5
Chapter

Physical and Chemical Changes

We'll cover the following key points:

- Physical Changes
- Chemical Changes
- Rusting of Iron and Crystallization

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Learning Outcomes

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

- Understand the concept of physical and chemical changes and their significance in daily life.
- Differentiate between physical changes, which do not alter the substance's composition, and chemical changes, which result in new substances.
- Explain the process of rusting of iron as a chemical change and identify the conditions that accelerate it.
- Describe crystallization as a method of obtaining pure substances from solutions.

Guidelines for Teachers

The teacher can begin the chapter by explaining the difference between physical and chemical changes using simple examples like melting ice (physical change) and burning paper (chemical change). Demonstrate rusting by exposing iron to air and moisture and discuss its environmental impact. Use experiments, such as the crystallization of salt from water, to provide hands-on learning. Linking these changes to real-world examples, like industrial corrosion or sugar crystallization, can make the topic relatable and engaging.

NCF Curricular Goals and Competencies

This chapter aligns with the following curricular goals and competencies:

CG-2 (C 2.1): Develops an understanding of the properties and changes in materials through observation and experimentation.CG-3 (C 3.4): Analyzes chemical changes, such as rusting, and explores methods to prevent or control them.

Mind Map

PHYSICAL AND CHEMICAL CHANGES

Physical Change

A change in which a substance undergoes a change in its physical properties is called a physical change.


Melting


Shredding


Boiling


Chopping

Rusting

The slow conversion of iron into its hydrated oxide, in the presence of moisture and air is called rusting , whereas the hydrated oxide of iron is called rust.

- **Reaction of Rusting**
  - ✓ Iron (Fe) + oxygen (O_2) + Water (H_2O) ⟶ Rust (iron oxide Fe_2O_3)
- **Galvanisation**
  - ✓ The process of depositing a layer of zinc on iron is called galvanization.

Chemical Change

A change which alters the specific properties of a material by bringing about a change in its molecular composition, followed by a change in state, is called a chemical change.


Combustion

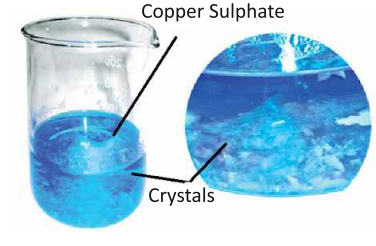

Rotting


Rusting


Digestion

Crystallization

Crystallization is a process by which a pure soluble substance separates out in the form of crystals form its hot and saturated solution on cooling.



Based on NCERT*

Introduction:

We notice different changes all around us. These changes in matter around us can be identified by observing changes in the physical characteristics like size, shape and colour of the matter. Yet there can be changes in chemical properties of a matter which tell us about their chemical composition. Try to make a list of changes which you commonly observe around you.

In history...

- **Antoine Lavoisier's Experiments (18th Century):** Antoine Lavoisier, often referred to as the "father of modern chemistry," demonstrated the difference between physical changes and chemical reactions, laying the foundation for modern chemical theory.
- **Discovery of Rusting Process (19th Century):** Scientists discovered that rusting is a chemical change involving the reaction of iron with oxygen and water, which was a significant step in understanding corrosion and material science.

Physical Changes

Riya and Kabir are playing with a piece of clay.

Let us carefully examine some changes by carrying the following activities to understand physical changes.

Activity 1

Melting of ice and again freezing of water (melted ice)

Take some cubes of ice in a 250 ml beaker and keep it in sunlight for some time. You will observe that ice starts melting and all the ice get melted in some time. Now put the melted ice (water) in a

ice tray and keep it into freezer. After some time you will again get the ice cubes.

Activity 2

Boiling of water to convert into steam and again cooling the steam to convert it into water

Take about 50 ml of water in a 250 ml beaker. Heat the beaker, containing water, on a gas burner. After some time, water will start boiling and water vapor will evolve. Hold an inverted pan by its handle over the steam at some distance from the boiling water. You will observe that the water droplets are collected on the inner surface of the pan.

In all the above two activities we see that the composition of the substance do not change.

