Orient BlackSwan

Inspired CHEMISTRY

For the CISCE curriculum

NEP Compliant inside

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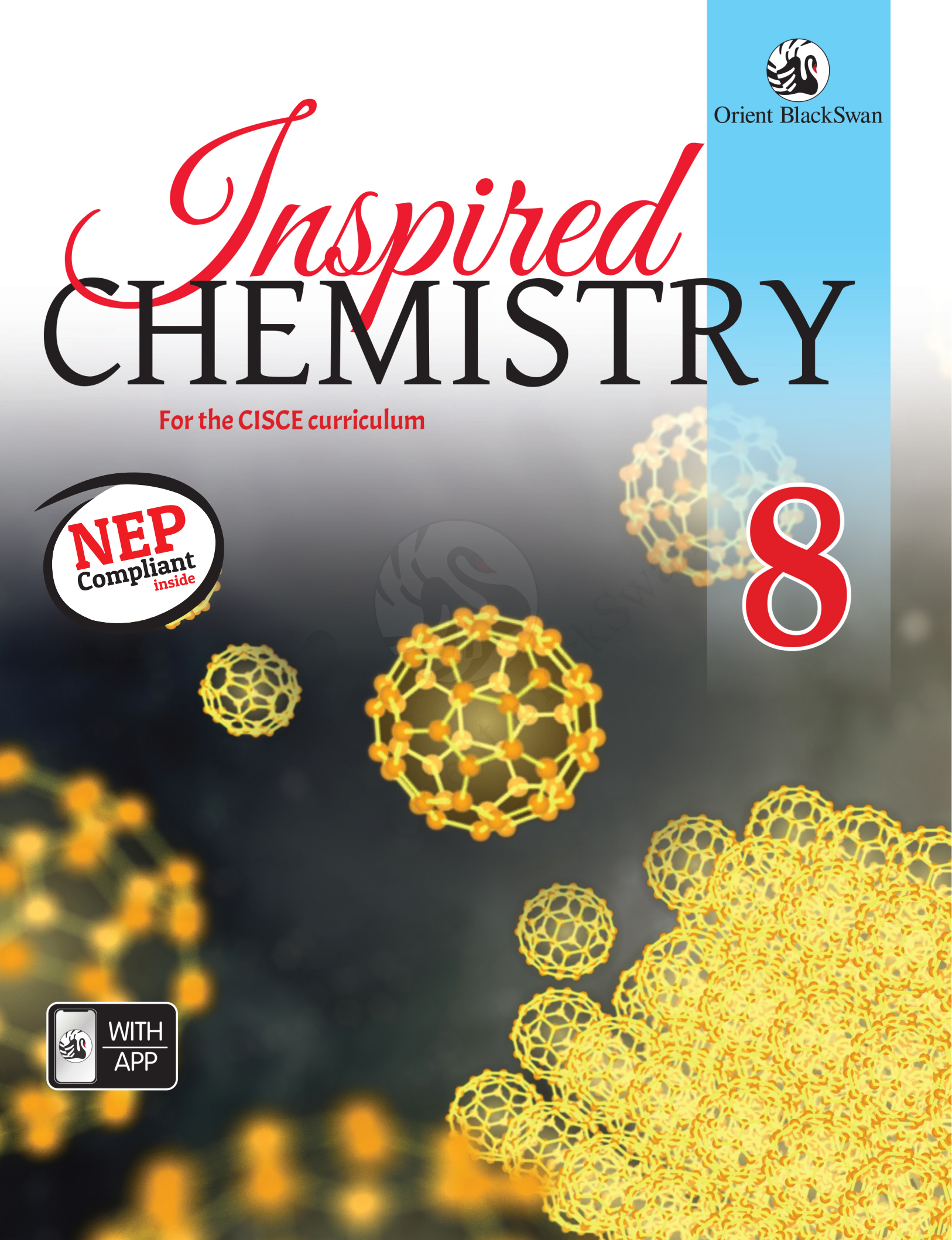


WITH APP

Inspired CHEMISTRY

8

Orient BlackSwan

Inspired Chemistry

has been developed in accordance with the CISCE Upper Primary Science (Chemistry) curriculum. Its aims are:

- to enable students to relate their daily life experiences and science by following a practical, thematic approach
- to focus on the development of scientific temper through skill and process development
- to encourage knowledge construction through information collection, organisation and reflection

Students' book

- complete syllabus coverage
- carefully graded text
- appropriate, well-labelled illustrations and photographs
- appropriate activities and exercises

Let's learn

Learning outcomes
encourage students to take responsibility for their learning

Get going
helps focus and direct students' attention to the lesson

Activities
help students learn through practical exercises

Stop and check
provides checkpoints for teachers and students to evaluate progress

Spotlight
focuses on important topics in greater detail

Go further
provides additional, interesting, relevant information

SciTech
links scientific concepts with real-life occurrences and applications

Eco corner
presents issues that are an environmental concern

Let's revise

In a nutshell
is a comprehensive revision corner

Concept map
is a graphic presentation of concepts linked logically

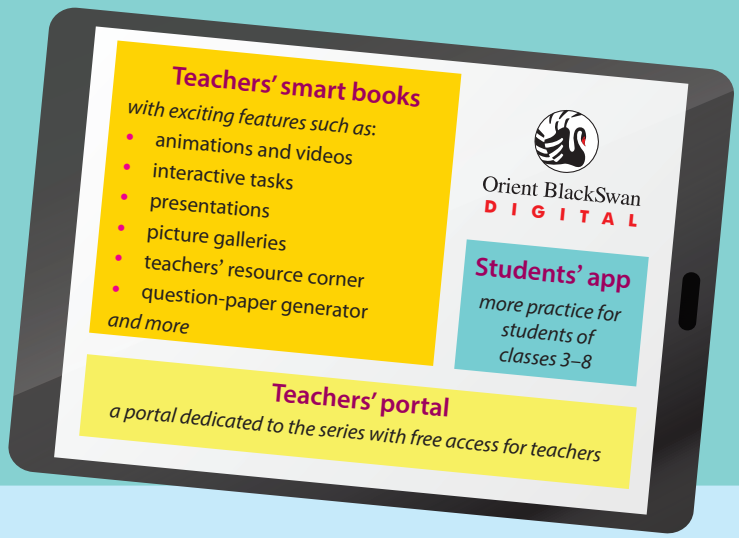
Summary
lists the main points of the lesson briefly

Keywords
lists important words and their definitions

Glossary
presents important words for quick revision at the end of the book

Teachers' resource packs

- lesson plans
- question bank with answers
- worksheets with answer key
- question papers with answer key
- answer key to the exercises in the students' book



Let's apply

Checkpoint
covers a variety of exercises (objective type, short answer and long answer)

Think and answer
encourages students to develop higher-order thinking skills necessary for the 21st century

Picture study
offers picture-based questions that encourage students to observe, identify and relate concepts to real life

Hands-on
offers a variety of projects that reinforce 21st century skills through experiments, model-making, discussion, role play, research work, report writing and so on

Subject integration
presents additional activities explicitly linking multiple subjects

Life skills and values
help children develop skills needed for everyday life and values needed to be well-adjusted members of society

Let's know more

Scientist in focus
describes the life and work of famous scientists to inspire students

Heritage corner
presents exciting and accurate information on India's scientific heritage

Internet links
provides sources for further study and research

Career watch
presents novel ideas for a career in science and technology

Let's work

- *Worksheets* a workbook corner with worksheets covering all lessons
- *Test papers* based on the ICSE pattern

CONTENTS

6 Chemical Reactions

Learning outcomes

By the end of this theme, you will be able to:

- describe the different types of chemical reactions with examples
- identify the type of chemical reaction
- explain the reactivity series of metals
- predict reactions based on the reactivity series of metals
- differentiate between exothermic and endothermic reactions
- describe neutralisation reactions
- describe how oxides are formed and classify them as acidic, basic, amphoteric and neutral
- explain the effect of heat on some oxides

Get going

What is happening in the picture? Can you identify the chemical reaction? Which are the reactants and which are the products? (It is enough to give their common names rather than exact chemical names.)

