

Acid and Alkali

Why do certain fruits taste sour?

What is the pH of pure water?

Is a bee sting acidic?

Let's understand:

- Properties of acid and alkali
- Neutralisation

SCIENCE BLOG

The pH of Human Skin

The human skin acts as a natural barrier to fight infection by pathogens. The skin pH level plays an important role in fighting these infections.

Our skin has a thin protective layer known as acid mantle. This layer which is made of a combination of an oily substance (sebum) and sweat makes the skin acidic and protects the skin from the external environment.

Keywords

- ▶ Corrosiveness
- ▶ Blue litmus paper and red litmus paper
- ▶ pH value
- ▶ Neutralisation
- ▶ Universal indicator
- ▶ pH scale
- ▶ Phenolphthalein
- ▶ Titration

6.1 Properties of Acids and Alkalis

Try to recall the knowledge of acids and alkalis that you have learned in primary school. Acids and alkalis can be found in various substances used in our daily lives. What are the acidic and alkaline substances that you know?

Table 6.1 Examples of acids and alkalis

Acid	Alkali
Hydrochloric acid	Sodium hydroxide solution
Vinegar	Soap water



Photograph 6.1
Orange juice is an acidic substance



What is the origin of the word 'acid'?

The word 'acid' comes from the Latin word, *acidus* which means sour, whereas the word 'alkali' comes from the Arabic word, *alqali* which means ashes of plants.



Let us carry out Activity 6.1 to study the properties of acids and alkalis.

Activity 6.1

Aim: To study the properties of acids and alkalis.

Materials: Dilute hydrochloric acid, concentrated hydrochloric acid, dilute sodium hydroxide solution, concentrated sodium hydroxide solution, lime juice, bitter gourd juice, magnesium ribbon, filter paper, sandpaper, blue litmus paper and red litmus paper, wooden splinter, matches, pH paper and pH chart

Apparatus: Test tube, dropper, Petri dish and white tile

Instruction

A pH value

- Put 10 drops of dilute hydrochloric acid in a Petri dish.
- Test the substance in the Petri dish with a piece of pH paper (Figure 6.1).
- Determine the pH value by comparing the colour of the pH paper with a pH chart.
- Record your observation.
- Repeat steps 1 to 4 by replacing dilute hydrochloric acid with dilute sodium hydroxide solution.



Figure 6.1

B Taste

1. Taste lime juice followed by bitter gourd juice. Gargle with water after tasting each substance.
2. Record your observations.

C Corrosiveness (Teacher's demonstration)

1. Put one drop of concentrated hydrochloric acid on a piece of filter paper placed on a white tile (Figure 6.2).
2. Record your observation.
3. Repeat steps 1 and 2 by replacing concentrated hydrochloric acid with concentrated sodium hydroxide solution.

Safety Precaution

- Carry out this activity in a fume chamber.
- Use the acid and alkali in small amounts.
- Wear safety goggles.

D Effect on blue litmus paper and red litmus paper

1. Place a blue litmus paper and a red litmus paper on a white tile.
2. Put one drop of dilute hydrochloric acid on both litmus papers and record your observations.
3. Repeat steps 1 and 2 by replacing dilute hydrochloric acid with dilute sodium hydroxide solution.

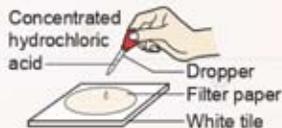


Figure 6.2

E Reaction with metals

1. Clean a magnesium ribbon with sandpaper.
2. Put the magnesium ribbon into a test tube filled with 5 ml of dilute hydrochloric acid.
3. Close the test tube with your thumb for one minute.
4. Remove your thumb and place a lighted wooden splinter at the mouth of the test tube (Figure 6.3).
5. Record your observation.
6. Repeat steps 1 to 5 by replacing dilute hydrochloric acid with dilute sodium hydroxide solution.

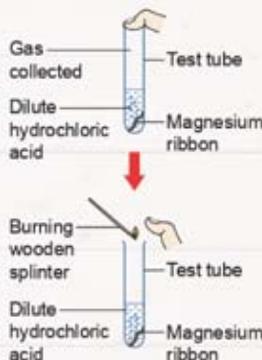


Figure 6.3

Observation

Activity \ Substance	Acidic	Alkaline
A		
B		
C		
D		
E		

Questions

1. What is the pH range of alkalis?
2. Give an inference for your observation in Activity E.
3. Why should the magnesium ribbon be cleaned with sandpaper before using it?
4. Predict the taste of vinegar and neem.
5. Give the operational definition of an acid and an alkali.

