Reaction of Metal Carbonates/Metal Hydrogen Carbonates with

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

Acids

Acid + Metal Carbonate/ Metal Hydrogen Carbonate → Salt + CO_2 + H_2O

Bases Base+ MetalCarbonate/MetalHydrogenCarbonate→ No Reaction

E.g., $2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$

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

$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O$

Sodium bicarbonate is also known as sodium hydrogen carbonate, baking soda, baking powder, bread soda and bicarbonate of soda.

next page for more reaction

$$Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + CO_2 + H_2O$$

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$$

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$$

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

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

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 forme

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 cal cium carbonate.

* CO_2 can be tested by passing it through lime water.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$ (Lime water turns milky.)

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.

* When excess CO_2 is passed,

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

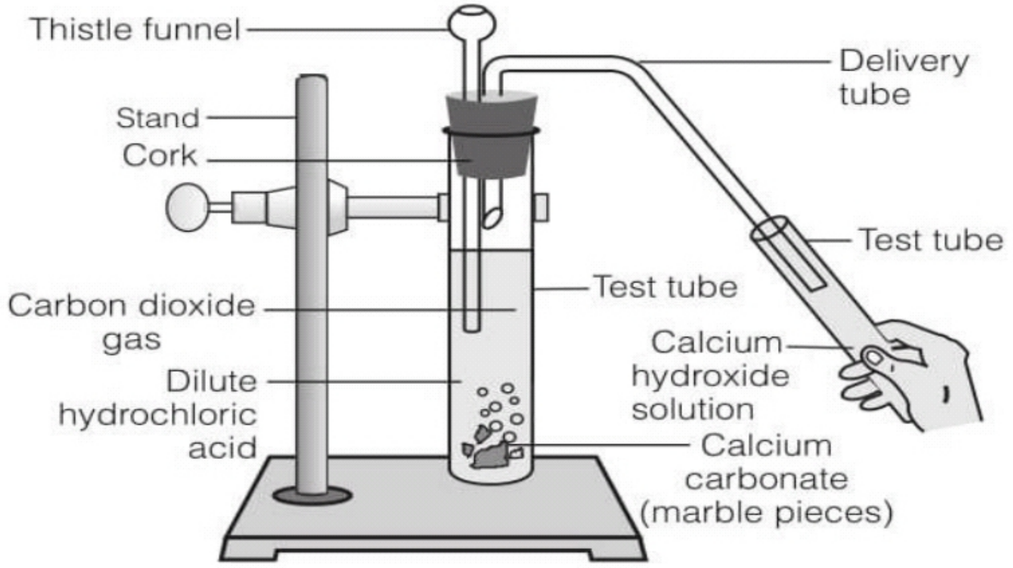
ACTIVITY 2 (NCERT Pg 20)

Objective

To study the reaction of metal carbonates and bicarbonates with acids.

Materials Required

Marble pieces (calcium carbonate, $CaCO_3$), baking soda (sodium bicarbonate, $NaHCO_3$), dilute hydrochloric acid (HCl), lime water, test tubes, thistle funnel and delivery tube (bent at two places).



Passing carbon dioxide gas through calcium hydroxide solution

Procedure

1. Take some marble pieces in the test tube and set the apparatus, as shown in the figure
2. Now add dilute HCl with the help of thistle funnel and pass the gas evolved in lime water. Observe the colour of lime water.
3. Repeat the same experiment with baking soda.

Observation

The lime water turns milky due to the formation of calcium carbonate. If the gas is passed for a longer time, milkiness disappears due to the conversion of white calcium carbonate into soluble calcium bicarbonate.

$$\underset{\text{Carbon dioxide}}{CO_2(g)} + \underset{\text{Lime water}}{Ca(OH)_2} \longrightarrow \underset{\text{Calcium carbonate (White ppt.)}}{CaCO_3(s)} + \underset{\text{Water}}{H_2O(l)}$$

$$\underset{\text{Calcium carbonate}}{CaCO_3(s)} + \underset{\text{Water}}{H_2O(l)} + \underset{\text{Carbon dioxide}}{CO_2(g)} \longrightarrow \underset{\text{Calcium bicarbonate (Soluble)}}{Ca(HCO_3)_2}$$

Conclusion

Carbon dioxide gas is evolved when metal carbonates and bicarbonates react with acids.

$$\underset{\text{Calcium Carbonate (Marble)}}{CaCO_3} + \underset{\text{Hydrochloric acid}}{2HCl(\text{dil.})} \longrightarrow \underset{\text{Calcium chloride}}{CaCl_2(aq)} + \underset{\text{Water}}{H_2O(l)} + \underset{\text{Carbon dioxide}}{CO_2(g)}$$

$$\underset{\text{Sodium bicarbonate}}{2NaHCO_3} + \underset{\text{Hydrochloric acid}}{2HCl(\text{dil.})} \longrightarrow \underset{\text{Salt}}{2NaCl(aq)} + \underset{\text{Water}}{2H_2O(l)} + \underset{\text{Carbon dioxide}}{2CO_2(g)}$$

Check Yourself 1

1. Which gas is produced by the reaction of zinc and dilute sulphuric acid?

Ans When zinc reacts with dilute sulphuric acid then hydrogen gas (H_2) is produced.

2. How will you test for the presence of the gas produced?

Ans When a burning candle is brought near the soap bubbles produced filled with gas, hydrogen gas burns with a pop sound.

3. Why zinc granules are preferred over zinc strip for the reaction of Zn with HCl?

Ans Zn granules are preferred because it provides large surface area (as it is present in powdered form) to react with dilute HCl.

4. Name the salt produced when zinc metal reacts with sodium hydroxide solution to produce hydrogen gas.

Ans When zinc metal reacts with sodium hydroxide solution then sodium zincate is formed.

5. Can all bases react with active metals to produce hydrogen gas?

Ans No, only strong base like sodium hydroxide is capable to release hydrogen gas with active metals.

Check Yourself 2

1. Which gas is evolved when calcium carbonate reacts with hydrochloric acid?

Ans Carbon dioxide gas is evolved when calcium carbonate reacts with hydrochloric acid.

2. How will you test for the presence of carbon dioxide gas (CO_2)?

Ans Carbon dioxide does not support combustion. Therefore, carbon dioxide gas can extinguish a burning candle if brought near to it.

3. What is the nature of carbon dioxide gas evolved?

Ans The nature of carbon dioxide gas is acidic.

