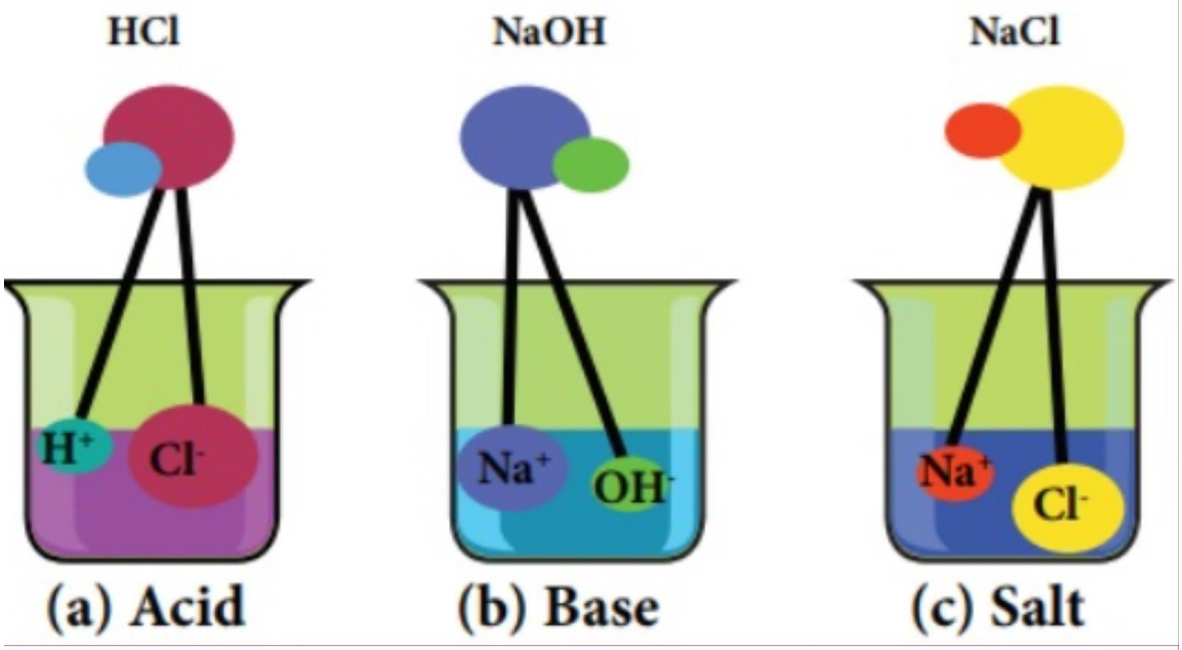
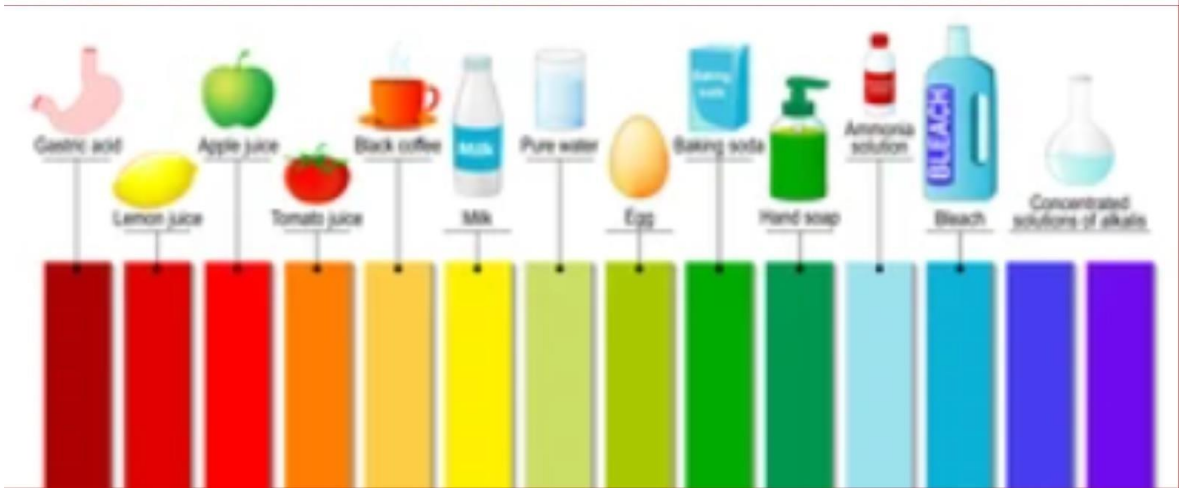
Acids Bases & salts