- In activity 1, ice changes into water and water changes back into ice. Thus, the chemical composition of the ice or water remains the same throughout the activity. Only the state of the substance changes from one state to another.
- In activity 2, water gets converted into water vapour and water vapour gets converted back into water. So, the composition of the water or water vapour remains the same. No new substance is formed. Only the change of state (liquid to vapour and vice versa) takes place.

Properties such as shape, size, colour and state, temperature of a substance are called its physical properties.

A change in which a substance undergoes a change in its physical properties is called a physical change. Examples are :

- Melting of ice or freezing of water.
- **Dissolution** of salt or sugar into water.
- Melting of wax.
- Evaporation or condensation.
- Expansion of iron rim on heating and contraction on cooling.
- Cutting of paper sheet into smaller pieces etc.

Characteristics of a Physical Change

- A physical change is generally reversible.
- In such a change, no new substance is formed.
- Only physical properties of the substance change.

KEYWORDS

Dissolution: Dissolution is the process in which a solute dissolves in a solvent to form a homogeneous solution.

Let's recall what we know

SCAN TO ACCESS

Take a Task

Watch Remedial

Apply Concept in Context

Apply

- Explain what happens to the properties of a substance during a physical change.
- Why is melting ice considered a physical change and not a chemical one?

Skills Covered: Critical and logical thinking, Brainstorming, Applicative thinking

Examine Further

Analyse

- Research what happens when you mix sand and water. Is it a physical or a chemical change, and why?
- Compare and contrast the processes involved in boiling water and freezing water.

Skills Covered: Critical and logical thinking, Brainstorming, Applicative thinking, Research

Self-Assessment Questions

Evaluate

- Define a physical change and give two examples from your surroundings.
- Identify physical changes that you see daily and explain why they are not chemical changes.

Skills Covered: Evaluation, Logical thinking

Creative Insight

Create

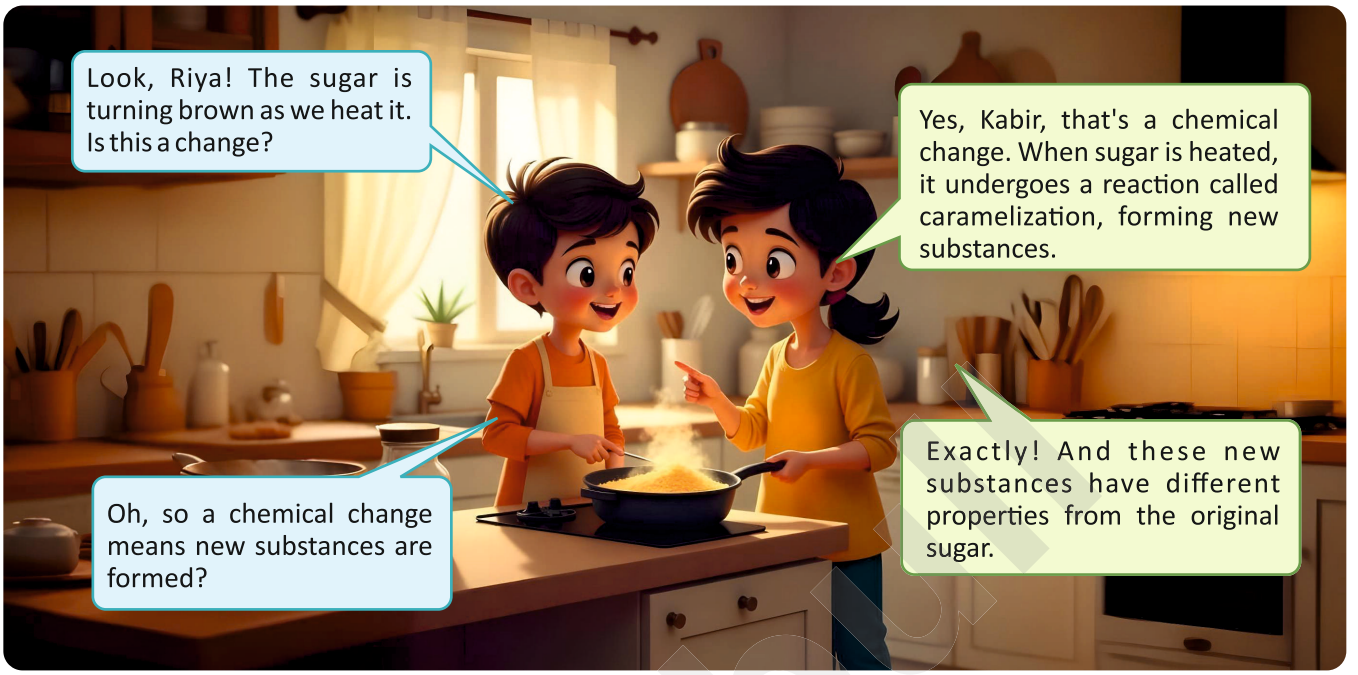
List ten examples of physical changes you observe in your surroundings. Present this information in a creative table or chart with columns for type of change, example, and characteristics.