4. Why the lime water turns milky in this activity?

Ans The lime water turns milky due to the formation of calcium carbonate.

$$\underset{\text{Slaked lime}}{Ca(OH)_2} + \underset{\text{Carbon dioxide}}{CO_2(g)} \longrightarrow \underset{\text{Calcium carbonate (White ppt.)}}{CaCO_3\downarrow} + \underset{\text{Water}}{H_2O(l)}$$

5. What happens when CO_2 gas is passed for a longer time?

Ans If the CO_2 gas is passed for a longer time, milkiness disappears due to the formation of soluble calcium bicarbonate.

$$\underset{\text{Calcium carbonate}}{CaCO_3} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon dioxide}}{CO_2(g)} \longrightarrow \underset{\text{Calcium bicarbonate (Soluble)}}{Ca(HCO_3)_2}$$

Reaction of Acids and Bases With Each Other

Acid + Base → Salt + H_2O

Neutralisation Reaction : Reaction of acid with base is called as neutralization 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.

E.g., $NaOH + HCl \rightarrow OH^- + Na^+ + H^+ + Cl^- \rightarrow NaCl + H_2O$

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

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

$NaOH + HCl \rightarrow NaCl + H_2O$

$HCl + NH_4OH \rightarrow NH_4Cl + H_2O$

$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

$CH_3COOH + NH_4OH \rightarrow CH_3COONH_4 + H_2O$

Strong Acid + Strong Base → Neutral salt + H_2O

Strong Acid + Weak Base → Acidic salt + H_2O

Weak Acid + Strong Base → Basic salt + H_2O

Weak Acid + Weak Base → Neutral salt + H_2O

ACTIVITY 3 (NCERT Pg 21)

Objective

To study the neutralisation reaction of an acid and a base.

Materials Required

Dilute sodium hydroxide solution, dilute hydrochloric acid, phenolphthalein, test tube, test tube stand and dropper.

Procedure

1. Take some sodium hydroxide solution in a test tube and add a few (one or two) drops of phenolphthalein.
2. Observe the colour.
3. Now add hydrochloric acid drop by drop with the help of a dropper and observe the change.

Observation

When phenolphthalein is added to sodium hydroxide solution, violet colour is obtained which gets disappeared when hydrochloric acid is added in excess. The violet colour reappear if sodium hydroxide is added again to resulted solution.

Conclusion

Acid nullified the effect of a base and base nullified the effect of an acid. This reaction is called neutralisation reaction.

$$\underset{\text{Base}}{NaOH(aq)} + \underset{\text{Acid}}{HCl(aq)} \longrightarrow \underset{\text{Salt}}{NaCl(aq)} + \underset{\text{Water}}{H_2O(l)}$$

Check Yourself 3

1. Write the products formed when an acid reacts with a base.

Ans When an acid reacts with a base then salt and water are formed.

$$\text{Acid} + \text{Base} \longrightarrow \text{Salt} + \text{Water}$$

2. Write the equation of an acid (HCl) with a base (NaOH).

Ans

$$\underset{\substack{\text{Hydrochloric}\\ \text{acid}\\ \text{(Acid)}}}{HCl} + \underset{\substack{\text{Sodium}\\ \text{hydroxide}\\ \text{(Base)}}}{NaOH} \longrightarrow \underset{\substack{\text{Sodium}\\ \text{chloride}\\ \text{(Salt)}}}{NaCl} + \underset{\text{Water}}{H_2O}$$

3. Write the colour of phenolphthalein indicator in sodium hydroxide solution.

Ans When phenolphthalein is added to NaOH, violet colour is obtained.

4. What happens if we add dilute HCl in the above solution drop by drop?

Ans Violet colour obtained in the above solution disappears when dilute HCl is added in the solution drop by drop.

5. What change in colour you observed when sodium hydroxide solution is added again to the above test tube solution?

Ans When some sodium hydroxide solution is added to the test tube, then violet colour reappears.

6. What conclusion can you draw from this activity?

Ans The conclusion drawn from this activity is that acid nullified the effect of a base and base nullified the effect of an acid.

Reaction of Metallic Oxides with Acids

Metallic Oxide + Acid → Salt + H_2O

$CaO + 2HCl \rightarrow CaCl_2 + H_2O$

$H_2SO_4 + ZnO \rightarrow ZnCl_2 + H_2O$

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

Reaction of Non-metallic Oxides with Bases

Non-metallic Oxide + Base → Salt + H_2O

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

$2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$

Metallic oxides are basic in nature. *E.g.,* CaO, MgO are basic oxides.

Non-metallic oxides are acidic in nature.

ACTIVITY 6 (NCERT Pg 21)

Objective

To study the reaction of metallic oxide with an acid.

Materials Required

Copper oxide, dilute hydrochloric acid, beaker and stirrer.

Procedure

1. Take 1g of copper oxide in a beaker.
2. Now, add dilute acid such as dil. HCl to it with constant stirring.
3. Observe the change in the reaction mixture.

Observation

The colour of the solution becomes blue-green due to the formation of copper (II) chloride.

$$\underset{\text{Copper oxide}}{CuO(s)} + \underset{\text{Hydrochloric acid}}{2HCl\ (aq)} \longrightarrow \underset{\substack{\text{Copper (II) chloride} \\ \text{(Blue-green)}}}{CuCl_2(aq)} + \underset{\text{Water}}{H_2O(l)}$$

Conclusion

Metallic oxide, i.e. CuO behaves as a base and forms salt and water when it reacts with an acid like HCl. In other words, a metallic oxide is basic in nature.

Check Yourself 6

1. What happens when metal oxides react with acids?

Ans Acids react with metal oxides to form their respective salts and water as the only products.

Metal oxide + Acid ⟶ Metal salt + Water

2. Write the reaction of magnesium oxide with hydrochloric acid.

Ans

$$\underset{\substack{\text{Magnesium} \\ \text{oxide}}}{MgO} + \underset{\substack{\text{Hydrochloric} \\ \text{acid}}}{2HCl} \longrightarrow \underset{\substack{\text{Magnesium} \\ \text{chloride}}}{MgCl_2} + \underset{\text{Water}}{H_2O}$$

3. What is the nature of metallic oxides?

Ans Metallic oxides are basic in nature.

4. What colour is observed when hydrochloric acid is mixed with copper oxide?

Ans The colour of the solution becomes blue-green due to the formation of copper (II) chloride.

5. What is the nature of non-metallic oxides?

Ans Non-metallic oxides are acidic in nature.

Reaction Of Acid

- + Metal → Salt + H_2
- + Metal Carbonate → Salt + CO_2 + Water
- + Metal Hydrogen Carbonate → Salt + CO_2 + H_2O
- + Base → Salt + H_2O
- + Metallic oxide → Salt + H_2O

Reaction Of Base

- + Metal → Salt + H_2 (Zn, Al)
- + Metal Carbonate → No Reaction
- + Metal Hydrogen Carbonate → No Reaction
- + Acid → Salt + H_2O
- + Non Metallic oxide → Salt + H_2O

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.

