

# CLASS 10 NOTES SCIENCE

## Acids, Bases and Salts

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# Acids and Bases



Acids	Bases
Sour in taste, Derived from Greek word "Acidus".	Bitter in taste.
Changes blue litmus into red.	Changes red litmus into blue.
e.g. Hydrochloric acid (HCl), Sulfuric acid, Nitric acid, Acetic acid, etc.	e.g. Sodium Hydroxide (NaOH), Potassium hydroxide (KOH), Calcium Hydroxide, Ammonium Hydroxide, etc.

## Acid-Base Indicators:

Natural indicators like litmus, turmeric, red cabbage leaves, and colored petals from flowers like Hydrangea, Petunia, and Geranium can show acidity or alkalinity. On the other hand, synthetic indicators such as methyl orange and phenolphthalein are also used for the same purpose.

Red litmus solution	Blue litmus solution	Phenolphthalein solution	Methyl Orange Solution
Acid - No change Base - Blue	Acid - Red Base - No Change	Acid - Colorless Base - Pink	Acid - Red Base - Yellow

## Some naturally occurring acids:



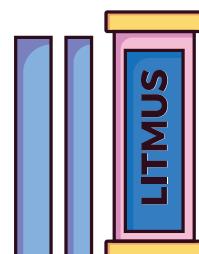
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Vinegar	Acetic Acid
Orange	Citric Acid
Lemon	Citric Acid
Tamarind	Tartaric Acid
Tomato	Oxalic Acid
Sour milk (Curd)	Lactic Acid
Ant and Nettle sting	Methanoic Ac

### Do You Know?

Litmus solution is a purple dye, which is extracted from lichen, a plant belonging to the division Thallophyta, and is commonly used as an indicator. When the litmus solution is neither acidic nor basic, its colour is purple. There are many other natural materials like red cabbage leaves, turmeric, coloured petals of some flowers such as *Hydrangea*, *Petunia* and *Geranium*, which indicate the presence of acid or base in a solution. These are called acid-base indicators or sometimes simply indicators.



## What Is an Acid and a Base?

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### **Ionizable and Non-Ionizable Compounds**

- An ionizable compound, when in water or molten form, breaks down into ions almost completely. Examples include NaCl, HCl, KOH, and others. In contrast, a non-ionizable compound does not separate into ions when dissolved in water or in its molten state. Examples of such compounds are glucose and acetone.

### **Acids and Bases**

- An acid is a substance that contains hydrogen and can donate a proton (hydrogen ion) to another substance. On the other hand, a base is a molecule or ion capable of accepting a hydrogen ion from an acid. Typically, acidic substances are recognized by their sour taste.

### **Arrhenius' Theory of Acids and Bases**

An Arrhenius acid is a substance that, when dissolved in water, breaks apart to yield  $\text{H}^+$  (aq) or  $\text{H}_3\text{O}^+$  ions.

#### **Acids**

Hydrochloric acid (HCl)  
Sulfuric acid ( $\text{H}_2\text{SO}_4$ )  
Nitric acid ( $\text{HNO}_3$ )

An Arrhenius base is a substance that, when dissolved in water, dissociates to produce  $\text{OH}^-$  ions.

#### **Bases**

Sodium hydroxide (NaOH)  
Potassium hydroxide (KOH)  
Calcium hydroxide [ $\text{Ca}(\text{OH})_2$ ]

### **Bronsted Lowry Theory**

A Bronsted acid is an  $\text{H}^+$  (aq) ion donor.

A Bronsted base is an  $\text{H}^+$  (aq) ion acceptor.

Examples:

In the reaction:  $\text{HCl} \text{ (aq)} + \text{NH}_3 \text{ (aq)} \rightarrow \text{NH}_4^+ \text{ (aq)} + \text{Cl}^- \text{ (aq)}$

$\text{HCl}$  - Bronsted acid and  $\text{Cl}^-$  : its conjugate acid

$\text{NH}_3$  - Bronsted base and  $\text{NH}_4^+$  : its conjugate acid



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### **Potential physical tests for identifying an acid or a base are:**

- **Taste**

Acids typically have a sour taste, while bases often taste bitter. However, relying on taste to identify acids or bases is not recommended due to the risk of contamination or corrosiveness.

