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Class X Science — Complete Compiled Volume
Study Material · NCERT Solutions · Extra Questions

CBSE 2026–27 · Subject Code 086 · All 13 chapters, step-wise, with CBSE-pattern mark allocation

FACULTY: MISHRA SIR · SESSION 2026–27 · REVISED EDITION

A Note on This Document: Parts of this material have been organised and formatted with the help of AI-based tools, and the solutions have been checked against the NCERT text. Even so, an occasional slip may remain — please bring anything doubtful to your teacher. Mark allocations follow the CBSE pattern and are indicative, not official. **Diagrams — our honest policy: a few diagrams are drawn in this volume. Wherever a diagram is not drawn accurately enough to learn from, we have clearly written "please refer to the NCERT textbook figure" and listed every label you must show. Always practise diagrams from the NCERT book itself.**

Syllabus note — Science (086), 2026–27. The NCERT Class X Science textbook for this session has **13 chapters**. Three chapters have been removed from the syllabus altogether: **Periodic Classification of Elements**, **Sources of Energy** and **Sustainable Management of Natural Resources**. Exercises belonging to the older, pre-rationalisation edition have been left out of this volume, because they are no longer part of the course.

Assessed formatively only (retained in the book, but not directly examined in the year-end paper): the Evolution portion of Heredity and the **electric motor / electromagnetic induction / electric generator** portion of Chapter 12 (as per the CBSE Note for Teachers; Periodic Classification is not part of this volume since the chapter is no longer in the NCERT book). **Always confirm the final scope with the official CBSE curriculum PDF (cbseacademic.nic.in) and your school circular.** Information printed inside **boxes** in the NCERT textbook is given for conceptual clarity and is **not assessed**.

✅ **What is inside**

1	**Chapter study material — concepts, tables and syllabus scope**	all 13 chapters
2	**NCERT exercise solutions, step-wise, with mark allocation**	every exercise in the current syllabus
3	**Frequently asked board questions & categorised question banks**	beyond the NCERT exercise

📊 **Unit-wise weightage — theory paper (80 marks)**

I	**Chemical Substances: Nature and Behaviour (Ch 1–4)**	25 marks
II	**World of Living (Ch 5–8)**	25 marks
III	**Natural Phenomena (Ch 9–10)**	12 marks
IV	**Effects of Current (Ch 11–12)**	13 marks
V	**Natural Resources (Ch 13)**	05 marks
+	**Internal assessment**	20 marks

📜 CONTENTS — CHAPTERS INCLUDED

1	**Chemical Reactions and Equations**	Study Material · NCERT Solutions (20 Questions) · Board Questions
2	**Acids, Bases and Salts**	Study Material · NCERT Solutions (15 Questions) · Board Questions
3	**Metals and Non-metals**	Study Material · NCERT Solutions (16 Questions) · Board Questions
4	**Carbon and its Compounds**	Study Material · NCERT Solutions (15 Questions) · Board Questions
5	**Life Processes**	Study Material · NCERT Solutions (13 Questions) · Board Questions
6	**Control and Coordination**	Study Material · NCERT Solutions (16 Questions) · Board Questions
7	**How do Organisms Reproduce?**	Study Material · NCERT Solutions (11 Questions) · Board Questions
8	**Heredity**	Study Material · NCERT Solutions (8 Questions) · Board Questions
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10 The Human Eye and the Colourful World — Study Material · NCERT Solutions (12 Questions) · Board Questions

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13 Our Environment — Study Material · NCERT Solutions (9 Questions) · Board Questions

CHAPTER 1

Chemical Reactions and Equations

Study Material · NCERT Solutions (20 Questions) · Board Questions

📋 SYLLABUS SCOPE — WHAT CBSE PRESCRIBES

UNIT I: CHEMICAL SUBSTANCES — NATURE AND BEHAVIOUR (25 marks). For this chapter the scope is: **chemical equations**, **balanced chemical equations**, and the **implications of a balanced chemical equation**; **types of chemical reactions** — combination, decomposition, displacement, double displacement, precipitation, neutralisation, oxidation and reduction.

Unit	Marks in the theory paper
I — Chemical Substances: Nature and Behaviour	25 marks (Chapters 1–4)
II — World of Living	25 marks (Chapters 5–8)
III — Natural Phenomena	12 marks
IV — Effects of Current	13 marks
V — Natural Resources	05 marks
Theory total	**80 marks** + 20 internal assessment

⚠ **Three chapters are out of the syllabus altogether** for 2026–27: **Periodic Classification of Elements**, **Sources of Energy** and **Sustainable Management of Natural Resources**. The syllabus now runs to **13 chapters**.

A distinction that matters more than most students realise. The official Note for Teachers names three portions that stay **in the syllabus** but are assessed **only formatively** — they will not carry direct questions in the year-end paper: Periodic Classification of Elements, Heredity and Evolution, and the motor / electromagnetic induction / electric generator portion. These are *not* deleted from the textbook; they are removed from the summative exam only, and may still be asked in school periodic tests or portfolio work.

One more official instruction: the information printed inside **boxes** in the NCERT textbook is given for conceptual clarity and is **not assessed** in the year-end examination. Do not spend revision time memorising box content.

📌 **Nothing is deleted from this particular chapter.** It is taught in full. What matters here is that Unit I carries the largest share of the practical list as well — four of the fourteen prescribed experiments come from this unit, including the classification of reaction types.

📘 CHAPTER AT A GLANCE

Topic	What You Will Learn
1. Chemical Change	How to tell a chemical change from a physical one
2. Chemical Equations	Word equation to skeletal equation to balanced equation
3. Balancing	The hit-and-trial method, step by step
4. Symbols and States	(s), (l), (g), (aq), ↑, ↓, Δ and what each means
5. Types of Reactions	The five types, with the general form and an example of each
6. Oxidation and Reduction	Redox in the simple gain/loss-of-oxygen sense
7. Effects in Daily Life	Corrosion and rancidity
8. Equation Bank	The equations most often asked, ready to memorise
9. Common Mistakes	Where marks are lost even when the chemistry is right
10. Categorised Questions	Every type, sorted, with HOTS and starred favourites

1. CHEMICAL CHANGE — HOW TO RECOGNISE ONE

A chemical change produces one or more **new substances** with new properties. Watch for these signs:

- **Change in state** — a solid appearing in a clear solution, or a gas bubbling out.
- **Change in colour** — for example white silver chloride turning grey in sunlight.
- **Evolution of a gas** — effervescence when an acid meets a carbonate.
- **Change in temperature** — the vessel becoming hot (exothermic) or cold (endothermic).
- Any **one** of these signs is enough to suspect a chemical reaction.

2. CHEMICAL EQUATIONS

A chemical equation is a short way of writing a reaction using symbols and formulae. It is built in three stages:

Stage	Example	What it shows
Word equation	Magnesium + Oxygen → Magnesium oxide	Names only
Skeletal equation	$Mg + O_2 \rightarrow MgO$	Formulae, but not yet balanced
Balanced equation	$2Mg + O_2 \rightarrow 2MgO$	Atoms equal on both sides

📌 **Why we must balance.** By the **law of conservation of mass**, matter can neither be created nor destroyed in a chemical reaction. So the total mass — and therefore the number of atoms of each element — must be the same on both sides. An unbalanced equation would break this law, which is why an unbalanced equation earns no marks.

Symbols you must use correctly

Symbol	Meaning
(s)	solid
(l)	liquid
(g)	gas
(aq)	aqueous — dissolved in water
↑	a gas is given off
↓	a precipitate is formed
Δ over the arrow	heat is supplied
→	yields / gives

⚠ **A frequent error:** writing (aq) after a gas, or (l) after water when water is in solution. Water as a liquid reactant is $H_2O(l)$; a substance dissolved in water is written (aq).

3. HOW TO BALANCE AN EQUATION

Use the **hit-and-trial method** in a fixed order and it works every time:

- Write the correct **skeletal equation** with proper formulae. **Never change a formula to balance** — only put numbers in front.
- Count the atoms of each element on both sides. Make a small table if the equation is long.
- Balance the element that appears in the **fewest** places first; leave hydrogen and oxygen for last.
- Balance oxygen, then hydrogen.
- Finally check every element once more, and add the physical states.

Worked example — balance $Fe + H_2O \rightarrow Fe_3O_4 + H_2$

- Iron: 1 on the left, 3 on the right → put 3 before Fe.
- Oxygen: 1 on the left, 4 on the right → put 4 before H_2O.
- Hydrogen: now 8 on the left, 2 on the right → put 4 before H_2.

```
3Fe(s) + 4H₂O(g) → Fe₃O₄(s) + 4H₂(g)
```

4. TYPES OF CHEMICAL REACTIONS

Type	General form	Standard example
Combination	A + B → AB	$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$
Decomposition	AB → A + B	$CaCO_3(s) \xrightarrow{heat} CaO(s) + CO_2(g)$
Displacement	A + BC → AC + B	$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$
Double displacement	AB + CD → AD + CB	$Na_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s)\downarrow + 2NaCl(aq)$