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.

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

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 : $CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$

What do all Acids and Bases have in common

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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.

A base dissociates hydroxide ion in aqueous solution is the common property in all bases.

- Acids produce H^+ ions in solution which are responsible for their acidic properties.
- which is responsible for the basic behavior of a compound.
- All acids have H^+ ions in common.
- All bases have OH^- (hydroxyl ions) in common.

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

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

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

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

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

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

Acid or Base in Water Solution

- Acids produce H^+ ions in presence of water.
- H^+ ions cannot exist alone, they exist as H_3O^+ (hydronium ions).

$$H^+ + H_2O \rightarrow H_3O^+$$

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

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

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).

Bases when dissolved in water gives OH^- ions.

$$NaOH \xrightarrow{H_2O} Na^+ + OH^-$$

$$Mg(OH) \xrightarrow{H_2O} Mg^{2+} + 2OH^-$$

- Bases soluble in water are called alkali.

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.

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.

ACTIVITY 5 (NCERT Pg 23)

Objective

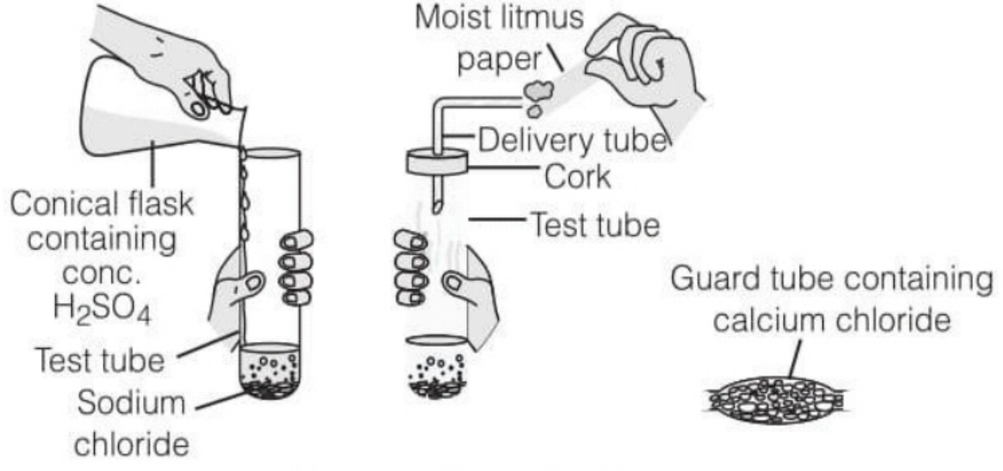
To study the effect of dry and wet blue litmus paper on (i) dry HCl *gas (ii)* HCl *solution.*

Materials Required

Test tubes, NaCl salt, conc. H_2SO_4, dry and wet litmus paper strips, delivery tube and one cork.

Procedure

Take about 1g solid NaCl in a clean and dry test tube. Add a small amount of conc. H_2SO_4 to the test tube. A gas is evolved. Test it with dry and wet litmus papers. Record the observations.



Preparation of HCl gas

Observation

(*i*) **Dry HCl gas**

- Only the colour of wet (moist) blue litmus paper turns to red.
- No change occur in dry blue litmus paper.

(*ii*) **HCl solution**

The colour of both wet and dry blue litmus papers turns to red.

Conclusion

This experiment suggests that hydrogen ion in HCl are produced in the presence of water. The separation of H^+ ion from HCl molecules cannot occur in the absence of water. As only colour of wet (moist) blue litmus paper change to red, no change is occur in dry litmus paper.

DILUTION OF ACID AND BASE:

This process of addition of acid or base to w ater is called dilution and the acid or base is called dilution or diluted

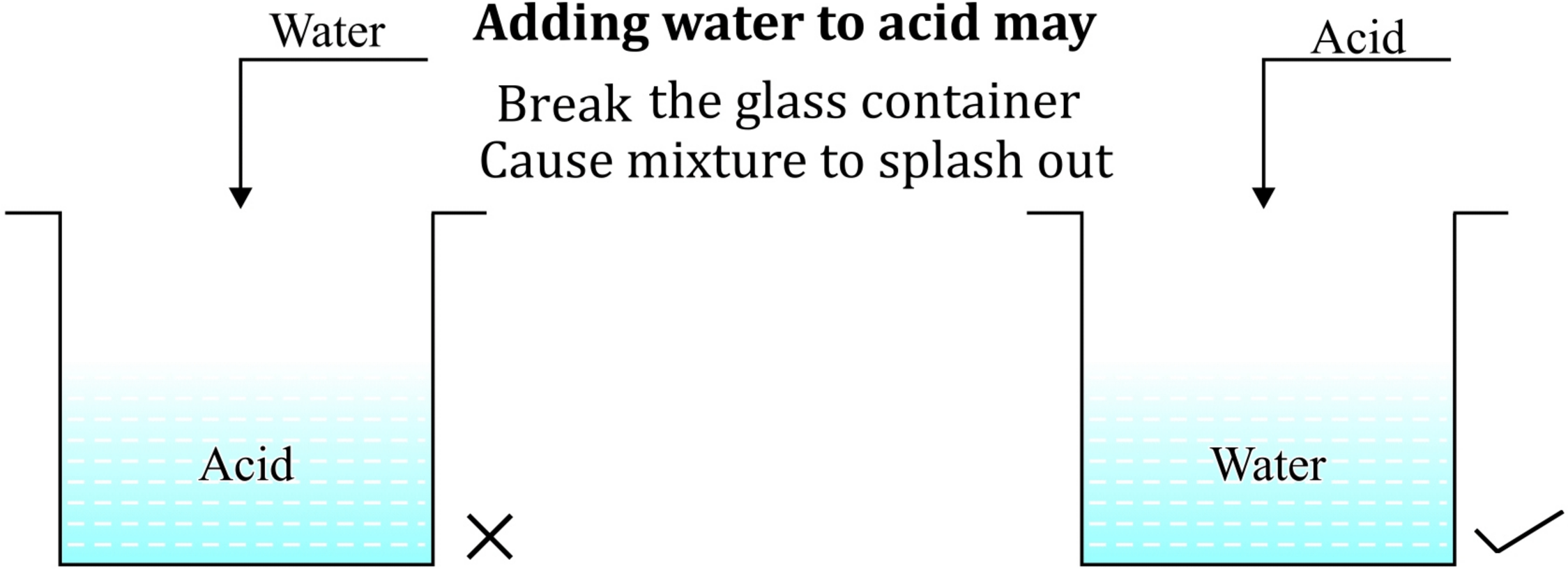
Mixing an acid or a base with H_2O results in decrease of concentration of ions (H_3O^+/OH^-) per unit volume. Such a process is called as dilution.