CHAPTER 2

ACIDS, BASES AND SALTS

Acids: Acids are sour in taste, turn blue litmus red, and dissolve in water to release H^+ ions.
Example: Sulphuric acid (H_2SO_4), Acetic Acid (CH_3COOH), Nitric Acid (HNO_3) etc.
Properties of Acids:

- Acids have a sour taste.
- Turns blue litmus red.
- Acid solution conducts electricity.
- Release H^+ ions in aqueous solution.

Types of Acids: Acids are divided into two types on the basis of their occurrence i.e., Natural acids and Mineral acids.
(i) Natural Acids: Acids which are obtained from natural sources are called Natural Acids or Organic Acids. Methanoic acid ($HCOOH$), Acetic acid (CH_3COOH), Oxalic acid ($C_2H_2O_4$) etc.
(ii) Mineral Acids: Acids that are prepared from minerals are known as Mineral Acids Example; Inorganic acids, man-made acids or synthetic acid are also known as Mineral Acids.
Hydrochloric acid (HCl), Sulphuric acid (H_2SO_4), Nitric acid (HNO_3), Carbonic acid (H_2CO_3) Phosphoric acid (H_3PO_4) etc.
Chemical Properties of Acid:
(i) Reaction of acids with metal: Acids give hydrogen gas along with respective salt when they react with a metal.
Examples: Hydrogen gas and zinc chloride are formed when hydrochloric acid reacts with zinc metal.

$$Zn\ (s) + 2HCl\ (aq) \longrightarrow ZnCl_2\ (aq) + H_2\ (g)$$

Test for Hydrogen Gas: The gas evolved after reaction of acid with metal can be tested by bringing a lighted candle near it. If the gas bums with a pop sound, then it confirms the evolution of hydrogen gas. Burning with pop sound is the characteristic test for hydrogen gas.
(ii) Reaction of acids with metal carbonate: Acids give carbon dioxide gas and respective salts along with water when they react with metal carbonates.
Examples: Hydrochloric acid gives carbon dioxide gas, sodium chloride along with water when reacts with sodium carbonate.

$$Na_2CO_3\ (aq) + 2HCl\ (aq) \longrightarrow 2NaCl\ (aq) + CO_2\ (g) + H_2O\ (l)$$

(iii) Reaction of acid with hydrogen carbonates (bicarbonates): Acids give carbon dioxide gas, respective salt and water when they react with metal hydrogen carbonate.
Example: Sulphuric acid gives sodium sulphate, Carbon dioxide gas and water when it reacts with sodium bicarbonate.

$$2NaHCO_3\ (aq) + H_2SO_4\ (aq) \longrightarrow Na_2SO_4\ (aq) + CO_2\ (g) + H_2O\ (l)$$

TYPES OF ACIDS:
Strong Acids: An acid which is completely ionized in water and produces (H^+) is called Strong Acid.
Examples: Hydrochloric acid (HCl), Sulphuric acid (H_2SO_4), Nitric acid (HNO_3)

Weak Acids: An acid which is partially ionized in water and thus produces a small amount of hydrogen ions (H^+) is called a Weak Acid.
Example: Acetic acid (CH_3COOH), Carbonic acid (H_2CO_3)

Bases: Bases are bitter in taste, have soapy touch, turn red litmus blue and give hydroxide ions (OH^-) in aqueous solution.
Examples: Sodium hydroxide (caustic soda) – NaOH, Calcium hydroxide – $Ca(OH)_2$
Potassium hydroxide (caustic potash) – (KOH)
Properties of Bases:

- Have a bitter taste.
- Soapy to touch.
- Turns red litmus blue.
- Conducts electricity in solution.
- Release OH^- ions in Aqueous Solution

Types of bases: Bases can be divided in two types – Water soluble and Water-insoluble.
The hydroxide of alkali and alkaline earth metals are soluble in water. These are also known as alkali. For example NaOH, $Mg(OH)_2$, $Ca(OH)_2$

Chemical properties of bases:
(i) Reaction of Base with Metals: When alkali (base) reacts with metal, it produces salt and hydrogen gas.