Skills Covered: Creativity, Critical and logical thinking, Brainstorming, Observation, Organization

Bloom's Taxonomy

Chemical Changes

Riya and Kabir are cooking in the kitchen.

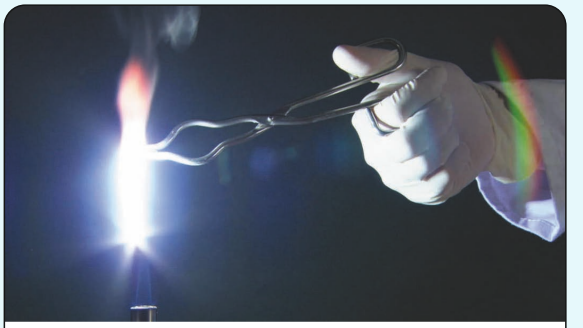


In order to understand the chemical changes, let us perform the following activities and carefully examine the changes that occur during these activities.

Activity 3

Changing magnesium into magnesium oxide and magnesium oxide into magnesium hydroxide.

(This activity needs caution. So, it should be demonstrated by the teacher) Take a small piece of magnesium ribbon. Clean the surface of the ribbon with the help of a piece of sandpaper. Burn the ribbon with the help of a candle flame. It burns with a brilliant white light.



Burning magnesium ribbon

On complete burning the magnesium ribbon gets converted into powdered ash which is different from the magnesium ribbon. Thus a new substance is formed. The change can be represented by the following equation:

$$\underset{\text{(Magnesium)}}{Mg} + \underset{\text{(Oxygen)}}{O_2} \longrightarrow \underset{\text{(Magnesium oxide)}}{MgO}$$

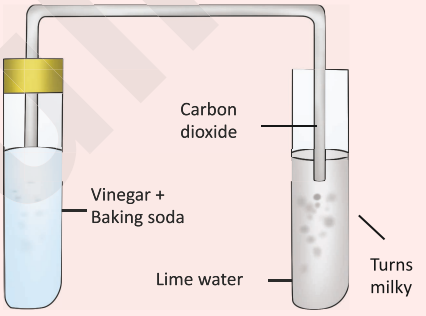
Collect the ash and mix it with a small amount of water. Stir the mixture (**aqueous solution**) well. Test the mixture with blue and red litmus papers. Does the mixture turn red litmus blue? Does the mixture turn blue litmus red? On the basis of this test, how do you classify the aqueous solution — acidic or basic? On dissolving the **ash** in water, it forms a new substance. This change can be written in the form of the following equation:

$$\underset{\text{(Magnesium oxide)}}{(MgO} + \underset{\text{(Water)}}{H_2O} \longrightarrow \underset{\text{(Magnesium hydroxide)}}{Mg(OH)_2}$$

As you have already learnt in this Chapter , magnesium hydroxide is a base. So, magnesium oxide is a new substance formed on burning of magnesium and magnesium hydroxide is another new substance formed by mixing magnesium oxide with water.

Activity 4

Take about a teaspoonful of vinegar in a test tube. Add a pinch of baking soda to it. You would hear a hissing sound and see bubbles of a gas coming out. Pass this gas into freshly prepared lime water solution as shown here.

