

CHAPTER – 2

ACIDS, BASES AND SALTS

GIST OF THE LESSON

Given are two possible physical tests to identify an acid or a base.

a. Taste

An acid tastes sour whereas a base tastes bitter.

The method of taste is not advised as an acid or a base could be contaminated or corrosive.

b. Effect on indicators by acids and bases

An indicator is a chemical substance which shows a change in its physical properties, mainly colour or odour when brought in contact with an acid or a base.

Below mentioned are commonly used indicators and the different colours they exhibit:

a) Litmus

In a neutral solution – purple

In acidic solution – red

In basic solution – blue

Litmus is also available as strips of paper in two variants – red litmus and blue litmus.

An acid turns a moist blue litmus paper to red.

A base turns a moist red litmus paper to blue.

b) Methyl orange

In a neutral solution – orange

In acidic solution – red

In basic solution – yellow

c) Phenolphthalein

In a neutral solution – colourless

In acidic solution – remains colourless

In basic solution – pink

Acid-Base Reactions

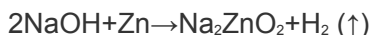
Reactions of acids and bases

a) Reaction of acids and bases with metals

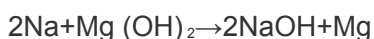
Acid + active metal $\rightarrow$ salt + hydrogen + heat



Base + metal $\rightarrow$ salt + hydrogen + heat

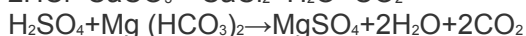
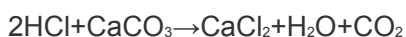


A more reactive metal displaces the less reactive metal from its base.



b) Reaction of acids with metal carbonates and bicarbonates

Acid + metal carbonate or bicarbonate $\rightarrow$ salt + water + carbon dioxide.



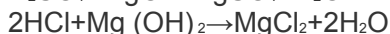
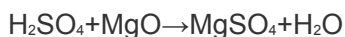
Effervescence indicates liberation of CO_2 gas.

c) Neutralisation reaction

1. Reaction of metal oxides and hydroxides with acids

Metal oxides or metal hydroxides are basic in nature.

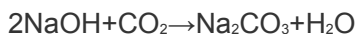
Acid + base $\rightarrow$ salt + water + heat



2. Reaction of non-metal oxides with bases

Non-metal oxides are acidic in nature

Base + Non-metal oxide $\rightarrow$ salt + water + heat



Water

Acids and bases in water

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

Difference between a base and an alkali

Base-

- Bases undergo neutralisation reaction with acids.
- They are comprised of metal oxides, metal hydroxides, metal carbonates and metal bicarbonates.
- Most of them are insoluble in water.

Alkali –

- An alkali is an aqueous solution of a base, (mainly metallic hydroxides).
- It dissolves in water and dissociates to give OH^- ion.
- All alkalis are bases, but not all bases are alkalis.

Dilution

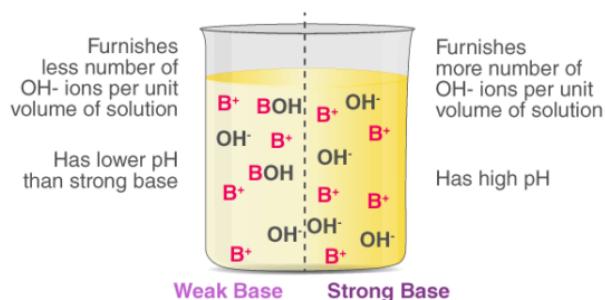
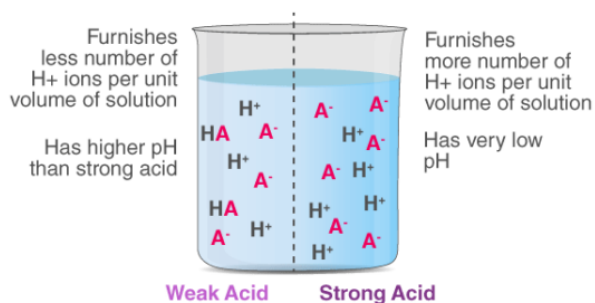
Dilution is the process of reducing the concentration of a solution by adding more solvent (usually water) to it. It is a highly exothermic process.