For instance, substances like curd, lemon juice, orange juice, and vinegar exhibit a sour taste because they contain acids. On the other hand, baking soda, despite having a somewhat sour taste, serves as an example of a base. It is essential to use proper testing methods rather than relying on taste alone.

- **Effect on Indicators by Acids and Bases**

An indicator is a chemical substance that exhibits a change in its physical properties,

particularly in color or odor, upon contact with an acid or a base.

Common indicators and the colors they display are as follows:

**a) Litmus:**

Neutral solution - purple

Acidic solution - red

Basic solution - blue

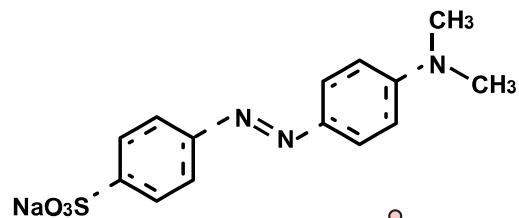
- Litmus is provided in paper strip forms as red litmus and blue litmus.
- Acid transforms moist blue litmus paper to red.
- Base transforms moist red litmus paper to blue.

**b) Methyl Orange:**

Neutral solution - orange

Acidic solution - red

Basic solution - yellow



**c) Phenolphthalein:**

Neutral solution - colorless

Acidic solution - remains colorless

Basic solution - exhibits a pink color.



## Acid-Base Reactions

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**When acid and bases react with metals:**

Acids, in general, react with metals to produce salt and hydrogen gas. Bases, in general, do not react with metals and do not produce hydrogen gas.

- Acid + active metal → salt + hydrogen + heat



- Base + metal → salt + hydrogen + heat



A more reactive metal displaces the less reactive metal from its base.



**When acid react with Metal Carbonates and Bicarbonates:**

When acids engage with metal carbonates or bicarbonates, the resulting reaction generates carbon dioxide, metal salts, and water. For example, the reaction between hydrochloric acid and sodium carbonate produces sodium chloride, carbon dioxide, and water. Notably, if the evolved carbon dioxide is passed through lime water, it causes the lime water to exhibit a milky appearance.

- Acid + metal carbonate or bicarbonate → salt + water + carbon dioxide.



Effervescence indicates the liberation of CO<sub>2</sub> gas.

**When acid and Base react with each other:**

A neutralization reaction takes place when an acid interacts with a base, resulting in the formation of salt and water as the final products. In this conventional approach, an acid-base neutralization reaction is expressed as a double-replacement reaction.



## 1. Metal Oxides and Hydroxides with Acids:

Metal oxides or metal hydroxides exhibit basic properties.

- Acid + Base → Salt + Water + Heat



## 2. Non-Metal Oxides with Bases:

Non-metal oxides demonstrate acidic properties.

- Base + Nonmetal Oxide → Salt + Water + Heat



### Reaction of acids and base

A very common acid is hydrochloric acid. The reaction between strong acid, say hydrochloric acid and strong base say sodium hydroxide, forms salt and water. The complete chemical equation is shown below.



## Acids and Bases in water

When added to water, acids and bases dissociate into their respective ions and help in conducting electricity.

### Acids:

**Ionization:** When an acid is dissolved in water, it ionizes to produce hydrogen ions ( $\text{H}^+$ ). These hydrogen ions combine with water molecules to form hydronium ions ( $\text{H}_3\text{O}^+$ ).

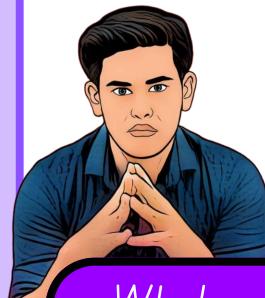


### Bases:

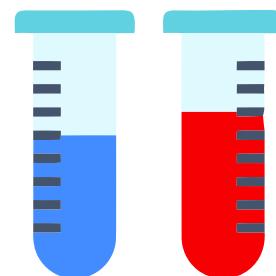
**Dissociation:** When a base is dissolved in water, it dissociates to produce hydroxide ions ( $\text{OH}^-$ ).