The four main types, with their general form and a standard example

(i) Combination reaction — two or more substances form one product

```
CaO(s) + H₂O(l) → Ca(OH)₂(aq) [quick lime + water → slaked lime]
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This one is **exothermic** — a large amount of heat is released and the mixture becomes hot. Slaked lime is used for whitewashing; it reacts slowly with CO_2 in air to give a shiny finish of calcium carbonate.

(ii) Decomposition reaction — one substance breaks into two or more

Named according to the form of energy supplied:

Type	Example
Thermal decomposition (heat)	$CaCO_3 \xrightarrow{\Delta} CaO + CO_2\uparrow$ and $2FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2 + SO_3$
Photolytic decomposition (light)	$2AgCl \xrightarrow{\text{sunlight}} 2Ag + Cl_2$ — white silver chloride turns **grey**
Electrolytic decomposition (electricity)	$2H_2O \xrightarrow{\text{electricity}} 2H_2 + O_2$ — hydrogen is **double** the volume of oxygen

📌 **Decomposition reactions are mostly endothermic**, because energy must be supplied to break a compound apart. Combination reactions are usually exothermic. This pairing is asked as a 1-mark reasoning question.

(iii) Displacement reaction — a more reactive element pushes out a less reactive one

$$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$$

The blue colour of copper sulphate fades to green, and a reddish-brown deposit of copper forms on the iron. Iron is more reactive than copper, so it displaces it.

(iv) Double displacement reaction — the two compounds exchange partners

$$Na_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s)\downarrow + 2NaCl(aq)$$

An insoluble solid, the **precipitate**, separates out. Any reaction that produces a precipitate is also called a **precipitation reaction**. **Neutralisation** (acid + base → salt + water) is another double displacement.

(v) Oxidation and reduction — redox reactions

Term	Meaning
Oxidation	**Gain of oxygen** or **loss of hydrogen**
Reduction	**Loss of oxygen** or **gain of hydrogen**
Oxidising agent	The substance that gives oxygen — it is itself reduced
Reducing agent	The substance that removes oxygen — it is itself oxidised

$$CuO(s) + H_2(g) \xrightarrow{\Delta} Cu(s) + H_2O(l)$$

Here CuO **loses** oxygen, so it is **reduced**; H_2 **gains** oxygen, so it is **oxidised**. Copper oxide is therefore the oxidising agent and hydrogen the reducing agent. Both happen together, which is why it is called a **redox** reaction.

⚠ **The memory trick students find useful: OIL RIG** — Oxidation Is Loss (of hydrogen), Reduction Is Gain (of hydrogen). For the oxygen version, simply reverse it: oxidation is gain of oxygen.

5. CORROSION AND RANCIDITY — REDOX IN DAILY LIFE

Term	Explanation
Corrosion	A metal is slowly eaten away by attack of air, moisture or chemicals on its surface. Iron rusts (reddish-brown), copper turns green, silver turns black. Rusting needs **both air (oxygen) and water**; if either is absent, iron does not rust.
Prevention of corrosion	Painting, oiling, greasing, galvanisation (a zinc coating), electroplating, or making alloys such as stainless steel.
Rancidity	Fats and oils in food are **oxidised** on standing, giving an unpleasant smell and taste.
Prevention of rancidity	Adding **antioxidants**; packing in **nitrogen** gas (chips packets); refrigeration; using **airtight** containers; keeping food away from light.

6. EQUATION BANK — MEMORISE THESE

Reaction	Balanced equation
Burning of magnesium	$2Mg + O_2 \rightarrow 2MgO$ (dazzling white flame, white powder)
Quick lime + water	$CaO + H_2O \rightarrow Ca(OH)_2$ (exothermic)
Heating limestone	$CaCO_3 \rightarrow(\Delta)\ CaO + CO_2$
Heating ferrous sulphate	$2FeSO_4 \rightarrow(\Delta)\ Fe_2O_3 + SO_2 + SO_3$ (green to brown)
Heating lead nitrate	$2Pb(NO_3)_2 \rightarrow(\Delta)\ 2PbO + 4NO_2 + O_2$ (brown fumes)
Silver chloride in sunlight	$2AgCl \rightarrow(\text{light})\ 2Ag + Cl_2$ (white to grey)
Electrolysis of water	$2H_2O \rightarrow 2H_2 + O_2$
Iron in copper sulphate	$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$ (blue to green)

Reaction	Balanced equation
Sodium sulphate + barium chloride	$Na_2SO_4 + BaCl_2 \rightarrow BaSO_4\downarrow + 2NaCl$ (white precipitate)
Lead nitrate + potassium iodide	$Pb(NO_3)_2 + 2KI \rightarrow PbI_2\downarrow + 2KNO_3$ (yellow precipitate)
Respiration	$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy (exothermic)
Iron + steam	$3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

7. COMMON MISTAKES THAT COST MARKS

- **Changing a formula to balance an equation.** H_2O can never become H_2O_2. Only coefficients change.
- **Forgetting the physical states** when the question says 'write a balanced equation with physical states'.
- **Writing '$Mg + O \rightarrow MgO$'.** Oxygen exists as O_2, not O.
- **Saying silver chloride turns black.** It turns **grey** in sunlight. (Silver bromide is also used in photography.)
- **Confusing the oxidising and reducing agent.** The substance reduced is the oxidising agent.
- **Saying rusting needs only oxygen.** It needs **both** oxygen and moisture.
- **Writing rancidity as a decomposition reaction.** It is an **oxidation** reaction.

CATEGORISED QUESTION BANK WITH SOLUTIONS

Sorted by Question Type — ⭐ marks CBSE's Frequently Asked Patterns

CATEGORY A

Balancing Equations (1–3 Marks)

Q1. Balance: $Fe + H_2O \rightarrow Fe_3O_4 + H_2$ [2 Marks] ⭐ FREQUENTLY ASKED

Ans. $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

- Balance Fe first: 3 atoms on the right, so write 3Fe on the left.
- Balance O next: 4 atoms in Fe_3O_4, so write $4H_2O$ on the left.
- Now H is 8 on the left, so write $4H_2$ on the right.
- **Check:** Fe 3 = 3, H 8 = 8, O 4 = 4 ✓

Q2. Balance: $Na + H_2O \rightarrow NaOH + H_2$ [2 Marks]

Ans. $2Na + 2H_2O \rightarrow 2NaOH + H_2$

- Hydrogen is the awkward element here, so balance it last.
- Take $2H_2O$ on the left; this gives 2 O and 4 H.
- So we need 2NaOH on the right (2 O, 2 H) and H_2 (2 H) — total 4 H ✓
- Finally balance Na by writing 2Na on the left.

Q3. Write a balanced equation with physical states: barium chloride solution reacts with sodium sulphate solution to give a white precipitate of barium sulphate and sodium chloride solution. [3 Marks] ⭐ FREQUENTLY ASKED

Ans. $BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s)\downarrow + 2NaCl(aq)$

- Both reactants are solutions, so both take (aq).
- Barium sulphate is a **precipitate**, so it takes (s) and the ↓ symbol.
- Sodium chloride stays dissolved, so it takes (aq).
- Balancing chlorine needs 2NaCl on the right; everything else is already balanced.
- This is a **double displacement** and also a **precipitation** reaction.

CATEGORY B

Identifying the Type of Reaction (1–3 Marks)

Q4. Identify the type of reaction: $CaO + H_2O \rightarrow Ca(OH)_2$ [1 Mark]

⭐ FREQUENTLY ASKED

Ans. Combination reaction — two reactants join to form a single product. It is also strongly **exothermic**.

Q5. Name the type of reaction in which a more reactive element displaces a less reactive one from its compound, and give an example. [2 Marks] ⭐ FREQUENTLY ASKED

Ans. It is a **displacement reaction**. Example: $Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$. Iron is more reactive than copper, so it displaces copper from copper sulphate solution.

Q6. Classify each of these: (i) $2AgCl \rightarrow 2Ag + Cl_2$ (ii) $NaOH + HCl \rightarrow NaCl + H_2O$ (iii) $2Mg + O_2 \rightarrow 2MgO$ [3 Marks] ⭐ FREQUENTLY ASKED

Ans. (i) **Decomposition** (photolytic — caused by light). (ii) **Double displacement**, and more specifically a **neutralisation** reaction. (iii) **Combination**, and also an **oxidation** since magnesium gains oxygen.

CATEGORY C

Observation-Based Questions (2–3 Marks)

Q7. Why does the colour of copper sulphate solution change when an iron nail is dipped in it? [3 Marks] ⭐ FREQUENTLY ASKED

Ans. Iron is more reactive than copper, so a displacement reaction occurs.

- The equation is $Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$.

- Iron displaces copper because it lies **above copper** in the reactivity series.
- The **blue** colour of copper sulphate fades to the **light green** of ferrous sulphate.
- A **reddish-brown** deposit of copper is seen on the surface of the nail.

Q8. A student heats green crystals of ferrous sulphate in a dry test tube. State two observations and write the equation. [3 Marks] ⭐ FREQUENTLY ASKED

Ans. The reaction is a thermal decomposition.

- **Observation 1:** the green colour of the crystals changes to a **brown** residue of ferric oxide.
- **Observation 2:** a gas with the **smell of burning sulphur** is given off, and the crystals first lose their water of crystallisation.
- $2FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2 + SO_3$
- It is a **decomposition** reaction, and it is **endothermic**.

Q9. Why is white silver chloride kept in dark-coloured bottles? [2 Marks] ⭐ FREQUENTLY ASKED

Ans. Silver chloride undergoes **photolytic decomposition** in sunlight: $2AgCl \xrightarrow{light} 2Ag + Cl_2$. It turns from white to **grey** because silver metal is set free. Dark bottles keep light out and stop this decomposition. (The same property is used in black-and-white photography.)

Q10. In the electrolysis of water, why is the volume of gas collected over one electrode double that over the other? [2 Marks] ⭐ FREQUENTLY ASKED

Ans. The reaction is $2H_2O \rightarrow 2H_2 + O_2$. Two molecules of hydrogen are produced for every one molecule of oxygen, so the volume of **hydrogen** (collected at the cathode) is **twice** the volume of oxygen (at the anode).

CATEGORY D

Oxidation and Reduction (2–3 Marks)

Q11. In the reaction $CuO + H_2 \rightarrow Cu + H_2O$, identify the substance oxidised, the substance reduced, the oxidising agent and the reducing agent. [3 Marks] ⭐ FREQUENTLY ASKED

Ans. Track the oxygen from left to right.

- CuO **loses** oxygen and becomes Cu, so **CuO is reduced**.
- H_2 **gains** oxygen and becomes H_2O, so **H_2 is oxidised**.
- The substance that supplies oxygen is the **oxidising agent**, so **CuO is the oxidising agent**.
- The substance that removes oxygen is the **reducing agent**, so **H_2 is the reducing agent**.
- Since both processes occur together, it is a **redox reaction**.

Q12. What is meant by a redox reaction? Give one example. [2 Marks]

Ans. A reaction in which **oxidation and reduction take place at the same time** is called a redox reaction. Example: $ZnO + C \rightarrow Zn + CO$. Here ZnO is reduced (loses oxygen) while carbon is oxidised (gains oxygen).

CATEGORY E

Corrosion and Rancidity (2–3 Marks)

Q13. What is corrosion? Write two methods of preventing the corrosion of iron. [3 Marks] ⭐ FREQUENTLY ASKED

Ans. Corrosion is the slow eating away of a metal surface by the action of air, moisture or chemicals around it. In iron it is called rusting and gives a reddish-brown coating.

- **Method 1 — barrier methods:** painting, oiling or greasing the surface keeps out air and moisture.