After carrying out Activity 6.1, can you identify the properties of acids and alkalis? Table 6.2 summarises the properties of an acid and an alkali.

Table 6.2 Properties of an acid and an alkali

Acid	Alkali
pH value less than 7	pH value more than 7
Tastes sour	Tastes bitter
Corrosive	Corrosive
Turns blue litmus paper red	Turns red litmus paper blue
Reacts with metals to produce hydrogen gas	Does not react with metals

The Role of Water in Showing the Properties of Acids and Alkalis



You should remember that acids and alkalis show their properties only in the presence of water.

Brain Teaser

What is the meaning of pH?

Acid

No change in the colour of blue litmus paper

Glacial ethanoic acid

Without water

Ethanoic acid in water

Blue litmus paper turns red

With water

Alkali

No change in the colour of red litmus paper

Solid sodium hydroxide

Without water

Sodium hydroxide in water

Red litmus paper turns blue

With water

Figure 6.4 Acids and alkalis show their properties in the presence of water

Acidic and Alkaline Substances

Substances that contain acids are known as **acidic substances**, whereas substances that contain alkali are known as **alkaline substances**. Various foods in the kitchen can be classified into acidic and alkaline substances. For example, apples and coffee are acidic substances while baking soda is alkaline. Can you name another alkaline substance found in your kitchen?

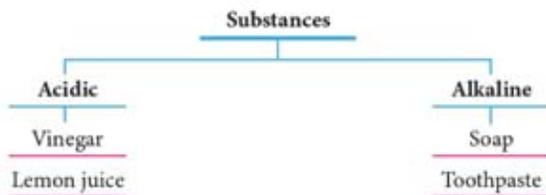


Figure 6.5 Examples of acidic and alkaline substances

The characteristic of different substances can be determined using a suitable **indicator**.

An indicator is a colouring or a mixture of different colourings that changes colour based on the substance tested. The colour change observed can be used to determine if a substance is neutral, acidic or alkaline.

Table 6.3 Colour change of various indicators

Indicator	Acid	Neutral	Alkali
Phenolphthalein	Colourless	Colourless	Pink
Universal indicator	Red	Green	Blue
Methyl orange	Red	Yellow	Yellow
Blue litmus paper	Red	Blue	Blue
Red litmus paper	Red	Red	Blue

Activity 6.2

Aim: To determine acidic and alkaline substances in daily life using various indicators.

Materials: Blue litmus paper, red litmus paper, universal indicator, methyl orange, phenolphthalein, fizzy drink, dishwashing liquid, distilled water, syrup and salt water

Apparatus: Dropper, test tube, measuring cylinder, pH meter and test tube rack

Note: The colours of substances tested with the universal indicator should be compared with the pH chart.

Instruction

1. Add 2 ml of a fizzy drink, dishwashing liquid, distilled water, syrup and salt water into separate test tubes, then place them in a test tube rack.
2. Test these substances with blue litmus paper and red litmus paper.
3. Record your observations in a table.
4. Repeat steps 1 to 3 by replacing the litmus papers with universal indicator, methyl orange, phenolphthalein and pH meter.

Observation

Substance	Indicator					Acid/ Alkali
	Blue litmus paper and red litmus paper	Universal indicator	Methyl orange	Phenolphthalein	pH meter	
Fizzy drink						
Dishwashing liquid						

Questions

1. What is the advantage of using universal indicator compared to litmus paper?
2. What is your inference on a substance that has a pH value of 7?

Strength of Acids and Alkalis

The **pH scale** is used to show the **strength** of acids or alkalis. The **range of pH value** is between 0 to 14. What is the relationship between the pH value and the strength of an acid and alkali?

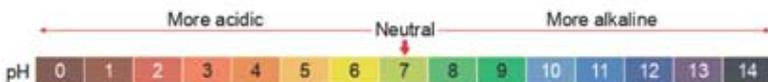


Figure 6.6 The pH scale

Activity 6.3

Aim: To study the relationship between the pH value and the strength of an acid and alkali.