Bases which are soluble in water are called alkalis. All bases do not dissolve in water. They are soapy to touch, bitter and corrosive.



What are alkali?



### Dilution:

Dilution involves decreasing the concentration of a solution by incorporating additional solvent, typically water. This process is highly exothermic. When diluting acid, it is essential to add the acid to water and not vice versa.

### Strength of Acids and Bases:

**Strong Acid or Base:** In the case of a strong acid or base, every molecule in a given quantity undergoes complete dissociation in water, resulting in the formation of their respective ions ( $\text{H}^+(\text{aq})$  for acids and  $\text{OH}^-(\text{aq})$  for bases).

**Weak Acid or Base:** Contrastingly, with weak acids or bases, only a few molecules from

a given amount undergo partial dissociation in water, producing their respective ions ( $\text{H}^+(\text{aq})$  for acids and  $\text{OH}^-(\text{aq})$  for bases).

**Dilute acid:** contains less number of  $\text{H}^+(\text{aq})$  ions per unit volume.

**Concentrated acid:** contains more number of  $\text{H}^+(\text{aq})$  ions per unit volume.

### Q. What is a universal indicator?

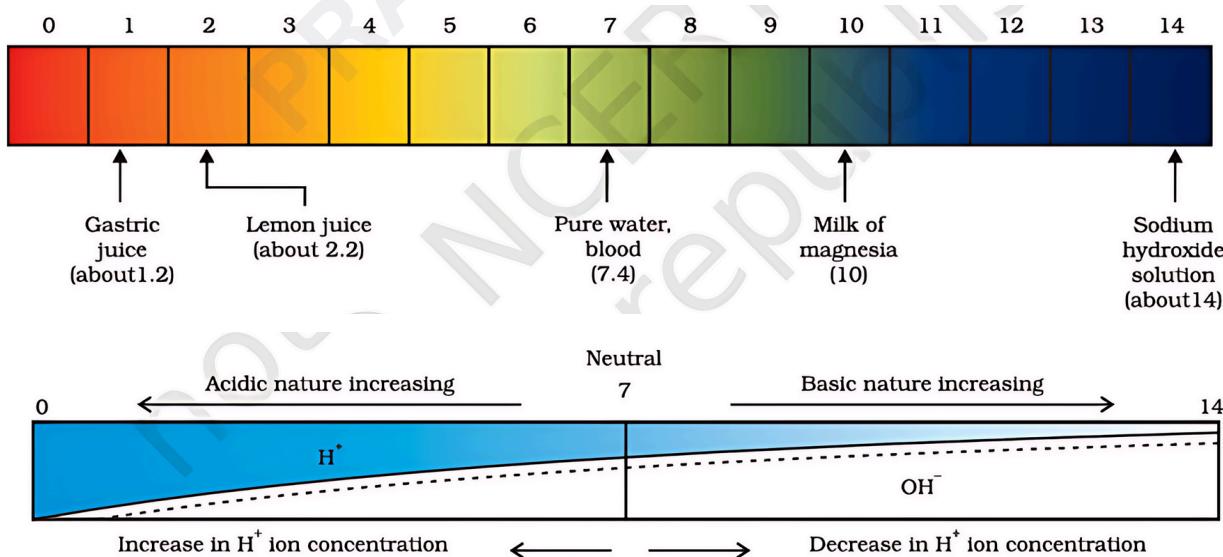
A universal indicator is a mixture of several pH indicators that shows a gradual color change over a wide range of pH values (typically from pH 1 to 14), allowing it to determine the acidity or alkalinity of a solution. It provides a different color for each pH value, making it useful for estimating the pH of a solution more accurately than using a single indicator.