INTRODUCTION

In the previous lesson, you learnt about chemical reactions and chemical equations. Chemical reactions are essential for our existence. Respiration, digestion, cell renewal, the processes of thinking, feeling and seeing, photosynthesis and a countless number of other processes that support life are the result of chemical reactions. So are other processes such as rusting and combustion.

You have studied that there are 118 elements; innumerable compounds are formed by the combination of these elements. There are an infinite number of chemical reactions occurring between these elements and compounds. However, if you take a random combination of compounds or elements, or both, and expect them to react with each other, it is unlikely to happen. To understand which chemicals will react with one another, what will

be the nature of the products and what conditions are required for the reaction, an understanding of chemical reactions is necessary.

CHEMICAL REACTIONS AND EQUATIONS

When two or more elements, compounds or a combination of both combine to form one or more products, a chemical reaction is said to have taken place. A chemical reaction is represented by a **chemical equation**. A chemical equation is a short form of writing a chemical reaction, as it uses **symbols** of elements and **formulae** of compounds.
A chemical equation has two parts: the **reactants** are placed on the left side and the **products** on the right side. An arrow is placed between the reactants and products pointing in the direction of the products. Products are formed by the rearrangement of atoms of elements present in the reactants.

For example, carbon burns in the presence of oxygen to form carbon dioxide. The reaction is expressed as:

$$\underbrace{C + O_2}_{\text{carbon oxygen}} \rightarrow \underbrace{CO_2}_{\text{carbon dioxide}}$$

reactants product

We can understand a chemical reaction better by studying the following:

- the changes accompanying the reaction
- the conditions necessary for the reaction to proceed
- the type of reaction it is

CHANGES THAT ACCOMPANY A CHEMICAL REACTION

A number of changes may accompany a chemical reaction. Not all of them are seen in the same reaction. Possible changes are:

- change in colour
- change of state
- evolution of a gas
- formation of a precipitate
- absorption or emission of energy

Change in Colour

We notice a change in colour when some chemical reactions occur.

- Iron in the presence of oxygen and moisture forms hydrated iron(III) oxide (rust). Rust is reddish-brown in colour.

$$\underset{\text{iron}}{4Fe\,(s)} + \underset{\text{oxygen}}{3O_2\,(g)} \rightarrow \underset{\substack{\text{iron(III) oxide}\\\text{(red deposit)}}}{2Fe_2O_3\,(s)}$$

- Iron reacts with copper sulphate solution (blue in colour). Reddish copper is deposited on the iron nail and the solution turns pale green due to the formation of ferrous sulphate.

$$\underset{\substack{\text{iron}\\\text{(grey}\\\text{metal)}}}{Fe\,(s)} + \underset{\substack{\text{copper sulphate}\\\text{(blue solution)}}}{CuSO_4\,(aq)} \rightarrow \underset{\substack{\text{iron sulphate}\\\text{(green solution)}}}{FeSO_4\,(aq)} + \underset{\substack{\text{copper}\\\text{(red}\\\text{deposit)}}}{Cu\,(s)}$$

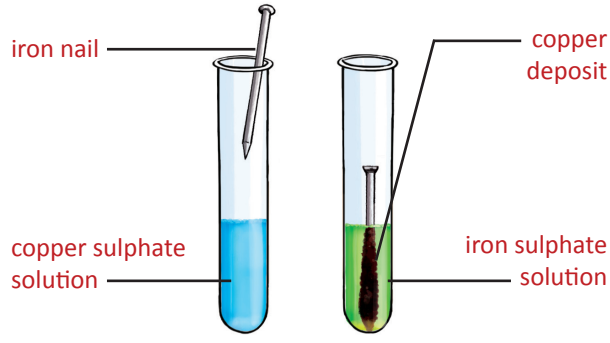


Fig. 6.1 Formation of ferrous sulphate

Change of State

In some chemical reactions, the reactants may be in a different state than the product. For example, gaseous reactants may give a solid product or a liquid product.

- Hydrogen and oxygen, which are both gases, react to form water, a liquid.

$$2H_2\,(g) + O_2\,(g) \rightarrow 2H_2O\,(l)$$

- Ammonia and hydrogen chloride, which are both colourless gases, react to form ammonium chloride, which is a white solid.

$$NH_3\,(g) + HCl\,(g) \rightarrow NH_4Cl\,(s)$$

ammonia — hydrogen chloride — ammonium chloride

Evolution of a Gas

During some chemical reactions, a gas is one of the products. The evolution of a gas may be termed as **effervescence** (bubbling). This is indicated by an arrow pointing upwards.

- When a metal is added to a dilute[1] acid, hydrogen gas is evolved and a salt is formed. For example, when sodium is added to dilute hydrochloric acid, sodium chloride is formed and hydrogen gas is evolved.

$$2Na + 2HCl\,(dil) \rightarrow 2NaCl + H_2\uparrow$$

sodium — dilute hydrochloric acid — sodium chloride — hydrogen

The hydrogen gas forms bubbles and can be seen clearly.

[1]**dilute** made weaker by adding water to it

Spotlight

In chemistry, a **salt** is a chemical that is formed when an **acid** reacts with a **base**. The salt that we add to food is sodium chloride or common salt.

An acid is a substance that tastes sour and is corrosive in nature. We use many acids in the laboratory. Hydrochloric acid is obtained by dissolving hydrogen chloride (HCl) in water. It is represented by HCl. Hydrochloric acid is secreted in our stomach too. Sulphuric acid, nitric acid, carbonic acid, acetic acid, lactic acid and citric acid are other examples of acids.

A base is a substance that tastes bitter and feels soapy to the touch. It is also corrosive in nature. Sodium hydroxide, calcium hydroxide and potassium hydroxide are examples of bases.

Caution: Never touch or taste acids or bases. They are corrosive substances and can cause severe damage to body tissues.

- Copper reacts with concentrated nitric acid to form copper nitrate, nitrogen dioxide and water. Nitrogen dioxide is a pungent reddish-brown poisonous gas.

$$Cu\,(s) + 4HNO_3\,(conc) \rightarrow Cu(NO_3)_2\,(aq) + 2NO_2\,(g) + 2H_2O\,(l)$$

copper — concentrated nitric acid — copper nitrate — nitrogen dioxide — water

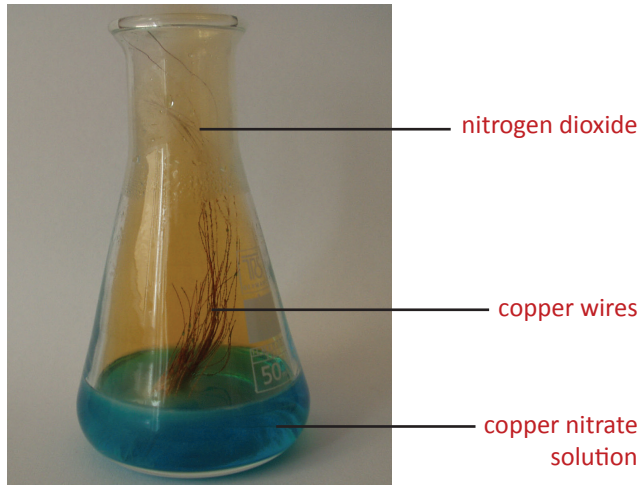


Fig. 6.2 Reaction of copper with concentrated nitric acid

Formation of a Precipitate

One of the products may be an insoluble solid (**precipitate**) that settles at the bottom of the test tube.

