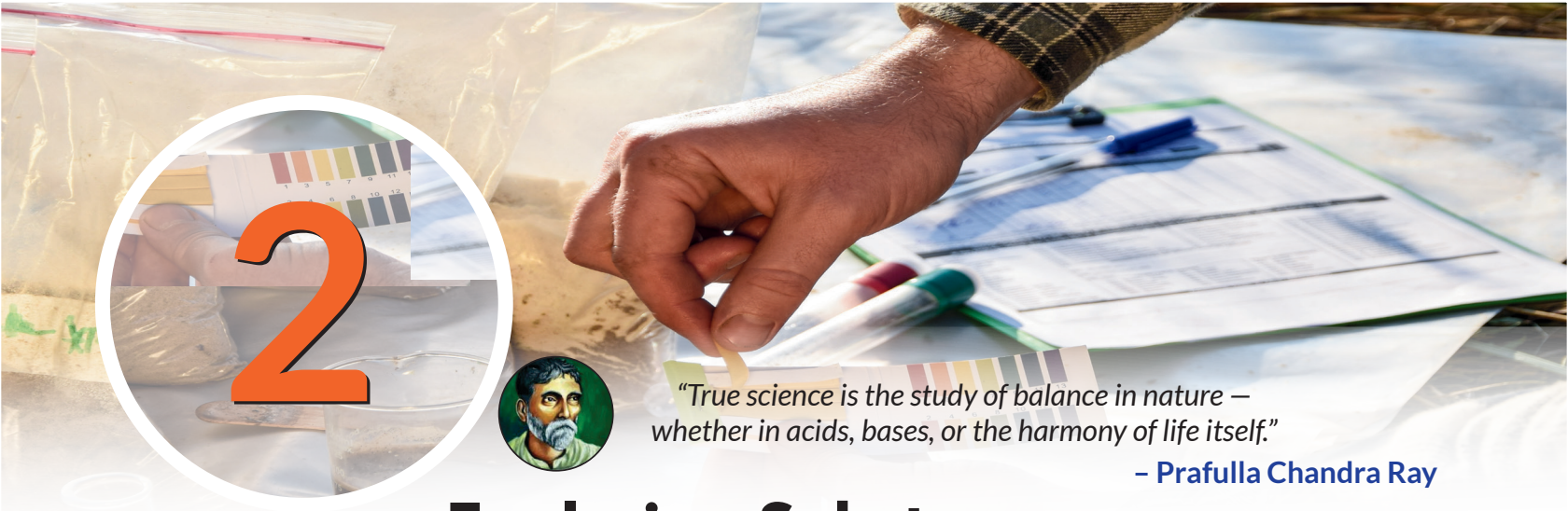


2

"True science is the study of balance in nature — whether in acids, bases, or the harmony of life itself."

– Prafulla Chandra Ray

Exploring Substances: Acidic, Basic, and Neutral

The Big Question

Imagine you're handed a slice of lemon, a drop of soap solution, and a glass of plain water. You taste each — one is sour, one bitter, and one tasteless. But what if you could see their hidden nature with just a drop of a special liquid that changes colour? Can everyday substances talk to us—in colour—revealing their acidic, basic, or neutral identity?

Meet EeeBee.AI

Hello, bright scientists! I'm EeeBee, your inquisitive AI helper, ready to sprinkle a dash of curiosity on our colorful chemistry quest. Did you know "the anthocyanin pigment in red cabbage" can shift from red through purple to green depending on acidity or alkalinity? And turmeric, that golden kitchen spice, quietly turns red in soap-basic mixtures, making it a secret pH detective! **Let's explore how everyday drops can reveal hidden stories in colour!**

Learning Outcomes

By the end of this chapter, students will be able to:

- Differentiate between acidic, basic, and neutral substances based on their properties.
- Define and identify various natural and olfactory indicators.

Science Around You

Acids, bases, and neutral substances are everywhere! From the lemon juice (acidic) in your lemonade and the soap (basic) you use to wash your hands, to the pure water (neutral) you drink. Understanding these substances helps us in cooking, cleaning, farming, and even in understanding how our own bodies work. This knowledge is crucial for many professions, including chemists, doctors, chefs, and environmental scientists.

NCF Curricular Goals and Competencies

Competency Goal (CG 4.1): Connects scientific knowledge with environmental awareness by identifying the impact of substances (acidic, basic, and neutral) on health, food, and ecosystems.

Mind Map

Exploring Substances – Acidic, Basic, and Neutral

Acid, Base, and Neutral

- **Acids:** Sour, turn blue litmus red, react with metals (H_2 gas) & carbonates (CO_2).
  - ✓ **Examples:** lemon, vinegar.

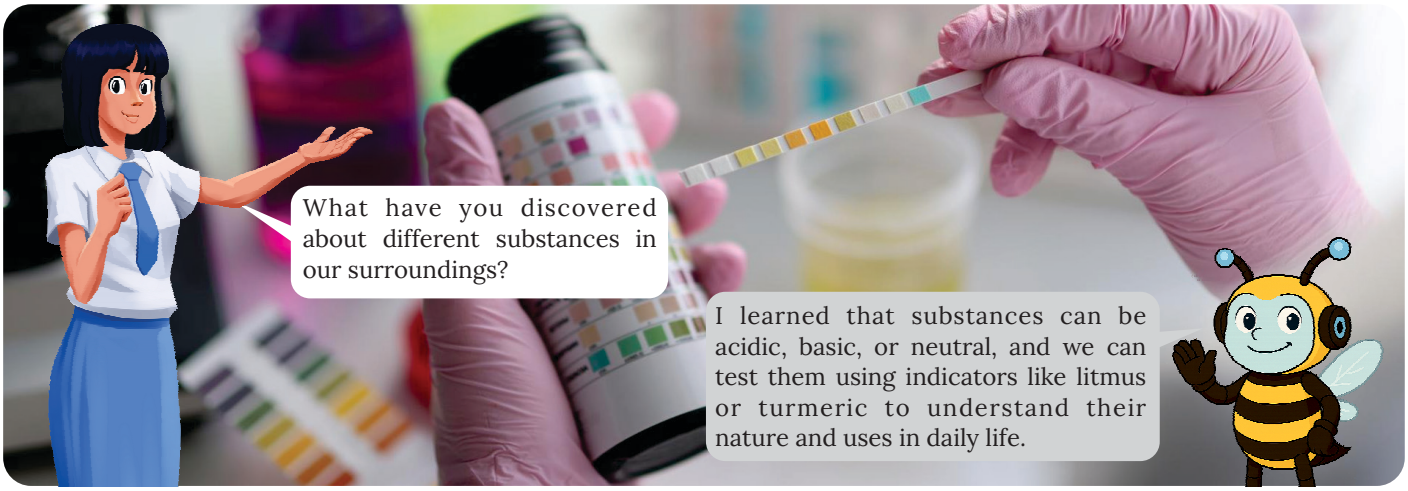
- **Bases:** Soapy, turn red litmus blue.
  - ✓ **Examples:** baking soda, soap solution.
- **Neutral substances:** Pure water, sugar/salt solution.
- **pH Scale:** <7 (acid), =7 (neutral), >7 (base).

Indicators and Their Types

- **Indicators:** Substances that show whether a solution is acidic, basic, or neutral.
- **Natural Indicators –** Derived from plants like lichens.
  - ✓ **Litmus:** Acids → red, Bases → blue, Neutral → no change.
- **Turmeric –** Yellow in acids/neutral, reddish-brown in bases.
- **Red Cabbage Extract –** Changes color with pH (red in acid, purple in neutral, blue/green in base).
- **Olfactory Indicators –** Change or lose smell in acids/bases.
  - ✓ **Example:** Onion & vanilla → smell lost in bases, retained in acids.