"pH scale topic is important"  
- Prashant Bhaiya



## pH Scale:

- The pH scale, developed for measuring hydrogen ion concentration in a solution, derives the "p" from the German term 'potenz,' meaning power.
- On the pH scale, readings range generally from 0 (indicating strong acidity) to 14 (indicating strong alkalinity).
- pH is a numerical representation of the acidic or basic nature of a solution.
- A lower pH value corresponds to a higher concentration of hydrogen ions.
- A neutral solution has a pH of 7.
- Values below 7 on the pH scale represent an acidic solution.
- As the pH value increases from 7 to 14, it signifies a rise in the concentration of  $\text{OH}^-$  ions, indicating an increase in the strength of the alkali.
- The pH scale is often measured using paper impregnated with a universal indicator.

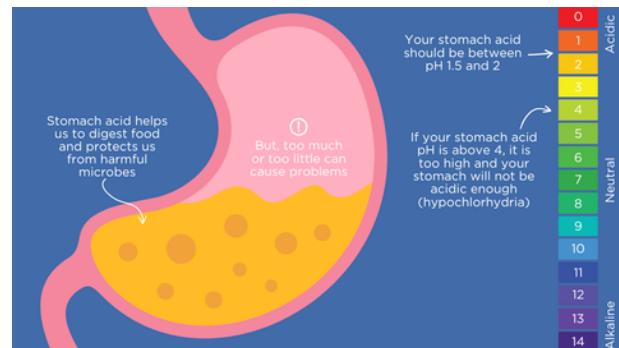


### Importance of pH in everyday life:

- Our body works within the pH range of 7.0 to 7.8.
- When pH of rainwater is less than 5.6, it is called acid rain.
- When acid rain flows into the rivers, it lowers the pH of the river water. The survival of aquatic life in such rivers becomes difficult.

## pH in our digestive system:

It's fascinating to observe that our stomach naturally produces hydrochloric acid, aiding in the digestion of food without causing harm to the stomach lining. However, in instances of indigestion, an excess of stomach acid can lead to discomfort and irritation. To alleviate this pain, individuals often turn to bases known as antacids. These antacids work by neutralizing the surplus acid. Magnesium hydroxide, commonly known as Milk of Magnesia, is a mild base frequently employed for this purpose.



## pH change as the cause of tooth decay:

- Tooth decay starts when the pH of the mouth is lower than 5.5.
- Tooth enamel, made up of calcium hydroxyapatite (a crystalline form of calcium phosphate) is the hardest substance in the body.
- Bacteria present in the mouth produce acids by degradation of sugar and food particles remaining in the mouth after eating.
- The best way to prevent this is to clean the mouth after eating food.
- Using toothpaste, which is generally basic, for cleaning the teeth can neutralize the excess acid and prevent tooth decay.



## Self-defense by animals and plants through chemical warfare:

Bee-sting leaves an acid that causes pain and irritation. The use of a mild base like baking soda on the stung area gives relief. Stinging hair of nettle leaves injects methanoic acid causing burning pain.

## Manufacture of Acids and Bases

a) Nonmetal oxide + water → acid



Non-metal oxides are thus referred to as acid anhydrides.

b) Metal + water → base or alkali + hydrogen



d) Few metallic oxides + water → alkali



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c) Hydrogen + halogen → acid



e) Ammonia + water → ammonium hydroxide



f) Metallic salt + conc. sulphuric acid → salt + more volatile acid



**Salts****EMA**

Salt is formed through the combination of an anion derived from an acid and a cation derived from a base.

Examples of salts include  $\text{KCl}$ ,  $\text{NaNO}_3$ ,  $\text{CaSO}_4$ , and others.

Typically, salts are produced through the neutralization reaction between an acid and a base.

Commonly known as common salt, Sodium Chloride ( $\text{NaCl}$ ) is extensively utilized globally in cooking.

Salts sharing the same cation or anion are considered part of the same salt family.

Examples include  $\text{NaCl}$ ,  $\text{KCl}$ ,  $\text{LiCl}$ .

**pH of Salts:**

Salts of a strong acid and a strong base are neutral with a pH value of 7.

Salts of a strong acid and weak base are acidic with a pH value of less than 7.

Those of a strong base and weak acid are basic in nature with a pH value of more than 7.