- When a solution of silver nitrate is added to a solution of sodium chloride, a white precipitate of silver chloride is formed.

$$NaCl\,(aq) + AgNO_3\,(aq) \rightarrow AgCl\downarrow + NaNO_3\,(aq)$$

sodium chloride — silver nitrate — silver chloride — sodium nitrate

- When solutions of potassium iodide and lead(II) nitrate are mixed, a golden yellow precipitate of lead(II) iodide is formed.

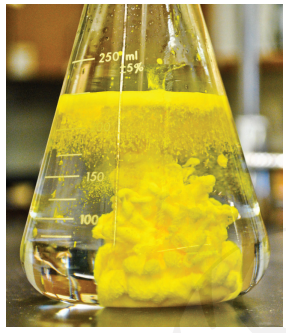


Fig. 6.3 Formation of lead iodide precipitate

$$2KI\,(aq) + Pb(NO_3)_2\,(aq) \rightarrow PbI_2\downarrow + 2KNO_3\,(aq)$$

potassium iodide — lead(II) nitrate — lead(II) iodide — potassium nitrate

Emission or Absorption of Energy (Exothermic or Endothermic Reactions)

Some reactions, besides forming products, release a large quantity of heat. They are called **exothermic reactions**.

- During combustion, new substances are formed as well as heat and light. For example, when methane (CH_4) gas burns in air, carbon dioxide and water vapour are formed, and a large quantity of heat is given out.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + \text{heat}$$

methane — oxygen — carbon dioxide — water

Materials such as coal, petrol, kerosene and methane gas, which give out large quantities of heat when they burn, are called **fuels**.

Some other reactions absorb heat from the surroundings. The reaction vessel becomes cooler as the reaction progresses. Such reactions are known as **endothermic reactions**.

- The reaction of barium hydroxide with ammonium chloride is endothermic.

$$Ba(OH)_2\,(s) + 2NH_4Cl\,(s) \rightarrow BaCl_2\,(s) + 2NH_3\,(g) + 2H_2O$$

barium hydroxide — ammonium chloride — barium chloride — ammonia — water

Go further...

A reaction may release or absorb energy in other forms, such as light. *A reaction that releases any form of energy is called an **exergonic reaction***. All exothermic reactions are exergonic. *A reaction that absorbs energy is called an **endergonic reaction***. Photosynthesis takes places in the presence of sunlight; it is an endergonic reaction.

Production or absorption of heat during a chemical reaction

The atoms in a molecule are held together by **chemical bonds**. When a new compound is formed in a chemical reaction, bonds have to be broken and formed again. For example, let us take a simple representation of a reaction.

$$AB + C \rightarrow AC + B$$

During this reaction, the bond between A and B has to be broken. Let us represent the energy required to break this bond by *X*. Then, a new bond is formed between A and C. Let us represent the energy required to form this bond by *Y*.

- If $X > Y$, the excess heat is given out and the reaction is exothermic.
- If $X < Y$, heat is absorbed from the surroundings and the reaction is endothermic.

CONDITIONS FOR A CHEMICAL REACTION TO OCCUR

There are some conditions that have to be met for a chemical reaction to occur.

- The reactants should be in contact so that the chemical reaction can occur. Powdering the reactants and mixing the reactants are some ways of making sure that a chemical reaction occurs. Barium hydroxide and ammonium chloride react in the solid state. In many cases, the reactants are made into solutions and mixed.
- Some reactions need heat to be applied to begin. This is the case with combustion reactions. A lit match is required to light a candle.
- Some reactions may need light to occur. They are called **photochemical reactions**. Photosynthesis and the formation of vitamin D in the skin are good examples. Photography also depends on photochemical reactions.

Eco corner

Photochemical smog

Oxides of nitrogen and volatile organic compounds are air pollutants produced by the burning of fossil fuels. These compounds undergo photochemical reactions in the presence of sunlight to form additional dangerous pollutants such as ozone and nitrates in the air. All these compounds can combine to form **photochemical smog**, which is seen as a brown haze, particularly over cities. This kind of smog is harmful to health, reduces photosynthesis and causes the degradation of rubber, fabric and other materials.

- Some reactions need an increase or a decrease in pressure to occur. This is because increasing the pressure brings molecules of reactants closer together. This is especially so in the case of gases. For example, the reaction of nitrogen with hydrogen to produce ammonia yields larger amounts of ammonia when the reactants are under high pressure.
- Some reactions need a **catalyst**. *A catalyst is a substance that causes a change in the rate of a reaction without undergoing any change itself.* For example, platinum acts as a catalyst in the reaction of carbon monoxide and oxygen to give carbon dioxide and increases reaction rate.

$$\underset{\text{carbon monoxide}}{2CO} + \underset{\text{oxygen}}{O_2} \xrightarrow{\text{platinum}} \underset{\text{carbon dioxide}}{2CO_2}$$

Enzymes are examples of biological catalysts. Enzymes in the digestive system speed up the digestive process.

Stop and check

Say if the following are true or false.

1. If the reactants are gases, the products will also be gases.
2. Effervescence is an indication that a chemical reaction is taking place.
3. A precipitate will dissolve in the liquid.
4. When a chemical bond is broken, energy is released.
5. Photosynthesis is an example of a photochemical reaction.
6. The reactants should always be heated for a chemical reaction to occur.

TYPES OF CHEMICAL REACTIONS

Reactions can be classified based on what happens in the reaction. Chemical reactions are classified into one or more of the following categories.

- combination or synthesis reactions
- decomposition reactions
- displacement reactions
- double displacement reactions

Combination or Synthesis Reactions

In a combination reaction, two or more reactants come together to form a single new product. The reactants can be elements, compounds or a combination of both. This type of reaction is also called a synthesis reaction since a new substance is synthesised.

The general representation of this type of reaction is:

$$A + B \rightarrow AB$$

- When carbon is heated in air, carbon dioxide is formed. This reaction is also a part of combustion of wood and fuels.

$$\underset{\text{carbon}}{C\,(s)} + \underset{\text{oxygen}}{O_2\,(g)} \xrightarrow{\text{heat}} \underset{\text{carbon dioxide}}{CO_2\,(g)}$$

- When iron powder is mixed with sulphur and heated, iron(II) sulphide is formed.

$$\underset{\text{iron}}{Fe\,(s)} + \underset{\text{sulphur}}{S\,(g)} \xrightarrow{\text{heat}} \underset{\text{iron(II) sulphide}}{FeS\,(s)}$$

- When carbon monoxide combines with oxygen, the more stable carbon dioxide is formed.

$$\underset{\text{carbon monoxide}}{2CO\,(g)} + \underset{\text{oxygen}}{O_2\,(g)} \rightarrow \underset{\text{carbon dioxide}}{2CO_2\,(g)}$$

- When calcium oxide is dissolved in water, calcium hydroxide is formed.

$$\underset{\text{calcium oxide}}{CaO\,(s)} + \underset{\text{water}}{H_2O\,(l)} \rightarrow \underset{\text{calcium hydroxide}}{Ca(OH)_2\,(aq)}$$

The presence of calcium hydroxide can be tested by bubbling carbon dioxide through the solution. Calcium carbonate is formed, which turns the solution milky.

$$\underset{\text{calcium hydroxide}}{Ca(OH)_2\,(aq)} + \underset{\text{carbon dioxide}}{CO_2\,(g)} \rightarrow \underset{\text{calcium carbonate}}{CaCO_3\downarrow} + \underset{\text{water}}{H_2O\,(l)}$$

- Ammonia and hydrogen chloride combine to form ammonium chloride.

$$\underset{\text{ammonia}}{NH_3\,(g)} + \underset{\text{hydrogen chloride}}{HCl\,(g)} \rightarrow \underset{\text{ammonium chloride}}{NH_4Cl\,(s)}$$

Activity 6.1

Aim: To observe the burning of a magnesium ribbon

Materials required: magnesium ribbon, tongs, Bunsen burner, watch glass

Method: Hold a piece of magnesium ribbon using the tongs and slowly introduce the other end into the flame of a Bunsen burner.

