06 PHYSICAL AND CHEMICAL CHANGES

🎯 Learning Objectives

- Understand what physical changes are and their characteristics
- Understand what chemical changes are and their characteristics
- Learn various examples of physical and chemical changes
- Compare and differentiate physical and chemical changes
- Understand rusting of iron, its causes and prevention methods
- Learn about crystallisation as a method of purification
- Explore changes in everyday life (galvanisation, stainless steel)
- Study solved examples on endothermic and exothermic reactions

6.1 Introduction

We have learnt in previous class about different changes around us like periodic and non-periodic, slow and fast changes, reversible and irreversible changes around us and their causes. Every change has a cause — for example, days change to night because of rotation of earth around the sun; melting of ice is due to heat supplied.

There are changes in everything — when we eat, breathe, talk or sleep, changes take place in our body. Changes can be in shape, size, temperature, state of substance etc. In this section we will learn about the classification of the changes around us into two main categories — Physical and chemical changes.

> **Definition: Change**
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> Changes can be in shape, size, temperature, or state of a substance. They are broadly classified into Physical Changes and Chemical Changes.

6.2 Physical Changes

A change in which physical properties of substance such as size, appearance or state may alter, but its chemical composition remains the same and no new substance is formed, are called physical changes. A physical change is a reversible change — for example dissolving sugar in water, cutting of wood etc.

> **Definition: Physical Change**
>
> A change in which no new substance is formed and the chemical composition of the substance remains unchanged. It is generally reversible.

6.2.1 Characteristics of Physical Changes

To bring about a physical change some external force or energy has to be applied — for example, for opening a door we push the door, or we kick the ball for changing its position. The molecules of the substance remain same after and before the change — for example, on dissolving sugar in water, properties of sugar and water remain the same.

Physical change is a temporary change — on removing the cause of the change, the substance regains its original form — for example, electric bulb glows on supplying current and comes to its original state on switching off the current.

> **Did You Know?**
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> By using a piece of gold, a goldsmith can make a large variety of ornaments, but all of them consist of the same substance, namely gold. This is a physical change!

6.2.2 Some Other Examples of Physical Changes

On heating, water evaporates and ice melts, but on cooling, water vapours change to water and water freezes to form ice — therefore, change in state of water is a physical change. When we dissolve salt in water or mix different vegetables and fruits to make salad, they form a mixture — properties of the salt in water and vegetables and fruits in salad remain the same, no new substance is formed — hence formation of mixture is a physical change.

> **📌 Important — Mixtures**
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> A mixture consists of two or more substances simply mixed together but not chemically combined — for example, air is a mixture of various gases — components of a mixture can be separated by different separation techniques like hand picking, sedimentation, decantation, evaporation, condensation etc.

When we crush ice cubes or a chalk stick, no new substance is formed — change in shape and size is a physical change.

> 💡 **Tip**
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> Remember: If you can get back the original substance by a simple process (cooling, filtering, evaporating), it is a Physical Change!

6.3 Chemical Changes

A change in which the identity of the original substance is changed and a new substance or new substances are formed is called a chemical change. It is an irreversible change — in chemical change, the properties of the substance get changed — e.g., souring of milk, burning of paper, burning of candle, rusting of iron, burning of magnesium ribbon.

There are various chemical changes taking place in our body — for example, digestion of food, water we drink is used and urine is formed, air we breathe is used in respiration etc. It may be interesting to note that tearing of paper is a physical change, but burning of paper is a chemical change — changing of water to steam or ice is a physical change, but formation of hydrogen and oxygen gases by passing electric current is a chemical change.

> **Definition: Chemical Change**
>
> A change in which the original substance is transformed into a new substance with different properties. It is generally permanent and irreversible.

6.3.1 Characteristics of Chemical Changes

Chemical change is permanent and irreversible — for example, on heating some sugar crystals, its colour changes to brown; this brown substance is caramel, which is a different substance from sugar crystals, and caramel cannot be converted back into sugar crystals.

> **📌 Important — Compound vs Mixture**
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> A compound is a substance that has been formed when two or more elements combine chemically. In a chemical reaction, the original substance is called reactant and the new substance formed is called product.