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

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.

Adding water to acid may

Break the glass container
Cause mixture to splash out



If water is added to acid, the heat generated may cause the mixture to splash out and cause burns and the glass container may also break due to excessive local heating.

While diluting acids, it is recommended that the acid should be added to water and not water to acid because the process of dissolving an acid or a base in water is highly exothermic.

ACTIVITY 7

(NCERT Pg 24)

Objective

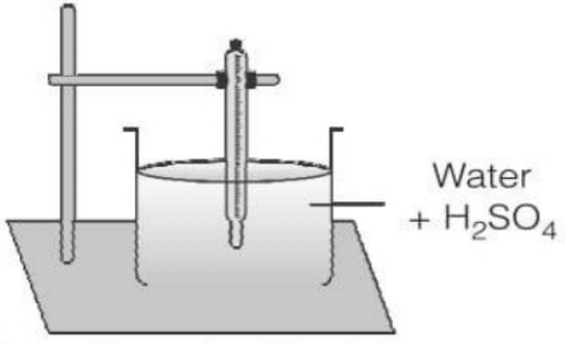
To study the reaction of dissolution of concentrated sulphuric acid (or any other) with water.

Materials Required

Water, conc. H_2SO_4, beaker, thermometer, stand, test tube and glass rod.

Procedure

1. Take water in a beaker.
2. Note the initial temperature with the help of a thermometer.
3. Take a small amount of conc. H_2SO_4 in a test tube and pour it drop by drop in the beaker (very slowly) along its sides.



Reaction of acid with water

4. Continue to stir the mixture with the help of a glass rod. Again note down the temperature.

Note As the reaction is too vigorous, safety tips must be taken.

Observation

A rise in temperature is observed.

Conclusion

Dissolution of conc. H_2SO_4 in water is an exothermic reaction, as heat is evolved in the reaction.

Check Yourself 7

1. Name the type of reaction between any concentrated acid and water.

Ans The reaction between any concentrated acid and water is exothermic reaction.

2. What precautions must be taken while mixing conc. H_2SO_4 with water?

Ans The acid must always be added slowly to water with constant stirring.

3. What happens when water is added to concentrated acid?

Ans If water is added to a concentrated acid, the heat generated is too large which may cause the mixture to splash out and cause burns.

4. Is there any change in temperature during this activity?

Ans Yes, rise in temperature is observed.

5. What conclusion can you draw from this experiment?

Ans A rise in temperature shows that dissolution of conc. H_2SO_4 in water is an exothermic reaction, as heat is evolved in the reaction.

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.

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.

Why do HCl, HNO3, 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 HNO3 to form hydrogen ions always occurs in the presence of water. Hydrogen ions (H^+) combine with H2O to form hydronium ions ($H3O^+$).

The reaction is as follows:

$$HCl_{(aq)} \longrightarrow H^+ + Cl^- \qquad H^+ + H_2O \longrightarrow H_3O^+$$

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.

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.

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.

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.

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.

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.

Example of complete dissociation:

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

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

Example of incomplete dissociation:

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

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

Strength of acid or base can be estimated using universal indicator.

Universal indicator : is a mixture of several indicators. It shows different colours at different concentrations of H^{+} ions in the solution.

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

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

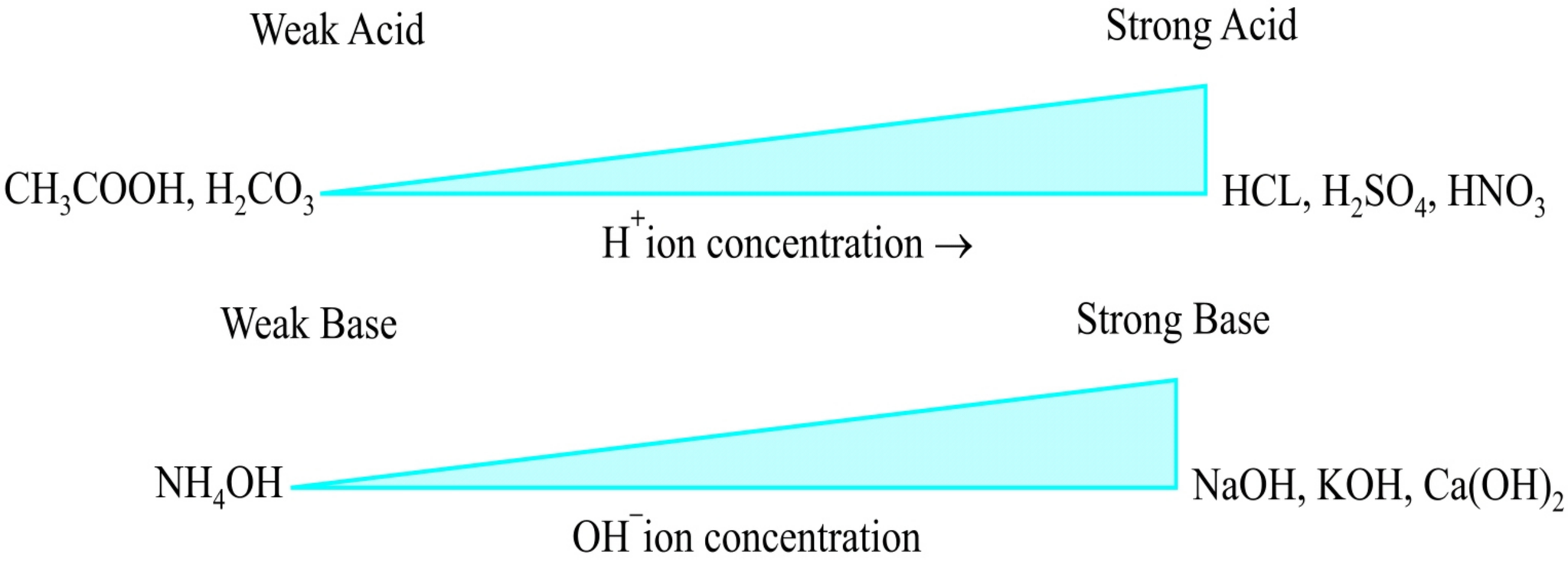
pH Scale : A scale for measuring H^+ ion concentration in a solution . p in pH stands for 'potenz' a German word which means power.