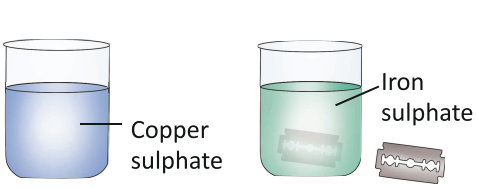


Set up to pass gas through lime water

Activity 5

Blue colour of aqueous solution of copper sulphate changes to green by the formation of iron sulphate.

Take about 50 g of copper sulphate (blue vitriol or **neela thotha**) in about 100 mL of water in a beaker. Add a few drops of dilute sulphuric acid to the solution. You should get a blue coloured solution. Take half of the solution in another beaker. Drop a nail or a used shaving blade into the remaining solution. Wait for half an hour or so. Observe the colour of the solution. Compare it with the colour of the sample solution saved separately. Take out the nail or the blade. Has it changed in any way?



Change in colour of the copper sulphate solution due to reaction with iron

KEYWORDS

Aqueous Solution: An aqueous solution is a liquid mixture where water acts as the solvent, dissolving other substances.

Ash: Ash is the solid residue left after the combustion of a material, primarily composed of inorganic minerals.

The changes that you notice are due to a reaction between copper sulphate and iron. The change in colour of the solution from blue to green is due to the formation of iron sulphate, a new substance. The brown deposit on the iron nail is copper, another new substance. We can write the reaction as:

Copper sulphate solution (blue) + Iron ⟶ Iron sulphate solution (green) + Copper (brown deposit)

What happens to the lime water? Do you see any change in the colour of the solution? The change in the test tube is as follows:

Vinegar (Acetic acid) + Baking soda (Sodium hydrogencarbonate) ⟶ Carbon dioxide + other substances

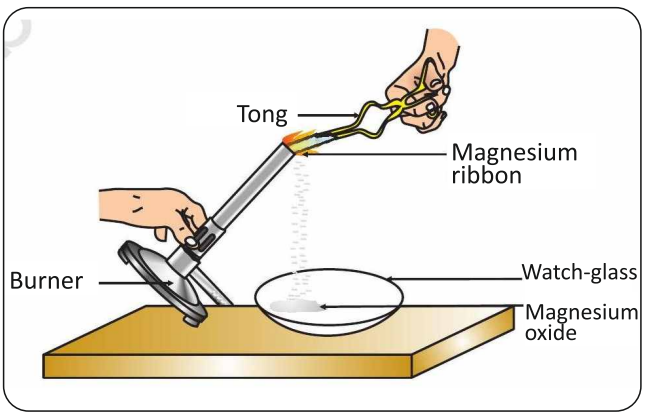
The reaction between carbon dioxide and lime water is as follows:

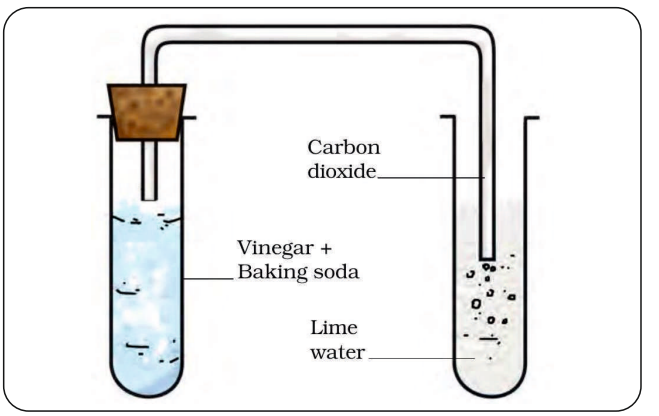
Carbon dioxide (CO_2) + Lime water [$Ca(OH)_2$] ⟶ Calcium Carbonate ($CaCO_3$) + Water (H_2O)

When carbon dioxide is passed through lime water, calcium carbonate is formed, which makes lime water milky. The turning of lime water into milky is a standard test of carbon dioxide.

In Activities , we observed that in each change one or more new substances were formed.

- In Activity 3, the ash was the new substance formed when magnesium was burnt. It is magnesium oxide. When this magnesium oxide is dissolved in water, another new substance magnesium hydroxide was formed.
- In Activity 4, vinegar and baking soda together produced carbon dioxide, which turned lime water milky. A change in which one or more new substances are formed is called a chemical change. A chemical change is also called a chemical reaction.
- In Activity 5, the reaction of copper sulphate with iron produced iron sulphate and copper. Both of these are new substances. Copper was deposited on the shaving blade of iron.