A new substance with different properties is formed — for example, on heating a mixture of iron and sulphur, a new compound iron sulphide is formed that has different properties than iron and sulphur. A chemical change involves exchange of energy — for example, heat is given out in burning of paper or in burning of wood.

Chemical change can be represented by a chemical equation, and a chemical change is also a chemical reaction. A chemical reaction may also be accompanied by change in colour, production of sound, change in smell, or formation of gas.

6.3.2 Some Examples of Chemical Changes

When magnesium ribbon is burnt, it burns with a brilliant white light, and when completely burnt it leaves behind a powdery ash — the chemical equation is: Magnesium (Mg) + Oxygen (O) → Magnesium oxide (MgO) (Powdery ash). The powdery ash is different from magnesium — it is magnesium oxide (basic substance) — when magnesium oxide is dissolved in water it forms magnesium hydroxide: $MgO + H_2O \rightarrow Mg(OH)_2$ — magnesium hydroxide is basic in nature.

$Mg + O \rightarrow MgO$ (Magnesium Oxide)

$MgO + H_2O \rightarrow Mg(OH)_2$ (Magnesium Hydroxide — basic in nature)

Blue vitriol is copper sulphate — it dissolves in water completely if we add a few drops of dilute sulphuric acid to it — the colour of solution obtained is blue. If we drop an iron nail into this blue solution and allow it to stand for 30 minutes, the blue colour changes to green — the green colour is due to formation of iron sulphate due to reaction between copper sulphate (blue) and iron: Copper sulphate solution (blue) + Iron → Iron sulphate solution (green) + Copper (brown deposit).

$CuSO_4$ (blue) + $Fe \rightarrow FeSO_4$ (green) + Cu (brown deposit)

Displacement reaction — Iron displaces Copper from Copper Sulphate solution

When a pinch of baking soda (sodium bicarbonate) is added to vinegar, a hissing sound is produced and bubbles of a gas came out — if the gas coming out is passed through lime water, the lime water turns milky. Vinegar (acetic acid) + Baking soda (sodium hydrogen carbonate) → Carbon dioxide (gas comes out) + Other substances — $CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$ — the lime water turns milky due to formation of calcium carbonate.

Explosion of fireworks is a chemical change — it produces sound, heat, light and some unpleasant gases that pollute the atmosphere — for this reason you are advised not to play with fireworks. Spoilage of food is a chemical change — the change in colour of slices of apple kept in open for sometime represents a chemical change — the slice acquires a brown colour, which is a different substance — similar changes are also observed in slices of potato or brinjal.

Neutralisation reaction between an acid and a base results in formation of salt and water — since new substances are formed, it is a chemical change. Browning of food may cause fruits and vegetables to lose their appeal, but there is no loss of their nutritive value — certain substances present in some fruits and vegetables have a great affinity for taking up oxygen from the air, which reacts with these substances turning them into a dark brown enzyme called "tyrosinase," responsible for the darkening of cut surfaces of potatoes, brinjals and apples.

In the process of photosynthesis, new substances are formed, so it is a chemical change. Change of oxygen to ozone in the upper atmosphere is also a chemical change because oxygen and ozone are different substances

— this chemical change is of great importance because ozone protects us from harmful radiations of the sun by absorbing them and breaking down into oxygen.

> ⚠️ **Common Mistake**
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> Tearing of paper → Physical Change. Burning of paper → Chemical Change. Students often confuse these two! Remember: if a new substance is formed, it is always a chemical change.

6.4 Difference between Physical and Chemical Change

S.No.	Physical Change	Chemical Change
1	Temporary change; original substance can be obtained back by simple means like heating/cooling	Permanent change; original substance cannot be brought back
2	No new substance formed; chemical composition remains unchanged	New substance formed with different chemical composition
3	Change may be reversible	Change is irreversible
4	Only physical properties like shape, colour, size get changed	Both physical and chemical properties get changed
5	Energy may or may not be absorbed or evolved	Energy is either absorbed or evolved (always involves energy change)

> **Examples at a Glance**
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> Physical Changes: Melting ice, dissolving sugar, crushing chalk, magnetisation, change of state.
> Chemical Changes: Burning wood, rusting iron, souring milk, digestion of food, photosynthesis.