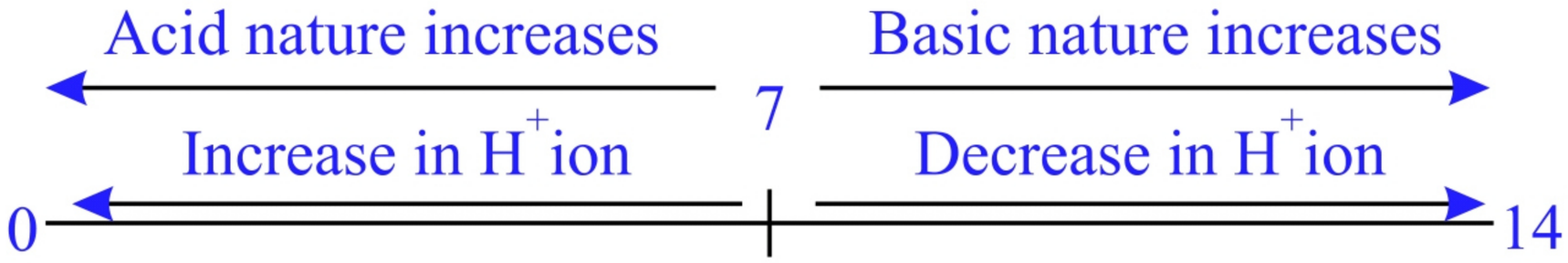
The range of pH scale is between 0 to 14.

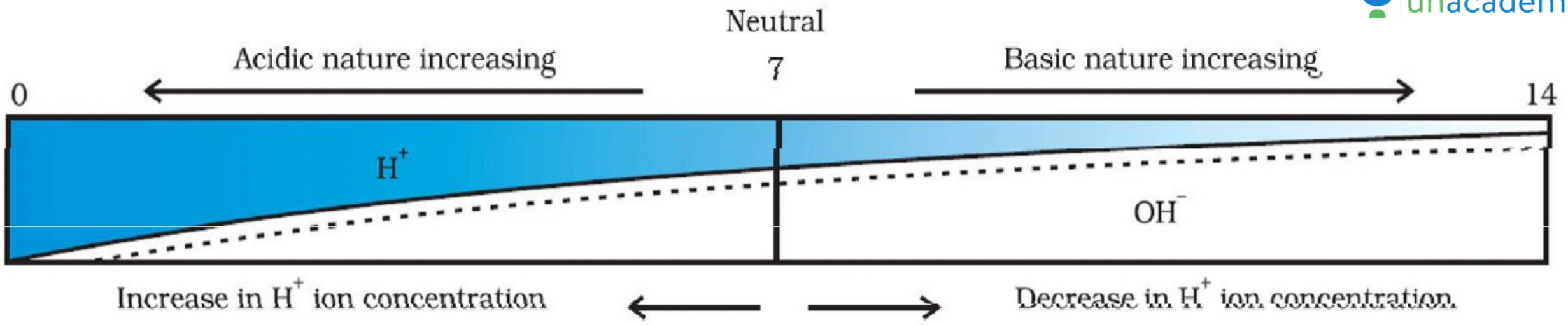
The strength of acid or base depends upon the hydrogen ion concentration. If the concentration of hydrogen ion is greater than hydroxide ion, the solution is called acidic. If the concentration of hydrogen ion is smaller than the hydroxide ion, the solution is called basic. If the concentration of hydrogen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

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.

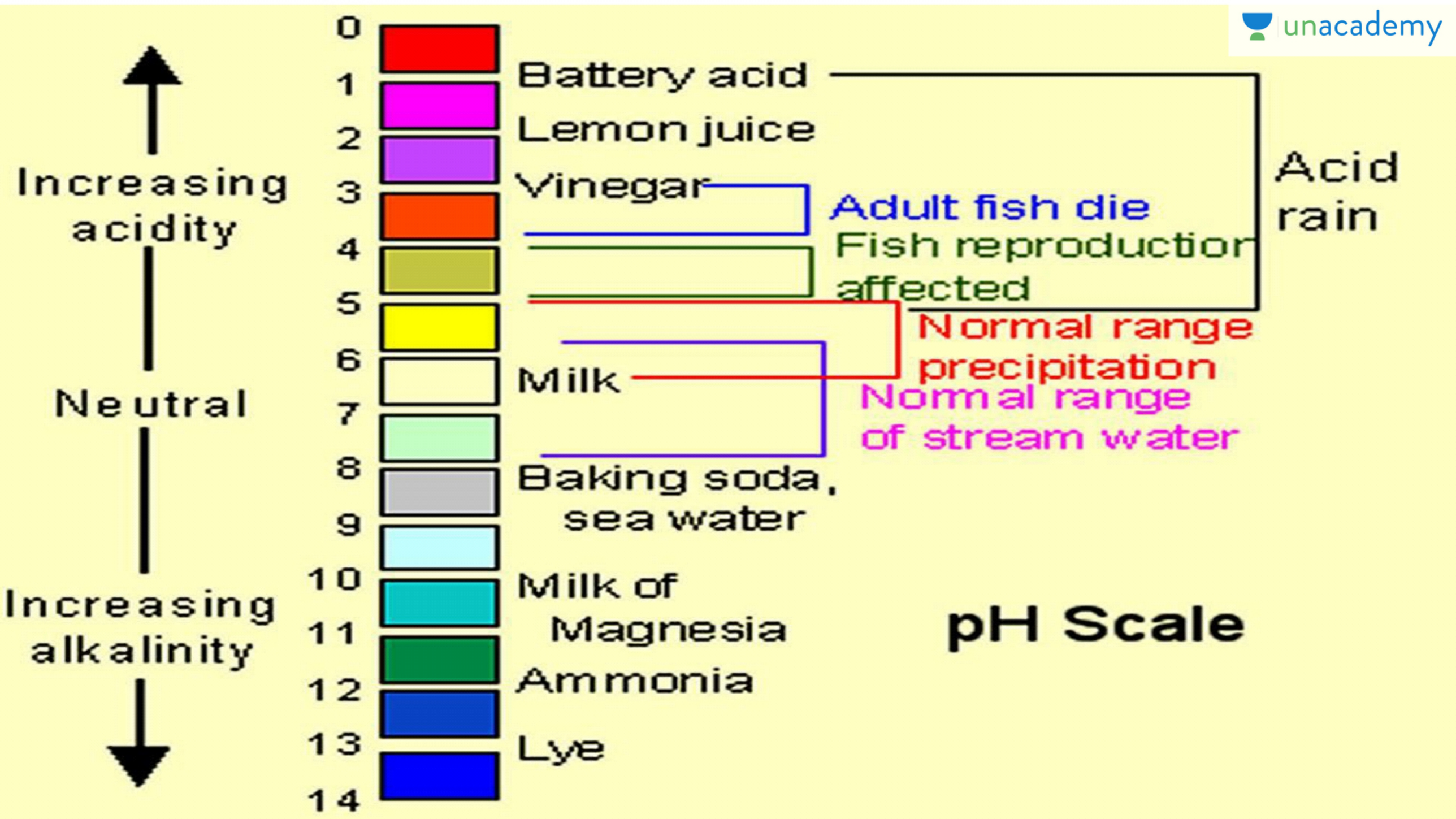

Weak Acid
Strong Acid
CH_3COOH, H_2CO_3
HCL, H_2SO_4, HNO_3
H^+ ion concentration →
Weak Base
Strong Base
NH_4OH
$NaOH, KOH, Ca(OH)_2$
OH^- ion concentration


Acid nature increases
Basic nature increases
7
Increase in H^+ ion
Decrease in H^+ ion
0
14



Mixing an acid or a base with H_2O results in decrease of concentration of ions (H_3O^+/OH^-) per unit volume. Such a process is called as dilution.