Neutralisation: Concept and Applications

- **Neutralisation:** Reaction between an acid and a base forming salt, water, and heat.
  - ✓ **General reaction:** Acid + Base → Salt + Water + Heat (exothermic).
- **Applications:**
  - ✓ **Indigestion –** Excess stomach acid neutralised by antacids (milk of magnesia).
  - ✓ **Bee & Wasp Stings –** Bee sting (acidic) neutralised by baking soda; wasp sting (alkaline) treated with vinegar/lemon juice.
  - ✓ **Soil Treatment –** Acidic soil corrected with lime/slaked lime to support crops.
  - ✓ **Industrial Waste –** Acidic/basic waste neutralised before release to protect rivers and aquatic life.



In Focus

- Acidic, Basic, and Neutral
- Indicators and their types
- Neutralisation: Concept and Applications

Introduction

The world around us is made up of countless different substances. We use them, consume them, and interact with them every day. Scientists classify these substances in many ways, and one important classification is based on their chemical nature: whether they are acidic, basic (or alkaline), or neutral. Understanding whether a substance is acidic, basic, or neutral is crucial not just in chemistry labs but also in many aspects of our daily lives, from cooking and cleaning to agriculture and medicine.

From History's Pages

The study of acids and bases began in ancient times when alchemists identified acids by their sour taste and corrosive nature, and bases (alkalis) by their bitter taste and slippery feel. The term "acid" comes from the Latin acidus (sour), and "alkali" from Arabic al-qaly (plant ashes). In the 17th century, Robert Boyle described their properties and used plant-based indicators. In the 18th century, Lavoisier linked acids to oxygen, though inaccurately. Later, Arrhenius defined acids as H^+ producers and bases as OH^- producers. In India, Acharya Prafulla Chandra Ray advanced chemical research, linking ancient Indian knowledge to modern science.

Acidic, Basic, and Neutral

Acids, Bases, and Neutral Substances

In our everyday life, we come across a variety of substances – some taste sour like lemon juice, some feel slippery like soap, and some are neither sour nor bitter like water or sugar. These differences arise due to their chemical nature. Substances are classified as acids, bases, or neutral substances based on their properties, especially how they react with indicators, their taste, feel, chemical behavior, and pH values.

Acidic Substances

Acids are chemical substances known for their sour taste. The tanginess of lemon, the sharpness of vinegar, and the tartness in tamarind are due to the presence of natural acids. However, tasting is never a safe or reliable method to identify acids in a science lab, as many acids are corrosive and dangerous. Acids show distinct behavior when they interact with certain chemical tools known as indicators, which help in identifying their presence.

Important Properties of Acids

1. **Taste**
   - Acids have a characteristic sour taste.
   - Found in foods like lemon (citric acid), vinegar (acetic acid), grapes (tartaric acid), curd (lactic acid), and amla (ascorbic acid).
   - Never taste unknown substances—strong acids can cause burns.

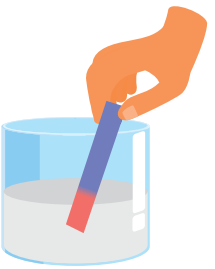


Fig. 2.1 Blue litmus paper

2. **Effect on Indicators**
   - Blue litmus paper → Red
   - Turmeric → No change (remains yellow)
   - Red/China rose extract → Deep pink or magenta
   - Methyl orange → Red
   - Phenolphthalein → Colourless (no change)

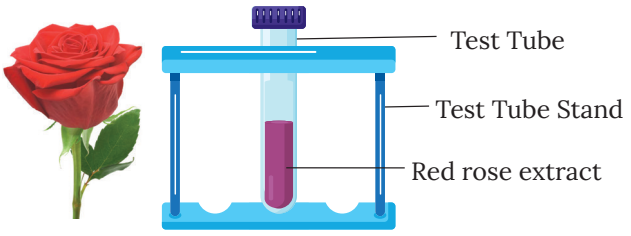


Fig. 2.2 Test tube containing the red rose extract

3. **Corrosive Nature**
   - Strong acids like hydrochloric acid (HCl), sulfuric acid (H_2SO_4), and nitric acid (HNO_3) are highly corrosive.
   - Can damage metals, skin, fabric, and even stone like marble.
   - Must be handled with protective gear (gloves, goggles, etc.).

4. **Common Acids and Their Sources**

- Citric acid – Lemons, oranges
- Lactic acid – Curd, sour milk
- Ascorbic acid – Amla, citrus fruits
- Oxalic acid – Spinach, tomatoes
- Sulfuric acid – Car batteries
- Acetic acid – Vinegar
- Tartaric acid – Tamarind, grapes
- Formic acid – Ant stings
- Hydrochloric acid – Stomach juices
- Nitric acid – Explosives, fertilizers

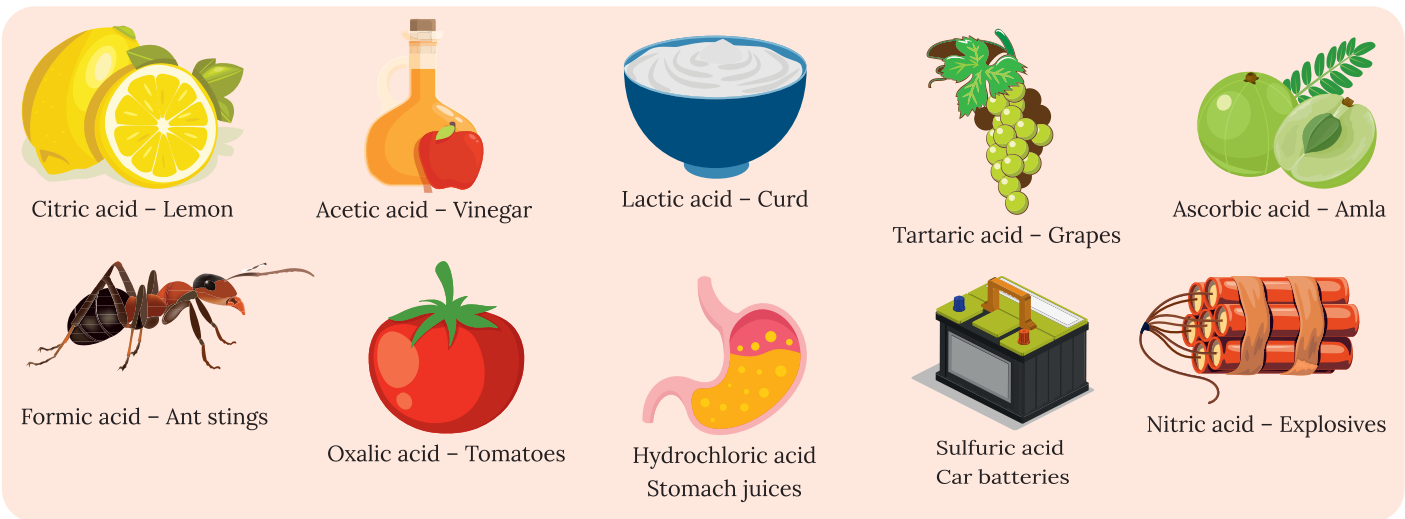


Fig. 2.3 Common Acids and Their Sources

Basic Substances (Bases or Alkalis)

Bases are substances with a bitter taste and a slippery or soapy feel. Many cleaning agents like soap, washing soda, and baking soda are basic in nature. Those bases that dissolve in water are called alkalis. Just like acids, tasting or touching bases is unsafe because strong bases can also be **corrosive**.

Important Properties of Bases

Taste

- Bases taste bitter.

  Example: Baking soda has a mildly bitter, salty taste.
- Do not taste unknown substances.

Touch

- Bases feel slippery or soapy when touched.
- They react with natural oils on skin to form soap.