**Chemicals From Common Salt**

The salt formed by the combination of hydrochloric acid and sodium hydroxide solution is called sodium chloride ( $\text{NaCl}$ )/Common Salt.

The common salt thus obtained is an important raw material for various materials of daily use, such as sodium hydroxide, baking soda, washing soda, bleaching powder, and many more.

- Sodium hydroxide or lye or caustic soda
- Baking soda or sodium hydrogen carbonate, or sodium bicarbonate
- Washing soda or sodium carbonate decahydrate
- Bleaching powder or calcium hypochlorite

**1. Sodium Hydroxide**

When electricity is passed through salty water (brine), it breaks down to make sodium hydroxide. This process is called the chlor-alkali process because it produces chlorine and alkali (sodium hydroxide).



At one end (anode), chlorine gas is released, and at the other end (cathode), hydrogen gas is given off. Close to the cathode, we get a solution of sodium hydroxide.

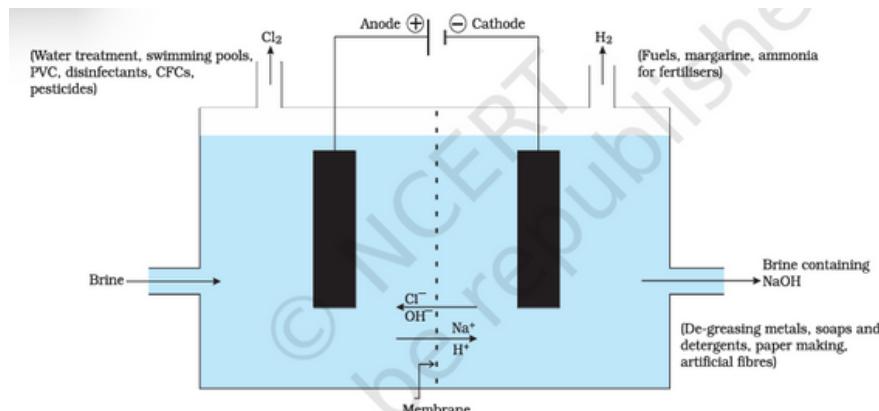


Figure 2.8 Important products from the chlor-alkali process

## 2.Bleaching Powder

Chlorine gas is utilized in the manufacturing process of bleaching powder. The production of bleaching powder involves the interaction of chlorine with dry slaked lime  $[Ca(OH)_2]$ . While bleaching powder is often represented as  $CaOCl_2$ , its actual composition is more complex.



### Bleaching powder is used -

- for bleaching cotton and linen in the textile industry, for bleaching wood pulp in paper factories, and for bleaching washed clothes in laundry;
- as an oxidizing agent in many chemical industries; and
- to make drinking water free from germs.

## 3.Baking Soda

Sodium bicarbonate, commonly known as baking soda or bicarbonate of soda, has the chemical formula  $NaHCO_3$  and is recognized by the IUPAC name sodium hydrogen carbonate. This salt is created by the combination of a sodium cation ( $Na^+$ ) and a bicarbonate anion ( $HCO_3^-$ ). Found as a fine powder, sodium bicarbonate is a white, crystalline substance. Its taste is mildly salty and alkaline, resembling that of washing soda (sodium carbonate).

**Chemical name** - Sodium hydrogen carbonate

**Chemical formula** -  $NaHCO_3$

## 4.Water of Crystallization

The water of crystallization is the fixed number of water molecules present in one formula unit of salt. Five water molecules are present in one formula unit of copper sulphate. The chemical formula for hydrated copper sulphate is  $CuSO_4 \cdot 5H_2O$ .

## 5.Plaster of Paris

On heating gypsum ( $CaSO_4 \cdot 2H_2O$ ) at 373 K, it loses water molecules and becomes calcium sulphate hemihydrate ( $CaSO_4 \cdot 1/2H_2O$ ). This is called Plaster of Paris.

### Uses of Plaster of Paris:

It is employed by medical professionals to create casts for maintaining fractured bones in the correct position.

In the realm of creativity, Plaster of Paris is utilized for crafting toys, decorative items, and achieving smooth surfaces.