On diluting an acid : pH increases ↑ On diluting a base : pH decreases ↓


Increasing acidity
Neutral
Increasing alkalinity
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Battery acid
Lemon juice
Vinegar
Milk
Baking soda, sea water
Milk of Magnesia
Ammonia
Lye
Adult fish die
Fish reproduction affected
Acid rain
Normal range precipitation
Nomal range of stream water
pH Scale

ACTIVITY 11 (NCERT Pg 26)

Objective

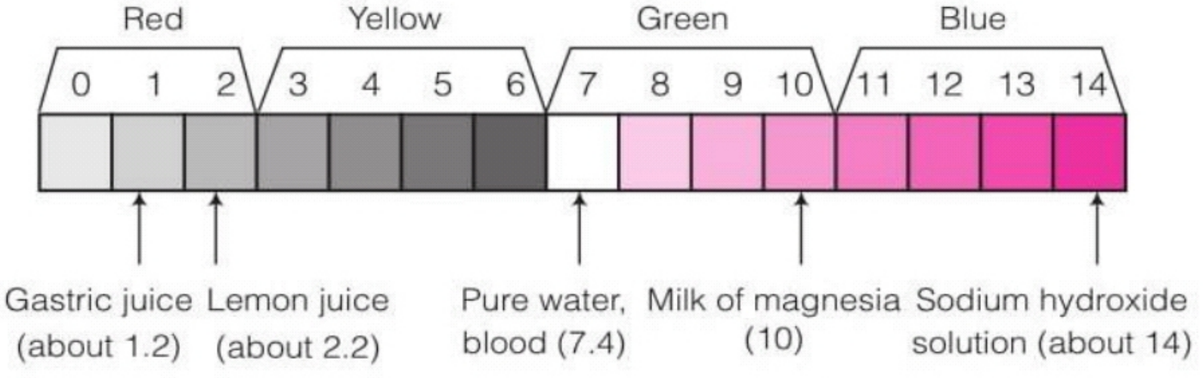
To determine the pH *values of the given solutions with the help of* pH *paper.*

Materials Required

Lemon juice, tomato juice, saliva, carrot juice, soda water, coffee, tea, tap water, 1 M NaOH solution, 1 M HCl solution and pH paper.

Procedure

1. Take different solutions in different test tubes.
2. Now, place one or two drops of lemon juice on a pH paper strip.
3. Note the colour obtained.
4. Repeat the same procedure with each given solution using a new pH paper strip and note the colours obtained.



pH paper chart showing colours for different pH values

Observation

S. No.	Solution	Colour of pH paper	Approximate pH value	Nature of the solution
1.	Lemon juice			
2.	Tomato juice			
3.	Saliva			
4.	Carrot juice			
5.	Soda water			
6.	Coffee			
7.	Tea			
8.	NaOH			
9.	HCl			
10.	Tap water			

Conclusion

Solutions having pH value less than 7 are acidic while those having pH value greater than 7 are basic in nature. As pH value of water is 7, therefore it is considered neither acidic nor basic but neutral.

Check Yourself 11

1. Which one is a stronger acid, acid with pH = 5 or with pH = 2?

Ans pH = 2, because lower the pH, stronger is the acid.

2. What is the pH of distilled water and common salt solution?

Ans pH of distilled water = 7, pH of common salt solution = 7
[As common salt (NaCl) is neutral].

3. What is the colour of tomato juice on pH paper?

Ans The colour of tomato juice on pH paper is orange.

4. What is the minimum and maximum value of pH scale?

Ans Minimum value = 0 and maximum value = 14.

5. According to pH scale, which solutions are acid and base?

Ans Solutions having pH value less than 7 are acidic while those having pH value greater than 7 are basic in nature.

6. What is the colour of pH paper in water?

Ans pH paper shows green colour in water.

Check Yourself 12

1. What do you mean by water of crystallisation?

Ans Crystals of some compounds seen to be dry (or anhydrous) but actually contain some water molecules, attached to them. This water is called water of crystallisation and such salts are called hydrated salts.

2. Name the chemical formula of hydrated copper sulphate salt.

Ans The chemical formula of hydrated copper sulphate is $CuSO_4 \cdot 5H_2O$.

3. Name one salt (other than hydrated copper sulphate) which show water of crystallisation.

Ans Hydrated sodium carbonate ($Na_2CO_3 \cdot 10H_2O$).

4. In the above activity, water droplets are formed near the mouth of the boiling tube. What does it indicate?

Ans It indicates that the sample present in the boiling tube is a hydrated salt (i.e. contain water of crystallisation).

Importance of pH in everyday life

1. Plants and animals are pH sensitive
   - Our body works within the pH range of 7-7.8.
   - When pH of rain water is less than 5.6, it is called acid rain.
2. pH of the soil
   - Plants require a specific pH range for their healthy growth.

pH in our digestive system

- Our stomach produces HCl acid which helps in digestion.
- During indigestion, stomach produces more acid and cause pain and irritation.
- To get rid of this pain, people uses antacid (mild base) like milk of magnesia [$Mg(OH)_2$] to neutralize excess acid.

4. pH change as cause of tooth decay

- Tooth decay starts when pH of mouth is lower than 5.5.
- Tooth enamel made up of calcium phosphate (hardest substance in body) does not dissolve in water but corrodes when pH is lower than 5.5 due to acids produced by degradation of food particles by bacteria.
- Using toothpaste (generally basic) tooth decay can be prevented.

5. Self defence by animals and plants through chemical warfare	(a) Bee sting leaves an acid which cause pain and irritation. Use of a mild base like baking soad on stung area gives relief. (b) Stinging hair of nettle leaves inject methanoic acid causing burning Sensation or pain. Rubbing with leaf of dock plant give relief.

ACTIVITY 13 (NCERT Pg 29)

Objective

To determine (a) the pH *value and nature (b) solubility of the given samples of salts.*

Materials Required

Sodium chloride, potassium nitrate, aluminium chloride, zinc sulphate, copper sulphate, sodium acetate, sodium carbonate, sodium hydrogen carbonate, water, test tubes and pH paper.