Effect on Indicators

Fig. 2.4 Red Litmus Paper

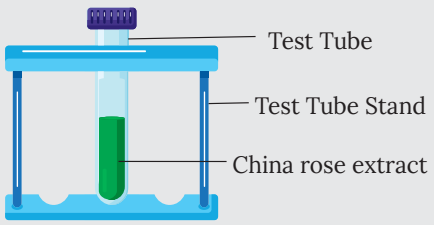


Fig. 2.5 China rose extract

- Red litmus paper → Blue
- Turmeric → Reddish-brown
- China rose extract → Green
- Phenolphthalein → Pink
- Methyl orange → Yellow

Corrosive Nature

- Strong bases like sodium hydroxide (NaOH) and potassium hydroxide (KOH) are very corrosive.
- Used in drain cleaners.
- Can cause skin burns.

Reaction with Acids (Neutralisation)

- Bases neutralize acids to form salt and water.

General Reaction:

Acid + Base → Salt + Water

- This is called a neutralisation reaction.

Common Bases and Their Uses

- **Sodium hydroxide (NaOH):** Soap, deterg-ent, drain cleaner
- **Calcium hydroxide ($Ca(OH)_2$):** White wash-ing, neutralizing acid soil
- **Magnesium hydroxide (Milk of magnesia):** Antacid
- **Ammonium hydroxide:** Window cleaner
- **Potassium hydroxide (KOH):** Battery, soft soap
- **Sodium bicarbonate ($NaHCO_3$):** Baking, antacid, fire extinguisher
- **Washing soda (Na_2CO_3):** Softens **hard water**, detergent aid

Keywords

Corrosive: It refers to a substance that can destroy or irreversibly damage living tissue or materials on contact.

Hard water: Water that contains high concentrations of dissolved minerals, mainly calcium and magnesium ions.

Fig. 2.6 Common Bases and Their Uses

Neutral Substances

Not all substances are acidic or basic. Some are neutral, meaning they do not show acidic or basic properties. These substances do not change the colour of indicators and are generally safe to taste or touch (though care should still be taken).

Important Properties of Neutral Substances

Taste

- Neutral substances are neither sour nor bitter.

Examples:

- **Sugar:** Sweet taste
- **Common salt:** Salty
- **Water:** Tasteless

Effect on Indicators

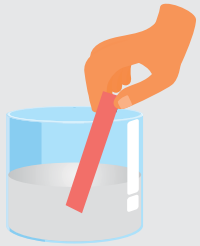


Fig. 2.7 Litmus (red or blue)

- **Litmus (red or blue):** No colour change
- **Turmeric:** Remains yellow
- **China rose extract:** No change
- **Phenolphthalein:** Remains colourless
- **Methyl orange:** Stays orange/yellow

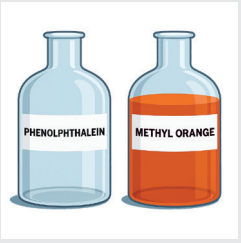


Fig. 2.8 Phenolphthalein Methyl Orange

pH Value

- pH = 7, which is exactly neutral.

Examples of Neutral Substances

- Pure water (distilled water)
- Sugar solution, Salt solution (NaCl)
- Ethanol (alcohol)
- Gases like oxygen and nitrogen

Importance

- Water is essential for life and a universal solvent.
- Salt and sugar are key food components.
- Many chemical processes need a neutral medium.

Comparison Table: Acids vs Bases vs Neutral Substances

Property	Acids	Bases (Alkalis)	Neutral Substances
Taste	Sour	Bitter	No characteristic taste (can be sweet/salty/tasteless)
Feel	May feel rough (not advised to touch)	Slippery/soapy	No specific feel
Litmus Test	Turns blue litmus red	Turns red litmus blue	No change
Turmeric	No change (yellow)	Turns reddish-brown	No change

China Rose Extract	Turns pink/magenta	Turns green	No change
Phenolphthalein	Colourless	Turns pink	No change
Methyl Orange	Turns red	Turns yellow	No change (orange/yellow)
pH Range	Less than 7	Greater than 7	Exactly 7
Examples	Lemon juice, vinegar, curd, HCl	Soap, baking soda, NaOH	Water, salt solution, sugar solution

Science Around Us

Acids taste sour, bases feel soapy, but did you know your tears are slightly basic and milk is slightly acidic? Also, bee stings are acidic while wasp stings are basic — that's why baking soda helps with bee stings, and vinegar soothes wasp stings!

Fact Flash

Did you know that the pain and burning you feel after an ant sting is due to formic acid injected into your skin?

Formic acid is a natural acid found in ant venom and is the same chemical used in some preservatives and cleaning agents!

Common Misconceptions

× **Misconception:** All sour things are safe to eat.

✓ **Correction:** While many edible sour fruits contain weak acids, many other acidic substances are highly corrosive and dangerous if ingested.

× **Misconception:** Neutral substances have no chemical reactivity.

✓ **Correction:** Neutral substances can still participate in many other types of chemical reactions that are not acid-base reactions. For example, sugar can be burned (combustion).

Activity

Objective: To observe how different substances interact with indicators and classify them as acidic, basic, or neutral.

- **Materials Required:**
  - Red and blue litmus papers
  - Turmeric paper (or turmeric paste on blotting paper)
  - China rose (hibiscus) indicator solution (boil petals in water and cool)
  - Phenolphthalein (optional if available)

- Dropper or spoon for testing
- Clear plastic cups or test tubes
- Water for diluting
- Labels or sticky notes

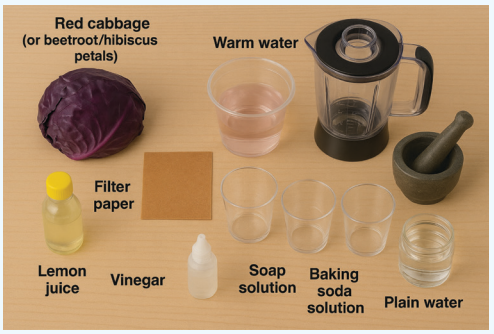


Fig. 2.9 Materials Required

- **Procedure:**
  1. Label each cup/test tube with the name of the substance.
  2. Add a small amount of each solution into its respective cup.
  3. Using litmus papers, turmeric, and china rose extract, test each solution:
     - **Litmus Test:** Dip red and blue litmus papers separately into each solution.
     - **Turmeric Test:** Place a drop of the solution on turmeric paper. Observe color change.
     - **China Rose Test:** Add a few drops of china rose indicator to each solution and observe color.
  4. Optionally, add phenolphthalein to a few test solutions and record color change (if available).

Observation Table:

Substance	Red Litmus	Blue Litmus	Turmeric	China Rose	(Optional) Phenolphthalein	Inference
Lemon juice	_____	Turns red	No change	_____	Colourless	Acidic
Bakingsoda sol.	Turns blue	_____	Reddish	Green	_____	_____
Salt solution	_____	No change	No change	_____	Colourless	Neutral

Discussion & Conclusion:

- Substances that turn blue litmus red and do not affect turmeric are acids.
- Substances that turn red litmus blue, make turmeric red, and phenolphthalein pink are bases.
- Substances with no change on any indicator are neutral.

Knowledge Checkpoint

Gap Analyzer™ Homework | Watch Remedial

Remembering

Multiple Choice Questions:

1. Which of the following is a characteristic taste of acidic substances?
   a) Sweet ☐ b) Bitter ☐ c) Sour ☐ d) Salty ☐
2. Which of these is an example of a neutral substance?
   a) Lemon juice ☐ b) Soap solution ☐ c) Distilled water ☐ d) Vinegar ☐
3. A substance that feels soapy to the touch is likely to be:
   a) Acidic ☐ b) Basic ☐ c) Neutral ☐ d) Salty ☐

Applying

Short Answer Question:

4. Give two common examples of acidic substances found in your kitchen.
5. Why is it advised not to taste unknown substances in a laboratory?