# Important activities

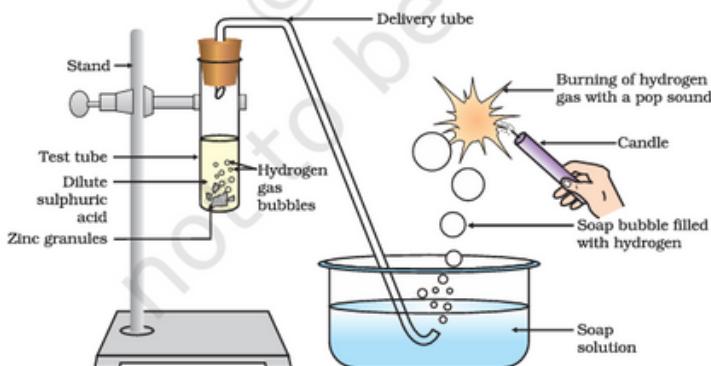


Figure 2.1 Reaction of zinc granules with dilute sulphuric acid and testing hydrogen gas by burning

## Activity 2.3

**CAUTION:** This activity needs the teacher's assistance.

- Set the apparatus as shown in Fig. 2.1.
- Take about 5 mL of dilute sulphuric acid in a test tube and add a few pieces of zinc granules to it.
- What do you observe on the surface of zinc granules?
- Pass the gas being evolved through the soap solution.
- Why are bubbles formed in the soap solution?
- Take a burning candle near a gas filled bubble.
- What do you observe?
- Repeat this Activity with some more acids like HCl, HNO<sub>3</sub> and CH<sub>3</sub>COOH.
- Are the observations in all the cases the same or different?

- Take a few zinc granules in a boiling tube and add approximately 5 mL of dilute sulphuric acid to it.
- Observe the formation of gas bubbles on the surface of the zinc granules. Direct the gas being produced through a soap solution in a trough using a glass delivery tube. This results in the formation of gas-filled bubbles in the soap solution that rise into the air.
- Bring a burning candle close to a gas-filled soap bubble. The gas within the soap bubble ignites with a 'pop' sound, indicating a small explosion.
- This demonstration confirms that only hydrogen gas, which has the characteristic 'pop' sound when ignited, is evolved in the reaction between dilute sulphuric acid and zinc metal (present in the form of zinc granules).

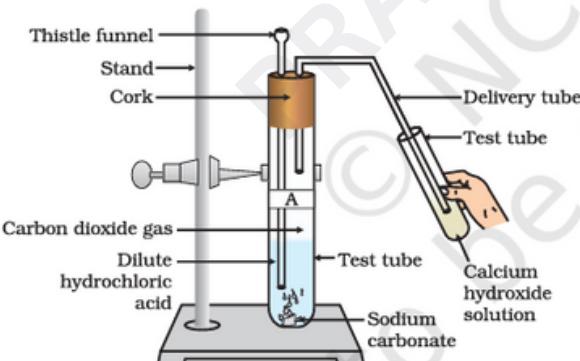


Figure 2.2  
Passing carbon dioxide gas through calcium hydroxide

## Activity 2.5

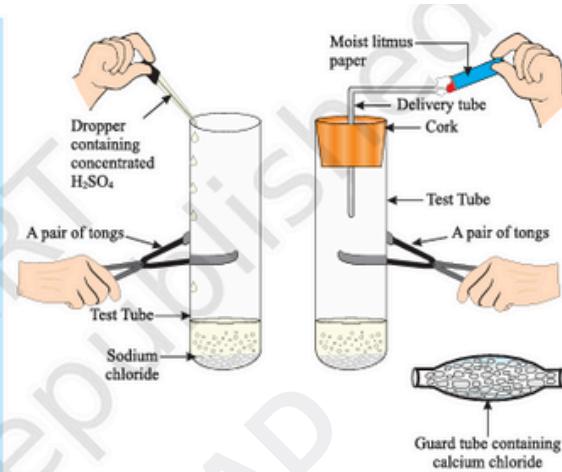
- Take two test tubes, label them as A and B.
- Take about 0.5 g of sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) in test tube A and about 0.5 g of sodium hydrogencarbonate ( $\text{NaHCO}_3$ ) in test tube B.
- Add about 2 mL of dilute HCl to both the test tubes.
- What do you observe?
- Pass the gas produced in each case through lime water (calcium hydroxide solution) as shown in Fig. 2.2 and record your observations.