- **Method 2 — galvanisation:** coating iron with a layer of zinc, which corrodes in place of the iron.
- Other accepted methods: electroplating, and alloying to make stainless steel.
- **Remember:** rusting needs **both** oxygen and moisture; removing either one prevents it.

Q14. Why are chips packets flushed with nitrogen gas? [2 Marks] ⭐ FREQUENTLY ASKED

Ans. The oils in the chips would be **oxidised** by the oxygen of the air, turning the food **rancid** and producing a bad smell and taste. Nitrogen is an **unreactive** gas, so flushing the packet with it removes the oxygen and prevents oxidation, keeping the chips fresh for longer.

Q15. Define rancidity. State two ways of preventing it. [2 Marks]

Ans. Rancidity is the oxidation of fats and oils in food on standing, which changes their smell and taste. It can be prevented by adding **antioxidants** to the food, and by packing the food in **nitrogen** gas or in **airtight** containers away from light.

CATEGORY F

Assertion – Reason (1 Mark)

Choose: (i) Both A and R true, R is the correct explanation of A. (ii) Both true, R is not the correct explanation. (iii) A true, R false. (iv) A false, R true.

Q16. Assertion (A): Decomposition reactions are usually endothermic. Reason (R): Energy must be supplied to break a compound into simpler substances. [1 Mark] ⭐ FREQUENTLY ASKED

Ans. Answer: (i) — Both are true and R correctly explains A. Heat, light or electricity has to be supplied in every decomposition, which is exactly why they absorb energy.

Q17. Assertion (A): Rusting of iron takes place in dry air alone. Reason (R): Rusting is an oxidation process. [1 Mark] FREQUENTLY ASKED

Ans. Answer: (iv) — A is false but R is true. Rusting **is** an oxidation, but it needs **both** oxygen and moisture; iron does not rust in perfectly dry air.

Q18. Assertion (A): A chemical equation must be balanced. Reason (R): Mass can be created during a chemical reaction. [1 Mark]

Ans. Answer: (iii) — A is true but R is false. Equations must indeed be balanced, but the reason is the **law of conservation of mass**, which says mass can neither be created nor destroyed.

CATEGORY G

Case Study (4 Marks)

A whitewashing experiment. A student puts a small lump of quick lime into a beaker and adds water slowly. The beaker becomes very hot, and a thick white suspension is formed. This suspension is applied to a wall, and after two or three days the wall develops a shiny white finish.

Q19. Name the compound formed when water is added, and write the equation. [2 Marks]

Ans. Slaked lime, calcium hydroxide, is formed: $\mathbf{CaO + H_2O \rightarrow Ca(OH)_2}$. This is a **combination** reaction.

Q20. Why does the beaker become hot? [1 Mark]

Ans. Because the reaction is **exothermic** — a large amount of heat is released as the product forms.

Q21. Explain the shiny white finish that appears after two or three days. [1 Mark]

Ans. The calcium hydroxide on the wall reacts slowly with **carbon dioxide** in the air to form a thin layer of calcium carbonate: $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$.

CATEGORY H

HOTS — Higher Order Thinking (3–5 Marks)

Q22. Why can a copper vessel not be used to store a solution of iron sulphate, while an iron vessel cannot be used to store copper sulphate solution? Explain both cases. [5 Marks] FREQUENTLY ASKED

Ans. The answer turns on which metal is more reactive.

- **Iron sulphate in a copper vessel:** copper is **less** reactive than iron, so copper cannot displace iron from its salt. **No reaction takes place**, and in fact a copper vessel would be safe on this ground.
- **Copper sulphate in an iron vessel:** iron is **more** reactive than copper, so iron displaces copper: $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$.
- The iron vessel would slowly be eaten away, and the copper sulphate solution would be spoilt, turning from blue to green.
- **Conclusion:** copper sulphate must not be stored in an iron vessel. A more reactive metal always displaces a less reactive one from its salt solution.

Q23. A silver article turns black when kept in the open for some time. What is this process called? How can the shine be brought back, and what is happening chemically? [4 Marks] FREQUENTLY ASKED

Ans. This is an example of corrosion.

- Silver reacts with **hydrogen sulphide** present in the air to form a black coating of **silver sulphide** (Ag_2S) on the surface.
- The process is called **corrosion** (specifically, tarnishing of silver).
- The shine can be restored by cleaning the article with a suitable polish, or by rubbing it with a paste that removes the sulphide layer.
- Note that this is a **surface** reaction — the silver underneath is unaffected, which is why the article recovers its shine once the coating is removed.

Q24. A student adds dilute hydrochloric acid to zinc granules and to sodium carbonate powder in separate test tubes. In both cases a gas is given off. How would you identify the two gases, and are the two reactions of the same type? [5 Marks] FREQUENTLY ASKED

Ans. The gases are different, and so are the reaction types.

- **With zinc:** $Zn + 2HCl \rightarrow ZnCl_2 + H_2$. The gas is **hydrogen**, identified because it burns with a **pop sound** when a burning splint is brought near it.
- **With sodium carbonate:** $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$. The gas is **carbon dioxide**, identified because it turns **lime water milky**.
- The first reaction is a **displacement** reaction — zinc, being more reactive than hydrogen, displaces it from the acid.
- The second is a **double displacement** reaction, in which the compounds exchange partners.
- **So no, the two reactions are not of the same type**, even though both produce a gas.

Q25. Explain why the burning of magnesium ribbon is called a combination reaction as well as an oxidation reaction. Why is the ribbon cleaned before burning? [4 Marks] FREQUENTLY ASKED

Ans. Both names describe the same event from different points of view.

- The equation is $2Mg + O_2 \rightarrow 2MgO$.
- It is a **combination** reaction because two substances join to form a single product.
- It is an **oxidation** reaction because magnesium **gains oxygen** to form its oxide.
- **Cleaning the ribbon:** magnesium reacts slowly with air, so a layer of magnesium oxide forms on its surface. This layer would stop the ribbon from burning properly, so it is rubbed with sandpaper before the experiment.
- The ribbon then burns with a **dazzling white flame**, leaving a **white powder** of magnesium oxide.

⭐ THE SEVEN MOST FREQUENTLY ASKED PATTERNS

Pattern	How to handle it
1. Balance a given equation	Balance the rarest element first; leave H and O for last; never alter a formula.
2. Identify the reaction type	Look at the shape: many→one, one→many, element swaps in, or partners exchange.
3. Colour-change observation	Learn the four standard ones: $FeSO_4$ green→brown, AgCl white→grey, $CuSO_4$ blue→green, PbI_2 yellow precipitate.
4. Oxidising and reducing agent	Follow the oxygen: whoever loses it is reduced and is the oxidising agent.
5. Corrosion / rusting	Always state that **both** air and moisture are needed.
6. Rancidity / nitrogen packing	Say the word **oxidation**, then name antioxidants or nitrogen.
7. Equation with physical states	(s), (l), (g), (aq) plus ↓ for a precipitate — the states carry their own mark.

✅ FINAL CHECK BEFORE THE EXAM

- Can you balance any given equation in under a minute, without altering a single formula?
- Do you know all five reaction types with **one balanced example each**, from memory?
- Can you state the four standard colour changes and what causes each?
- Do you say **both** oxygen and moisture whenever rusting is mentioned?
- Can you name the oxidising and reducing agent in any redox equation put in front of you?

- Have you written out the twelve equations in the Equation Bank at least twice from memory?

PART B — NCERT SOLUTIONS

NCERT Solutions — Chapter 1 Exercises (20 Questions)

How to approach this chapter

Almost every mark in this chapter comes from **writing equations correctly**, not from long explanations. Four habits carry you through: **(1)** write the correct formula of each substance *before* balancing — never change a formula to make an equation balance, only change the coefficients in front; **(2)** balance by the **hit-and-trial method**, leaving hydrogen and oxygen for the last; **(3)** add **state symbols** — (s), (l), (g), (aq) — because the board awards marks for them; **(4)** for "identify the type" questions, match against the five types below.

> **The five reaction types:**
> **Combination:** A + B → AB (two or more substances form one)
> **Decomposition:** AB → A + B (one substance breaks into two or more)
> **Displacement:** A + BC → AC + B (a more reactive element displaces a less reactive one)
> **Double displacement:** AB + CD → AD + CB (ions are exchanged; often a precipitate forms)
> **Oxidation–reduction (redox):** oxygen gained / hydrogen lost = oxidation; oxygen lost / hydrogen gained = reduction

Q1. Which of the statements about the reaction below are incorrect? **1 mark**

$2PbO(s) + C(s) \rightarrow 2Pb(s) + CO_2(g)$

(a) Lead is getting reduced. (b) Carbon dioxide is getting oxidised. (c) Carbon is getting oxidised. (d) Lead oxide is getting reduced.

(i) (a) and (b) (ii) (a) and (c) (iii) (a), (b) and (c) (iv) all

SOLUTION:

Answer: (i) (a) and (b) **1 mark**

Reasoning — check each statement:

(a) "Lead is getting reduced" — **incorrect**. Lead is already present as free metal on the product side; it is *lead oxide* (PbO) that loses oxygen and is reduced, not lead itself.

(b) "Carbon dioxide is getting oxidised" — **incorrect**. CO_2 is a product formed *by* the oxidation of carbon; it is not itself being oxidised.

(c) "Carbon is getting oxidised" — correct. Carbon gains oxygen to become CO_2.

(d) "Lead oxide is getting reduced" — correct. PbO loses oxygen to become Pb.

So the two *incorrect* statements are (a) and (b).

📌 Read the question word carefully: it asks which statements are **incorrect**. Marking (ii) — the two correct ones — is the commonest error here.

Q2. Fe_2O_3 + 2Al → Al_2O_3 + 2Fe. The above reaction is an example of a (a) combination reaction (b) double displacement reaction (c) decomposition reaction (d) displacement reaction 1 mark

SOLUTION:

Answer: (d) displacement reaction 1 mark

Reasoning. Aluminium is more reactive than iron, so it displaces iron from its oxide. The pattern is A + BC → AC + B, which is exactly a displacement reaction.

📌 This particular reaction is the **thermite reaction**. It is highly exothermic and is used to join broken railway tracks and cracked machine parts — a favourite board question.

Q3. What happens when dilute hydrochloric acid is added to iron filings? Tick the correct answer.
(a) Hydrogen gas and iron chloride are produced. (b) Chlorine gas and iron hydroxide are produced. (c) No reaction takes place. (d) Iron salt and water are produced. 1 mark