6.5 Rusting of Iron

When a piece of iron is left in open for sometime, it acquires a film of brownish substance which is called rust — this process of change of iron to rust is called rusting of iron. Rust is different from iron — this rust is iron oxide — the chemical equation for rusting is: Iron (Fe) + Oxygen (O_2) + Water (H_2O) → Rust (iron oxide, Fe_2O_3).

$$Fe + O_2 + H_2O \rightarrow Fe_2O_3 \text{ (Rust / Iron Oxide)}$$

Essential conditions for rusting: (i) Presence of air/oxygen (ii) Presence of moisture (water vapour)

6.5.1 Prevention of Rusting

Galvanisation is considered the best method to prevent rusting — it is the process of deposition of a thin layer of zinc on iron surface and is done to prevent rusting of iron — rusting can also be prevented by deposition of a thin layer of chromium on iron articles — we use galvanised Iron (G.I.) pipes to carry water in taps. It is estimated that about 15% of the total world production of iron is destroyed due to rusting. Application of a coat of paint or grease on the surface of iron also helps in prevention of rusting.

📌 Important — Iron Pillar of Delhi

Near the Qutub Minar in Delhi stands a 7-metre-high iron pillar braving heat, rain and rough weather for more than 1600 years — it has not rusted even after so many years — its quality of rust-resistant iron is still a mystery for present-day scientists.

Definition: Galvanisation

The process of depositing a thin layer of zinc on iron surface to prevent rusting. We use galvanised iron (G.I.) pipes to carry water in taps.

6.5.2 Factors That Speed Up Rusting

Higher moisture content in air increases the rate of rusting. Presence of salts (electrolytes) in water also makes the process of rusting faster — due to presence of many salts in sea water, ships suffer a lot of damage from rusting, inspite of being painted.

💡 Tip — Mnemonic for Rusting Conditions

R-A-M: Rusting needs Air + Moisture. No air or no moisture = No rusting! (Boiled, cooled water with oil layer prevents rusting because oxygen is removed.)

6.6 Crystallisation

When a hot saturated solution of an impure compound is allowed to cool slowly undisturbed in a beaker or crystallising dish, after some time the crystals of pure compound are formed and impurities are left behind in solution. Crystallisation is a process of obtaining pure compound from impure compound — it is a method of purification — for example: (1) This process is used to get crystals of pure copper sulphate from an impure sample of copper sulphate; (2) Table salt is obtained from sea water by crystallisation process.

Definition: Crystallisation

A process of obtaining a pure compound from its impure sample by allowing a hot saturated solution to cool slowly so that pure crystals form. It is a method of purification and an example of a physical change.

📌 Important

Crystallisation is an example of physical change — in it, no new substance is formed. The impurities remain dissolved in the solution (mother liquor) while pure crystals settle out.

6.7 Changes in Our Everyday Life

Rusting of iron is a chemical change which can be prevented by depositing a layer of zinc on iron — this process is called galvanization — water pipes are galvanised to prevent rusting. Stainless steel is made by mixing iron with carbon and metals like chromium, nickel and manganese — it does not rust. The formation of large crystals of pure substance from their solutions is called crystallization — it is a physical change.

Did You Know? — Stainless Steel

Stainless steel is an alloy of iron with carbon and chromium, nickel, and manganese. The chromium forms a thin oxide layer on the surface that protects iron from rusting — that's why your spoon doesn't rust!

6.8 Solved Examples

Example 1 — Change of State

Change of state from ice to water and to steam — Ice → (heating) → Water → (heating) → Steam — ice on heating melts into water and water on heating changes into steam — conversely, on cooling, steam converts to water and water into ice — thus, it is a physical and reversible change.

Example 2 — Physical and Reversible Changes

Which of the following changes are physical and reversible? (a) Magnetisation of an iron bar (b) Water cycle (c) Sublimation of iodine (d) Melting of ice — if we magnetise an iron bar, on demagnetisation it loses its magnetism — similarly in water cycle, evaporated water comes back as rain — cooling the vapour of the sublimated substance gives back the solid — ice when melted forms water and on cooling gets back its original shape. All four are physical and reversible changes.

