11, 7 and 9, respectively. Which solution is
(a) neutral?
(b) strongly alkaline?
(c) strongly acidic?
(d) weakly acidic?
(e) weakly alkaline?
Arrange the pH in increasing order of hydrogen-ion concentration.
Answer :
(a) Neutral → Solution D with pH 7
(b) Strongly alkaline → Solution C with pH 11
(c) Strongly acidic → Solution B with pH 1
(d) Weakly acidic → Solution A with pH 4
(e) Weakly alkaline → Solution E with pH 9
The pH can be arranged in the increasing order of the concentration of hydrogen ions as: 11 < 9 < 7 < 4 < 1

Question 10: Equal lengths of magnesium ribbons are taken in test tubes A and B. Hydrochloric acid (HCl) is added to test tube A, while acetic acid (CH3COOH) is added to test tube B. In which test tube will the fizzing occur more vigorously and why?
Answer : The fizzing will occur strongly in test tube A, in which hydrochloric acid (HCl) is added. This is because HCl is a stronger acid than CH3COOH and therefore produces hydrogen gas at a faster speed due to which fizzing occurs.

Question 11: Fresh milk has a pH of 6. How do you think the pH will change as it turns into curd? Explain your answer.
Answer : The pH of milk is 6. As it changes to curd, the pH will reduce because curd is acidic in nature. The acids present in it decrease the pH.

Question 12: A milkman adds a very small amount of baking soda to fresh milk.
(a) Why does he shift the pH of the fresh milk from 6 to slightly alkaline?
(b) Why does this milk take a long time to set as curd?
Answer : (a) The milkman shifts the pH of the fresh milk from 6 to slightly alkaline because in alkaline condition, milk does not set as curd easily.
(b) Since this milk is slightly basic than usual milk, acids produced to set the curd are neutralized by the base. Therefore, it takes a longer time for the curd to set.

Question 13: Plaster of Paris should be stored in a moisture-proof container. Explain why?
Answer : Plaster of Paris (POP) should be stored in a moisture-proof container because Plaster of Paris, a powdery mass, absorbs water (moisture) to form a hard solid known as gypsum.

$$CaSO_4 \cdot \frac{1}{2}H_2O + 1\frac{1}{2}H_2O \longrightarrow CaSO_4.2H_2O$$

Plaster of Paris Water Gypsum

Question 14: What is a neutralization reaction? Give two examples.
Answer : A reaction in which an acid and base react with each other to give a salt and water is termed as neutralization reaction. In this reaction, energy is evolved in the form of heat.
For example:(i)

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

(Base) (Acid) (Salt) (Water)

(ii) During indigestion (caused due to the production of excess of hydrochloric acid in the stomach), we administer an antacid (generally milk of magnesia, $Mg(OH)_2$ which is basic in nature). The antacid neutralizes the excess of acids and thus gives relief from indigestion.

$$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$$

Question 15: Give two important uses of washing soda and baking soda.
Answer : Two important uses of washing soda and baking soda are as follows:
(1) Washing soda:
(a) It is used in glass, soap, and paper industries.
(b) It is used to remove permanent hardness of water.

(2) Baking soda:
(a) It is used as baking powder. Baking powder is a mixture of baking soda and a mild acid known as tartaric acid. When it is heated or mixed in water, it releases CO2 that makes bread or cake fluffy.
(b) It is used in soda-acid fire extinguishers.