- Take a boiling tube and place approximately 0.5 g of sodium carbonate in it.
- Add about 2 mL of dilute hydrochloric acid to the boiling tube using a thistle funnel.
- Observe the brisk effervescence of a gas being produced.
- Pass the gas generated through lime water. Notice that the lime water turns milky, indicating the presence of carbon dioxide gas.
- Continue passing carbon dioxide gas through the milky lime water for some time. Eventually, the lime water becomes clear again.

- This demonstrates that the initially formed white precipitate of calcium carbonate dissolves when excess carbon dioxide gas is passed.
- Repeat the experiment using sodium hydrogen carbonate instead of sodium carbonate. Again, carbon dioxide gas is produced, turning the lime water milky. Upon passing an excess of carbon dioxide, the milky lime water once again becomes clear.

### Activity 2.9

- Take about 1g solid NaCl in a clean and dry test tube and set up the apparatus as shown in Fig. 2.4.
- Add some concentrated sulphuric acid to the test tube.
- What do you observe? Is there a gas coming out of the delivery tube?
- Test the gas evolved successively with dry and wet blue litmus paper.
- In which case does the litmus paper change colour?
- On the basis of the above Activity, what do you infer about the acidic character of:
  - (i) dry HCl gas
  - (ii) HCl solution?



**Figure 2.4 Preparation of HCl gas**

**Note to teachers:** If the climate is very humid, you will have to pass the gas produced through a guard tube (drying tube) containing calcium chloride to dry the gas.

- Place 1 g of solid sodium chloride (NaCl) in a clean, dry boiling tube.
- Carefully add concentrated sulfuric acid, fitting the rubber cone over the glass tube.
- The reaction forms hydrogen chloride gas, observed escaping from the open end.
- Test the gas with a 'dry' blue litmus paper, noting no change in color, indicating HCl gas doesn't act as an acid in the absence of water.
- Test the gas with a 'moist' blue litmus paper, observing a color change to red, revealing acidic behavior of HCl gas in the presence of water.
- Conclusion: HCl gas is not acidic in the absence of water but displays acidic behavior in the presence of water.

## # TOP 7



## IMPORTANT QUESTIONS

1) A dry pellet of a common base B absorbs moisture and turns sticky when kept open. The compound is also a by-product of the chlor-alkali process. Identify B. What type of reaction occurs when B is treated with an acidic oxide? Write a balanced chemical equation for one such solution.

**Solution:**

Sodium hydroxide (NaOH) is a commonly used base and is hygroscopic; it absorbs moisture from the atmosphere and becomes sticky. A neutralization reaction occurs when acidic oxides react with the base to give salt and water.



2) Give reasons for the following:

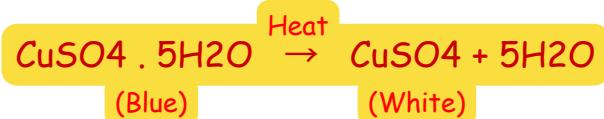
- (i) Only one-half of the water molecule is shown in the formula of the plaster of Paris.
- (ii) Sodium hydrogen carbonate is used as an antacid.
- (iii) On strong heating, blue-colored copper sulfate crystals turn white. (2020)

**Solution:**

(i) Only one-half of the water molecule is shown in the formula of plaster of Paris ( $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ ) as one molecule of water is being shared by two molecules of calcium sulphate ( $\text{CaSO}_4$ ). So the effective water of crystallization for one  $\text{CaSO}_4$  unit comes to half a molecule of water.

(ii) Acidity can be neutralized by a base. Sodium hydrogen carbonate can be used as an antacid solution because it is a weak base and will react with excess acid produced in the stomach due to hyperacidity and will neutralize it.