Once the ribbon starts burning, collect the ash in a watch glass.

Observations and conclusions: You will notice that the magnesium ribbon burns with a bright white light and a white-coloured ash is formed. The ash is magnesium oxide. The chemical reaction is:

$$2Mg + O_2 \rightarrow 2MgO$$

Caution: Avoid looking directly at the flame. The bright light can damage the retina of the eyes.

Decomposition Reactions

In a decomposition reaction, a single reactant breaks down into two or more products. This type of reaction takes place on heating or exposure to light or due to the passing of electricity through the reactant. The products can be elements, compounds or a combination of both.

The general representation of this type of reaction is:

$$AB \rightarrow A + B$$

Some examples are given below.

- When electricity is passed through acidified water, water breaks up into hydrogen and oxygen.

$$\underset{\text{water}}{2H_2O\,(l)} \xrightarrow{\text{electricity}} \underset{\text{oxygen}}{O_2\,(g)} + \underset{\text{hydrogen}}{2H_2\,(g)}$$

- When potassium chlorate is heated in the presence of manganese dioxide (MnO_2), it breaks down into potassium chloride and oxygen.

$$\underset{\text{potassium chlorate}}{2KClO_3\,(s)} \xrightarrow[MnO_2]{\text{heat}} \underset{\text{potassium chloride}}{2KCl\,(s)} + \underset{\text{oxygen}}{3O_2\,(g)}$$

- When calcium carbonate is heated, it decomposes into calcium oxide and carbon dioxide.

$$\underset{\text{calcium carbonate}}{CaCO_3\,(s)} \xrightarrow{\text{heat}} \underset{\text{calcium oxide}}{CaO\,(s)} + \underset{\text{carbon dioxide}}{CO_2\,(g)}$$

- Hydrogen peroxide, when heated, splits into water and oxygen.

$$\underset{\text{hydrogen peroxide}}{2H_2O_2\,(s)} \rightarrow \underset{\text{water}}{2H_2O\,(l)} + \underset{\text{oxygen}}{O_2\,(g)}$$

- When lead nitrate is heated, it decomposes into lead(II) oxide, nitrogen dioxide and oxygen. This reaction happens around 250–430 °C.

$$\underset{\text{lead(II) nitrate}}{2Pb(NO_3)_2\,(s)} \xrightarrow{\text{heat}} \underset{\text{lead(II) oxide}}{2PbO\,(s)} + \underset{\text{nitrogen dioxide}}{4NO_2\,(g)} + \underset{\text{oxygen}}{O_2\,(g)}$$

- When lead(IV) oxide is heated to around 600 °C, it decomposes to lead(II) oxide.

$$\underset{\text{lead(IV) oxide}}{2PbO_2\,(s)} \rightarrow \underset{\text{lead(II) oxide}}{2PbO\,(s)} + \underset{\text{oxygen}}{O_2\,(g)}$$

SciTech

- Potassium chlorate is a highly reactive substance. It is used to make firecrackers and in some applications as a replacement for gunpowder. It is also used as a disinfectant.
- Lead(II) oxide is a component of lead glass, which is used to make 'crystal' glassware. It gives the sparkling quality to the glass.
- Lead(IV) oxide forms the cathode of lead–acid batteries.

Displacement Reactions

In a displacement reaction, an element replaces another element. This type of reaction is also called a **substitution reaction** or a **single replacement reaction**.

The general representation of this type of reaction is:

$$AB + C \rightarrow AC + B$$

- When zinc reacts with copper(II) sulphate, zinc replaces the copper in copper(II) sulphate to form zinc(II) sulphate and copper.

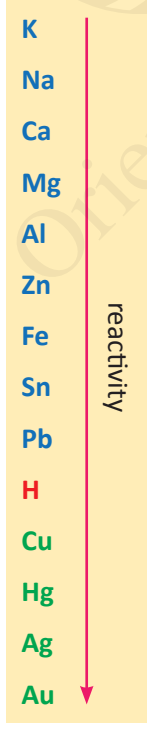
$$Zn\,(s) + CuSO_4\,(aq) \rightarrow ZnSO_4\,(aq) + Cu\,(s)$$

zinc — copper(II) sulphate — zinc(II) sulphate — copper

However, copper will not replace zinc from zinc(II) sulphate because copper is less reactive than zinc. The **reactivity series of metals** lists the reactivity of metals so that you can know whether a metal will replace another one in a displacement reaction.

The reactivity series

The reactivity series lists metals in the order of their reactivity. Metals at the top of the list are more reactive than those at the lower end. The reactivity of the metals decreases down the list. A metal will replace the metals below it in the list, but not those above it. (Hydrogen is given in the series for reference, though it is not a metal.)



Since zinc is higher in the list than copper, zinc can replace copper in compounds of copper but copper cannot replace zinc in compounds of zinc.

All the metals that are more reactive than hydrogen replace it in acids and liberate hydrogen gas.

$$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$$

iron — sulphuric acid — iron sulphate — hydrogen

Let us study a few examples to understand how the reactivity series helps us predict when a displacement reaction will occur.

Activity 6.2

Aim: To observe the displacement of the copper in copper sulphate by iron

Materials required: copper sulphate solution, iron nail, test tube

Method: Place an iron nail in a test tube containing copper sulphate solution (blue coloured) and leave it aside for a few days.

Observations and conclusions: The blue solution turns light green. Iron displaces the copper in the copper sulphate to form iron(II) sulphate, which is green.

The displaced copper coats the iron nail as a brownish deposit.

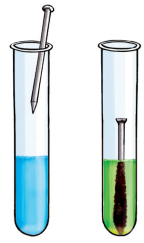


Fig. 6.4 Displacement of copper from copper sulphate by iron

- When zinc chloride and calcium are mixed together, calcium displaces zinc to form calcium chloride. This is because calcium is more reactive than zinc.

$$ZnCl_2 + Ca \rightarrow CaCl_2 + Zn$$

zinc chloride — calcium — calcium chloride — zinc

- When aluminium hydroxide is mixed with copper, there is no change. This is because copper is less reactive than aluminium.

Go further...

The group of elements in the periodic table that has chlorine is called the **halogen group**. Fluorine, chlorine, bromine and iodine are **halogens**.

The reactivity of the halogens is:

F > Cl > Br > I

Thus, fluorine displaces chlorine, bromine and iodine in compounds. Chlorine displaces bromine and iodine, but not fluorine.

Activity 6.3

Aim: To observe the displacement of the silver in silver nitrate by copper

Materials required: silver nitrate solution, copper wire, test tube

Method: Place the copper wire in a test tube containing silver nitrate solution (colourless) and leave it aside for a few hours.

Observations and conclusions:
The colourless solution turns blue.

Copper displaces the silver in the silver nitrate solution to form copper(II) nitrate solution, which is blue. The displaced silver is deposited on the copper wire.