SOLUTION:

Answer: (a) Hydrogen gas and iron chloride are produced. 1 mark

Reasoning. Iron is more reactive than hydrogen, so it displaces hydrogen from the acid:

$$Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$$

Option (d) is wrong because water is formed only when an acid reacts with a *base* (neutralisation), not with a metal.

Q4. What is a balanced chemical equation? Why should chemical equations be balanced? 2 marks

SOLUTION:

Balanced chemical equation: an equation in which the **number of atoms of each element is equal on both sides** of the arrow — that is, the same on the reactant side and the product side. 1 mark

Why equations must be balanced. Because of the **law of conservation of mass**, which states that mass can neither be created nor destroyed in a chemical reaction. Since atoms are neither created nor destroyed, the total mass of the reactants must equal the total mass of the products. An unbalanced equation would wrongly suggest that atoms had appeared from nowhere or vanished. 1 mark

📌 Both parts carry a mark. Naming the **law of conservation of mass** explicitly is what earns the second one.

Q5. Translate the following statements into chemical equations and then balance them. 4 marks

(a) Hydrogen gas combines with nitrogen to form ammonia.

(b) Hydrogen sulphide gas burns in air to give water and sulphur dioxide.

(c) Barium chloride reacts with aluminium sulphate to give aluminium chloride and a precipitate of barium sulphate.

(d) Potassium metal reacts with water to give potassium hydroxide and hydrogen gas.

SOLUTION:

(a) Hydrogen + Nitrogen → Ammonia

Unbalanced: $H_2 + N_2 \rightarrow NH_3$

$$3H_2(g) + N_2(g) \rightarrow 2NH_3(g)$$

Check: H — 6 on each side; N — 2 on each side ✓ 1 mark

(b) Hydrogen sulphide + Oxygen → Water + Sulphur dioxide

Unbalanced: $H_2S + O_2 \rightarrow H_2O + SO_2$

$$2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(l) + 2SO_2(g)$$

Check: H — 4; S — 2; O — 6 on each side ✓ **1 mark**

("Burns in air" always means reaction with oxygen.)

(c) Barium chloride + Aluminium sulphate → Aluminium chloride + Barium sulphate

Unbalanced: $BaCl_2 + Al_2(SO_4)_3 \rightarrow AlCl_3 + BaSO_4$

$$3BaCl_2(aq) + Al_2(SO_4)_3(aq) \rightarrow 2AlCl_3(aq) + 3BaSO_4(s)\downarrow$$

Check: Ba — 3; Cl — 6; Al — 2; SO_4 — 3 on each side ✓ **1 mark**

(The word "precipitate" tells you $BaSO_4$ is a solid, so mark it (s).)

(d) Potassium + Water → Potassium hydroxide + Hydrogen

Unbalanced: $K + H_2O \rightarrow KOH + H_2$

$$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$$

Check: K — 2; H — 4; O — 2 on each side ✓ **1 mark**

> 📌 **Treat a polyatomic ion as one unit.** In (c), balance SO_4 as a whole group rather than counting S and O separately — it is far quicker and less error-prone.

Q6. Balance the following chemical equations. **4 marks**

(a) $HNO_3 + Ca(OH)_2 \rightarrow Ca(NO_3)_2 + H_2O$

(b) $NaOH + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$

(c) $NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$

(d) $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + HCl$

SOLUTION:

(a)

$$2HNO_3 + Ca(OH)_2 \rightarrow Ca(NO_3)_2 + 2H_2O$$

Check: H — 4; NO_3 — 2; Ca — 1; O (from OH) — 2 ✓ **1 mark**

(b)

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

Check: Na — 2; SO_4 — 1; H — 4; O — 2 ✓ **1 mark**

(c)

$$NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$$

This equation is **already balanced** as written — each element appears once on each side.

1 mark

(d)

$$BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl$$

Check: Ba — 1; Cl — 2; H — 2; SO_4 — 1 ✓ **1 mark**

📌 Part (c) is deliberately included to test whether you actually *check* rather than add coefficients out of habit. Writing "already balanced" after verifying is the full answer.

Q7. Write the balanced chemical equations for the following reactions. **4 marks**

(a) Calcium hydroxide + Carbon dioxide → Calcium carbonate + Water

(b) Zinc + Silver nitrate → Zinc nitrate + Silver

(c) Aluminium + Copper chloride → Aluminium chloride + Copper

(d) Barium chloride + Potassium sulphate → Barium sulphate + Potassium chloride

SOLUTION:

(a)

$$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$$

Already balanced. *(This is the lime-water test — the white precipitate of $CaCO_3$ turns lime water milky.)* **1 mark**

(b)

$$Zn(s) + 2AgNO_3(aq) \rightarrow Zn(NO_3)_2(aq) + 2Ag(s)$$

Check: Zn — 1; Ag — 2; NO_3 — 2 ✓ **1 mark**

(c)

$$2Al(s) + 3CuCl_2(aq) \rightarrow 2AlCl_3(aq) + 3Cu(s)$$

Check: Al — 2; Cu — 3; Cl — 6 ✓ 1 mark

(d)

$BaCl_2(aq) + K_2SO_4(aq) \rightarrow BaSO_4(s)\downarrow + 2KCl(aq)$

Check: Ba — 1; Cl — 2; K — 2; SO_4 — 1 ✓ 1 mark

📌 **Valency decides the formula.** Aluminium is trivalent and chlorine monovalent, so the formula must be $AlCl_3$. Writing $AlCl_2$ to make balancing easier is the single biggest error in this question — never adjust a formula, only the coefficient in front of it.

Q8. Write the balanced chemical equation for the following and identify the type of reaction in each case. 4 marks

(a) Potassium bromide(aq) + Barium iodide(aq) → Potassium iodide(aq) + Barium bromide(s)

(b) Zinc carbonate(s) → Zinc oxide(s) + Carbon dioxide(g)

(c) Hydrogen(g) + Chlorine(g) → Hydrogen chloride(g)

(d) Magnesium(s) + Hydrochloric acid(aq) → Magnesium chloride(aq) + Hydrogen(g)

SOLUTION:

(a)

$2KBr(aq) + BaI_2(aq) \rightarrow 2KI(aq) + BaBr_2(s)$

Type: **Double displacement reaction** — the ions K^+ and Ba^{2+} exchange their partners. 1 mark

(b)

$ZnCO_3(s) \rightarrow ZnO(s) + CO_2(g)$

Type: **Decomposition reaction** — one compound breaks up into two simpler products (here on heating, so it is thermal decomposition). 1 mark

(c)

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

Type: **Combination reaction** — two elements combine to form a single compound. **1 mark**

(d)

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Type: **Displacement reaction** — magnesium, being more reactive, displaces hydrogen from the acid. **1 mark**

> 📌 Each part carries the mark only if **both** the balanced equation and the correct type are given. Note that (a) is *double* displacement (two compounds swap ions) while (d) is *single* displacement (an element replaces another).

Q9. What does one mean by exothermic and endothermic reactions? Give examples. **3 marks**

SOLUTION:

Exothermic reaction: a reaction in which heat energy is **released** along with the products. The surroundings become warmer. **1 mark**

Examples:

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) + \text{heat}$ *(burning of natural gas)*

$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq) + \text{heat}$ *(quick lime slaking in water)*

½ mark

Endothermic reaction: a reaction in which heat energy is **absorbed** from the surroundings. The surroundings become cooler, and such reactions usually need continuous heating.

1 mark

Examples:

$2AgCl(s) \xrightarrow{\text{sunlight}} 2Ag(s) + Cl_2(g)$

$CaCO_3(s) \xrightarrow{\text{heat}} CaO(s) + CO_2(g)$

½ mark

📌 **Most decomposition reactions are endothermic** (energy must be supplied to break a compound apart), while **most combination reactions are exothermic**. That single sentence answers a large family of board questions.

Q10. Why is respiration considered an exothermic reaction? Explain. 2 marks

SOLUTION:

During respiration, glucose obtained from food combines with oxygen inside our cells and breaks down to carbon dioxide and water: 1 mark

$$C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l) + energy$$

This process **releases energy**, which the body uses to maintain its temperature and to carry out all life activities. Since energy is given out rather than absorbed, respiration is classified as an **exothermic reaction**. 1 mark

📌 The released energy is stored as **ATP** and is also what keeps our body warm — mentioning this application strengthens the answer.

Q11. Why are decomposition reactions called the opposite of combination reactions? Write equations for these reactions. 3 marks

SOLUTION:

The two are opposite in **what happens to the number of substances** and in **energy**: 1 mark

Combination reaction	Decomposition reaction
Two or more substances combine to form a **single** product	A **single** compound breaks down into two or more products
General form: A + B → AB	General form: AB → A + B
Usually **exothermic** (energy released)	Usually **endothermic** (energy absorbed)

Example of a combination reaction:

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$$

1 mark

Example of a decomposition reaction:

$CaCO_3(s) \xrightarrow{heat} CaO(s) + CO_2(g)$

1 mark

📌 Notice that the two examples chosen here are literally the reverse of each other around CaO — that makes the word "opposite" vivid and is worth pointing out in the answer.

Q12. Write one equation each for decomposition reactions where energy is supplied in the form of heat, light or electricity. 3 marks

SOLUTION:

(a) By heat — thermal decomposition:

$2FeSO_4(s) \xrightarrow{heat} Fe_2O_3(s) + SO_2(g) + SO_3(g)$

(Green ferrous sulphate crystals lose water and then turn brown.) 1 mark

(b) By light — photolytic decomposition:

$2AgBr(s) \xrightarrow{sunlight} 2Ag(s) + Br_2(g)$

(This reaction is used in black-and-white photography.) 1 mark

(c) By electricity — electrolytic decomposition:

$2H_2O(l) \xrightarrow{electricity} 2H_2(g) + O_2(g)$

(Hydrogen is collected at the cathode and oxygen at the anode, in a 2 : 1 volume ratio.)

1 mark

📌 Write the energy source **above the arrow**. An equation without it does not show which type of decomposition is meant, and the mark can be withheld.

Q13. What is the difference between displacement and double displacement reactions? Write equations for these reactions. 3 marks

SOLUTION:

Displacement reaction	Double displacement reaction
A **more reactive element** displaces a less reactive element from its compound	Two compounds **exchange their ions** with each other
Only **one** element is displaced	**Two** ions are exchanged
Form: A + BC → AC + B	Form: AB + CD → AD + CB
Involves an element and a compound	Involves two compounds, often in solution

1 mark

Example of displacement:

$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$

(The blue colour of copper sulphate fades and a reddish-brown deposit of copper appears on the iron.) 1 mark

Example of double displacement:

$Na_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s)\downarrow + 2NaCl(aq)$

(A white precipitate of barium sulphate is formed.) 1 mark

Q14. In the refining of silver, the recovery of silver from silver nitrate solution involved displacement by copper metal. Write down the reaction involved. 2 marks

SOLUTION:

Copper is more reactive than silver, so it displaces silver from silver nitrate solution: 1 mark

$\mathbf{Cu(s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2Ag(s)}$

Check: Cu — 1; Ag — 2; NO_3 — 2 on each side ✓