Long Answer Question:

Analyzing

6. Explain the differences between acidic, basic, and neutral substances, giving at least one common example and one characteristic property for each (other than taste for acids and bases).

Indicators and their types

What are Indicators?

Indicators: are substances that change their colour when they come into contact with acidic or basic solutions. They "indicate" the chemical nature of the substance being tested. This colour change is a visual cue that helps us classify substances.

There are many different types of indicators. Some are found naturally in plants, while others are synthesized in laboratories (synthetic indicators). In this chapter, we will primarily focus on natural indicators.

Why do indicators change colour?

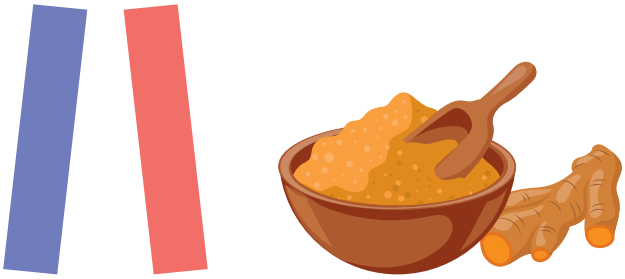
The colour change happens because the indicator molecules themselves are complex chemical compounds that can exist in different forms depending on whether they are in an acidic or basic environment. When an acid or a base is added, the structure of the indicator molecule changes slightly, and this change in structure affects how it absorbs and reflects light, leading to a different perceived colour.

Types of Indicators:

1. **Natural Indicators:** These are obtained from natural sources like plants (flowers, leaves, roots, lichens). **Examples:** litmus, turmeric, red cabbage extract, China rose (hibiscus) petals, and beetroot extract.
2. **Synthetic Indicators:** These are man-made chemical substances prepared in laboratories.

   Examples: phenolphthalein and methyl orange.
3. **Olfactory Indicators:** These are substances whose odour (smell) changes in acidic or basic media.

   Examples: onion and vanilla extract.



Blue and red litmus paper strips

Turmeric paste

Fig. 2.10 Natural Indicators

Litmus (Natural Indicator)

Litmus is one of the most commonly used natural indicators in science laboratories. It provides a simple and reliable way to test whether a substance is acidic or basic.

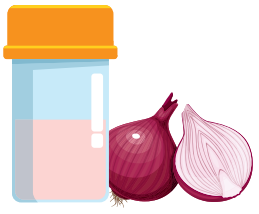


Fig. 2.11 Onion Extract

Source of Litmus:

Litmus is extracted from **lichens**. Lichens are fascinating composite organisms that arise from algae or cyanobacteria living among filaments of multiple fungi species in a mutualistic relationship. They are often found growing on rocks, walls, and trees.

Fig. 2.12 Lichens

Forms of Litmus:

Litmus is available in two main forms:

1. **Litmus Solution:** This is a solution of litmus extract in water. It is naturally purple, but it's often prepared as blue litmus solution or red litmus solution for testing.
2. **Litmus Paper:** This is filter paper that has been soaked in litmus solution and then dried. It is more convenient to use than the solution form for many tests. Litmus paper comes in two colours:
    - Blue Litmus Paper
    - Red Litmus Paper

Action of Litmus on Acidic and Basic Substances:

The way litmus changes colour helps us identify acids and bases:

Fig. 2.13 Litmus Solution

- **In Acidic Solutions:**
    - Blue litmus paper turns **red**.
    - Red litmus paper remains **red** (no change).
    - Litmus solution (if purple or blue) turns **red**.
- **In Basic Solutions:**
    - Red litmus paper turns **blue**.
    - Blue litmus paper remains **blue** (no change).
    - Litmus solution (if purple or red) turns **blue**.
- **In Neutral Solutions:**
    - Blue litmus paper remains **blue** (no change).
    - Red litmus paper remains **red** (no change).
    - Litmus solution (purple) remains **purple** (or shows no change if it's already blue or red).

Fig. 2.14 Blue and red litmus

Turmeric (Natural Indicator)

Turmeric (Haldi) is a common spice found in almost every Indian kitchen, known for its vibrant yellow colour and medicinal properties. But did you know it can also act as a natural acid-base indicator?

Preparation of Turmeric Indicator:

Turmeric indicator is usually used in the form of turmeric paper.

1. **Make Turmeric Paste:** Take a spoonful of turmeric powder and add a little water to make a paste. You can also grind fresh turmeric root to get a paste.
2. **Prepare Turmeric Paper:** Take a strip of filter paper (or any plain white paper) and apply the turmeric paste evenly on it. Allow it to dry completely.
3. **Cut into Strips:** Once dry, cut the yellow turmeric paper into thin strips. These strips are now ready to be used as an indicator

Action of Turmeric on Acidic, Basic, and Neutral Substances:

Turmeric shows a distinct colour change, primarily with basic substances.

- **In Acidic Solutions:**
  - Turmeric paper remains **yellow** (no change).
  - Example: If you put a drop of lemon juice or vinegar on turmeric paper, it will stay yellow.
- **In Basic Solutions:**
  - Turmeric paper turns from yellow to **reddish-brown** or **red**.
  - Example: If you put a drop of soap solution or lime water on turmeric paper, it will turn reddish-brown.
- **In Neutral Solutions:**
  - Turmeric paper remains **yellow** (no change).
  - Example: If you put a drop of pure water or sugar solution on turmeric paper, it will stay yellow. – Image - drop of pure water

Fig. 2.15 Turmeric (Natural Indicator)

Fig. 2.16 Turmeric Paper Remains Yellow

The Curry Stain Secret

Turmeric, a common ingredient in curry, acts as a natural acid-base indicator. When curry spills on a white fabric, it leaves a yellow stain due to the presence of turmeric. If soap—a basic substance—is used to wash the stain, a surprising change occurs: the yellow stain turns reddish-brown. This happens because turmeric reacts with the base in the soap, changing its color. When the fabric is rinsed thoroughly with plenty of water, the basic nature of the soap is diluted, and the reddish stain may fade back to yellow. However, turmeric stains are often stubborn and may not disappear completely even after washing.

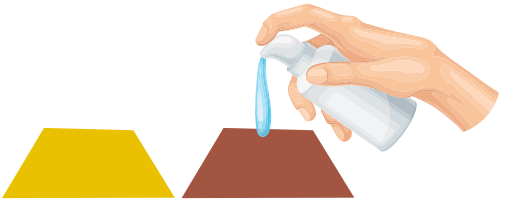


Fig. 2.17 Turn Reddish-brown

Natural Indicator: Red Rose Extract (or China Rose/Hibiscus)

Extracts from certain colourful flowers can also serve as excellent natural acid-base indicators. Red Rose extract, and China Rose (Hibiscus) petals are also commonly used and give similar results. These flowers contain pigments called **anthocyanins**, which change colour with varying acidity.

Keywords

Anthocyanins: They are natural pigments found in many fruits, vegetables, and flowers that give them red, purple, or blue colors.

Preparation of Red Rose (or China Rose/Hibiscus) Extract:

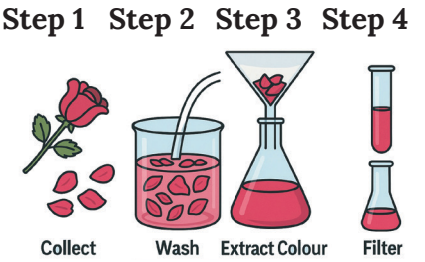


Fig. 2.18 Red Rose Extract

1. **Collect Petals:** Collect some petals of red roses (or China rose/ hibiscus flowers). It's advised to use fallen petals if possible.
2. **Wash Petals:** Gently wash the petals with water to remove any dirt.
3. **Extract Colour:**
   - Place the petals in a beaker or glass tumbler.
   - Pour some warm (not boiling) water over the petals, just enough to cover them.
   - Let it stand for about 10-15 minutes, or until the water becomes distinctly coloured (usually light pink or magenta).
   - Alternatively, you can crush the petals slightly with a mortar and pestle before adding warm water.
4. **Filter:** Filter the solution to remove the petals. The coloured liquid obtained is the indicator solution.