Let's recall what we know

SCAN TO ACCESS

Take a Task

Watch Remedial

Apply Concept in Context

Apply

- Provide two examples of chemical changes that occur in the kitchen. How do these changes affect the original materials?
- How does heating sugar lead to a chemical change?

Skills Covered: Critical and logical thinking, Brainstorming, Applicative thinking

Examine Further

Analyse

- Research the process of cooking an egg. Is it a physical or a chemical change, and why?
- Compare the changes that occur during the cooking of vegetables and the rusting of iron.

Skills Covered: Critical and logical thinking, Brainstorming, Applicative thinking, Research

Self-Assessment Questions

Evaluate

- Define a chemical change and explain how it differs from a physical change.
- Identify chemical changes that occur when cooking food and explain why they are chemical changes.

Skills Covered: Evaluation, Logical thinking, Observation

Creative Insight

Create

List ten examples of substances that undergo chemical changes in the kitchen. Create a table or chart with columns for substance, type of chemical change, and result.

Skills Covered: Creativity, Critical and logical thinking, Brainstorming, Observation, Organization

Bloom's Taxonomy

Rusting of Iron and Crystallization

Riya and Kabir are observing an old, rusted bicycle.

You must have noticed many a times, iron benches, gates and railings in the park need to be painted regularly?

When a piece of iron is left in an open place with lots of humidity or in a wet place for a few days, a reddish-brown colour appears on its surface. This is rust.

Rust is an iron compound that forms due to the reaction of iron with water and oxygen. The process of formation of rust is called rusting. It is a chemical reaction that takes place over a period of time. Oxygen and water must be present for iron to rust.

Rusting of Iron

Iron (Fe) + Oxygen (O_2, from the air) + Water(H_2O) ⟶ Rust (iron oxide Fe_2O_3)

Did You Know ?

Rusting is faster in presence of salt. Parts of a ship which remain submerged in sea water rust much faster than the other parts. In spite of painting them regularly, they get demaged by rusting and need regular repairing.

For rusting, the presence of both oxygen and water (or water vapour) is essential.

In fact, if the content of moisture in air is high, which means if it is more humid, rusting becomes faster.

Prevention of rusting

- Prevent iron articles from coming in contact with oxygen or water or both.
- One simple way is to apply a coat of paint or grease. In fact, these coats should be applied regularly to prevent rusting.
- Another way is to deposit a layer of a metal like chromium or zinc on iron.
- This process of depositing a layer of zinc on iron is called galvanisation. The iron pipes we use in our homes to carry water are galvanised to prevent rusting.

You know that ships are made of iron and a part of them remains under water. On the part above water also, water drops keep clinging to the ship's outer surface. Moreover, the water of the sea contains many salts. The salt water makes the process of rust formation faster.

Crystallisation

Crystallisation is the process by which pure crystals of a substance are obtained from its impure solution.

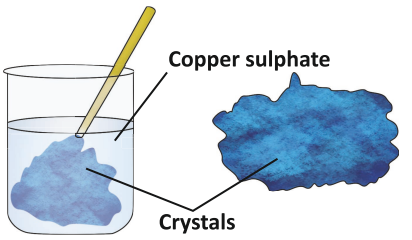
Pure salt crystals can be obtained from sea water by the method of crystallization.

Let us understand the concept of crystallization with the help of an activity.

Activity 6

(To be performed in the presence of a teacher)

Take a cup full of water in a beaker and add a few drops of dilute sulphuric acid. Heat the water. When it starts boiling, add copper sulphate powder slowly while stirring continuously. Continue adding copper sulphate powder till no more powder can be dissolved. Filter the solution. Allow it to cool. Do not disturb the solution when it is cooling. Look at the solution after some time. Can you see the crystals of copper sulphate? If not, wait for some more time.



Crystals of copper sulphate

Let's recall what we know

SCAN TO ACCESS

Take a Task

Watch Remedial

Apply Concept in Context

Apply

- Provide two examples of chemical changes involving metals. How do these changes affect the original material?
- How does exposure to air and moisture lead to the rusting of iron?