To dilute acid, the acid must be added to water and not the other way round.

Strength of acids and bases

Strong acid or base: When all molecules of a given amount of an acid or a base dissociate completely in water to furnish their respective ions, $\text{H}^+(\text{aq})$ for acid and $\text{OH}^-(\text{aq})$ for base).

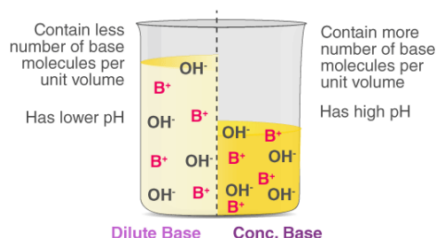
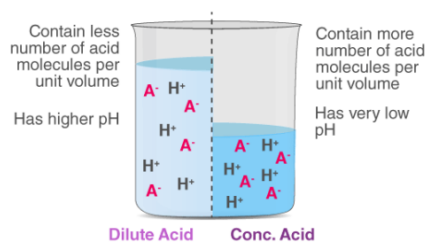
Weak acid or base: When only a few of the molecules of a given amount of an acid or a base dissociate in water to furnish their respective ions, $\text{H}^+(\text{aq})$ for acid and $\text{OH}^-(\text{aq})$ for base).



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Dilute acid: contains less number of $H^+(aq)$ ions per unit volume.

Concentrated acid: contains more number of $H^+(aq)$ ions per unit volume.



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Universal indicator

A universal indicator has a pH range from 0 to 14 that indicates the acidity or alkalinity of a solution.
A neutral solution has $pH=7$

pH

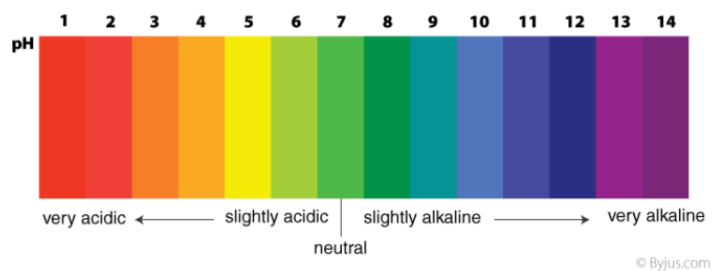
$$pH = -\log_{10}[H^+]$$

In pure water, $[H^+] = [OH^-] = 10^{-7}$ mol/L. Hence, the pH of pure water is 7.

The pH scale ranges from 0 to 14.

If $pH < 7$ – acidic solution

If $pH > 7$ – basic solution



pH scale

Importance of pH in everyday life

1. pH sensitivity of plants and animals

Plants and animals are sensitive to pH. Crucial life processes such as digestion of food, functions of enzymes and hormones happen at a certain pH value.

2. pH of a soil

The pH of a soil optimal for the growth of plants or crops is 6.5 to 7.0.

3. pH in the digestive system

The process of digestion happens at a specific pH in our stomach which is 1.5 – 4.

The pH of the interaction of enzymes, while food is being digested, is influenced by HCl in our stomach.

4. pH in tooth decay

Tooth decay happens when the teeth are exposed to an acidic environment of pH 5.5 and below.

5. pH of self-defence by animals and plants

Acidic substances are used by animals and plants as a self-defence mechanism. For example, bee and plants like nettle secrete a highly acidic substance for self-defence. These secreted acidic substances have a specific pH.

Salts

Salts

A salt is a combination of an anion of an acid and a cation of a base.

Examples – KCl, NaNO₃, CaSO₄, etc.

Salts are usually prepared by the neutralisation reaction of an acid and a base.

Common salt

Sodium Chloride (NaCl) is referred to as common salt because it's used all over the world for cooking.

Family of salts

Salts having the same cation or anion belong to the same family. For example, NaCl, KCl, LiCl.

pH of salts

A salt of a strong acid and a strong base will be neutral in nature. pH = 7 (approx.).

A salt of a weak acid and a strong base will be basic in nature. pH > 7.