Examples: Sodium hydroxide gives hydrogen gas and sodium zincate when reacts with zinc metal.
$2NaOH\ (aq) + Zn\ (s) \longrightarrow Na_2ZnO_2\ (aq) + H_2\ (g)$

(ii) Reaction of Base with Oxides of Non-metals: when a base reacts with non-metal oxide, both neutralize each other resulting respective salt and water.
Examples: Sodium hydroxide gives sodium carbonate and water when it reacts with carbon dioxide.
$2NaOH\ (aq) + CO_2\ (g) \longrightarrow Na_2CO_3\ (aq) + H_2O\ (l)$
(iii) Neutralisation Reaction: An acid neutralizes a base when they react with each other and respective salt and water are formed.
Examples: Sodium chloride and water are formed when hydrochloric acid reacts with sodium hydroxide (a strong base).
$HCl\ (aq) + NaOH\ (aq) \longrightarrow NaCl\ (aq) + H_2O\ (l)$
(iv) 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, the respective salt and water are formed.
Examples: When an acid, such as hydrochloric acid, reacts with calcium oxide, neutralization reaction takes place and calcium chloride, along with water is formed.
$2HCl\ (aq) + CaO\ (aq) \longrightarrow CaCl_2\ (aq) + H_2O\ (l)$

Salts: 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.

Acid + Base → Salt + Water

$HCl\ (aq) + NaOH\ (aq) \longrightarrow NaCl\ (aq) + H_2O\ (l)$

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 the salts conducts electricity in their molten state also.
- The salt may be salty, sour, sweet, and bitter.
- Neutral salts are odourless.
- Salts can be colourless or coloured.

Example: Sodium chloride (NaCl), Sodium Sulphate (Na_2SO_4), Calcium chloride ($CaCl_2$), Calcium sulphate ($CaSO_4$), Zinc chloride ($ZnCl_2$) and Zinc sulphate ($ZnSO_4$)

Neutral, Acidic and Basic Salts:

(i) Neutral Salt: Salts produced because of reaction between a strong acid and strong base are neutral in nature. The pH value of such salts is equal to 7, i.e. neutral.

Example: Sodium chloride, Sodium sulphate. Potassium chloride, etc.

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

$HCl\ (aq) + NaOH\ (aq) \longrightarrow NaCl\ (aq) + H_2O\ (l)$

Sodium Sulphate (Na_2SO_4): It is formed after the reaction between sodium hydroxide (a strong base) and Sulphuric acid (a strong acid).

$H_2SO_4\ (aq) + 2NaOH\ (aq) \longrightarrow Na_2SO_4\ (aq) + 2H_2O\ (l)$

Potassium Chloride (KCl): It is formed after the reaction between potassium hydroxide (a strong base) and hydrochloric acid (a strong acid).

$HCl\ (aq) + KOH\ (aq) \longrightarrow KCl\ (aq) + H_2O\ (l)$

(ii) Acidic Salts: Salts which are formed after the reaction between a strong acid and weak base are called Acidic salts. The pH value of acidic salt is lower than 7. For example: Ammonium chloride, Ammonium sulphate etc.

Ammonium chloride is formed after reaction between hydrochloric acid (a strong acid) and ammonium hydroxide (a weak base).

$HCl\ (aq) + NH_4OH\ (aq) \longrightarrow NH_4Cl\ (aq) + H_2O\ (l)$

Ammonium sulphate is formed after reaction between ammonium hydroxide (a weak base) and Sulphuric acid (a strong acid).