This is a **displacement reaction**. The colourless silver nitrate solution slowly turns **blue** (due to copper nitrate formed) and shining silver is deposited. 1 mark

📌 The colour change is worth writing — observations like this are frequently asked as a separate one-mark question.

Q15. What do you mean by a precipitation reaction? Explain by giving examples. 2 marks

SOLUTION:

Precipitation reaction: a reaction in which two solutions react to produce an **insoluble solid**, called a precipitate, which separates out from the solution. 1 mark

Example 1:

$Na_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s)\downarrow + 2NaCl(aq)$

(White precipitate of barium sulphate.)

Example 2:

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

(Bright yellow precipitate of lead iodide.) 1 mark

📌 Every precipitation reaction is also a **double displacement** reaction. Stating the colour of the precipitate — white for $BaSO_4$, yellow for PbI_2 — makes the answer complete.

Q16. Explain the following in terms of gain or loss of oxygen with two examples each. (a) Oxidation (b) Reduction 4 marks

SOLUTION:

(a) Oxidation: the **gain of oxygen** (or loss of hydrogen) by a substance during a reaction. 1 mark

Example 1:

$2Cu(s) + O_2(g) \xrightarrow{heat} 2CuO(s)$

Copper gains oxygen, so copper is oxidised. *(The reddish-brown surface turns black.)*

Example 2:

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

Magnesium gains oxygen and is oxidised. **1 mark**

(b) Reduction: the **loss of oxygen** (or gain of hydrogen) by a substance during a reaction. **1 mark**

Example 1:

$$CuO(s) + H_2(g) \xrightarrow{\text{heat}} Cu(s) + H_2O(l)$$

Copper oxide loses oxygen, so it is reduced (while H_2 is oxidised to water).

Example 2:

$$ZnO(s) + C(s) \rightarrow Zn(s) + CO(g)$$

Zinc oxide loses oxygen and is reduced. **1 mark**

📌 **Oxidation and reduction always occur together** — such reactions are called **redox reactions**. In each example above, whatever is reduced has handed its oxygen to something that is thereby oxidised.

Q17. A shiny brown coloured element 'X' on heating in air becomes black in colour. Name the element 'X' and the black coloured compound formed. **2 marks**

SOLUTION:

The element **X is copper (Cu)** — it is the shiny brown metal described. **1 mark**

On heating in air, copper combines with oxygen to form a black coating of **copper(II) oxide, CuO**:

$$2Cu(s) + O_2(g) \xrightarrow{\text{heat}} 2CuO(s)$$

(brown) *(black)*

So the black compound is **copper oxide (CuO)**. **1 mark**

📌 If hydrogen gas is now passed over the hot black CuO, the brown colour returns as copper is regenerated — a common follow-up question.

Q18. Why do we apply paint on iron articles?

2 marks

SOLUTION:

Iron articles are painted **to prevent rusting (corrosion)**. 1 mark

Iron rusts when it comes into contact with **both moisture and air (oxygen)**, forming hydrated iron(III) oxide, $Fe_2O_3 \cdot xH_2O$ — the reddish-brown flaky substance we call rust. A coat of paint forms a **protective barrier** that keeps air and water away from the iron surface, so rusting cannot begin. 1 mark

Since rusting weakens the article and eats it away over time, painting also extends its life.

> 📌 **Both** air and moisture are needed for rusting. Iron does not rust in dry air, nor in water that has been fully boiled to remove dissolved oxygen.

Q19. Oil and fat containing food items are flushed with nitrogen. Why?

2 marks

SOLUTION:

Oily and fatty foods are flushed with nitrogen **to prevent rancidity**. 1 mark

When fats and oils are exposed to air, they get **oxidised**, and the food develops an unpleasant smell and taste — this spoilage is called **rancidity**. Nitrogen is an **unreactive (inert) gas**. Filling the packet with nitrogen drives out the oxygen, so the oxidation cannot take place and the food stays fresh for longer. 1 mark

> 📌 This is why packets of chips feel puffed up — the "air" inside is actually nitrogen. Other ways to slow rancidity: adding **antioxidants**, refrigeration, and storing in airtight containers away from light.

Q20. Explain the following terms with one example each. (a) Corrosion (b) Rancidity

4 marks

SOLUTION:

(a) Corrosion: the process in which a metal is slowly **eaten away** by the action of air, moisture or chemicals present in the surroundings, forming a compound on its surface. 1 mark

Example — rusting of iron:

$4Fe(s) + 3O_2(g) + xH_2O(l) \rightarrow 2Fe_2O_3{\cdot}xH_2O(s)$
(reddish-brown rust)

Other examples: silver develops a **black** coating (Ag_2S), and copper a **green** coating (basic copper carbonate). **1 mark**

(b) Rancidity: the process in which fats and oils present in food get **oxidised on exposure to air**, changing their smell and taste and making the food unfit to eat. **1 mark**
Example: butter or cooking oil kept open for a long time develops a foul smell and bitter taste; similarly, fried snacks left unpacked turn stale. **1 mark**

> 📌 **Keep the two apart:** corrosion happens to *metals*, rancidity to *food containing fats and oils*. Both, however, are oxidation processes caused by exposure to air.

— End of Chapter 1 Exercises —

PART C — FREQUENTLY ASKED BOARD QUESTIONS

⭐ Frequently Asked Board Questions — Chapter 1

📌 **About this section**

Q. Why is respiration considered an exothermic reaction?

During respiration glucose combines with oxygen in our cells to give carbon dioxide, water and **energy**: $C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$ + energy. Since energy is released, it is exothermic.

Q. Why is decomposition called the opposite of combination? Give one equation of each.

In combination two or more reactants form a single product; in decomposition a single reactant breaks into two or more products. Combination: $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$ + heat. Decomposition: $CaCO_3(s) \xrightarrow{heat} CaO(s) + CO_2(g)$.

Q. What happens when an iron nail is dipped in copper sulphate solution for 20 minutes? Write the equation.

The nail becomes **brownish** (copper deposited) and the blue colour of the solution **fades** (light green $FeSO_4$ forms). $Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$. It is a displacement reaction — iron is more reactive than copper.

Q. Why are decomposition reactions of silver chloride and silver bromide used in black-and-white photography?

They decompose in sunlight (photolytic decomposition): $2AgCl(s) \xrightarrow{sunlight} 2Ag(s) + Cl_2(g)$ (white → grey); $2AgBr(s) \rightarrow 2Ag(s) + Br_2(g)$. The grey silver forms the image.

Q. In the electrolysis of water, why is the volume of gas at one electrode double that at the other? Name the gases.

$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$. Water gives hydrogen and oxygen in the ratio **2 : 1** by volume. Hydrogen (double volume) collects at the cathode, oxygen at the anode.

Q. Identify the substance oxidised and reduced: $CuO + H_2 \rightarrow Cu + H_2O$.

CuO loses oxygen → **reduced** (it is the oxidising agent). H_2 gains oxygen → **oxidised** (it is the reducing agent).

Q. Why are chips packets flushed with nitrogen?

To prevent **rancidity**. Nitrogen is an unreactive gas; it replaces oxygen, so fats and oils in the chips are not oxidised and the taste and smell do not change.

— Chapter 1 Complete —

CHAPTER 2

Acids, Bases and Salts

Study Material · NCERT Solutions (15 Questions) · Board Questions

📋 SYLLABUS SCOPE — WHAT CBSE PRESCRIBES

UNIT I: CHEMICAL SUBSTANCES — NATURE AND BEHAVIOUR (25 marks). The scope for this chapter is: **acids, bases and salts** — their definitions in terms of furnishing of H^+ and OH^- ions, general properties, examples and uses; the concept of **pH scale** (definition relating to logarithm not required); importance of pH in **everyday life**; **preparation and uses** of sodium hydroxide, bleaching powder, baking soda, washing soda and plaster of Paris.

Unit	Marks in the theory paper
I — Chemical Substances: Nature and Behaviour	25 marks (Chapters 1–4)
II — World of Living	25 marks (Chapters 5–8)
III — Natural Phenomena	12 marks
IV — Effects of Current	13 marks
V — Natural Resources	05 marks
Theory total	**80 marks** + 20 internal assessment

⚠ **Three chapters are out of the syllabus altogether** for 2026–27: **Periodic Classification of Elements**, **Sources of Energy** and **Sustainable Management of Natural Resources**. The syllabus now runs to **13 chapters**.

A distinction that matters more than most students realise. The official Note for Teachers names three portions that stay **in the syllabus** but are assessed **only formatively** — they will not carry direct questions in the year-end paper: Periodic Classification of Elements, Heredity and Evolution, and the motor / electromagnetic induction / electric generator portion. These are *not* deleted from the textbook; they are removed from the summative exam only, and may still be asked in school periodic tests or portfolio work.

One more official instruction: the information printed inside **boxes** in the NCERT textbook is given for conceptual clarity and is **not assessed** in the year-end examination. Do not spend revision time memorising box content.

📌 **Two scope notes specific to this chapter.** First, the **logarithmic definition of pH is not required** — you must know what the scale means and how to use it, but not pH = $-\log[H^+]$. Second, this chapter contributes **four of the fourteen prescribed practicals**: pH of samples, properties of acids and bases, properties of acetic acid, and the cleaning capacity of soap.

📘 CHAPTER AT A GLANCE

Topic	What You Will Learn
1. Acids and Bases	What they are, and the ion each one furnishes in water
2. Indicators	Natural, synthetic and olfactory — with the full colour table
3. Reactions of Acids	With metals, carbonates, metal oxides and bases
4. Reactions of Bases	With metals and with non-metal oxides
5. Why Water Matters	Why acids conduct only in solution; the dilution rule
6. The pH Scale	Reading the scale and what each region means
7. pH in Everyday Life	Six standard applications CBSE asks about
8. Salts	Family, pH of a salt, and water of crystallisation
9. The Five Important Compounds	NaOH, bleaching powder, baking soda, washing soda, POP
10. Categorised Questions	Every type, sorted, with HOTS and starred favourites

1. ACIDS AND BASES — THE DEFINITIONS THAT EARN MARKS

Term	Definition
Acid	A substance that furnishes **hydrogen ions, H^+** (as H_3O^+) when dissolved in water. Sour in taste, turns blue litmus red.
Base	A substance that furnishes **hydroxide ions, OH^-** when dissolved in water. Bitter in taste, soapy to touch, turns red litmus blue.
Alkali	A base that is **soluble in water**. All alkalis are bases, but not all bases are alkalis — a favourite 1-mark distinction.

⚠ **Write the definition in terms of ions.** An answer that says only 'acids are sour' will not get the mark. The examiner is looking for the words **furnishes H^+ ions in aqueous solution**.

2. INDICATORS

Indicator	With an acid	With a base
Litmus	Red in acid	Blue in base