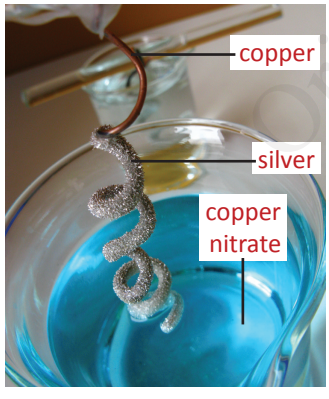


Fig. 6.5 Displacement of silver from silver nitrate by copper

Stop and check

1. What is the general representation of combination and decomposition reactions?
2. Write the equation for the reaction that occurs when electricity is passed through acidified water.
3. Which of these reactions will not occur?
   i. $Zn + Pb(NO_3)_2 \rightarrow Zn(NO_3)_2 + Pb$
   ii. $ZnSO_4 + Cu \rightarrow Zn + CuSO_4$

Double Displacement Reactions

Let us first recap what you have learnt earlier. **Ions** are charged particles. A **cation** is positively charged; metals readily form cations (example: Na^+, Mg^{2+}). An **anion** is negatively charged; non-metals readily form anions (example: Cl^-, O^{2-}). Ions may be formed from groups of atoms (example: NO_3^-, SO_4^{2-}).

Double displacement reactions occur between two ionic compounds. In this type of reaction, two compounds exchange their ions to form two new compounds.

The general representation of this type of reaction is:

$$AB + CD \rightarrow AD + CB$$

Here, A and C are the cations (positively charged), while B and D are the anions (negatively charged). For a double displacement reaction to occur, the reactants should generally be in the aqueous state.

Let us study two specific examples of double displacement reactions—**precipitation reactions** and **neutralisation reactions**.

Precipitation reactions

In this type of double displacement reaction, one of the products is a precipitate. The precipitate is indicated by a downward-facing arrow. Let us re-examine two reactions studied earlier.

- When a solution of silver nitrate is added to a solution of sodium chloride, a white precipitate of silver chloride is formed.

$$\underset{\text{sodium chloride}}{NaCl\,(aq)} + \underset{\text{silver nitrate}}{AgNO_3\,(aq)} \rightarrow \underset{\text{silver chloride}}{AgCl\downarrow} + \underset{\text{sodium nitrate}}{NaNO_3\,(aq)}$$

- When solutions of potassium iodide and lead(II) nitrate are mixed, a yellow precipitate of lead(II) iodide is formed.

$$\underset{\text{potassium iodide}}{2KI\,(aq)} + \underset{\text{lead(II) nitrate}}{Pb(NO_3)_2\,(aq)} \rightarrow \underset{\text{lead(II) iodide}}{PbI_2\downarrow} + \underset{\text{potassium nitrate}}{2KNO_3\,(aq)}$$

- When sodium sulphate is added to barium chloride solution, a white precipitate of barium sulphate is formed.

$$\underset{\text{barium chloride}}{BaCl_2\,(aq)} + \underset{\text{sodium sulphate}}{Na_2SO_4\,(aq)} \rightarrow \underset{\text{sodium chloride}}{2NaCl\,(aq)} + \underset{\text{barium sulphate}}{BaSO_4\downarrow}$$

Neutralisation reactions

In a neutralisation reaction, an acid and a base react to form a salt and water. It is called a neutralisation reaction because the solution after the reaction is neutral.

The general representation of this type of reaction is:

acid + base → salt + water

Neutralisation reactions are exothermic.

- When a base such as sodium hydroxide is added to hydrochloric acid, neutral sodium chloride and water are formed.

$$\underset{\text{hydrogen chloride}}{HCl\,(aq)} + \underset{\text{sodium hydroxide}}{NaOH\,(aq)} \rightarrow \underset{\text{sodium chloride}}{NaCl\,(aq)} + \underset{\text{water}}{H_2O}$$

- When potassium hydroxide (a base) is added to sulphuric acid, potassium sulphate (neutral salt) and water are formed.

$$\underset{\text{potassium hydroxide}}{2KOH\,(aq)} + \underset{\text{sulphuric acid}}{H_2SO_4\,(aq)} \rightarrow \underset{\text{potassium sulphate}}{K_2SO_4\,(aq)} + \underset{\text{water}}{2H_2O}$$

Spotlight

Indicators

An indicator is a substance that changes colour when exposed to an acidic or basic substance and thus indicates its presence. Litmus is a mixture of compounds obtained from a type of lichen. Litmus turns red in acidic solutions, and blue in basic solutions. Thus, litmus is used to indicate if a solution is acidic or basic. Other indicators include **phenolphthalein**, which turns pink in the presence of a base, and **methyl yellow**, which turns red in the presence of an acid.

Activity 6.4

Aim: To observe a neutralisation reaction

Materials required: dilute sodium hydroxide solution, dilute hydrochloric acid, phenolphthalein solution, conical flask, burette, stand, blue and red litmus papers

Method

1. Fill the burette with hydrochloric acid solution and fix it to the stand as shown.
2. Take sodium hydroxide solution in the conical flask.
3. Test the hydrochloric acid and the sodium hydroxide solution with the litmus papers.

The acid turns blue litmus paper red, and the base turns red litmus paper blue.

4. Add a few drops of phenolphthalein solution to the base in the conical flask. The solution turns pink.
5. Now, add the dilute hydrochloric acid from the burette drop by drop to the pink solution in the conical flask, mixing it well between the addition of each drop.
6. You will notice that at a point, the pink solution becomes colourless. Test this solution with blue and red litmus papers.

Observations and conclusion: The solution does not turn blue litmus paper red, and thus it is not acidic. It does not turn red litmus paper blue, and thus it is not basic either. This shows that the acid and the base have neutralised each other.

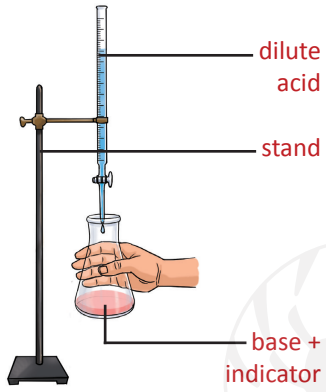


Fig. 6.6 Observing a neutralisation reaction

Uses of neutralisation reactions

Acidity treatment Our stomach produces hydrochloric acid to break down food. When too much acid is produced, it causes **acidity**, which leads to a burning sensation in the stomach. We take **antacids** containing magnesium hydroxide to neutralise the excess acid in the stomach.

Prevention of tooth decay The bacteria in the mouth act on sugars left behind and break them down to acids. Toothpaste contains bases to neutralise these acids.

Ant bite treatment An ant bite hurts because a little formic acid is left on the skin. By applying baking soda, a base, on the bite, the acid can be neutralised.

Soil treatment Farmers require soil of the correct level of acidity or alkalinity to grow specific crops. Acidic soil can be neutralised by adding lime, and alkaline soil can be neutralised by adding compost that is acidic.

Pollution reduction The burning of coal to produce electricity leads to the liberation of sulphur dioxide, which is acidic. This is neutralised using powdered lime (CaO) or limestone ($CaCO_3$). Acidic effluents (liquid wastes from industries) may also be treated this way.

Baking Baking powder is used to make cake batter or bread dough rise. It contains sodium bicarbonate, which is basic, and a dry acidic substance. When water is added to baking powder, the constituents react, liberating carbon dioxide and water. The bubbles of carbon dioxide are trapped in the batter or dough, which makes the cake or bread fluffy.

Stop and check

Answer the following questions.

1. What are anions and cations?
2. How is a double displacement reaction represented?
3. How can you treat an ant bite at home?
4. What do farmers do to make acidic soil suitable for growing crops?