$H_2SO_4\ (aq) + 2NH_4OH\ (aq) \longrightarrow [NH_4]_2SO_4\ (aq) + 2H_2O\ (l)$

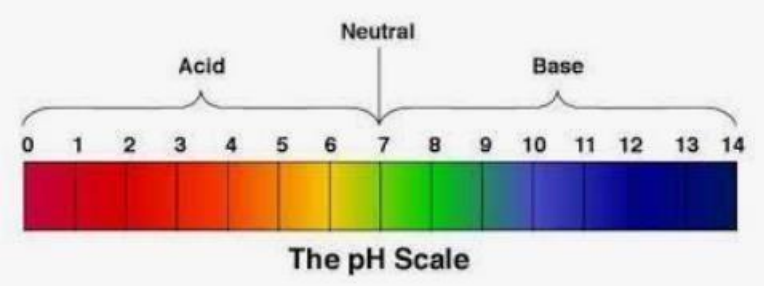
(iii) Basic Salts: Salts which are formed after the reaction between a weak acid and strong base are called Basic Salts. For example; Sodium carbonates, Sodium acetate, etc.
Sodium carbonate is formed after the reaction between sodium hydroxide (a strong base) and carbonic acid (a weak acid).

H_2CO_3 (aq) + 2NaOH (aq) $\longrightarrow$ Na_2CO_3 (aq) + $2H_2O$ (l)

Sodium acetate is formed after the reaction between a strong base, sodium hydroxide (a strong base) and acetic acid, (a weak acid).

CH_3COOH (aq) + NaOH (aq) $\longrightarrow$ CH_3COONa (aq) + H_2O (l)

pH Scale:



Strength of Acid and Base: Acids in which complete dissociation of hydrogen ion takes place are called Strong Acids. Similarly, bases in which complete dissociation of hydroxide ion takes place are called Strong Bases.
In mineral acid, such as hydrochloric acid, Sulphuric acid, nitric acid, etc. hydrogen ion dissociates completely and hence, they are considered as strong acids. Since inorganic acids hydrogen ions do not dissociate completely, so they are weak acids.

pH is equal to the logarithm to the base 10, inverse of hydrogen ion concentration.
$pH = -\log [H^+] = \log \{1/[H^+]\} = 10^{-pH}$
Similarly, $pOH = -\log [OH^-] = \log \{1/[OH^-]\}$
And $pH + pOH = pKw = 14$
Higher the hydronium ion concentration present in the solution, lower is its pH value.
For water or neutral solutions: pH = 7
for acidic solutions: pH < 7
for basic solution: pH > 7

Importance of pH everyday life:

(i) pH in our digestive system: Dilute HCl (Hydrochloric acid) helps in digestion of food (proteins) in our stomach. Excess acid in stomach causes acidity (indigestion). Antacids like magnesium hydroxide [$Mg(OH)_2$] also known as milk of magnesia and sodium hydrogen carbonate (baking soda) are used to neutralize excess acid.

(ii) Tooth decay caused by acids: The bacteria present in our mouth converts the sugar into acids. When the pH of acid formed in the mouth falls below 5.5, tooth-decaying starts. The excess acid has to be removed by cleaning the teeth with good quality toothpaste because these kinds of toothpaste are alkaline in nature.

(iii) Soil of pH and plant growth: Most of the plants have a healthy growth when the soil has a specific pH (close to 7) range which should be neither alkaline nor highly acidic.

Some Important Chemical Compounds

1. 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 the manufacturing of many chemicals.

$$HCl\ (aq) + NaOH\ (aq) \longrightarrow NaCl\ (aq) + H_2O\ (l)$$

2. Sodium Hydroxide (NaOH): Sodium hydroxide is a strong base. It is also known as caustic soda. 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 by products. This whole process is known as Chloro – Alkali process.

$$2NaCl\ (aq) + 2H_2O\ (l) \longrightarrow 2NaOH\ (aq) + Cl_2\ (g) + H_2\ (g)$$

3. 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.

$$Ca\ (OH)_2\ (aq) + Cl_2\ (aq) \longrightarrow CaOCl_2\ (aq) + H_2O\ (l)$$

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.