(iii) Blue colored copper sulphate crystals are hydrated copper sulphate,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ . On heating blue copper sulphate crystals lose their water of crystallization and turn into anhydrous copper sulphate which is white.



3) A white powder is added while baking cakes to make them soft and spongy. Name its main ingredients. Explain the function of each ingredient. Write the chemical reaction taking place when the powder is heated during baking. (AI2019)

**Solution:**

The white powder added while baking cakes to make them soft and spongy is baking

powder. Its main ingredients are sodium hydrogen carbonate and a mild edible acid like tartaric acid or citric acid.  $\text{NaHCO}_3$  decomposes to give out  $\text{CO}_2$  which causes the cake to rise and makes it soft and spongy. The function of tartaric acid or citric acid is to neutralize sodium carbonate formed during heating which can otherwise make the cake bitter. The reaction taking place when the powder is heated:



4) The pH of a salt used to make tasty and crispy pakoras is 14. Identify the salt and write a chemical equation for its formation. List its two uses. (2018)

Solution:

Salt used to make tasty and crispy pakoras is sodium bicarbonate ( $\text{NaHCO}_3$ ),  $\text{pH} = 9$ . On a large scale, sodium bicarbonate is prepared as:



5) A white-colored powder is used by doctors to support fractured bones.

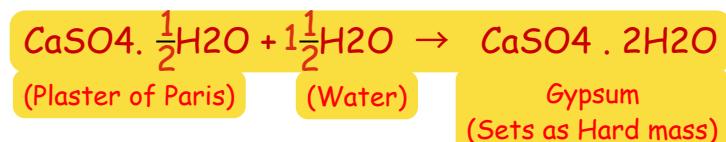
(a) Write the chemical name and formula of the powder.

(b) When this white powder is mixed with water a hard solid mass is obtained. Write the balanced chemical equation for this change. (Board Term I, 2016)

Solution:

(a) Chemical name of the powder is calcium sulphate hemihydrate. The chemical formula of the powder is  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ .

(b) When water is added to the plaster of Paris, it sets into a hard mass in about half an hour. The setting of the plaster of Paris is due to its hydration to form crystals of gypsum which set to form a hard, solid mass.



6) List the important products of the Chlor-alkali process. Write one important use of each. (2020)

Solution:

Sodium hydroxide is prepared by electrolysis of an aqueous solution of sodium chloride (brine). The complete reaction can be represented as:

The process of electrolysis of sodium chloride solution is called chlor-alkali process because of the products formed : chlor for chlorine and alkali for sodium hydroxide. The three very useful products obtained by the electrolysis of sodium chloride solution are sodium hydroxide, chlorine and hydrogen.



At anode:  $\text{Cl}_2$  gas is liberated and at cathode:  $\text{H}_2$  gas is liberated.

**Uses of sodium hydroxide:** In the manufacture of soaps and detergents.

**Uses of chlorine:** As a germicide and disinfectant for sterilization of drinking water and for water of swimming pools.

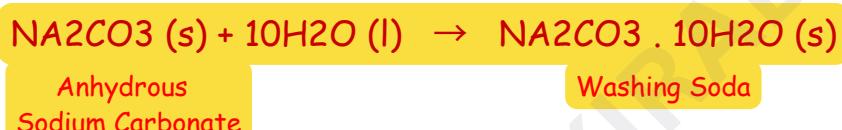
**Uses of hydrogen:** In the manufacture of ammonia which is used for the preparation of various fertilizers like urea, ammonium sulphate, etc.

7) How is washing soda prepared from sodium carbonate? Give its chemical equation.

State the type of this salt. Name the type of hardness of water which can be removed by it. (2020)

Solution:

Washing soda is prepared by recrystallization of sodium carbonate:



It is used to remove the permanent hardness of water. Hard water is treated with a calculated amount of washing soda when chlorides and sulfates of calcium and magnesium present in hard water get precipitated as insoluble calcium and magnesium carbonates which can be easily filtered off. The water thus becomes soft.



"Class 10th Phodenge"