OXIDES

An oxide is a compound of an element or a group of atoms with oxygen. Let us learn a little bit about the oxides of metals and non-metals in this section.

Metal Oxides

*A **metal oxide** is a compound containing a metal and oxygen.* For example, when magnesium burns in air, it combines with oxygen to form magnesium oxide. Some metals form more than one oxide since they have a variable valency.

Table 6.1 Some metallic oxides and their formulae

Metal	Oxide	Formula
sodium	sodium oxide	Na_2O
calcium	calcium oxide	CaO
magnesium	magnesium oxide	MgO
zinc	zinc oxide	ZnO
aluminium	aluminium oxide	Al_2O_3
copper	copper(I) oxide	Cu_2O
copper	copper(II) oxide	CuO
iron	iron(II) oxide	FeO
iron	iron(III) oxide	Fe_2O_3

The preparation of metal oxides

Metal oxides can be prepared in different ways, including:

- by direct heating or combustion of a metal in the presence of oxygen
- by heating a carbonate, nitrate or hydroxide of a metal

Reaction with oxygen Some metals form an oxide when they react with oxygen with or without heating.

- Sodium reacts with oxygen to form sodium oxide.

$$\underset{\text{sodium}}{4Na} + \underset{\text{oxygen}}{O_2} \rightarrow \underset{\text{sodium oxide}}{2Na_2O}$$

- Calcium reacts with oxygen to form calcium oxide.

$$\underset{\text{calcium}}{2Ca} + \underset{\text{oxygen}}{O_2} \rightarrow \underset{\text{calcium oxide}}{2CaO}$$

- Copper reacts with oxygen on heating to form copper(II) oxide.

$$\underset{\text{copper}}{2Cu} + \underset{\text{oxygen}}{O_2} \xrightarrow{\text{heat}} \underset{\text{copper(II) oxide}}{2CuO}$$

- Manganese reacts with oxygen on heating to form manganese oxide.

$$\underset{\text{manganese}}{3Mn} + \underset{\text{oxygen}}{2O_2} \xrightarrow{\text{heat}} \underset{\text{manganese oxide}}{Mn_3O_4}$$

Thermal decomposition When the carbonates, nitrates or hydroxides of certain metals are heated, the compounds decompose to form oxides.

- **Carbonates** give the oxide and carbon dioxide.

$$\underset{\substack{\text{copper(II)}\\\text{carbonate}}}{CuCO_3} \xrightarrow{\text{heat}} \underset{\text{copper(II) oxide}}{CuO} + \underset{\text{carbon dioxide}}{CO_2}$$

- **Nitrates** give oxides, nitrogen dioxide and oxygen.

$$\underset{\substack{\text{magnesium}\\\text{nitrate}}}{2Mg(NO_3)_2} \xrightarrow{\text{heat}} \underset{\text{magnesium oxide}}{2MgO} + \underset{\text{nitrogen dioxide}}{4NO_2} + \underset{\text{oxygen}}{O_2}$$

$$\underset{\substack{\text{zinc}\\\text{nitrate}}}{2Zn(NO_3)_2} \xrightarrow{\text{heat}} \underset{\text{zinc oxide}}{2ZnO} + \underset{\text{nitrogen dioxide}}{4NO_2} + \underset{\text{oxygen}}{O_2}$$

Activity 6.5

Aim: To observe the thermal decomposition of limestone ($CaCO_3$)

Materials required: limestone, test tubes, limewater, delivery tube, stand, Bunsen burner

Method: Set up the apparatus as shown in the figure. Take about 2 g of limestone in the test tube and heat it strongly over a Bunsen burner.

Observations and conclusions: As you continue heating, the limewater will turn milky, showing that carbon dioxide is evolved. Calcium oxide is left behind in the test tube.

$$\underset{\text{calcium carbonate}}{CaCO_3} \xrightarrow{\text{heat}} \underset{\text{calcium oxide}}{CaO} + \underset{\text{carbon dioxide}}{CO_2}$$

Cool the contents of the test tube and add water. The resulting solution will turn red litmus paper blue, showing it is basic. This is because the calcium oxide has reacted with water to form calcium hydroxide.

You can also heat lead carbonate ($PbCO_3$) in the same way to get lead oxide (PbO).

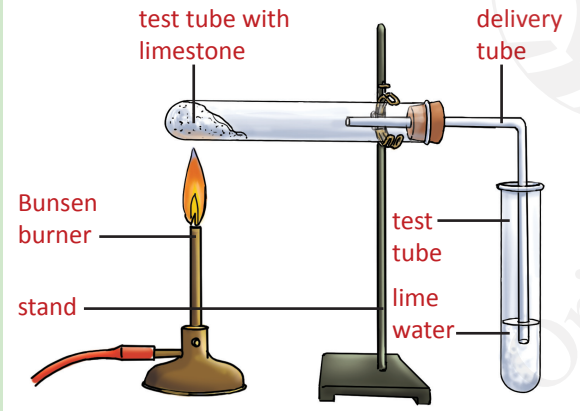


Fig. 6.7 Thermal decomposition of limestone

- **Hydroxides** give the oxide and water.

$$\underset{\text{iron(III) hydroxide}}{2Fe(OH)_3} \xrightarrow{\text{heat}} \underset{\text{iron(III) oxide}}{Fe_2O_3} + \underset{\text{water}}{3H_2O}$$

$$\underset{\text{aluminium hydroxide}}{2Al(OH)_3} \xrightarrow{\text{heat}} \underset{\text{aluminium oxide}}{Al_2O_3} + \underset{\text{water}}{3H_2O}$$

Non-metal Oxides

An oxide of a non-metal is a compound containing a non-metal and oxygen. For example, carbon forms carbon dioxide and carbon monoxide. Sulphur forms sulphur dioxide and sulphur trioxide.

Table 6.2 Some non-metallic oxides and their formulae

Non-Metal	Oxide	Formula
carbon	carbon monoxide	CO
	carbon dioxide	CO_2
nitrogen	nitrous oxide	N_2O
	nitric oxide	NO
	nitrogen dioxide	NO_2
	nitrogen trioxide	NO_3
phosphorus	phosphorus trioxide	P_2O_3
	phosphorus pentoxide	P_2O_5
sulphur	sulphur dioxide	SO_2
	sulphur trioxide	SO_3

The preparation of non-metal oxides

Most non-metal oxides are produced by direct reaction of the non-metal with oxygen on heating.

$$\underset{\text{carbon}}{C} + \underset{\text{oxygen}}{O_2} \xrightarrow{\text{heat}} \underset{\text{carbon dioxide}}{CO_2}$$

$$\underset{\text{sulphur}}{S} + \underset{\text{oxygen}}{O_2} \xrightarrow{\text{heat}} \underset{\text{sulphur dioxide}}{SO_2}$$

$$\underset{\text{nitrogen}}{N} + \underset{\text{oxygen}}{O_2} \xrightarrow{\text{heat}} \underset{\text{nitrogen dioxide}}{NO_2}$$

The Nature of Oxides

Oxides can be classified on the basis of their reaction with acids and bases.