Skills Covered: Critical and logical thinking, Brainstorming, Applicative thinking

Examine Further

Analyse

- Research the process of crystallization. How is it different from other physical changes?
- Compare rusting and crystallization as types of chemical changes.

Skills Covered: Critical and logical thinking, Brainstorming, Applicative thinking, Research

Self-Assessment Questions

Evaluate

- Define rusting and explain why it is a chemical change.
- Which materials around you are prone to rusting? How can we prevent it?

Skills Covered: Evaluation, Logical thinking

Creative Insight

Create

List ten examples of substances that undergo chemical changes and categorize them (e.g., oxidation, burning, crystallization). Create a table or chart with columns for substance, type of chemical change, and result.

Skills Covered: Creativity, Critical and logical thinking, Brainstorming, Observation, Organization

Bloom's Taxonomy

SUMMARY

Physical Changes

A physical change is a change in a substance that does not alter its chemical composition. Physical changes are usually reversible and involve changes in physical properties such as size, shape, phase, or texture. Examples include melting ice, breaking a piece of chalk, or dissolving salt in water. In these cases, the substance maintains its original identity, and the change can often be undone. Melting, freezing, evaporation, condensation, and sublimation are all examples of phase changes, which are types of physical changes.

Physical changes are characterized by the absence of any new substance formation. For instance, when ice melts into water, it remains H_2O in both solid and liquid states. Physical changes are often caused by changes in temperature, pressure, or physical forces.

Chemical Changes

A chemical change, on the other hand, results in the formation of one or more new substances with different chemical properties from the original. These changes are usually irreversible without chemical intervention. Chemical changes are also called chemical reactions. Common examples include rusting of iron, burning wood, cooking food, or the formation of curd from milk.

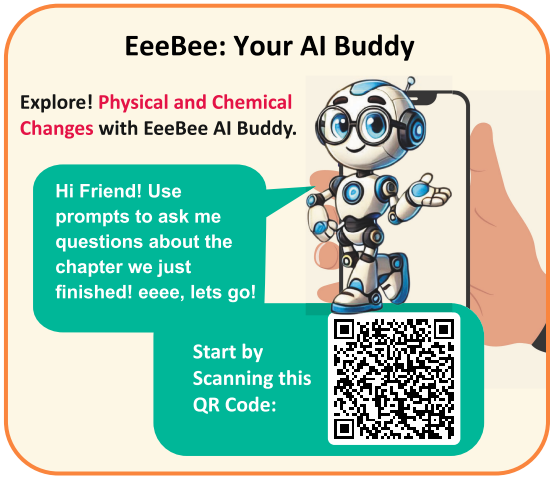
A classic chemical change is the rusting of iron, which occurs when iron reacts with oxygen in the presence of moisture to form iron oxide, commonly known as rust. This process not only changes the appearance of iron but also weakens its structural integrity. Unlike physical changes, chemical changes involve breaking and forming chemical bonds, which results in different molecular compositions.

Rusting of Iron and Crystallization

Rusting and crystallization are both examples of chemical changes that involve the formation of new substances. Rusting involves the reaction of iron with oxygen and moisture, producing a flaky, reddish-brown substance called rust. Crystallization, on the other hand, is a process in which a dissolved substance forms solid crystals from a solution.

Differences Between Physical and Chemical Changes

The fundamental difference between physical and chemical changes is that a physical change affects only physical properties, while a chemical change alters the composition and produces new substances. Physical changes are usually temporary and reversible, whereas chemical changes are permanent and often irreversible. The study of these changes is crucial in understanding the material world and in various fields such as chemistry, engineering, materials science, and environmental science.



EXERCISE

That turn curiosity into confidence—let's begin!