Procedure

(*i*) Make the solutions of the given salts in different test tubes by dissolving them in water.

(*ii*) Note down, whether the salt is soluble or not; and if soluble, then upto what extent.

(*iii*) Now, test all the solutions with the help of pH paper as in the activity 8 and record the observations.

Observation

Salt	*Solubility in water*	*Colour with* pH *paper and* pH	*Acidic/ basic*	*Acid and base from which salt is formed*
NaCl				HCl + NaOH
KNO_3				HNO_3 + KOH
$AlCl_3$				HCl + $Al(OH)_3$
$ZnSO_4$				H_2SO_4 + $Zn(OH)_2$
$CuSO_4$				H_2SO_4 + $Cu(OH)_2$
CH_3COONa				CH_3COOH + NaOH
Na_2CO_3				H_2CO_3 + NaOH
$NaHCO_3$				H_2CO_3 + NaOH

Conclusion

This activity shows that nature of salt depends on its origin. It means that salts have four categories:

(*i*) Salt of strong acid and strong base = Neutral (pH = 7).

(*ii*) Salt of weak acid and strong base = Basic (pH > 7).

(*iii*) Salt of strong acid and weak base = Acidic (pH < 7).

(*iv*) Salt of weak acid and weak base = Neutral (pH = 7).

Check Yourself 13

1. Give two examples of:

(*i*) soluble bases

(*ii*) partially soluble bases

(*iii*) insoluble bases

Ans (*i*) **Soluble bases** Sodium hydroxide (NaOH) and potassium hydroxide (KOH).

(*ii*) **Partially soluble bases** Calcium hydroxide [$Ca(OH)_2$] and magnesium hydroxide [$Mg(OH)_2$].

(*iii*) **Insoluble bases** Zinc hydroxide [$Zn(OH)_2$] and copper (II) hydroxide [$Cu(OH)_2$].

2. The pH of an aqueous solution of hydrochloric acid is 2. What will be the pH of the acid after the addition of 10 g of sodium chloride?

Ans Sodium chloride (NaCl) is a neutral salt, that dissolves to form a neutral salt solution. Hence, the pH will not be affected.

3. Arrange the following solutions in the order of decreasing $H^+(aq)$ ions concentration.

(*i*) Ammonium hydroxide (*ii*) Gastric juice

(*iii*) Vinegar (*iv*) Sodium hydroxide

Ans Gastric juice > Vinegar > Ammonium hydroxide > Sodium hydroxide.

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.

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.

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.

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.

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
- Neutral salts are odourless
- Salts can be colourless or coloured

Classification of salts

1. **Normal salts or Neutral salts**
2. **Acid salts**
3. **Basic salts**
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 $KAl(SO_4)_2 \cdot 12H_2O$

$K_2(SO_4) \cdot Al_2(SO_4)_3 \cdot 24H_2O$

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.

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.

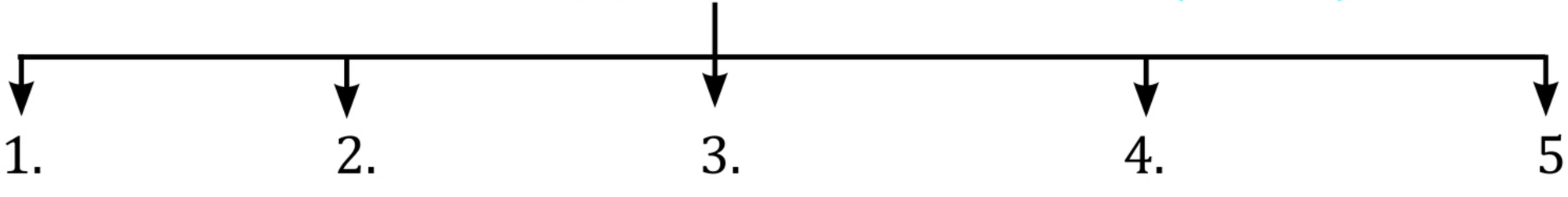
Calcium chloride ($CaCl_2$) and calcium sulphate ($CaSO_4$) belong to calcium family.

Zinc chloride ($ZnCl_2$) and Zinc sulphate ($ZnSO_4$) belong to zinc family.

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.

Chemicals from Common Salt (NaCl)



1. Sodium Hydroxide ($NaOH$)
2. Bleaching Powder ($CaOCl_2$)
3. Baking Soda ($NaHCO_3$)
4. Washing Soda ($Na_2CO_3.10H_2O$)
5. Plaster of Paris ($CaSO_4.½H_2O$)

Sodium Hydroxide (NaOH) :

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 byproducts.

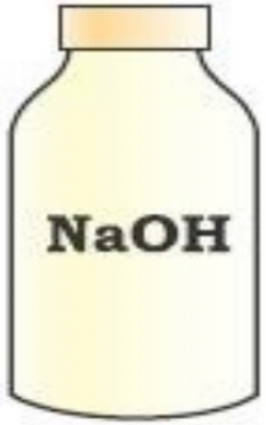
This whole process is known as Chlor-Alkali process.

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

At anode : Cl_2 gas At cathode : H_2 gas Near cathode : NaOH solution is formed.

at Cathode

at Anode



Fuels, margarine, ammonia for fertilisers

Water treatment, swimming pools, PVC, disinfectants, CFCs, pesticides

De-greasing metals, soaps and detergents, paper making, artificial fibres

HYDROCHLORIC ACID
For: cleaning steel, ammonium chloride, medicines, cosmetics

BLEACH
For: household bleaches, bleaching fabric

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

Uses :

H_2 : Fuels, margarine , in making of ammonia for fertilizer, etc.

Cl_2 : Water treatment, PVC, CFC's ,pesticides. It is also used in manufacturing of bleaching powder and hydrochloric acid.

HCl : Cleaning steels, medicines

NaOH : Degreasing metals, soaps and paper making

Cl_2 + NaOH → Bleach : Household bleaches, bleaching fabrics

Bleaching Powder ($CaOCl_2$):

Bleaching powder is also known as chloride of lime or Calcium oxychloride

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.

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

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

Uses :

(a) Bleaching cotton and linen in textile industry.

(b) Bleaching wood pulp in paper factories.

(c) Oxidizing agent in chemical industries.

(d) Disinfecting drinking water.

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.

Baking Soda (Sodium Hydrogen Carbonate) ($NaHCO_3$) :

The chemical name of baking soda is sodium hydrogen carbonate 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.

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

It is mild non-corrosive base.