Basic oxides

Generally, oxides of metals react with water to form bases. The solutions of such oxides in water turn red litmus blue, showing the presence of a base.

$$\underset{\text{calcium oxide}}{CaO} + \underset{\text{water}}{H_2O} \rightarrow \underset{\text{calcium hydroxide}}{Ca(OH)_2}$$

$$\underset{\text{sodium oxide}}{Na_2O} + \underset{\text{water}}{H_2O} \rightarrow \underset{\text{sodium hydroxide}}{2NaOH}$$

Basic oxides react with acids to form a salt and water (neutralisation).

$$\underset{\text{copper(II) oxide}}{CuO} + \underset{\text{sulphuric acid}}{H_2SO_4} \rightarrow \underset{\text{copper sulphate}}{CuSO_4} + \underset{\text{water}}{H_2O}$$

$$\underset{\text{aluminium oxide}}{Al_2O_3} + \underset{\text{hydrochloric acid}}{6HCl} \rightarrow \underset{\text{aluminium chloride}}{2AlCl_3} + \underset{\text{water}}{3H_2O}$$

Acidic oxides

Non-metal oxides react with water to form acids. The solutions of such oxides turn blue litmus red, showing the presence of an acid.

$$\underset{\text{carbon dioxide}}{CO_2} + \underset{\text{water}}{H_2O} \rightarrow \underset{\text{carbonic acid}}{H_2CO_3}$$

$$\underset{\text{sulphur trioxide}}{SO_3} + \underset{\text{water}}{H_2O} \rightarrow \underset{\text{sulphuric acid}}{H_2SO_4}$$

Acidic oxides react with a base to form a salt and water (neutralisation).

$$\underset{\text{sulphur trioxide}}{SO_3} + \underset{\text{sodium hydroxide}}{2NaOH} \rightarrow \underset{\text{sodium sulphate}}{Na_2SO_4} + \underset{\text{water}}{H_2O}$$

$$\underset{\text{carbon dioxide}}{CO_2} + \underset{\text{potassium hydroxide}}{2KOH} \rightarrow \underset{\text{potassium carbonate}}{K_2CO_3} + \underset{\text{water}}{H_2O}$$

Amphoteric oxides

The oxides of some metals like aluminium, zinc and lead are amphoteric. They react with both acids and bases to form a salt and water. The solutions of these oxides are neutral and do not change the colour of blue or red litmus paper.

Reaction of zinc oxide with acid and base

$$\underset{\text{zinc oxide}}{ZnO} + \underset{\text{sulphuric acid}}{H_2SO_4} \rightarrow \underset{\text{zinc sulphate}}{ZnSO_4} + \underset{\text{water}}{H_2O}$$

$$\underset{\text{zinc oxide}}{ZnO} + \underset{\text{sodium hydroxide}}{2NaOH} \rightarrow \underset{\text{sodium zincate}}{Na_2ZnO_2} + \underset{\text{water}}{H_2O}$$

Reaction of aluminium oxide with acid and base

$$\underset{\text{aluminium oxide}}{Al_2O_3} + \underset{\text{hydrochloric acid}}{6HCl} \rightarrow \underset{\text{aluminium chloride}}{2AlCl_3} + \underset{\text{water}}{3H_2O}$$

$$\underset{\text{aluminium oxide}}{Al_2O_3} + \underset{\text{sodium hydroxide}}{2NaOH} \rightarrow \underset{\text{sodium aluminate}}{2NaAlO_2} + \underset{\text{water}}{H_2O}$$

Neutral oxides

Water (H_2O), carbon monoxide (CO) and nitrous oxide (N_2O) are neutral oxides. They do not react with acids or bases.

Career watch

Chemical metallurgist

Metallurgy deals with the study of metals and their uses. Chemical metallurgists work in industry to design methods to extract metals from their ores, prepare alloys with properties for specific uses and study metal reactions to prevent corrosion. Study of a subject such as metallurgy, chemical engineering or materials science will prepare you for this field.

CHECKPOINT

A. Choose the correct answer.

1. In which type of reaction does a compound break down into two compounds?
   a) synthesis reaction
   b) decomposition reaction
   c) displacement reaction
   d) double displacement reaction
2. When carbon dioxide is bubbled through limewater, the limewater turns milky. What kind of reaction is this?
   a) synthesis reaction
   b) decomposition reaction
   c) displacement reaction
   d) double displacement reaction
3. Which of the following represents a displacement reaction?
   a) $A + B \rightarrow AB$
   b) $AB \rightarrow A + B$
   c) $AB + C \rightarrow AC + B$
   d) $AB + CD \rightarrow AD + CB$
4. Which of the following metals is more reactive than magnesium?
   a) zinc b) sodium c) iron d) copper
5. Which of the following is an example of a double displacement reaction?
   a) $CaCO_3 (s) \rightarrow CaO (s) + CO_2 (g)$
   b) $2H_2 + O_2 \rightarrow 2H_2O$
   c) $2KI + Pb(NO_3)_2 \rightarrow PbI_2 + 2KNO_3$
   d) $2Fe(OH)_3 \rightarrow Fe_2O_3 + 3H_2O$

B. Fill in the blanks.

1. A chemical reaction is represented by a _____ _____.
2. Elements are represented in chemical equations by _____.
3. A chemical reaction that gives out heat is called an _____ reaction.
4. When silver nitrate and sodium chloride are mixed together, a white _____ of silver chloride is formed.
5. Magnesium when burned in oxygen forms _____ _____.
6. Non-metal oxides react with water to form _____.

C. Complete the equations.

1. $Fe + CuSO_4 \rightarrow$ _____ + _____
2. $NH_3 + HCl \rightarrow$ _____
3. $2Na +$ _____ $\rightarrow 2NaCl + H_2$
4. _____ + _____ $\rightarrow 2NaCl + BaSO_4\downarrow$
5. $CH_4 + 2O_2 \rightarrow$ _____ + _____

D. Differentiate between the following.

1. Decomposition reactions and displacement reactions
2. Amphoteric oxides and neutral oxides

E. What happens in the following cases? Write balanced equations for the reactions (if any).

1. Iron reacts with oxygen in the presence of moisture
2. Copper reacts with concentrated nitric acid
3. Calcium oxide is dissolved in water
4. Hydrogen peroxide is heated
5. Copper is added to zinc sulphate
6. Sodium hydroxide is added to hydrochloric acid
7. Carbon dioxide is bubbled through sulphuric acid

F. Short-answer questions

1. Why should reactions be classified?
2. Name the four main types of reactions.
3. Give an example of a precipitation reaction.
4. What decides whether a reaction is exothermic or endothermic?
5. What happens when carbon dioxide is dissolved in water and blue litmus paper is dipped in the solution?