Gap Analyzer™
Take a Test

A. Choose the correct answer.

1. Which of the following best describes a physical change?
   (a) Producing a new substance ☐ (b) Changing shape ☐
   (c) Rusting ☐ (d) Burning wood ☐
2. Which of the following is a chemical change?
   (a) Freezing water ☐ (b) Dissolving sugar in water ☐
   (c) Rusting of iron ☐ (d) Melting ice ☐
3. Which of the following substances undergoes crystallization?
   (a) Wood ☐ (b) Iron ☐
   (c) Salt in a solution ☐ (d) Plastic ☐
4. Which of the following is a characteristic of a chemical change?
   (a) No new substance is formed ☐ (b) It can be easily reversed ☐
   (c) New substances are formed with different properties ☐ (d) It only changes the state of matter ☐
5. What is the result of rusting of iron?
   (a) Iron oxide ☐ (b) Water ☐
   (c) Salt ☐ (d) Hydrogen gas ☐

B. Fill in the blanks.

1. The process of changing shape without altering the chemical composition is called a _____ change.
2. Rusting of iron is an example of a _____ change.
3. _____ is the process in which dissolved substances form solid crystals.
4. Boiling water is a _____ change.
5. During a chemical change, _____ substances are formed.

C. Write True or False.

1. Physical changes involve the formation of new substances. _____
2. Rusting of iron is a chemical change. _____
3. Crystallization is always a physical change. _____
4. Boiling water is an example of a physical change. _____
5. Rusting weakens the original metal. _____

D. Define the following terms.

1. Physical change
2. Chemical change
3. Rusting
4. Crystallization
5. Chemical reaction

E. Match the columns.

Column A	Column B
(i) Physical change	(a) Formation of crystals
(ii) Chemical change	(b) Rusting of iron
(iii) Rusting	(c) Changes in shape
(iv) Crystallization	(d) New substances formed
(v) Boiling water	(e) Evaporation

F. Give reasons for the following statements.

1. Rusting is considered a chemical change.
2. Boiling water is a physical change and not a chemical change.
3. Crystallization can result in the formation of a pure substance.
4. Physical changes are usually reversible.
5. Chemical changes often involve energy changes.

G. Answer in brief.

1. What is a physical change?
2. How does rusting occur?
3. Why is crystallization important in daily life?
4. How do physical and chemical changes differ?
5. Provide an example of a physical change involving water.

H. Answer in detail.

1. Explain the process of rusting. How can rusting be prevented?
2. Describe crystallization and its significance.
3. Compare and contrast physical changes and chemical changes with examples.
4. Discuss the various ways physical changes can occur in substances.
5. How does a chemical change differ from a physical change in terms of energy requirements and new substance formation?

NEP Corner

Know about NEP 2020

More Play, Less Pressure!

The policy encourages bagless days and internships even for school students, so you learn through fun and hands-on experience.

Skill-based Activity

Mapping Changes

STEM

Observe the melting of ice and the rusting of iron. Write a question about how each change occurs. Using the scientific method, describe the steps you would take to answer your questions.

Skills Covered: Critical and logical thinking, Brainstorming, Analytical thinking, Problem-solving, Curiosity, Observation, Decision-making skills

Wonders of Change

Art

Create a detailed sketch showing the rusting process of iron or the process of crystallization. Write a description explaining how the process occurs. Present your work to the class.

Skills Covered: Creativity, Critical and logical thinking, Applicative thinking

Types of Changes in Action

Group Activity

In groups, create a chart comparing physical and chemical changes with examples from daily life. Present your findings, highlighting similarities and differences.

Skills Covered: Critical and logical thinking, Brainstorming, Teamwork, Communication, Applicative thinking, Decision-making skills

Technology in Focus

Case to Investigate

Research how chemical changes are applied in technology, such as rust prevention or crystal production. Write a short report on how these processes benefit industries or daily life.

Skills Covered: Critical and logical thinking, Brainstorming, Research, Applicative thinking

Sustainable Changes

Aligning with SDGs

Research a program or initiative that focuses on preventing material degradation, like rusting. Highlight its key features and how it aligns with sustainable development goals. Present your findings to the class.

Aligned with: SDG 12 – Responsible Consumption and Production

Skills Covered: Critical and logical thinking, Brainstorming, Research, Problem-solving, Ethics

Curious Minds at Work

Integrated Learning

Using the Internet, create a map showing different regions where specific materials (e.g., iron or salt) undergo significant changes like rusting or crystallization. Explain how environmental conditions affect these changes.

Integrated Learning: Geography and Chemistry

Skills Covered: Critical and logical thinking, Brainstorming, Analytical thinking, Applicative thinking