4. 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.

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

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

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.
- When baking soda is heated, it decomposes into sodium carbonate, carbon dioxide and water.
  $2NaHCO_3 + heat \rightarrow Na_2CO_3 + CO_2 + H_2O$
- Sodium carbonate formed after thermal decomposition of sodium hydrogen carbonate decomposes into sodium oxide and carbon dioxide on further heating.
  $Na_2CO_3 \rightarrow Na_2O + CO_2$

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 an 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 silver.
- Since sodium hydrogen carbonate gives carbon dioxide and sodium oxide on strong heating, thus, it is used as a fire extinguisher.

4. Washing Soda (Sodium Carbonate)

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

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

$2NaHCO_3 + Heat \rightarrow Na_2CO_3 + CO_2 + H_2O$

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.

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

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 the cleaning of cloths.
- In the making of detergent cake and powder.
- In removing the permanent hardness of water.
- It is used in glass and paper industries.

(v) Plaster of Paris: Calcium sulphate hemihydrate [$CaSO_4$. ½ H_2O]

$CaSO_4.2H_2O \xrightarrow{373K} \mathbf{CaSO_4.\ ½\ H_2O} + 3/2H_2O$

Plaster of Paris

$CaSO_4.1/2H_2O + 3/2H_2O \longrightarrow CaSO_4.2H_2O$ (Gypsum)

Multiple Choice Questions:

Q1. Which of the following acids is present in sour milk?
(a) Glycolic acid
(b) Oxalic acid
(c) Lactic acid
(d) Citric acid

Q2. Which of the following statements is not correct?
(a) All metal carbonates react with acid to give a salt, water and carbon dioxide
(b) All metal oxides react with water to give salt and acid
(c) Some metal react with acids to give salt and hydrogen
(d) Some non-metal oxides react with water to form an acid

Q3. Which of the following statements is incorrect about bases?
(a) Bases are bitter in taste
(b) They are soapy to touch
(c) They are corrosive in nature
(d) All bases are alkali

Q4. Mixing of acid or base with water results in …… in the concentration of ions per unit volume.

(a) Decreases
(b) Increases
(c) No change
(d) Reverse change

Q5. What is pH?
(a) The positive logarithm of the hydroxide ion concentration
(b) The positive logarithm of the hydrogen ion concentration
(c) The negative logarithm of the hydroxide ion concentration
(d) The negative logarithm of the hydrogen ion concentration

Q6. Which of the following statements is correct about an aqueous solution of an acid and a base?
1. Higher the pH, stronger the acid.
2. Higher the pH, weaker the acid.
3. Lower the pH, stronger the base.
4. Lower the pH, weaker the base.

(a) 1 and 3
(b) 2 and 3
(c) 1 and 4
(d) 2 and 4

Q7. The chemical formula of washing soda is ……
(a) $NaHCO_3$
(b) $Na_2CO_3.10H_2O$
(c) $CaOCl_2$
(d) NaOH

Q8. Baking soda is a mixture of
(a) Sodium carbonate and acetic acid
(b) Sodium carbonate and tartaric acid
(c) Sodium hydrogen carbonate and tartaric acid
(d) Sodium hydrogen carbonate and acetic acid

Q9. What happens, when a solution of an acid is mixed with a solution of a base in a test tube?
1. The temperature of the solution increases.
2. The temperature of the solution decreases.
3. The temperature of the solution remains the same.
4. Salt formation takes place.

(a) Only 1
(b) 1 and 3
(c) 2 and 3
(d) 1 and 4

Q10. Which of the following salts does not contain water of crystallization?