Action of Red Rose Extract on Acidic, Basic, and Neutral Substances:

Fig. 2.19 Red Rose Petals Indicator

- **In Acidic Solutions:**
  - The extract turns a **bright magenta** or **deep pink** (or dark pink/reddish).
  - Example: If you add lemon juice or vinegar to the light pink extract, it will intensify to a magenta/ deep pink colour.
- **In Basic Solutions:**
  - The extract turns **green** or sometimes **yellowish-green**.
  - Example: If you add soap solution or lime water to the extract, it will change to green.
- **In Neutral Solutions:**
  - The extract shows **no significant colour change** (remains its original light pink/magenta colour).
  - **Example**: If you add pure water or sugar solution, the colour will not change.

Fact Flash

Some flowers, like hydrangeas, act as natural indicators for the soil they grow in! Hydrangea flowers can be blue if the soil is acidic, and pink or red if the soil is basic (alkaline). Gardeners sometimes change the soil's nature to get their desired flower colour.

Science Around Us

Red cabbage juice acts as a pH indicator, showing green in bases and red in acids? It contains anthocyanins, natural pigments that change colour with pH. Interestingly, petals of some flowers like hibiscus and hydrangea can also be used to test acidity or alkalinity of solutions!

Common Misconceptions

× **Misconception:** All sour things are safe to eat.

✓ **Correction:** Not all sour things are safe to eat—some sour substances like lemon or tamarind are edible, but others like strong acids (e.g., hydrochloric acid) are dangerous and can cause harm. Sour taste alone does not determine safety.

× **Misconception:** An indicator tells you exactly **how** acidic or basic a substance is.

✓ **Correction:** An indicator shows whether a substance is acidic, basic, or neutral—**not** how strongly acidic or basic it is. For exact pH levels, we need tools like **pH meters or universal indicator paper** that give numerical values

Activity

Testing with Turmeric Paper

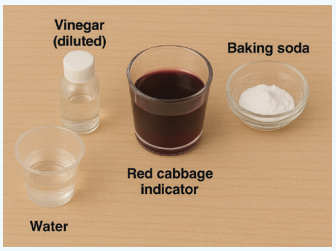


Fig. 2.20 Materials Required

Objective: To test various substances using homemade turmeric paper.

- **Materials:**
  - Turmeric paper strips (prepared as described above), samples of lemon juice, vinegar, soap solution, baking soda solution, lime water, sugar solution, salt solution. Droppers, white tile.
- **Procedure:**
  1. Place a few turmeric paper strips on a clean white tile.
  2. Using a clean dropper for each sample, put one drop of lemon juice on a turmeric paper strip. Observe and record the colour.
  3. Repeat step 2 for all other samples, using a fresh strip and a clean/rinsed dropper for each.
  4. Record your observations.

Sample Tested	Original Colour of Turmeric Paper	Colour After Adding Sample	Inferred Nature
Lemon Juice	_____	_____	_____
Vinegar	_____	_____	_____
Soap Solution	_____	_____	_____
Baking Soda Sol.	_____	_____	_____
Lime Water	_____	_____	_____
Sugar Solution	_____	_____	_____
Salt Solution	_____	_____	_____

- **Discussion:** Which substances caused a colour change in the turmeric paper? What does this tell you about their nature? Could you distinguish between all the acidic and neutral solutions using only turmeric?

Knowledge Checkpoint

Gap Analyzer™ Homework | Watch Remedial

Remembering

Multiple Choice Questions:

1. Litmus and turmeric are examples of:
   a) Synthetic indicators ☐ b) Natural indicators ☐
   c) Olfactory indicators ☐ d) Universal indicators ☐
2. A substance that changes its smell in acidic or basic solutions is called:
   a) A visual indicator ☐ b) A synthetic indicator ☐
   c) An olfactory indicator ☐ d) A neutral indicator ☐

Understanding

3. What is the primary function of an indicator?
   a) To change the taste of a substance ☐
   b) To change the colour of a substance when it reacts with an acid or a base ☐
   c) To make a substance neutral ☐
   d) To increase the strength of an acid ☐

Short Answer Question:

4. Define 'indicator' in your own words.
5. Why are indicators important in chemistry?

Applying

Long Answer Question:

6. Explain the different types of indicators (natural, synthetic, olfactory) with at least one example for each. Why do you think visual indicators are more commonly used in simple school experiments than olfactory indicators?

Neutralisation: Concept and Applications

What is Neutralisation?

When an acid reacts with a base, they "cancel out" or neutralize each other's properties. The resulting solution is often neutral (or closer to neutral than the original acid and base).

The reaction between an acid and a base to form **salt** and **water** is called a **neutralisation reaction**.

General Reaction:

Acid + Base → Salt + Water + Heat

Example:

Hydrochloric acid (HCl) + Sodium hydroxide (NaOH) → Sodium chloride (NaCl) + Water (H_2O) + Heat

- **Hydrochloric acid (HCl):** The acid
- **Sodium hydroxide (NaOH):** The base
- **Sodium chloride (NaCl):** The salt formed (this is common table salt)
- **Water (H_2O):** Also formed

Heat Evolution:

Neutralisation reactions are generally **exothermic**, meaning they release heat. If you perform a neutralisation reaction in a test tube, you might feel the test tube getting warm.

What is a Salt?

In chemistry, a "salt" is an **ionic compound** formed from the reaction of an acid and a base. It consists of a positive ion (cation) from the base and a negative ion (anion) from the acid.

- Common table salt (NaCl) is just one example of many different salts.
- Other examples: Potassium nitrate (KNO_3), Calcium sulfate ($CaSO_4$), Copper sulfate ($CuSO_4$).
- Salts can be acidic, basic, or neutral depending on the strengths of the acid and base that formed them.

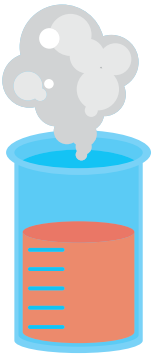


Fig. 2.21 Neutralisation reactions

Applications of Neutralisation in Daily Life

Neutralisation in Dental Care (Toothpaste Action)

The Problem:

This acid attacks the tooth enamel, the hard outer covering of teeth, leading to:

- Tooth decay
- Cavities
- Tooth sensitivity

The Solution:

Toothpaste contains mild bases such as:

- Calcium carbonate
- Magnesium hydroxide
- Sodium bicarbonate

These substances neutralise the acids in the mouth, protecting enamel and maintaining oral hygiene.

Health Tip:

Brushing your teeth twice a day—especially after meals—reduces acid buildup and helps prevent decay.

Fig. 2.22 Applications of Neutalisation

Keywords

Exothermic: A process that releases heat to the surroundings.

Ionic compound: A chemical compound formed by the electrostatic attraction between oppositely charged ions (typically a metal and a non-metal).

Science Behind It

The human stomach naturally produces hydrochloric acid (HCl) to help digest food and kill harmful microbes. This acid is essential but in moderation.

The Problem:

Sometimes, due to stress, irregular eating habits, or spicy food, the stomach secretes too much acid. This leads to a condition called acidity or indigestion, causing symptoms like:

The Solution:

To neutralise the excess acid, doctors recommend antacids, which are mild bases. Common antacids include:

- Milk of magnesia (magnesium hydroxide)
- Sodium bicarbonate (baking soda)
- Aluminium hydroxide

These bases react with the excess hydrochloric acid in the stomach to produce salt and water, providing quick relief.

a. Neutralisation in the Stomach (Acidity Relief)

Did You Know?