Methyl orange	Red / pink in acid	Yellow in base
Phenolphthalein	**Colourless** in acid	**Pink** in base
Turmeric	Stays yellow in acid	Turns **red** in base
Red cabbage juice	Red in acid	Green in base

Olfactory indicators are substances whose **smell** changes with acids and bases — for example onion and vanilla essence. Their smell is lost in a basic solution but persists in an acid. These are used to test acids and bases for a visually impaired student, which is exactly how CBSE frames the question.

3. THE FOUR REACTIONS OF ACIDS

(i) Acid + Metal → Salt + Hydrogen gas

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

Test for hydrogen: bring a burning splint near the mouth of the tube; the gas burns with a **pop sound**.

(ii) Acid + Metal carbonate / hydrogencarbonate → Salt + Water + Carbon dioxide

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$

Test for carbon dioxide: pass the gas through lime water — it turns **milky**. On passing excess CO_2 the milkiness **disappears**, because soluble calcium hydrogencarbonate is formed.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3\downarrow + H_2O \text{ then } CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$$

(iii) Acid + Metal oxide → Salt + Water

$$CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$$

The black copper oxide dissolves and the solution turns **blue-green**. Since metal oxides behave like bases here, metal oxides are said to be **basic oxides**.

(iv) Acid + Base → Salt + Water (neutralisation)

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NaOH(aq) + HCl(aq) → NaCl(aq) + H₂O(l)
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Reaction of a base with a non-metal oxide

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2NaOH + CO₂ → Na₂CO₃ + H₂O
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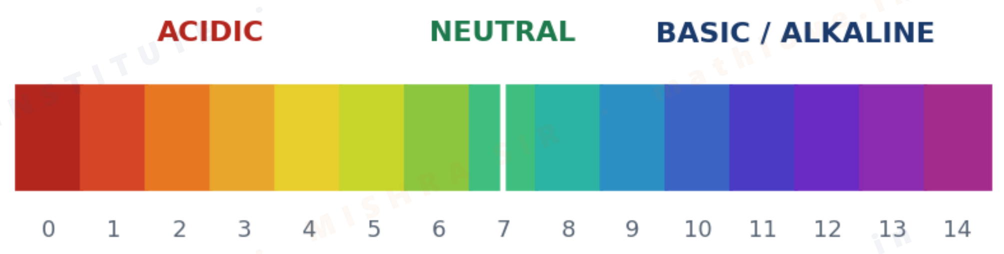
Because non-metal oxides react with bases to give salt and water, non-metal oxides are said to be **acidic oxides**.

4. WHY WATER IS ESSENTIAL — AND THE DILUTION RULE

- **Dry HCl gas does not turn blue litmus red**, but hydrochloric acid solution does. Acids show acidic behaviour only when they **ionise in water** to give H^+ ions.
- Hydrogen ions cannot exist alone; they attach to water to give **hydronium ions, H_3O^+**.
- **Dilution** means adding water to an acid or base. This **decreases the concentration** of H^+ or OH^- ions per unit volume.
- **The safety rule:** always add the **acid to water**, slowly and with stirring — **never water to acid**. The process is highly exothermic; adding water to concentrated acid can make the mixture splash out and cause burns, and the glass container may crack.

📌 The dilution safety rule is asked almost every year, usually as a 2-mark question with the reason. Write the direction **and** the reason (large heat evolved).

5. THE pH SCALE



The pH scale from 0 to 14 — acidic below 7, neutral at 7, basic above 7

pH value	What it means
pH less than 7	**Acidic.** The lower the number, the stronger the acid.
pH exactly 7	**Neutral** — pure water, or a neutral salt solution such as sodium chloride.
pH greater than 7	**Basic / alkaline.** The higher the number, the stronger the base.
The p in pH	Stands for **'potenz'**, the German word for power. The scale measures the concentration of hydrogen ions.

⚠ **A common error:** saying a strong acid has a **high** pH. It is the opposite — a strong acid has a **low** pH, because pH falls as the H^+ ion concentration rises.

Strong and weak acids

A **strong** acid ionises **completely** in water and gives many H^+ ions (HCl, H_2SO_4, HNO_3). A **weak** acid ionises only **partially** and gives fewer H^+ ions (acetic acid, carbonic acid, citric acid). The same distinction applies to strong bases ($NaOH$, KOH) and weak bases (ammonium hydroxide).

6. IMPORTANCE OF pH IN EVERYDAY LIFE

Application	Explanation
In our body	Our body works within the narrow range pH 7.0 to 7.8. Living organisms survive only in this range.
Acid rain	When the pH of rain water falls **below 5.6** it is called acid rain. It flows into rivers and lowers their pH, making survival of aquatic life difficult.
In the stomach	The stomach produces hydrochloric acid for digestion. Too much acid causes indigestion and pain; an **antacid** such as milk of magnesia, $Mg(OH)_2$, a mild base, neutralises the excess.
Tooth decay	Tooth enamel is calcium phosphate, the hardest substance in the body. It begins to corrode when the pH in the mouth falls **below 5.5**. Bacteria produce acid from leftover sugar. Cleaning with an alkaline toothpaste neutralises the acid and prevents decay.
Plants and soil	Plants grow well only in a particular soil pH range. Farmers correct acidic soil by adding quick lime or slaked lime.

Application	Explanation
Self-defence by animals and plants	Bee sting injects an acid causing pain; rubbing with **baking soda**, a mild base, gives relief. Nettle leaf stings with methanoic acid; rubbing with **dock plant** leaf helps. A wasp sting is alkaline, so it is treated with a mild **acid** such as vinegar.

7. SALTS

A salt is formed when the hydrogen of an acid is replaced by a metal, that is, from the reaction of an acid with a base.

Family of salts

Salts sharing the same positive or negative radical belong to one family. $NaCl$ and Na_2SO_4 belong to the **sodium** family; $NaCl$ and KCl belong to the **chloride** family.

pH of a salt — from its parent acid and base

Parent acid and base	Nature of the salt	Example
Strong acid + Strong base	**Neutral**, pH = 7	$NaCl$
Strong acid + Weak base	**Acidic**, pH < 7	NH_4Cl
Weak acid + Strong base	**Basic**, pH > 7	Na_2CO_3, CH_3COONa

Water of crystallisation

This is the **fixed number of water molecules** present in one formula unit of a salt. Examples: $CuSO_4 \cdot 5H_2O$ (blue vitriol), $Na_2CO_3 \cdot 10H_2O$ (washing soda), $CaSO_4 \cdot 2H_2O$ (gypsum).

On heating, blue copper sulphate crystals turn **white** as the water is driven off; adding water restores the blue colour.

8. THE FIVE IMPORTANT COMPOUNDS

Compound	Preparation	Uses
Sodium hydroxide NaOH	**Chlor-alkali process** — electrolysis of brine (concentrated $NaCl$ solution). Chlorine at the anode, hydrogen at the cathode, $NaOH$ near the cathode.	De-greasing metals, soaps and detergents, paper making, artificial fibres

Compound	Preparation	Uses
Bleaching powder $CaOCl_2$	Cl_2 passed over **dry slaked lime**: $Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$	Bleaching cotton, linen and wood pulp; oxidising agent; disinfecting drinking water
Baking soda $NaHCO_3$	$NaCl + H_2O + CO_2 + NH_3 \rightarrow NH_4Cl + NaHCO_3$	Baking powder ingredient, antacid, soda-acid fire extinguisher
Washing soda $Na_2CO_3 \cdot 10H_2O$	Heating baking soda gives sodium carbonate, then recrystallising it with water	Glass, soap and paper industries; removing permanent hardness of water; domestic cleaning
Plaster of Paris $CaSO_4 \cdot \frac{1}{2}H_2O$	Heating gypsum at **373 K (100°C)**: $CaSO_4 \cdot 2H_2O \xrightarrow{373\text{ K}} CaSO_4 \cdot \frac{1}{2}H_2O + 1\frac{1}{2}H_2O$	Plastering fractured bones, making toys and decorative material, smoothing surfaces

⚠ **Three details CBSE checks in this table.** (1) Plaster of Paris must be heated at **373 K only** — above this, all the water is lost and anhydrous calcium sulphate (dead burnt plaster) forms, which will not set. (2) The half-molecule of water in $CaSO_4 \cdot \frac{1}{2}H_2O$ is written as ½, and students often mark it wrong. (3) POP must be stored in a **moisture-proof** container, or it will set into a hard mass.

Baking powder is not the same as baking soda

Baking powder = baking soda + a mild edible acid (tartaric acid). On heating, the soda gives carbon dioxide which makes the cake rise; the tartaric acid neutralises the sodium carbonate that would otherwise be left behind and make the cake taste bitter.

$$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2$$

CATEGORISED QUESTION BANK WITH SOLUTIONS

Sorted by Question Type — ⭐ marks CBSE's Frequently Asked Patterns

CATEGORY A

Definitions and Indicators (1–2 Marks)

Q1. Define an acid and a base in terms of the ions they furnish. **[2 Marks]**

⭐ FREQUENTLY ASKED

Ans. An **acid** is a substance that furnishes **hydrogen ions (H^+)** when dissolved in water. A **base** is a substance that furnishes **hydroxide ions (OH^-)** when dissolved in water. A base that is soluble in water is called an **alkali**.

Q2. What is an olfactory indicator? Give two examples and state how it would help a visually impaired student. [2 Marks] ⭐ FREQUENTLY ASKED

Ans. An **olfactory indicator** is a substance whose **smell** changes in acidic and basic media. Examples: **onion** and **vanilla essence**. Their characteristic smell is destroyed in a basic solution but remains in an acidic one, so a visually impaired student can tell an acid from a base by smell alone.

Q3. Name the indicator that is colourless in acid and pink in base. [1 Mark]

Ans. Phenolphthalein.

CATEGORY B

Reactions and Gas Tests (2–3 Marks)

Q4. What happens when dilute hydrochloric acid is added to zinc granules? Write the equation and the test for the gas evolved. [3 Marks] ⭐ FREQUENTLY ASKED

Ans. A displacement reaction takes place and hydrogen gas is released.

- $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$
- **Observation:** brisk effervescence is seen, and the zinc granules slowly dissolve.
- **Test:** bring a **burning splint** near the mouth of the test tube.
- The gas burns with a **pop sound**, which confirms it is **hydrogen**.

Q5. On adding dilute HCl to sodium carbonate, a gas is evolved which turns lime water milky. Identify the gas and explain what happens if the gas is passed in excess. [3 Marks] ⭐ FREQUENTLY ASKED

Ans. The gas is carbon dioxide.

- $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$
- CO_2 turns lime water milky because insoluble calcium carbonate is formed: $Ca(OH)_2 + CO_2 \rightarrow CaCO_3\downarrow + H_2O$
- **On passing excess CO_2, the milkiness disappears.**
- This is because the insoluble calcium carbonate reacts further to form **soluble** calcium hydrogencarbonate: $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$

Q6. Why does dry HCl gas not change the colour of dry litmus paper? [2 Marks] ⭐ FREQUENTLY ASKED

Ans. Acids show acidic behaviour only when they **ionise in water** to furnish H^+ ions. Dry HCl gas contains no water, so it does not ionise and no H^+ ions are produced. Since there are no hydrogen ions, the dry litmus paper shows no colour change. In the presence of moisture, HCl ionises and turns blue litmus red.

CATEGORY C

The pH Scale and Everyday Life (2–3 Marks)

Q7. A milkman adds a very small amount of baking soda to fresh milk. Why does he do this, and why does the milk take longer to set into curd? [3 Marks]

FREQUENTLY ASKED

Ans. Baking soda is a mild base and it shifts the pH of the milk.

- Fresh milk has a pH of about 6, that is, slightly acidic.