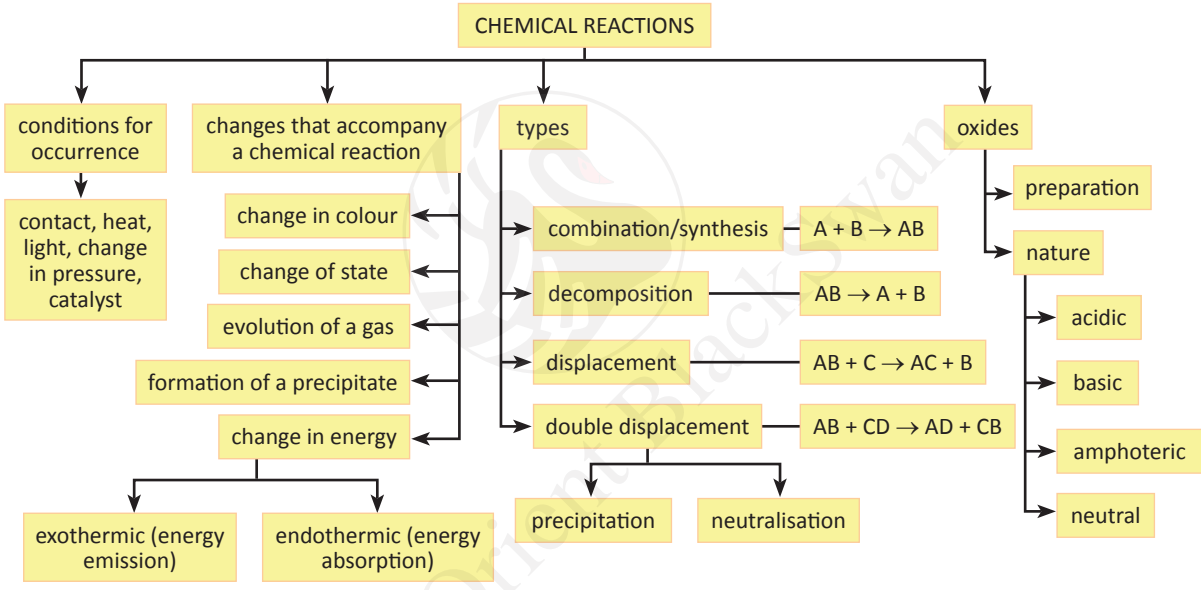
G. Long-answer questions

1. What are the kinds of observable changes that take place during reactions? Explain with an example each.
2. Give any three conditions for a chemical reaction to occur, with an example each.
3. Identify the type of the reactions and balance them where necessary.
   i. $CuSO_4 + H_2S \rightarrow CuS + H_2SO_4$
   ii. $SO_2 + KOH \rightarrow K_2SO_3 + H_2O$
   iii. $Mg + FeSO_4 \rightarrow MgSO_4 + Fe$
   iv. $CuSO_4 + NaOH \rightarrow Cu(OH)_2 + Na_2SO_4$
   v. $CuCO_3 \rightarrow CuO + CO_2$
   vi. $PCl_3 + Cl_2 \rightarrow PCl_5$
4. What is a reactivity series? How is it useful?
5. Write the following metals in the order of their reactivity, from most reactive to least reactive.

   gold, aluminium, tin, lead, copper, sodium, magnesium, calcium, zinc, silver, aluminium
6. Explain the term neutralisation with the help of two suitable examples.
7. How are the oxides of metals prepared?

In a nutshell

CONCEPT MAP



SUMMARY

- A chemical change is also called a chemical reaction. A chemical reaction is represented by a chemical equation.
- A chemical equation is a short form of representing a chemical reaction using symbols and formulae.
- The force that holds atoms in a molecule together is called a chemical bond.
- Different kinds of changes accompany a chemical reaction—change in colour, change of state, evolution of a gas, formation of a precipitate, or the absorption or emission of energy.
- There are some conditions that have to be met for a chemical reaction to occur—contact between reactants, heat, light, change in pressure or the presence of a catalyst.
- In an exothermic reaction, heat is given out. In an endothermic reaction, heat is absorbed.
- Chemical reactions are classified into four main types based on what happens in the reaction.
- In a combination or synthesis reaction, two or more reactants join to form a single product. It may be represented by A + B → AB.

- In a decomposition reaction, a single reactant breaks down to form more than one product. It may be represented by $AB \rightarrow A + B$.
- In a displacement reaction, an element is displaced by a more reactive element. This type of reaction may be represented by $AB + C \rightarrow AC + B$.
- In a double displacement reaction, two compounds exchange ions to form new products. This type of reaction may be represented by $AB + CD \rightarrow AD + CB$.
- Precipitation reactions and neutralisation reactions are two examples of double displacement reactions.
- In a precipitation reaction, an insoluble solid is formed that may settle in the container.
- In a neutralisation reaction, an acid and a base react to form a salt and water.
- An oxide is a compound formed when an element or a group of atoms reacts with oxygen.
- Oxides are prepared by heating a metal or a non-metal in the presence of oxygen or by heating a metal carbonate, nitrate or hydroxide.
- Oxides can be acidic, basic, amphoteric or neutral.

KEYWORDS

amphoteric able to act both as an acid and as a base

antacid a substance that neutralises acid in the stomach

catalyst a substance that affects the rate of a reaction without being used up in the reaction

effervescence vigorous bubbling in a liquid due to the evolution of a gas

endothermic accompanied by the absorption of heat

exothermic accompanied by the release or production of heat

oxide a compound of an element and oxygen

precipitate an insoluble solid substance formed in a reaction that may settle in the reaction vessel

salt a neutral substance that is formed when an acid reacts with a base

Think and Answer

A substance is taken in a test tube and heated strongly. The gas evolved turns limewater milky. The test tube is cooled and the contents are dissolved in water. The solution turns red litmus paper blue. What kind of substance was heated and what was left behind in the test tube?

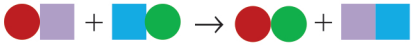
Life Skills and Values

1. There may be some people in class or in your neighbourhood that you do not like. Do not pick fights with the people you do not like. Learn to control your feelings and be at peace.
2. We use many toxic chemicals for cleaning. Some of the cleaners, such as toilet cleaners, are very strong to remove stains and mineral build up. When such chemicals are discharged into the rivers and seas, aquatic plants and animals are destroyed. Try to limit the usage of such harsh chemicals and look for less toxic chemicals to clean the house.

Picture Study

Identify the type of reaction that each set represents.

i. 

ii. 

iii. 

iv. 

Hands-on

1. You may notice white stains left by water around taps and in the sinks at home. Soak some cotton wool in vinegar and rub the stains with it. You will find the stains are removed. Vinegar is a less toxic substitute to the usual cleaning chemicals that are used in homes.
2. **Activity**

   Aim: To observe an exothermic reaction

   Materials required: dilute hydrochloric acid, dilute sodium hydroxide solution, test tube, glass rod

   Method: Take dilute hydrochloric acid in a test tube and add dilute sodium hydroxide solution to the test tube carefully. Mix the solutions well using a glass rod. Then, touch the beaker carefully.

   Observation and conclusion: You will notice that the beaker feels warm to the touch. This shows that the reaction is exothermic.

Scientist in Focus

Margaret Rousseau

Margaret Hutchinson Rousseau (1910–2000) was an American chemical engineer. She set up the first commercial plant for producing penicillin during the Second World War. This helped to save millions of lives during the war and since. She also worked on producing aviation fuel and improved distillation columns. In 1945, she became the first female member of the American Institute of Chemical Engineers.

Internet Links

https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Supplemental_Modules_(Inorganic_Chemistry)/Chemical_Reactions/Chemical_Reactions

http://www.ric.edu/faculty/ptiskus/reactions/

Heritage Corner

Fireworks

We celebrate Diwali in India by lighting lamps and setting off fireworks. Fireworks were first used by the Chinese in the 9th century and have since become popular around the world. The noisy bursts and colourful showers of light are the result of innumerable chemical reactions occurring within the firework. When ignited, a series of quick explosions propel the device high into the air, where the stunning sprays of coloured light are seen.

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For the CISCE curriculum

CLASS 8

Orient BlackSwan

The National Education Policy (NEP) 2020 emphasises certain crucial parameters based on content and pedagogy. The Inspired Chemistry series provides a rich range of exercises and activities for each of the parameters. Here is a quick reference guide to some of the examples in this book.

The Inspired Chemistry series is mapped perfectly to the National Education Policy 2020.

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An approach to teaching and learning that works by connecting knowledge and skills across the curriculum, by bringing real life examples to the classroom

The NEP parameters	Features	Page nos.
The 4Cs		
Critical Thinking	Think and Answer	146
Creativity	Get Going	27
Collaboration	Hands-on (2)	78
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	Picture Study	146
Multiple Intelligences	Hands-on	64
	Hands-on (3 and 5)	147

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Sustainable Development Goals

A framework of 17 global goals designed to be a blueprint to achieve a better and more sustainable future for all

The NEP parameters	Features	Page nos.
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The NEP parameters	Features	Page nos.
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Teacher Empowerment

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