Cows and other ruminants chew cud, producing lots of alkaline saliva, which acts as a natural antacid and helps in digestion.

Science Behind It

Soil is the foundation of all plant life, and its pH level is a key factor in determining crop health.

The Problem:

Over time, soils may become too acidic due to:

- Use of acidic fertilizers (like ammonium sulfate)
- Acid rain
- Over-cultivation

Acidic soil makes it difficult for plants to absorb nutrients, leading to poor growth and low crop yield.

Fig. 2.23 Acidic Fertilizers

The Solution:

To correct this, farmers use basic substances to neutralise the acidity. These include:

- Quicklime (Calcium oxide - CaO)
- Slaked lime (Calcium hydroxide - $Ca(OH)_2$)
- Limestone (Calcium carbonate - $CaCO_3$)

These bases react with the acids in the soil, restoring a neutral or slightly basic pH, which is ideal for most crops.

b. Neutralisation in Agriculture (Soil Treatment)

Farmer's Tip:

Healthy agricultural soil typically has a pH between 6 and 7.5, which supports nutrient availability and microbial activity.

Science Behind It

Insect stings can introduce venom into the body, which can be either acidic or alkaline, depending on the insect.

The Problem:

Bee stings inject acidic venom into the skin.

Fig. 2.24 Bee stings

- Wasp stings, in contrast, inject alkaline venom.

These cause pain, swelling, redness, and irritation.

The Solution:

By applying the opposite type of substance, the venom is neutralised:

- For bee stings (acidic): Apply a mild base, like baking soda paste.
- For wasp stings (alkaline): Apply a mild acid, like lemon juice or vinegar.

This reduces pain and helps prevent further irritation.

c. Neutralisation in Insect Stings

Science in Action:

Always try to identify the insect before treating a sting, so that you can apply the right neutralising substance.

Science Behind It

Industries such as textiles, leather processing, and chemical manufacturing often release waste water containing strong acids or bases. These corrosive substances can harm aquatic life and damage pipelines or treatment infrastructure if not neutralized properly.If untreated, this polluted water can also contaminate soil and groundwater, posing risks to human health and agriculture.

Fig. 2.25 Industries Wastewater Flow

The Problem:

If this water is released into rivers or lakes without treatment, it can:

- Harm or kill aquatic life
- Disrupt **ecosystems**
- Corrode pipelines and storage systems

The Solution:

Before discharging the wastewater, it is tested for its pH. If it's:

- Too acidic, bases such as slaked lime or sodium hydroxide are added.
- Too basic, acids like sulfuric acid or carbon dioxide can be bubbled through.

This neutralises the water and brings its pH closer to neutral (7).

d. Neutralisation in Waste Water Treatment

Environment Alert:

Proper neutralisation in wastewater treatment is a legal and ecological requirement to protect the environment.

Science Behind It

When we eat sugary foods, bacteria in our mouth break down sugars and produce lactic acid as a by-product.

Keywords

Ecosystems: A community of living organisms interacting with each other and their physical environment.

Summary Table of Applications

Application Area	Problem (Acid/Base)	Solution (Neutralising Agent)	Result
Dental Care	Acids from bacteria	Toothpaste (mild base)	Protects enamel and prevents decay
Stomach (Acidity)	Excess HCl (acid)	Antacids (Milk of magnesia)	Relief from indigestion
Soil Treatment	Acidic soil	Quicklime or Slaked Lime	Fertile soil
Insect Stings	Acidic or basic venom	Baking soda / Vinegar or Lemon juice	Pain relief
Waste Water Treatment	Acidic industrial waste	Basic substances (e.g., lime)	Safe for discharge

Fact Flash

The "fizzing" when you take an antacid tablet (which is basic) for an upset stomach (excess stomach acid) is partly due to the neutralisation reaction, and some antacids also contain carbonates that release CO_2 gas, contributing to the fizz and sometimes a burp!

This is a chemical reaction between hydrochloric acid (HCl) in the stomach and metal carbonates like sodium bicarbonate ($NaHCO_3$) in the antacid.

The reaction produces salt, water, and carbon dioxide gas:

$$\mathbf{HCl + NaHCO_3 \rightarrow NaCl + H_2O + CO_2\uparrow}$$

This CO_2 gas is what causes bubbling in the stomach and can lead to **belching**.

Science Around Us

Our blood stays slightly basic (pH ~7.4) to keep us healthy and stable. When acids build up—like after intense exercise or certain illnesses—our body uses natural bases like bicarbonates to neutralise them. This ongoing neutralisation reaction helps maintain pH balance, protecting cells and organs. It's like having a tiny chemist inside you, working 24/7 to keep things just right!

Common Misconceptions

- × **Misconception:** Any base can be used as an antacid.
- ✓ **Correction:** Only mild, non-toxic bases like magnesium hydroxide or aluminum hydroxide are suitable as antacids. Strong bases like sodium hydroxide would be extremely harmful.
- × **Misconception:** Adding a lot of lime to soil is always good.
- ✓ **Correction:** Over-liming can make the soil too alkaline, which is also bad for most plants. Soil testing is important to determine the correct amount of treatment needed.

Keywords

Belching is the release of gas from the stomach through the mouth, often accompanied by a sound. It usually occurs when excess air or carbon dioxide builds up in the stomach and needs to escape.

Activity

Simulating Antacid Action

Objective: To demonstrate how an "antacid" (baking soda) neutralizes an "acid" (vinegar), using an indicator.

Materials: Vinegar (diluted), baking soda, water, a transparent glass, red cabbage indicator.

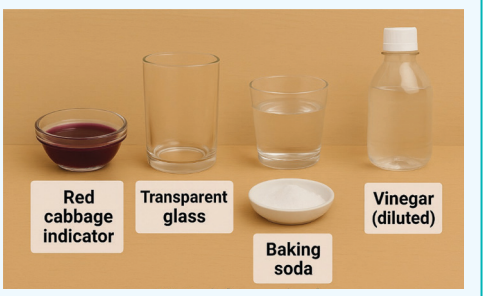


Fig. 2.26 Materials Required

Procedure:

1. Pour a small amount of diluted vinegar into the glass. This represents stomach acid.
2. Add a few drops of red cabbage indicator. The vinegar should turn red/pink (acidic).
3. Now, slowly add a small amount of baking soda (the "antacid") to the vinegar. Stir gently.
4. Observe the fizzing and the colour change of the indicator. As the baking soda neutralizes the acid, the colour should change from red/pink towards purple (neutral) and then possibly blue (if excess baking soda makes it basic).

Discussion: How did the colour of the indicator change as you added baking soda? What does this show about the effect of baking soda on the vinegar? How does this relate to how antacids work in your stomach?

Knowledge Checkpoint

Gap Analyzer™ Homework | Watch Remedial

Remembering

Short Answer Question:

1. Which of the following is used as an antacid to relieve indigestion?

   a) Vinegar ☐ b) Milk of Magnesia ☐ c) Lemon juice ☐ d) Common salt ☐

2. To treat an ant sting, which injects formic acid, one might apply:

   a) Baking soda solution ☐ b) Vinegar ☐

   c) Orange juice ☐ d) Salt water ☐

Applying

3. If factory waste is acidic, it is often treated with _____ before being discharged into water bodies.

   a) More acid ☐ b) Slaked lime (a base) ☐

   c) Salt ☐ d) Pure water ☐

Understanding

Short Answer Question:

4. Why is toothpaste generally basic in nature?

5. How does the treatment for an ant sting differ from the treatment for a wasp sting? Explain why.

Analyzing

Long Answer Question:

6. Describe three different situations from everyday life where the principle of neutralisation is applied. For each situation, explain the problem and how neutralisation provides a solution, naming the types of substances involved (acidic/basic).