Materials: pH paper, 0.1 M hydrochloric acid, sodium hydroxide solution, 0.1 M ethanoic acid, ammonia solution, pH chart and salt solution

Apparatus: Measuring cylinder, test tube and test tube rack

Note: Make sure all the solutions used have the same concentration.

Instruction

1. Pour 2 ml of hydrochloric acid into a test tube.
2. Test the substance in the test tube with a pH paper.
3. Observe the colour change of the pH paper and compare it with a pH chart to determine the pH value.
4. Record your observation in a table.
5. Repeat steps 1 to 4 by replacing hydrochloric acid with the other substances.

Observation

Substance	Hydrochloric acid	Sodium hydroxide solution	Ethanoic acid	Ammonia solution	Salt solution
pH value					

Questions

1. Relate the strength of acid to the pH value.
2. Identify the substance which is a:

(a) strong acid	(d) weak alkali
(b) strong alkali	(e) neutral solution
(c) weak acid	
3. Predict the pH value of rain water in an industrial area. Explain your answer.

After carrying out Activity 6.3, we can conclude that the lower the pH value, the stronger the acid; the higher the pH value, the stronger the alkali.

Uses of Acids and Alkalis in Daily Life

Acids and alkalis are widely used in our daily lives. For instance, we use vinegar which is acidic in cooking, and detergent which is alkaline for washing clothes. Besides, acids and alkalis are also used in various sectors such as the **agricultural**, **industrial** and **medical** sectors. For example, fertilisers used in agriculture are produced from the reaction between acidic and alkaline substances. Can you name the alkaline substance?

Brain**Teaser**

What will happen to crops if the acidity of soil increases?



Photograph 6.2 Ammonia solution is used to produce fertilisers

Let us carry out Activity 6.4 to find out the usage of acids and alkalis in daily life.

**Activity 6.4**

Aim: To gather information on the usage of acids and alkalis in daily life.

Instruction:

1. Work in groups.
2. Gather information on the usage of acids and alkalis in daily life including agricultural and industrial sectors.
3. Present the finding using a mind map.

ACID



Tartaric acid

Tartaric acid



Fizzy drink

Carbonic acid



Car battery

Sulphuric acid



Pickle

Vinegar

ALKALI



Soap

Potassium hydroxide



Fertiliser

Ammonia



Antacid pills

Magnesium hydroxide



Detergent

Sodium hydroxide

Photograph 6.3 Uses of acids and alkalis in daily life

Formative Practice 6.1

1. Predict the arrangement of the following substances in decreasing order of pH value.

Orange juice Bitter gourd juice Hydrochloric acid Mineral water

2. Explain the reason why the labels of acid and alkali bottles have the symbol as in the diagram below.

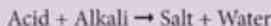


3. The colour of liquid X changes from green to red when universal indicator is added.
 (a) Determine whether liquid X is acidic, neutral or alkaline.
 (b) Predict the colour of liquid X if a few drops of methyl orange are added into it.
4. Arrange the following substances in increasing order of acid strength.

Pineapple juice: pH 4 Fresh milk: pH 6 Vinegar: pH 2

6.2 Neutralisation

What will happen if an acid is mixed with an alkali? The reaction between an acid and an alkali produces **salt** and **water**. This reaction is called **neutralisation**. During neutralisation, an acid loses its acidity while an alkali loses its alkalinity. The method used to carry out this reaction is called **titration**. The word equation for this neutralisation reaction is:



Different acids and alkalis produce different salts. For example:



Activity 6.5

Aim: To study the neutralisation reaction between hydrochloric acid and sodium hydroxide solution.

Materials: Phenolphthalein, 0.5 M hydrochloric acid and 0.5 M sodium hydroxide solution

Apparatus: Burette, pipette, conical flask, retort stand with clamp, white tile and filter funnel

Instruction

- Fill 30 ml of hydrochloric acid into a burette using a filter funnel and record the initial reading of the burette.
- Transfer 25 ml of sodium hydroxide solution into a conical flask using a pipette.
- Add three drops of phenolphthalein into the conical flask. Set up the apparatus as shown in Figure 6.7.
- Add the hydrochloric acid from the burette drop by drop into the conical flask while shaking the flask gently.
- Stop adding the acid when the sodium hydroxide solution changes colour from pink to colourless.
- Record the final reading of the burette.