(a) Blue vitriol
(b) Baking soda
(c) Washing soda
(d) Gypsum

ANSWERS

Q1. (c)	**Q2. (b)**	**Q3. (d)**	**Q4. (a)**	**Q5. (d)**
Q6. (d)	**Q7. (b)**	**Q8. (c)**	**Q9. (d)**	**Q10. (b)**

Assignment:

Q1. Name the natural source of each of the following acid
(i) Citric acid (ii) Oxalic acid
(iii) Lactic acid (iv) Tartaric acid
Answer. (i) Lemon and orange (ii) Tomatoes and Guava
(iii) Sour milk (curd) (iv) Tamarind

Q2**.** A student detected the pH of four unknown solution A, B, C and D as follows 11, 5, 7 and 2. Predict the nature of the solution.
Answer. A is basic _B' is acidic _C' is natural and _D' is strongly acidic.

Q3. How will you test for the gas which is liberated when hydrochloric acid reacts with an active metal?
Answer. Bring a burning matchstick near the gas. It burns with _pop' sound showing that it is hydrogen.

Q4. (a) Write the name given to bases that are highly soluble in water. Give an example.
(b) How is tooth decay related to pH? How can it be prevented?
(c) Why does bee sting cause pain and irritation? Rubbing of baking soda on the sting area gives relief. How?
Answer. (a) Alkali, e.g. NaOH (Sodium hydroxide).
(b) Lower the pH more will be tooth decay. Acid reacts with $Ca_3(PO_4)_2$ and cause tooth decay. It can be prevented by brushing teeth after every meal.
(c) It is due to formic acid. Sodium hydrogencarbonates (Baking soda) neutralizes formic acid giving relief.

Q5. A white powder is added while baking breads and cakes to make them soft and fluffy. Write the name of the powder. Name its main ingredients. Explain the function of each ingredient. Write the chemical reaction taking place when the powder is heated during baking.
Answer. Baking powder. It consists of sodium hydrogencarbonates and tartaric acid. Sodium hydrogencarbonates gives CO_2 which makes cake soft and fluffy. Tartaric acid neutralizes the bitterness due to sodium carbonate produced.
$2NaHCO_3\,(s) \longrightarrow Na_2CO_3\,(s) + CO_2\,(g) + H_2O\,(l)$

Q6. A student dropped few pieces of marble in dilute hydrochloric acid, contained in a test-tube. The evolved gas was then passed through lime water. What change would be observed in lime water? What will happen if excess of gas is passed through lime water? With the help of balanced chemical equations for all the changes explain the observations.

Answer.

$CaCO_3$ (s) + 2HCl (dilute) $\longrightarrow$ $CaCl_2$ (s) + CO_2 (g) + H_2O (l)

Lime water turns milky due to liberation of CO_2.

$Ca(OH)_2$ (aq) + CO_2 (g) $\longrightarrow$ $CaCO_3$ (s) + H_2O (l)

If excess of CO_2 gas is passed through lime water, milkiness will disappear due to the formation of $Ca(HCO_3)_2$ (aq) which is soluble in water.

$CaCO_3$ (s) + CO_2 (g) + H_2O (l) $\longrightarrow$ $Ca(HCO_3)_2$ (aq)

Q7. 15 mL of water and 10 mL of Sulphuric acid are to be mixed in a beaker

(i) State the method that should be followed with reason.

(ii)What is this process called?

Answer.

(i) The acid is to be added slowly in water to prevent the mixture to be splashed. The reaction is highly exothermic; therefore, constant cooling should be done.

(ii) The process is called dilution**.**

Q8. Choose strong acids and weak acids from the following:

CH_3COOH, H_2SO_4, H_2CO_3, HNO_3

Answer. H_2SO_4 and HNO_3 are strong acids.

CH_3COOH and H_2CO_3 are weak acids.

Q9. A white coloured powder is used by doctors for supporting fractured bones.

(a) Write chemical name and formula of the powder.

(b) When this white powder is mixed with water a hard solid mass is obtained. Write balanced chemical equation for the change.

Answer. (a) Calcium sulphate hemihydrate ($CaSO_4 .1/_2 H_2O$)

(b) $CaSO_4 .1/_2 H_2O + 3/_2 H_2O \longrightarrow CaSO_4. 2H_2O$

Q10**.** How will you test for the gas which is liberated when hydrochloric acid reacts with an active metal?

Answer. Bring a burning matchstick near the gas. It burns with _pop' sound showing that it is hydrogen.

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