SUMMARY

1. Acid, Base, and Neutral

All substances around us can be grouped as acidic, basic, or neutral based on how they behave in a solution.

- Acids are substances that usually taste sour. They are found in lemon juice, vinegar, and tamarind. Strong acids like hydrochloric acid and sulfuric acid can be corrosive, meaning they can wear away materials and should be handled with care. Acids turn blue litmus paper red, react with metals to release hydrogen gas, and with carbonates to release carbon dioxide.
- Neutral substances are neither acidic nor basic. They do not change the colour of indicators like litmus paper. Pure water, sugar solution, and salt solution are common neutral substances.
- The pH scale helps measure how acidic or basic a solution is. A pH less than 7 means acidic, more than 7 means basic, and exactly 7 means neutral.

2. Indicators and their types

There are different types of indicators:

- Natural indicators come from plants. One common natural indicator is litmus, made from lichens. Litmus paper comes in red and blue. Acids turn blue litmus red, and bases turn red litmus blue. If there is no change, the substance is likely neutral.
- Turmeric, a yellow spice, also acts as a natural indicator. It stays yellow in acids and neutral substances but turns reddish-brown in bases. However, it cannot distinguish between acids and neutral substances.
- Red cabbage extract is another powerful indicator. It gives a variety of colours depending on the pH of the solution—from red in acids, purple in neutral, to blue or green in bases.
- Olfactory indicators change their smell in acidic or basic solutions. For example, onion and vanilla lose their smell in a basic solution but retain it in acidic conditions. This is especially useful in identifying chemical nature when visual changes are hard to detect.

3. Neutralisation: Concept and Applications

Neutralisation is a chemical reaction that occurs when an acid and a base combine. In this reaction, the acid and base cancel each other out, forming salt and water. This process also gives off heat, making it an exothermic reaction.

The general form of the reaction is:

Acid + Base → Salt + Water + Heat

This reaction has many useful applications in daily life:

- When we suffer from indigestion due to excess acid in the stomach, we take antacids like milk of magnesia (a base) to neutralise the acid and relieve discomfort.
- Bee stings are acidic. Applying a base like baking soda helps neutralise the pain. On the other hand, wasp stings are alkaline, so applying lemon juice or vinegar (acidic) helps reduce irritation.
- Farmers use neutralisation to correct the pH of soil. If the soil is too acidic, adding slaked lime or quicklime (both are bases) helps to balance it, making it more suitable for growing crops.
- In factories, waste often contains acidic or basic substances. These are neutralised before the waste is released into rivers to protect aquatic life.

Example Based Questions

Multiple Choice Questions

1. What helps flowers bloom beautifully in a garden?

(a) Rain only

(b) Sunlight and temperature through photosynthesis

(c) Just soil nutrients

(d) Strong winds

Answer: (b) Sunlight and temperature through photosynthesis

Explanation: Flowers respond to sunlight and temperature. Through photosynthesis, plants use sunlight to make their own food, which helps them grow and bloom. Rain and soil are important, but without sunlight, plants cannot produce food. Strong winds don't help flowers bloom.

2. When ice melts in your juice, which change is happening?

(a) Liquid to gas (b) Gas to solid

(c) Solid to liquid (d) Liquid to solid

Answer: (c) Solid to liquid

Explanation: Melting is the process where a solid changes into a liquid because of heat. Ice (solid) takes in heat from the juice and turns into water (liquid). This is a change in the state of matter.

Short Answer Questions

5. Why do astronauts use the scientific method while growing food in space?

Answer: Astronauts use the scientific method because conditions in space are very different from Earth. In microgravity, plants may not grow in the same way. By using the scientific method—making observations, forming hypotheses, conducting experiments, and drawing conclusions—astronauts can test how light, water, soil, and air affect plants in space. This helps them discover the best way to grow food, which is important for long space journeys and future space missions.

6. Give one difference between an observation and a conclusion in the scientific method.

Answer: An observation is something that we notice directly using our senses or instruments. For example, "the plant grew 5 cm taller in a week". A conclusion is the explanation or decision we make after studying and analyzing those observations. For example, "plants grow faster in sunlight than in shade". Thus, observation is about what we see or measure, while conclusion is about the meaning we take from it.

7. Name two ways scientists study the universe.

Answer: Using telescopes: Scientists use optical telescopes and radio telescopes to observe stars, planets, galaxies, and other heavenly bodies. Telescopes help us see far-away objects and collect light or radio waves from space.

Sending satellites and space probes: Space agencies send satellites and spacecraft into space to study planets, moons, and even distant asteroids. For example, satellites give us images of Earth and Mars, while space probes like Voyager explore the outer solar system.

Long Answer Questions

8. Riya noticed that the Moon looks different on different nights. She wanted to study this scientifically. Write the steps of the scientific method she would follow.

Answer: Observation: Riya saw that the Moon looks different in the sky every night.

Question: She wondered, "Why does the Moon keep changing its shape?"

Hypothesis: She guessed that maybe clouds are covering the Moon and changing its shape.

Experiment/Investigation: Riya carefully observed the Moon for a full month and kept daily notes. She also compared her observations with information in science books.

Result: She found that the changes in the Moon are regular and follow a cycle, not because of clouds.

Conclusion: The different shapes are due to the revolution of the Moon around Earth. These are called phases of the Moon.

EXERCISE

Gap Analyzer™
Complete Chapter Test

A. MCQ (Multiple Choice Questions)

1. Which of the following substances will turn blue litmus paper red?
   (a) Soap solution ☐ (b) Lime water ☐
   (c) Lemon juice ☐ (d) Common salt solution ☐
2. A substance that is used to test if a solution is acidic or basic is called an:
   (a) Catalyst ☐ (b) Indicator ☐
   (c) Solvent ☐ (d) Reactant ☐
3. When an acidic solution reacts with a basic solution, the reaction is called:
   (a) Oxidation ☐ (b) Reduction ☐
   (c) Neutralization ☐ (d) Dissolution ☐
4. Turmeric paper turns which color when dipped in a basic solution?
   (a) Red ☐ (b) Yellow ☐
   (c) Green ☐ (d) Blue ☐
5. Which of the following is a neutral substance?
   (a) Vinegar ☐ (b) Baking soda solution ☐
   (c) Distilled water ☐ (d) Window cleaner ☐

B. Fill in the Blanks

1. Substances that taste sour are typically _____.
2. Bases usually have a _____ taste and a soapy feel.
3. The products of a neutralization reaction are salt and _____.
4. China rose indicator turns _____ to green in a basic solution.
5. Common examples of strong acids include hydrochloric acid and _____ acid.

C. Write True or False.

1. All acids are corrosive and dangerous to touch. _____
2. Phenolphthalein indicator remains colorless in basic solutions. _____
3. Wasp stings are acidic, and applying baking soda can provide relief. _____
4. Acid rain is caused by acidic gases like sulfur dioxide and nitrogen dioxide mixing with rainwater. _____
5. Tooth decay is primarily caused by acids produced by bacteria in the mouth. _____

D. Define the following terms

1. Acid
2. Base
3. Indicator
4. Neutralization Reaction
5. Salt

E. Match the column

Column A	Column B
1. Vinegar	(a) Turns red litmus blue
2. Baking Soda Solution	(b) Found in stomach acid
3. Hydrochloric Acid	(c) Neutralizes acid rain
4. Lime water	(d) Turns blue litmus red
5. Slaked Lime	(e) Used as an antacid (mild base)

F. Assertion and Reason

Directions: In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is NOT the correct explanation of A.

(c) A is true but R is false.

(d) A is false but R is true.

(e) Both A and R are false.

1. **Assertion (A):** All indicators show the same color change for both acids and bases.

   Reason (R): Indicators are natural substances derived from plants.

2. **Assertion (A):** Antacids are used to relieve stomach acidity.

   Reason (R): Antacids are basic in nature and neutralize excess acid.