A salt of a strong acid and a weak base will be acidic in nature. $\text{pH} < 7$.
The pH of a salt of a weak acid and a weak base is determined by conducting a pH test.

Preparation of Sodium hydroxide

Chemical formula – NaOH

Also known as – caustic soda

Preparation (Chlor-alkali process):

Electrolysis of brine (solution of common salt, NaCl) is carried out.

At anode: Cl_2 is released

At cathode: H_2 is released

Sodium hydroxide remains in the solution.

Bleaching powder

Chemical formula – $\text{Ca}(\text{OCl})\text{Cl}$ or CaOCl_2

Preparation – $\text{Ca}(\text{OH})_2(\text{aq}) + \text{Cl}_2(\text{g}) \rightarrow \text{CaOCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l})$

On interaction with water – bleaching powder releases chlorine which is responsible for bleaching action.

Baking soda

Chemical name – Sodium hydrogen carbonate

Chemical formula – NaHCO_3

Preparation (Solvay process) –

a. Limestone is heated: $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$

b. CO_2 is passed through a concentrated solution of sodium chloride and ammonia:

$\text{NaCl}(\text{aq}) + \text{NH}_3(\text{g}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{NaHCO}_3(\text{aq}) + \text{NH}_4\text{Cl}(\text{aq})$

Uses:

1. Textile industry
2. Paper industry
3. Disinfectant

Washing soda

Chemical name – Sodium hydrogen carbonate

Chemical formula – NaHCO_3

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Uses

1. In glass, soap and paper industries
2. Softening of water
3. Domestic cleaner

Crystals of salts

Certain salts form crystals by combining with a definite proportion of water. The water that combines with the salt is called water of crystallisation.

Plaster of paris

Gypsum, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ (s) on heating at 100°C (373K) gives $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ and $\frac{3}{2}\text{H}_2\text{O}$

$\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ is plaster of paris.

$\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ means two formula units of CaSO_4 share one molecule of water.

Uses – cast for healing fractures.

IMPORTANT QUESTIONS (SOLVED)

1. You are given three test tubes. The three test tubes contain distilled water, acidic solution and the basic solution respectively. There is only red litmus paper available in order to identify what is there in each test tube. How will you find out what is in each of the test tubes?

Solution: We can identify the content in each of the test tubes using red litmus paper. This can be done by noticing the colour change of the red litmus paper.

- If the red litmus paper changes to blue colour the solution is a basic solution.
- If the red litmus paper changes to red colour the solution is acidic solution.
- If you did not observe any colour change then the solution is distilled water.

2. Why should curd and sour substances not be kept in brass and copper vessels?

Solution: Curd and sour food substances contain acids; these acidic substances combine with metal. This reaction turns food to poison which damage people's health.

3. 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?

Solution: When an acid reacts with any metal, salt and hydrogen gas are formed.



4. 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.

Solution: As metal compound released is Calcium Chloride the gas evolved here is CO_2 . Hence metal A should be Calcium Carbonate. Hence the reaction between Calcium Carbonate and HCl is



5. Why do HCl, HNO_3 , etc., show acidic characters in aqueous solutions while solutions of compounds like alcohol and glucose do not show acidic character?

Solution: Release of H^+ ion in water will make a compound acidic or non-acidic. Acids are the substance which upon dissociating with water results in production of Hydrogen ions. Some compounds show acidic character as they dissociate in the aqueous solution which results in the production of hydrogen ions (acids like HCl, HNO_3).

Compounds similar to glucose or alcohol do contain hydrogen element but they do not show signs of acidic nature. The fact that the hydrogen in them will not separate as like the hydrogen in the acids. They will not separate to become hydrogen ions, on dissolving in the water.

Hence dissociation of hydrogen gas will decide the acidic or non-acidic nature of a compound.

6. Why does an aqueous solution of an acid conduct electricity?

Solution: Charged particles are responsible for the conductance of electricity in an acid. These charged particles called as ions are the reason behind conductance of electricity in acid.