- Adding a little baking soda makes the milk **slightly alkaline**, raising its pH above 6.
- In this alkaline medium the milk **does not turn sour easily**, so it can be kept for longer.
- However, curd forms by the action of bacteria producing **lactic acid**. The added base must first be neutralised by this acid, so the milk takes **longer to set** into curd.

Q8. Explain why tooth decay starts when the pH of the mouth falls below 5.5. [3 Marks] FREQUENTLY ASKED

Ans. The link is between acidity and the enamel.

- Tooth enamel is made of **calcium phosphate** and is the hardest substance in the body.
- Bacteria in the mouth act on **leftover sugar and food particles** and produce acids.
- When these acids lower the pH below **5.5**, the enamel begins to **corrode**, and decay sets in.
- **Prevention:** cleaning the mouth after eating, and using an **alkaline toothpaste** which neutralises the excess acid.

Q9. A person suffering from acidity is advised to take an antacid. Name one antacid and explain how it works. [2 Marks] FREQUENTLY ASKED

Ans. Milk of magnesia, which is magnesium hydroxide $Mg(OH)_2$, is a common antacid. It is a **mild base**, so it **neutralises** the excess hydrochloric acid produced in the stomach, giving relief from pain. Baking soda is also used for the same purpose.

Q10. What is acid rain? Why is it harmful to aquatic life? [2 Marks]

Ans. Rain water with a pH **below 5.6** is called acid rain. It is formed when oxides of sulphur and nitrogen in the air dissolve in rain water. When this acid rain flows into rivers and lakes, it **lowers the pH of the water**, and aquatic organisms cannot survive outside their narrow pH range.

CATEGORY D

Salts and Water of Crystallisation (2–3 Marks)

Q11. What is water of crystallisation? What happens when blue copper sulphate crystals are heated? [3 Marks] ⭐ FREQUENTLY ASKED

Ans. It is the fixed number of water molecules present in one formula unit of a salt.

- Copper sulphate crystals are written as $\mathbf{CuSO_4 \cdot 5H_2O}$, so each formula unit holds five water molecules.
- **On heating**, the water of crystallisation is driven off and the **blue** crystals turn **white** (anhydrous copper sulphate).
- **On adding water again**, the blue colour returns, showing the change is reversible.
- This colour change is used as a **test for the presence of water**.

Q12. Predict whether an aqueous solution of sodium carbonate will be acidic, basic or neutral. Justify. [2 Marks] ⭐ FREQUENTLY ASKED

Ans. It will be **basic**, with a pH greater than 7. Sodium carbonate is the salt of a **strong base** (NaOH) and a **weak acid** (carbonic acid). The salt of a strong base and a weak acid always gives a basic solution.

CATEGORY E

The Five Important Compounds (2–5 Marks)

Q13. Write the chemical name and formula of Plaster of Paris. How is it prepared, and why must it be stored in a moisture-proof container? [5 Marks] ⭐ FREQUENTLY ASKED

Ans. Plaster of Paris is calcium sulphate hemihydrate.

- **Chemical name:** calcium sulphate hemihydrate. **Formula:** $CaSO_4 \cdot \frac{1}{2}H_2O$.
- **Preparation:** gypsum is heated to a temperature of **373 K (100°C)**.
- $CaSO_4 \cdot 2H_2O \xrightarrow{373\ K} CaSO_4 \cdot \frac{1}{2}H_2O + 1\frac{1}{2}H_2O$
- **Storage:** on coming into contact with moisture, POP sets into a **hard solid mass** of gypsum again, so it becomes useless. It must therefore be kept in a moisture-proof container.
- **Uses:** supporting fractured bones in the hospital, making toys and decorative materials, and smoothing surfaces.
- **Careful:** heating above 373 K gives **dead burnt plaster**, which will not set at all.

Q14. What is the chlor-alkali process? Name the products formed at each electrode. [3 Marks] ⭐ FREQUENTLY ASKED

Ans. It is the electrolysis of concentrated sodium chloride solution, called brine.

- The name comes from the two products: **chlor** for chlorine and **alkali** for sodium hydroxide.
- $2NaCl(aq) + 2H_2O(l) \rightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$
- **At the anode:** chlorine gas is liberated.

- **At the cathode:** hydrogen gas is liberated, and sodium hydroxide forms near the cathode.

Q15. Why is baking powder used instead of baking soda for making cakes? [3 Marks]

⭐ FREQUENTLY ASKED

Ans. The difference lies in the acid that baking powder contains.

- **Baking powder = baking soda + a mild edible acid** such as tartaric acid.
- On heating, baking soda alone gives sodium carbonate: $2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2$
- The CO_2 makes the cake **rise and become soft and spongy**.
- But the sodium carbonate left behind would make the cake taste **bitter**.
- In baking powder the tartaric acid **neutralises** this sodium carbonate, so the cake rises without turning bitter.

CATEGORY F

Assertion – Reason (1 Mark)

Choose: (i) Both A and R true, R is the correct explanation of A. (ii) Both true, R is not the correct explanation. (iii) A true, R false. (iv) A false, R true.

Q16. Assertion (A): Acid must always be added to water and never water to acid. Reason (R): The dilution of a concentrated acid is a highly exothermic process. [1 Mark] ⭐ FREQUENTLY ASKED

Ans. Answer: (i) — Both are true and R correctly explains A. The heat evolved is so large that adding water to acid can make the mixture splash out and can crack the container.

Q17. Assertion (A): A solution of pH 2 is a stronger acid than one of pH 6. Reason (R): pH increases as the concentration of hydrogen ions increases. [1 Mark]

⭐ FREQUENTLY ASKED

Ans. Answer: (iii) — A is true but R is false. A pH of 2 is indeed more acidic, but pH **decreases** as the hydrogen ion concentration increases.

Q18. Assertion (A): All alkalis are bases. Reason (R): All bases are alkalis. [1 Mark]

Ans. Answer: (iii) — A is true but R is false. An alkali is a base that dissolves in water, so every alkali is a base; but bases such as copper oxide are insoluble and are therefore not alkalis.

CATEGORY G

Case Study (4 Marks)

Soil in a farmer's field. A farmer finds that his crop yield has fallen sharply. On testing, the pH of his soil is found to be 4.5. He is advised to treat the field before the next sowing.

Q19. Is the soil acidic, basic or neutral? Give a reason. [1 Mark]

Ans. The soil is **acidic**, because its pH of 4.5 is **less than 7**.

Q20. What should the farmer add to the soil, and why? [2 Marks]

Ans. He should add a **base** to neutralise the excess acid — **quick lime (CaO)** or **slaked lime, $Ca(OH)_2$**. These raise the pH of the soil towards neutral, bringing it into the range in which crops grow well.

Q21. What would you advise if the soil had been found too alkaline instead? [1 Mark]

Ans. He should add **organic matter (compost or manure)**, which releases acids on decomposition and lowers the pH.

CATEGORY H

HOTS — Higher Order Thinking (3–5 Marks)

Q22. Two beakers A and B contain colourless solutions. Beaker A turns blue litmus red and gives a gas with zinc that burns with a pop sound. Beaker B turns red litmus blue and feels soapy. Identify the nature of each, and describe what happens when the two are mixed in the right proportions. [5 Marks] ⭐ FREQUENTLY ASKED

Ans. The tests identify one acid and one base.

- **Beaker A is an acid.** Turning blue litmus red is the standard acid test, and the pop-sound gas is **hydrogen**, released when an acid reacts with a metal: $Zn + 2HCl \rightarrow ZnCl_2 + H_2$.
- **Beaker B is a base.** Turning red litmus blue and feeling soapy to the touch are both properties of bases.
- **On mixing in the right proportions**, a **neutralisation** reaction occurs: Acid + Base → Salt + Water.
- For example, $NaOH + HCl \rightarrow NaCl + H_2O$.
- The resulting solution would be **neutral, with pH 7**, and would have no effect on either litmus paper. Heat is also evolved, as neutralisation is exothermic.

Q23. A compound X is used for disinfecting drinking water and for bleaching cotton in the textile industry. It is prepared by the action of chlorine on dry slaked lime. Identify X, write the equation, and give two more uses. [4 Marks] ⭐ FREQUENTLY ASKED

Ans. The description points to bleaching powder.

- **X is bleaching powder**, with the formula **$CaOCl_2$**.
- **Preparation:** $Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$
- Note that the slaked lime must be **dry** for this reaction.

- **Two more uses:** bleaching wood pulp in the paper industry and bleaching washed clothes in the laundry; it is also used as an **oxidising agent** in many chemical industries.

Q24. Fresh milk has a pH of 6. Explain what happens to the pH of milk when it turns into curd, and give the reason. [3 Marks] ⭐ FREQUENTLY ASKED

Ans. The change is caused by acid production.

- Fresh milk has a pH of about 6, which is **slightly acidic**.
- When milk turns into curd, bacteria act on the milk and produce **lactic acid**.
- This increases the concentration of H^+ ions in the milk.
- Since pH **falls** as hydrogen ion concentration rises, the pH of the curd is **lower than 6**, that is, the curd is **more acidic** than the milk.

Q25. Sodium hydrogencarbonate is used in soda-acid fire extinguishers. Explain the chemistry involved and why the gas produced is effective in putting out a fire. [4 Marks] ⭐ FREQUENTLY ASKED

Ans. The extinguisher works by producing carbon dioxide under pressure.

- The extinguisher contains a solution of **sodium hydrogencarbonate** and a separate bottle of **sulphuric acid**.
- When the knob is pressed, the acid mixes with the sodium hydrogencarbonate solution.
- $2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2CO_2$
- **Why CO_2 works:** it is **heavier than air**, so it settles over the fire and cuts off the supply of oxygen. It is also itself **non-supporter of combustion**.
- Without oxygen the fire cannot continue, so it is extinguished.

⭐ THE SEVEN MOST FREQUENTLY ASKED PATTERNS

Pattern	How to handle it
1. Define acid / base	Always in terms of H^+ and OH^- ions furnished in water.
2. Identify the gas	Pop sound = hydrogen; lime water milky = carbon dioxide.
3. Excess CO_2 in lime water	Milkiness **disappears** — soluble calcium hydrogencarbonate forms.
4. Dilution safety	Acid into water, never the reverse; because the process is highly exothermic.
5. pH in daily life	Learn the six: body, acid rain, stomach, tooth decay, soil, stings.
6. The five compounds	For each: formula, preparation equation, and two uses.

Pattern	How to handle it
7. Nature of a salt	Trace its parent acid and base — strong/strong is neutral, and so on.

✅ FINAL CHECK BEFORE THE EXAM

- Can you define acid and base using the words **furnishes H^+ / OH^- ions in aqueous solution**?
- Do you know the full indicator colour table, including turmeric and methyl orange?
- Can you write the four reactions of acids with a balanced example of each?
- Do you remember that excess CO_2 makes the milkiness **disappear**, and why?
- For all five compounds — formula, preparation and uses — can you write them without the book?