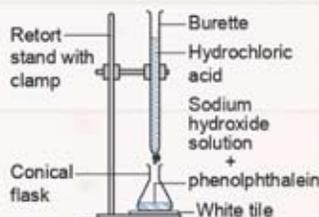


Figure 6.7

Observation

Initial reading of the burette (ml)	
Final reading of the burette (ml)	
Volume of hydrochloric acid used (ml)	

Questions

1. What is the volume of hydrochloric acid required to neutralise 25 ml of sodium hydroxide solution?
2. Write the word equation for the reaction between the acid and alkali in this activity.

Applications of Neutralisation in Daily Life

Neutralisation has many applications in our daily lives. Besides, it is also used in the agricultural and industrial sectors.

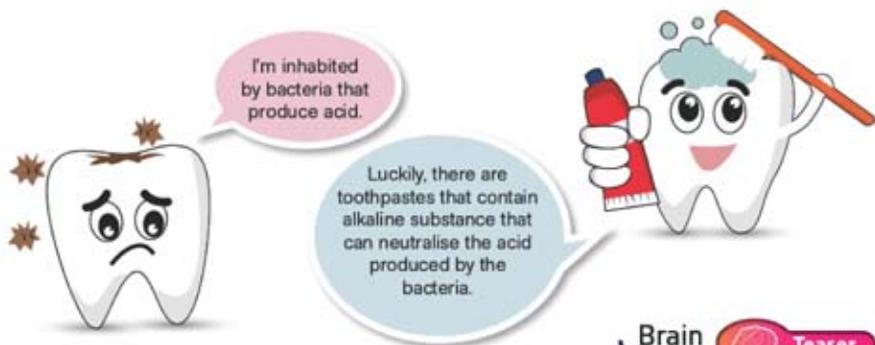


Figure 6.8 Application of neutralisation of acid on dental care

Brain Teaser

How can alkaline shampoo and acidic hair conditioner be combined into a 2 in 1 shampoo bottle?



Photograph 6.4 Applications of neutralisation in self-care products



Acidic soil can be treated by adding slaked lime which is alkaline in order for plants to grow well.

Fabric softeners are acidic, thus they reduce the pH level of fabrics which become alkaline after being washed with detergents.



Acidic waste substances from factories are treated with alkalis before being discharged into the river.

Photograph 6.5 Applications of neutralisation in the agricultural and industrial sectors