Example 3 — Pasteurisation of Milk

Pasteurisation of milk: milk gets spoiled over time due to harmful bacteria — it is preserved by pasteurisation where milk is boiled for 15 minutes at 72°C and then cooled — this process kills harmful bacteria — however, no new substance is formed and milk retains its original properties — it is a physical but irreversible change.

Example 4 — Dissolving Sugar in Water

When sugar is added to water, it gets dissolved and we cannot see sugar grains — no new substance is formed — the sugar remains as sugar and water remains as water — you can get back the two components by allowing water to evaporate and condensing the vapour — sugar or salt dissolves faster in hot water compared to cold water, and stirring helps them dissolve faster.

Example 5 — Rusting Experiment

When iron and steel are exposed to damp air, they interact with oxygen and water vapour in the air to form rust — the experiment shows that air and water are necessary for rusting — boiled water when cooled has little air; an oil layer prevents air from getting into the water, so iron nails placed in it do not rust because there is not enough oxygen. Ways to prevent rusting: only things made of iron and steel will rust — they can be prevented from rusting by painting, oiling or greasing them — paint, oil, grease are waterproof materials that prevent iron and steel from coming into contact with water — in some cases, iron and steel sheets are coated with a thin layer of tin or chromium, which act as a protective coating.

Example 6 — Quicklime + Water

Take a beaker and fill it with water — add quicklime, a white powder (CaO) — the moment quicklime comes in contact with water the mixture gets heated up, felt by touching the beaker — a new substance, slaked lime, is formed and heat is liberated — this is a chemical change.

$$CaO + H_2O \rightarrow Ca(OH)_2 + Heat$$

Quicklime (CaO) + Water → Slaked Lime $Ca(OH)_2$ — exothermic chemical change

Example 7 — Exothermic and Endothermic Changes

For a change to occur, interaction between substances is essential along with energy change — broadly speaking there are two kinds of heat changes: exothermic and endothermic. Exothermic changes are those which give out heat — for example: burning of wood, glowing of an electric lamp, dissolution of sodium hydroxide flakes in water, bursting of a cracker etc. Endothermic changes are those during which heat is absorbed — for example: melting of ice, cooking of food, drying of wet clothes, dissolution of ammonium chloride in water etc. — these changes can occur only if the substance gets heat from outside.

Type	Definition	Examples
Exothermic	Heat is given OUT	Burning wood, dissolution of NaOH, cracker explosion
Endothermic	Heat is absorbed IN	Melting ice, cooking food, drying wet clothes, dissolution of NH_4Cl

Example 8 — Burning Candle

When a candle burns, the wax melts and the wick burns — the melting of wax is a physical change while the burning is a chemical change — the chemical energy of the candle gets converted to heat and light energy.

> ⚠️ **Common Mistake — Candle Burning**
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> The melting of wax = Physical Change (reversible, wax can solidify again). The burning of the wick = Chemical Change (irreversible, new substances CO_2 and H_2O are formed). A single event can involve BOTH types of changes!

Example 9 — LPG vs Chemical Change

Which of the following is NOT a chemical change? (a) burning (b) Digestion of food (c) Conversion of liquified petroleum gas (LPG) into gas on opening the cylinder (d) Production of biogas from animal waste — liquified petroleum gas is in liquid state because of high pressure — on opening the cylinder valve, pressure releases and gas comes out — if this gas is collected and pressurised, we get back LPG — cases (a), (b) and (d) are

chemical changes since new products are formed. Answer: (c) is NOT a chemical change — it is a physical change.

Example 10 — Vaporisation of Perfume

When you spray perfume on your body, the perfume droplets get heat from the body through skin and change to vapour — the skin feels cool because it loses heat to vaporise the perfume droplets — the drying up (or vaporisation) of the perfume is an endothermic reaction.

> 💡 **Tip — Endothermic Cooling Effect**
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> Endothermic reactions absorb heat from surroundings — that is why evaporation causes cooling. Sweating cools the body by the same principle!