7. Why does dry HCl gas not change the colour of the dry litmus paper?

Solution: HCL does not give out Hydrogen ions, therefore HCL does not show any acidic behaviour and colour of the litmus paper remain the same on reacting with HCl gas.

8. While diluting an acid, why is it recommended that the acid should be added to water and not water to the acid?

Solution: While diluting an acid, it is recommended that the acid should be added to water and not water to the acid because if water is added to concentrated acid, it release huge amount of heat which may result in explosion and can cause acid burns o face, clothes and body parts. Hence it is safe to add acid to water but not water to acid.

9. How is the concentration of hydronium ions (H_3O^+) affected when a solution of an acid is diluted?

Solution: When acid is added to water there will be a fixed amount of hydronium present in the fixed volume of solution. If we dilute the solution hydronium ion per volume of solution decrease, this in-turn decreases Hydronium concentration in the solution.

10. What is the common name of the compound CaOCl_2 ?

Solution: Common name of CaOCl_2 is bleaching powder.

11. Name the substance which on treatment with chlorine yields bleaching powder

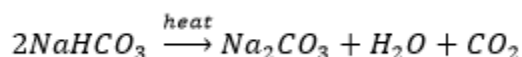
Solution: The substance which on treatment with chlorine yields bleaching powder is Calcium hydroxide.

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

Solution: Sodium carbonate is the compound which is used for softening hard water.

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

Solution: Heating sodium hydrocarbonate yields sodium carbonate and carbon dioxide gas is liberated in the process.



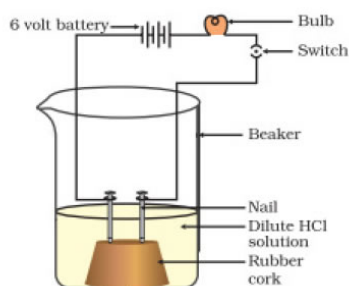
14. Write an equation to show the reaction between Plaster of Paris and water.

Solution: The chemical equation for the reaction of Plaster of Paris and water is



15. Compounds such as alcohols and glucose also contain hydrogen but are not categorised as acids. Describe an Activity to prove it

Solution: Insert two nails on the wooden or rubber cork and place them on a beaker as shown in figure. Connect iron nail to a bulb, 6 volt battery and a wire connected to switch. Pour some alcohol or glucose so as to dip the nails in glucose or alcohol. Turn the switch on and you the see the bulb not glowing despite of connection to switch. Now empty the beaker and add HCL solution. This time bulb glows. This proves acid can conduct electricity but alcohol and glucose does not conduct electricity.



16. Fresh milk has a pH of 6. How do you think the pH will change as it turns into curd? Explain your answer.

Solution: Fresh milk is turned to curd due to production of lactic acid. Lactic acid reduces the pH of the milk.

17. A milkman adds a very small amount of baking soda to fresh milk.

(a) Why does he shift the pH of the fresh milk from 6 to slightly alkaline?

(b) Why does this milk take a long time to set as curd?

Solution: (a) He shifted the pH of the fresh milk from 6 to slightly alkaline to prevent milk from getting sour due to production of lactic acid.

(b) This milk takes long time to set into curd because the lactic acid produced here first neutralises the pH then the pH is reduced to turn milk to curd.

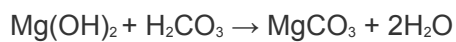
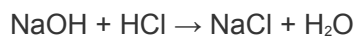
18. Plaster of Paris should be stored in a moisture-proof container. Explain why?

Solution: Plaster of Paris should be stored in moisture-proof container because moisture can affect plaster of Paris by slowing down the setting of the plaster because of hydration. This will turn plaster useless.

19. What is a neutralisation reaction? Give two examples.

Solution: The reaction of the acid + base gives a product of salt + water, which is considered as neutralization reaction.

Examples:



20. Give two important uses of washing soda and baking soda.

Solution:

Washing soda	Baking soda
1. It is used as an electrolyte	1. It can be used to test the garden soil for acidity. If bubbles are developed then the soil is too acidic
2. It can be used domestically as water softener for laundry.	2. If used on washing car then it will remove dead bug bodies without damaging the colour or the paint on the car.