3. **Assertion (A):** Distilled water does not change the color of litmus paper.

   Reason (R): Distilled water is a neutral substance.

G. Give Reason for the following Statement

1. Why do chemists often use litmus paper to test unknown solutions?
2. Why should you never taste an unknown substance to determine if it is acidic or basic?
3. Why is toothpaste generally basic in nature?
4. Why might a farmer add quicklime (calcium oxide) to their soil?

H. Answer in Brief

1. How do indicators help identify whether a substance is acidic, basic, or neutral?
2. What happens during a neutralisation reaction?
3. Can you name three acidic and three basic substances found at home?
4. Why do ant stings feel painful or itchy?

I. Answer in Detail

1. Why is the pH scale important in science and health? Explain what pH values indicate about a substance's nature (acidic, basic, or neutral).
2. How do synthetic indicators like phenolphthalein and methyl orange behave in different solutions? Describe the color changes you would observe.
3. What are the major impacts of acid rain on ecosystems and buildings? Explain how acidic substances in the atmosphere contribute to this issue.
4. In what ways can natural materials like litmus, turmeric, or hibiscus petals be used to detect acids and bases? Describe the color changes seen.

SKILL-BASED PRACTICE

Activity Time

STEM

Homemade pH Indicators

Materials Needed: Red cabbage, hot water, a strainer, clear cups, and liquids like lemon juice, vinegar, baking soda solution, soap solution, soda water, and distilled water.

Activity Steps:

1. Soak chopped cabbage in hot water for 10–15 minutes.
2. Strain to get a purple indicator liquid.
3. Pour each test liquid into clear cups.
4. Add a few drops of the cabbage indicator to each and watch the colors change!

Materials Required

Questions:

- Which liquids turned the indicator pink, green, or stayed purple?
- What do these color changes say about acids, bases, and neutral substances?
- Why is this a fun way to learn about indicators?

Skills Covered: Observation, Scientific Reasoning, Data Collection and Analysis

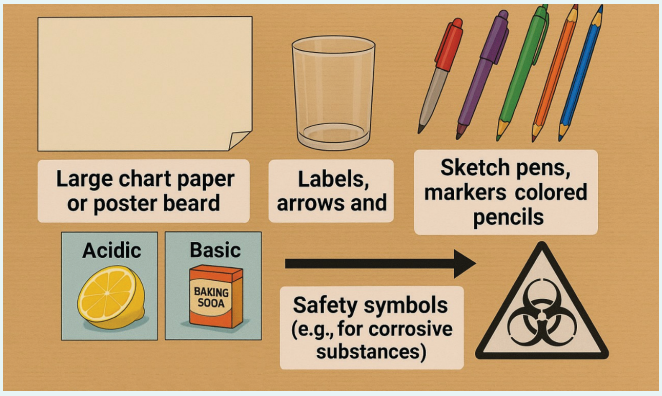
Creativity Art

Art

Acids, Bases, & Neutral Poster

Task: Design a colorful and informative poster that visually represents the properties of acids, bases, and neutral substances. Include examples, common indicators and their color changes, and relevant safety symbols.

Materials to Use: Large chart paper or poster board, Sketch pens, markers, colored pencils, Pictures or drawings of common acidic/basic items, Labels, arrows, and clear headings, Safety symbols (e.g., for corrosive substances)



Materials Required

Questions to Answer:

- How did you clearly show the color changes of different indicators?
- How does your poster effectively convey important safety information related to handling acids and bases?

Skills Covered: Creativity, Visual Representation, Conceptual Understanding, Safety Awareness

Soil pH Testing

Group Activity

Activity Instructions: Work in a group. Collect small samples of soil from 2-3 different locations (e.g., garden, potted plant, near a wall).

1. Mix each soil sample with a bit of distilled water to make a muddy paste.
2. Dip a strip of universal or litmus paper into the liquid part of each mixture.
3. Watch for a color change and compare it with a pH chart to find the pH level.
4. Find out which plants grow best in acidic, neutral, or basic soil based on your results.

Questions:

- What were the approximate pH values of your soil samples?
- Which soil sample was the most acidic, basic, or neutral?
- Based on your findings, what types of plants would thrive best in each of your soil samples?

Skills Covered: Scientific Testing, Data Interpretation, Teamwork, Environmental Awareness

The Antacid Dilemma

Case Study

Mr. Sharma often experiences indigestion after meals, which gives him a burning sensation in his stomach. He knows that his stomach produces too much acid, and he takes an antacid tablet to relieve the discomfort. His friend, Mrs. Kapoor, suggests that instead of antacids, he could just drink a glass of vinegar.

- **Guiding Questions:**
  1. What is causing Mr. Sharma's burning sensation in his stomach?
  2. What is the chemical nature (acidic, basic, or neutral) of an antacid?
  3. How does an antacid tablet relieve Mr. Sharma's indigestion?
  4. Why is Mrs. Kapoor's suggestion of drinking vinegar a bad idea for relieving stomach acidity? (Hint: Think about the nature of vinegar.)
  5. What are the general products formed when an antacid reacts with the excess acid in the stomach?

Skills Covered: Classification, Analysis, Teamwork, Communication, Scientific Investigation.

The Discovery of Acids, Bases, and Neutral Substances

Source Based Question

"In the 17th century, Irish chemist Robert Boyle was among the first to distinguish acids and bases by their properties. He noted that acids taste sour and could dissolve metals, while bases felt slippery and could counteract acids. Later, in the 18th century, French chemist Antoine Lavoisier proposed that acids contained oxygen, although this idea was revised by other scientists. In 1884, Swedish chemist Svante Arrhenius gave the first modern definition: acids are substances that release hydrogen ions in water, and bases release hydroxide ions. Over time, natural indicators such as litmus from lichens and turmeric were used to test substances. These historical discoveries laid the foundation for today's understanding of acids, bases, and neutral substances, which continue to be vital in chemistry, medicine, and industry."

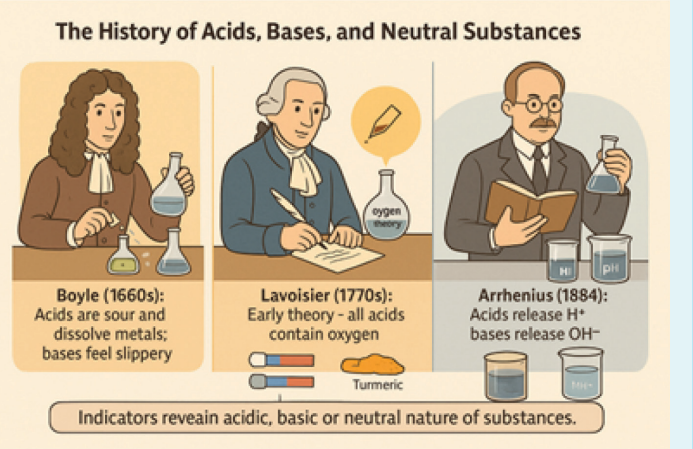


Image Credit: : NASA Climate Education

Guiding Questions for Analysis:

1. **Early Observations**
   - What properties of acids and bases did Robert Boyle identify in the 17th century?
   - Why do you think these observations were important for future experiments?
2. **Scientific Contributions**
   - What was Antoine Lavoisier's early idea about acids, and how was it later changed?
   - Which chemist gave the first modern definition of acids and bases?
3. **Use of Indicators**
   - What natural indicators were used historically to test acids and bases?
   - How do these indicators help in identifying whether a substance is acidic or basic?
4. **Critical Thinking (Historical Connection)**
   - Imagine you are a scientist in the 17th century with no modern lab equipment. How would you test if a substance was an acid or a base?
   - Why is it important to study the historical background of scientific concepts like acids and bases?

Skills Covered: Historical analysis in science, Observation and classification, Understanding scientific