CHAPTER 6: PHYSICAL & CHEMICAL CHANGES

Physical Changes

- Reversible
- No new substance
- Shape/size/state change
- Examples: ice → water, dissolving

Chemical Changes

- Irreversible
- New substance formed
- Energy change
- Examples: burning, rusting, digestion

Rusting & Prevention

- $Fe + O_2 + H_2O \rightarrow Fe_2O_3$
- Galvanisation (Zinc coating)
- Paint/oil/grease
- Stainless steel

Crystallisation & Everyday Changes

- Purification method
- Physical change
- Exothermic vs Endothermic
- Stainless steel alloy

Multiple Choice Questions

1. Which of the following is a physical change?

A) Burning of wood B) Rusting of iron C) Melting of ice ✅ D) Souring of milk

Explanation: Melting of ice is reversible and no new substance is formed — it is a physical change.

2. Which gas is produced when baking soda is added to vinegar?

A) Oxygen B) Hydrogen C) Carbon Dioxide ✅ D) Nitrogen

Explanation: The reaction between acetic acid (vinegar) and sodium bicarbonate produces CO_2 gas which turns lime water milky.

3. Rusting of iron requires which two conditions?

A) Heat and Light B) Air and Water ✅ C) Salt and Acid D) Heat and Pressure

Explanation: Rusting requires the presence of oxygen (from air) and moisture (water vapour) simultaneously.

4. What is galvanisation?

A) Painting iron with red oxide B) Coating iron with a layer of zinc ✅ C) Mixing iron with carbon

D) Coating iron with copper

Explanation: Galvanisation is the process of depositing a thin layer of zinc on iron to prevent rusting.

5. Crystallisation is an example of which type of change?

A) Chemical Change B) Both physical and chemical C) Physical Change ✅ D) Irreversible Change

Explanation: Crystallisation produces pure crystals without forming any new substance — it is a physical and reversible change.

6. Which of the following is a chemical change?

A) Dissolving salt in water B) Cutting of wood C) Burning of magnesium ribbon ✅ D) Melting of wax

Explanation: Burning of magnesium forms magnesium oxide (MgO), a new substance — making it a chemical change.

7. In an exothermic reaction:

A) Heat is absorbed B) No energy change occurs C) Heat is released ✅ D) Temperature decreases

Explanation: Exothermic reactions release heat to the surroundings — examples include burning of wood and dissolution of NaOH.

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8. Stainless steel does not rust because:

A) It is coated with zinc B) It contains chromium which forms a protective oxide layer ✅

C) It is a pure metal D) It is coated with paint

Explanation: Chromium in stainless steel forms a thin protective oxide layer on the surface, preventing iron from coming in contact with air and moisture.

✅ QUICK REVISION

- Physical change: no new substance formed, usually reversible (e.g., melting ice, dissolving sugar).
- Chemical change: new substance formed, usually irreversible (e.g., burning, rusting, digestion).
- Rusting equation: $Fe + O_2 + H_2O \rightarrow Fe_2O_3$ (requires air and moisture).
- Galvanisation: coating iron with zinc to prevent rusting.
- Crystallisation: method of purification — a physical change.
- Exothermic changes release heat; endothermic changes absorb heat.
- Burning of paper = chemical change; tearing of paper = physical change.
- Stainless steel (iron + chromium + nickel + manganese) does not rust.

Glossary & Key Terms

Physical Change
Change where no new substance is formed; generally reversible.

Chemical Change
Change where a new substance with different properties is formed; generally irreversible.

Reversible Change
A change that can be undone to restore the original substance.

Irreversible Change
A change that cannot be undone to get back the original substance.

Reactant
The original substance that undergoes a chemical reaction.

Product
The new substance formed as a result of a chemical reaction.

Rusting
The process of formation of iron oxide (rust) on iron due to air and moisture.

Galvanisation
Deposition of a thin layer of zinc on iron to prevent rusting.

Crystallisation
Method of purification; forming pure crystals from a hot saturated solution.

Exothermic Reaction
A reaction that releases heat energy to the surroundings.

Endothermic Reaction
A reaction that absorbs heat energy from the surroundings.

Compound
A substance formed when two or more elements combine chemically.