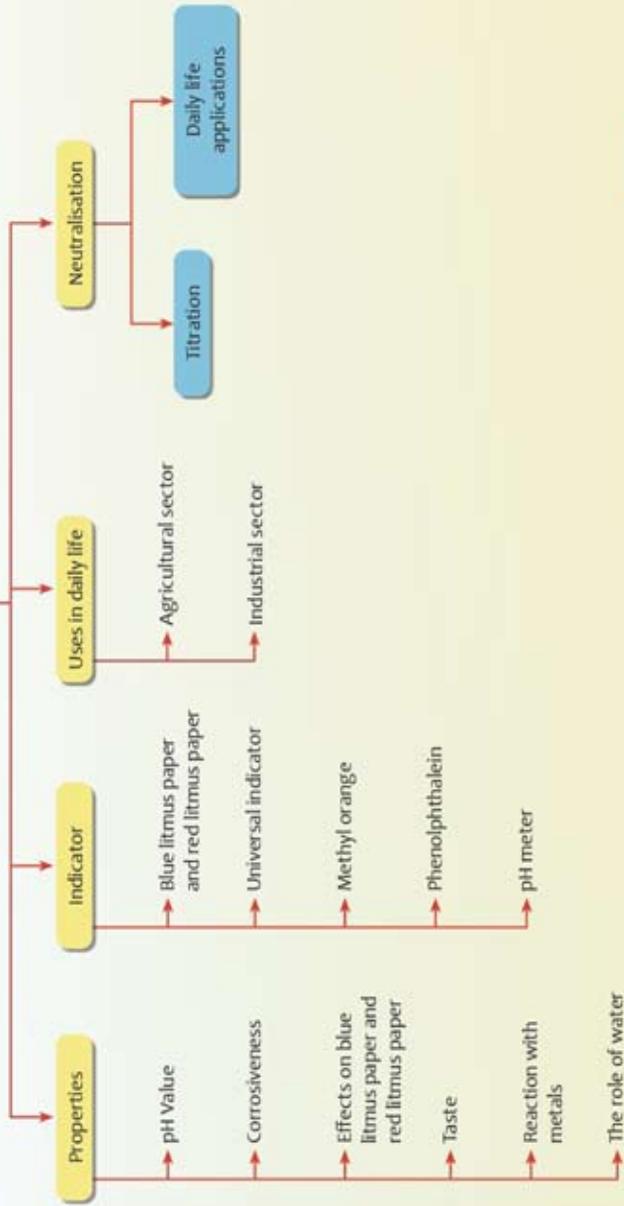
Formative Practice 6.2

1. (a) Complete the following equation.



- (b) If sulphuric acid and sodium hydroxide solution are added together, what would be the product?
Write down your answer in a word equation.
2. Explain how toothpaste works in cleaning teeth and preventing dental caries.
3. Is hair conditioner important? Explain your answer.

Acid and Alkali



Interactive Quiz 6

Quiz



SELF-REFLECTION

After learning this chapter, you are able to:

6.1 Properties of Acids and Alkalis

- Define operationally acid and alkali.
- Explain with examples of acidic and alkaline substances.
- Demonstrate the technique to determine the strength of acid and alkali based on pH value.
- Identify the uses of acids and alkalis in daily life.

6.2 Neutralisation

- Explain the neutralisation reaction.
- Explain with examples the applications of neutralisation reaction in daily life.

Summative Practice 6

1. The following is a list of several substances.

Malic acid Formic acid Potassium hydroxide solution

Based on the list above, answer the following questions.

- (a) Which substance has the pH value of less than 7?
 - (b) State the substance found in
 - (i) fire ants
 - (ii) green apples
 - (c) Predict your observation if a magnesium ribbon is put in potassium hydroxide solution and tested with a lighted wooden splinter. 
2. (a) Shida wants to carry out an activity to determine the pH value of ammonia gas. Based on your knowledge of acid and alkali, explain how Shida can determine the pH value of the ammonia gas. 
- (b) State one advantage of pH paper compared to litmus paper. 
 - (c) Grace added two drops of phenolphthalein into colourless solution *M*. She found that the solution remained colourless.
 - (i) Is solution *M* acidic? Explain your answer. 
 - (ii) Suggest another test that should be carried out to strengthen your answer in (i).

3. Figure 1 shows the reactions of blue litmus paper and red litmus paper when tested with three different solutions.

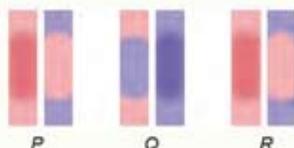


Figure 1

- Based on your observation, classify the solutions into two groups according to their common characteristics.
 - State two other characteristics of each group that you stated in 3 (a).
 - State one example of daily life substance that has the characteristic as
 - solution P
 - solution Q
4. Amran was stung by a jellyfish when he was swimming in the sea with his friends. The part of his body stung by the jellyfish became red and swollen. The pain became worse when his friend applied soap and toothpaste on the affected area.
- Explain why Amran's pain became worse when applied with soap and toothpaste. 🧠
 - Suggest a way to reduce Amran's pain. 🧠

HOTS Mastery 6

- Kiran was cleaning the fish she bought from the market. The fishy smell made her feel sick. Suggest one way to remove the fishy smell. 🧠
 - How can you neutralise vinegar using sodium hydroxide solution? State the procedure for this activity. 🧠
- A farmer found out that his agricultural land is not fertile. His son carried out simple tests on the soil sample to identify the cause. Table 1 shows the tests carried out and the observations obtained.

Table 1

Test	Observation
Soil sample + Baking soda + Water	Gas bubbles are observed
Soil sample + Vinegar	No gas bubbles are observed

- Based on the observation for both tests on the soil sample, what can be concluded? 🧠
- Relate your answer in 6 (a) with infertility of the soil. 🧠
- Suggest and explain one way to overcome the farmer's problem. 🧠