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

Sodium hydrogen carbonate is amphoteric in nature.(acidic as well as basic)

When baking soda is heated, it decomposes into sodium carbonate, carbon dioxide and water.

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

decomposes into sodium oxide and carbon dioxide on further heating

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

Uses :

(a) For making baking powder (mixture of baking soda and tartaric acid). When baking powder is heated or mixed with water, CO_2 is produced which causes bread and cake to rise making them soft and spongy.

(b) An ingredient in antacid.

(c) Used in soda acids, fire extinguishers.

(d) Baking soda is used in cleansing of ornaments made of sliver

BAKING POWDER:

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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.

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.

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

Baking powder $NaHCO_3 + C_4H_6O_6 \rightarrow CO_2 + H_2O + Na_2C_4H_4O_6$

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 ($Na_2CO_3.10H_2O$) :

The chemical name of baking soda is sodium sodium carbonate.

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

$$\mathbf{NaCl + H_2O + CO_2 + NH_3 \rightarrow NH_4Cl + NaHCO_3}$$

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

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.

$$\mathbf{Na_2CO_3 + 10H_2O \rightarrow Na_2CO_3.10H_2O}$$

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

Uses :

(a) In glass, soap and paper industry.

(b) Manufacture of borax.

(c) Cleaning agent for domestic purposes.

(d) For removing permanent hardness of water.

Water of Crystallization : It is a fixed number of water molecules present in one formula unit of a salt is known as water of crystallization.

Many salts contain water molecule and are known as hydrated salts.

E.g., $CuSO_4.5H_2O$ has 5 water molecules.

$Na_2CO_3.10H_2O$ has 10 water molecules.

$CaSO_4.2H_2O$ has 2 water molecules.

Plaster of Paris (Calcium sulphate hemihydrates) ($CaSO_4.\frac{1}{2}H_2O$) :

On heating gypsum ($CaSO_4.2H_2O$) at 373K, it loses water molecules and becomes Plaster of Paris (POP).

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

It is a white powder and on mixing with water it changes to gypsum.

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

Uses :

(a) Doctors use POP for supporting fractured bones.

(b) For making toys, material for decoration.

(c) For making surfaces smooth.

ACTIVITY 12

(NCERT Pg 27)

Objective

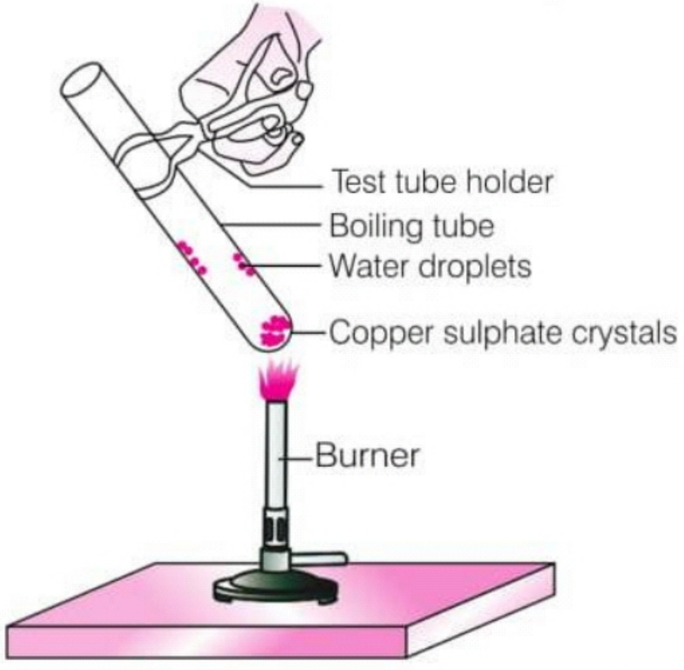
To observe water of crystallisation in copper sulphate crystals.

Materials Required

Boiling tube, test tube holder, copper sulphate crystals and Bunsen burner.

Procedure

1. Take about 2 g crystals of copper sulphate salt in a dry boiling tube and note the colour of crystals.



Removing water of crystallisation

2. Heat the boiling tube containing copper sulphate crystals and observe the changes occur.
3. Some water droplets are formed in the boiling tube.
4. Put off the burner after few minutes of heating. And add 2-3 drops of water in same sample.
5. Observe the colour change after addition of 2-3 drops of water.

Observation

Before heating The copper sulphate crystals which seems to be dry, contain water of crystallisation that's why, salt is blue in colour.

After heating On heating, this water (hydrated $CuSO_4$) is removed and the salt turns white.

And when crystals are again moisten with few drops of water, blue colour of the crystals reappears.

Chemical formula of hydrated copper sulphate is $CuSO_4 \cdot 5H_2O$.

$$\underset{\text{(Blue)}}{CuSO_4 \cdot 5H_2O} \underset{+5H_2O}{\overset{\Delta,\ -5H_2O}{\rightleftharpoons}} \underset{\text{(White)}}{CuSO_4}$$

Conclusion

The blue colour of copper sulphate is due to the presence of water of crystallisation, which can be removed by heating.

Check Yourself 11

1. Which one is a stronger acid, acid with pH = 5 or with pH = 2?

Ans pH = 2, because lower the pH, stronger is the acid.

2. What is the pH of distilled water and common salt solution?

Ans pH of distilled water = 7, pH of common salt solution = 7
[As common salt (NaCl) is neutral].

3. What is the colour of tomato juice on pH paper?

Ans The colour of tomato juice on pH paper is orange.

4. What is the minimum and maximum value of pH scale?

Ans Minimum value = 0 and maximum value = 14.

5. According to pH scale, which solutions are acid and base?

Ans Solutions having pH value less than 7 are acidic while those having pH value greater than 7 are basic in nature.

6. What is the colour of pH paper in water?

Ans pH paper shows green colour in water.

Check Yourself 12

1. What do you mean by water of crystallisation?

Ans Crystals of some compounds seen to be dry (or anhydrous) but actually contain some water molecules, attached to them. This water is called water of crystallisation and such salts are called hydrated salts.

2. Name the chemical formula of hydrated copper sulphate salt.

Ans The chemical formula of hydrated copper sulphate is $CuSO_4 \cdot 5H_2O$.

3. Name one salt (other than hydrated copper sulphate) which show water of crystallisation.

Ans Hydrated sodium carbonate ($Na_2CO_3 \cdot 10H_2O$).

4. In the above activity, water droplets are formed near the mouth of the boiling tube. What does it indicate?

Ans It indicates that the sample present in the boiling tube is a hydrated salt (i.e. contain water of crystallisation).

What is the common name of the compound CaOCl2?

Answer : The common name of the compound CaOCl2 is bleaching powder.

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

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

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

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

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.

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NCERT

CHAPTER-2

ACIDS BASES SALTS

THEORY