- Do you know that POP is heated at **373 K only**, and why heating further ruins it?

PART B — NCERT SOLUTIONS

NCERT Solutions — Chapter 2 Exercises (15 Questions)

How to approach this chapter

Everything in this chapter grows from one idea: **acids give H^+ ions in water, bases give OH^- ions in water**. That single sentence explains why acids conduct electricity, why dry HCl gas does not turn dry litmus red, and why neutralisation always produces salt and water.

> **Reactions you must be able to write from memory:**
> Acid + Metal → Salt + Hydrogen gas
> Acid + Metal carbonate / hydrogencarbonate → Salt + Water + Carbon dioxide
> Acid + Base → Salt + Water *(neutralisation)*
> Metal oxide + Acid → Salt + Water *(metal oxides are basic)*
> Non-metal oxide + Base → Salt + Water *(non-metal oxides are acidic)*

The pH scale runs 0 to 14. Lower pH means **more** H^+ ions and a stronger acid; higher pH means a stronger base; 7 is neutral.

- **0–3 strongly acidic**
- **4–6 weakly acidic**
- **7 neutral**
- **8–10 weakly alkaline**
- **11–14 strongly alkaline**

Most marks in this chapter are lost on two things — **unbalanced equations**, and **confusing the four common salts** (baking soda, washing soda, bleaching powder, plaster of Paris). Learn their formulae and uses as a block.

Q1. A solution turns red litmus blue, its pH is likely to be **1 mark**

(a) 1 (b) 4 (c) 5 (d) 10

SOLUTION:

Answer: (d) 10 **1 mark**

Reasoning. Only a **base** turns red litmus blue. Bases have pH **greater than 7**. Among the options, 1, 4 and 5 are all below 7 (acidic), so the only possible value is 10.

> 📌 Remember the pair: **acids turn blue litmus red**; **bases turn red litmus blue**. A quick way to

recall it — the colour always changes to the *other* one.

Q2. A solution reacts with crushed egg-shells to give a gas that turns lime-water milky. The solution contains **1 mark**

(a) NaCl (b) HCl (c) LiCl (d) KCl

SOLUTION:

Answer: (b) HCl **1 mark**

Reasoning. Egg-shells are made of **calcium carbonate ($CaCO_3$)**. A carbonate reacts only with an **acid** to release carbon dioxide, and CO_2 is the gas that turns lime water milky. Of the four options only HCl is an acid; NaCl, LiCl and KCl are neutral salts.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

The milkiness is due to insoluble calcium carbonate:

$$\underset{\text{(lime water)}}{Ca(OH)_2(aq)} + CO_2(g) \rightarrow \underset{\text{(milky)}}{CaCO_3(s)\downarrow} + H_2O(l)$$

📌 If excess CO_2 is passed, the milkiness **disappears**, because soluble calcium hydrogencarbonate $Ca(HCO_3)_2$ is formed. This follow-up is asked very often.

Q3. 10 mL of a solution of NaOH is found to be completely neutralised by 8 mL of a given solution of HCl. If we take 20 mL of the same solution of NaOH, the amount of HCl solution required to neutralise it will be **1 mark**

(a) 4 mL (b) 8 mL (c) 12 mL (d) 16 mL

SOLUTION:

Answer: (d) 16 mL **1 mark**

Reasoning. Both solutions are unchanged in concentration, so the volumes needed are in **direct proportion**. The NaOH volume is doubled (10 mL → 20 mL), so the HCl volume must also double:

$$8\text{ mL} \times 2 = \mathbf{16\text{ mL}}$$

📌 The word "same solution as before" is the key — it tells you the concentration has not changed, so simple proportion applies.

Q4. Which one of the following types of medicines is used for treating indigestion? **1 mark**

(a) Antibiotic (b) Analgesic (c) Antacid (d) Antiseptic

SOLUTION:

Answer: (c) Antacid **1 mark**

Reasoning. Indigestion is caused by **excess hydrochloric acid** in the stomach. An antacid is a mild base — such as milk of magnesia, $Mg(OH)_2$, or baking soda — which **neutralises** the excess acid and gives relief.

The others: an antibiotic kills bacteria, an analgesic relieves pain, and an antiseptic is applied to wounds to prevent infection.

📌 A common extension: "Why is a *weak* base used and not a strong one like NaOH?" — because a strong base would damage the stomach lining.

Q5. Write word equations and then balanced equations for the reaction taking place when — **4 marks**

(a) dilute sulphuric acid reacts with zinc granules

(b) dilute hydrochloric acid reacts with magnesium ribbon

(c) dilute sulphuric acid reacts with aluminium powder

(d) dilute hydrochloric acid reacts with iron filings

SOLUTION:

All four follow the same pattern: **Acid + Metal → Salt + Hydrogen gas**.

(a) *Word equation:* Sulphuric acid + Zinc → Zinc sulphate + Hydrogen

$$H_2SO_4(dil.) + Zn(s) \rightarrow ZnSO_4(aq) + H_2(g)$$

Already balanced: H — 2; SO_4 — 1; Zn — 1 ✓ **1 mark**

(b) *Word equation:* Hydrochloric acid + Magnesium → Magnesium chloride + Hydrogen

$2HCl(dil.) + Mg(s) \rightarrow MgCl_2(aq) + H_2(g)$

Check: H — 2; Cl — 2; Mg — 1 ✓ **1 mark**

(c) *Word equation:* Sulphuric acid + Aluminium → Aluminium sulphate + Hydrogen

$3H_2SO_4(dil.) + 2Al(s) \rightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$

Check: H — 6; SO_4 — 3; Al — 2 ✓ **1 mark**

(d) *Word equation:* Hydrochloric acid + Iron → Iron(II) chloride + Hydrogen

$6HCl(dil.) + 2Fe(s) \rightarrow 2FeCl_3(aq) + 3H_2(g)$

Check: H — 6; Cl — 6; Fe — 2 ✓ **1 mark**
(With dilute HCl, ferrous chloride $FeCl_2$ is also accepted: $Fe + 2HCl \rightarrow FeCl_2 + H_2$.)

📌 **Aluminium is trivalent**, so its sulphate must be $Al_2(SO_4)_3$ — never $AlSO_4$. Fix the formula first from valency, then balance with coefficients only.

Q6. Compounds such as alcohols and glucose also contain hydrogen but are not categorised as acids. Describe an Activity to prove it. **3 marks**

SOLUTION:

Aim: To show that alcohol and glucose do not release H^+ ions in solution, and so are not acids.

Procedure. Take a beaker containing a solution of glucose. Fit a cork with **two iron nails** pushed through it and place it in the beaker so that the nails dip into the solution. Connect the nails to the two terminals of a battery through a **bulb** and a switch. Switch on the current. **1 mark**

Observation. The **bulb does not glow**. Repeat the same with alcohol — again the bulb does not glow. But when the experiment is repeated with dilute HCl or dilute H_2SO_4, the **bulb glows brightly**. **1 mark**

Conclusion. Conduction of electricity requires free ions. Acids dissociate in water to give **H^+ ions**, which carry the current, so the bulb glows. Alcohols and glucose do contain hydrogen, but that hydrogen stays bound in the molecule and is **not released as H^+ ions**. Hence they are not acids. **1 mark**

> 📌 The definition being tested is precise: an acid is not simply "a compound containing hydrogen", but one that **produces H^+ ions in aqueous solution**.

Q7. Why does distilled water not conduct electricity, whereas rain water does? **2 marks**

SOLUTION:

Distilled water is pure water. It contains almost no dissolved salts or acids, so there are **no free ions** in it to carry charge. Hence it does not conduct electricity. **1 mark**

Rain water, while falling through the atmosphere, dissolves gases such as carbon dioxide and sulphur dioxide and forms weak acids (for example carbonic acid):

$$H_2O(l) + CO_2(g) \rightarrow H_2CO_3(aq)$$

These acids dissociate to give **free H^+ ions**, which can carry electric current. Therefore rain water conducts electricity. **1 mark**

> 📌 The general rule: **conduction needs free ions**, not merely a liquid. This same reasoning answers Q6 and Q8 as well.

Q8. Why do acids not show acidic behaviour in the absence of water? **2 marks**

SOLUTION:

An acid shows its acidic behaviour only when it can produce **hydrogen ions (H^+)**. This dissociation happens only **in the presence of water**: **1 mark**

$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$

In the absence of water, the acid molecules stay undissociated, so no H^+ ions are released and no acidic behaviour is shown. **1 mark**

Evidence. Dry HCl gas does **not** turn dry blue litmus paper red; but if the litmus paper is moistened, it turns red at once — the water lets the HCl dissociate.

📌 Note that H^+ ions cannot exist alone in solution; they attach to water molecules and exist as **hydronium ions, H_3O^+**. Writing this earns full credit.

Q9. Five solutions A, B, C, D and E when tested with universal indicator showed pH as 4, 1, 11, 7 and 9 respectively. Which solution is (a) neutral (b) strongly alkaline (c) strongly acidic (d) weakly acidic (e) weakly alkaline? Arrange the pH in increasing order of hydrogen-ion concentration. 3 marks

SOLUTION:

Solution	pH	Nature
A	4	Weakly acidic
B	1	Strongly acidic
C	11	Strongly alkaline
D	7	Neutral
E	9	Weakly alkaline

(a) Neutral — D (b) Strongly alkaline — C (c) Strongly acidic — B (d) Weakly acidic — A (e) Weakly alkaline — E 2 marks

Increasing order of hydrogen-ion concentration:

Since a **lower pH means a higher** H^+ concentration, increasing H^+ concentration means **decreasing** pH:

11 < 9 < 7 < 4 < 1 that is, C < E < D < A < B

1 mark

📌 This last part is the trap — the relation is **inverse**. Students routinely write 1 < 4 < 7 < 9 < 11, which is increasing *pH*, not increasing H^+ concentration.

Q10. Equal lengths of magnesium ribbons are taken in test tubes A and B. Hydrochloric acid (HCl) is added to test tube A, while acetic acid (CH_3COOH) is added to test tube B. Amount and concentration taken for 2 marks

both the acids are same. In which test tube will the fizzing occur more vigorously and why?

SOLUTION:

The fizzing will be **more vigorous in test tube A**, the one containing hydrochloric acid. **1 mark**

Reason. HCl is a **strong acid** — it dissociates completely in water and therefore gives a much larger number of **H^+ ions**. Acetic acid is a **weak acid** and dissociates only partially, giving far fewer H^+ ions. Since the fizzing is caused by hydrogen gas produced when H^+ ions react with magnesium, the tube with more H^+ ions produces hydrogen faster. **1 mark**

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)\uparrow$$

📌 Note the phrase "same amount and concentration" — it rules out concentration as the reason, forcing you to answer in terms of **strong versus weak acid**.

Q11. Fresh milk has a pH of 6. How do you think the pH will change as it turns into curd? Explain your answer. **2 marks**

SOLUTION:

The pH will **decrease** — it will fall below 6. **1 mark**

Reason. When milk turns into curd, bacteria convert the lactose in milk into **lactic acid**. The formation of this acid increases the concentration of H^+ ions in the milk, and a higher H^+ concentration means a **lower pH**. This is also why curd tastes sour. **1 mark**

Q12. A milkman adds a very small amount of baking soda to fresh milk. **2 marks**
(a) Why does he shift the pH of the fresh milk from 6 to slightly alkaline?
(b) Why does this milk take a long time to set as curd?

SOLUTION:

(a) Baking soda ($NaHCO_3$) is a **mild base**. Adding it neutralises the small amount of acid already present and makes the milk **slightly alkaline**. Milk in alkaline conditions does not turn sour easily, so it **does not spoil quickly** and can be stored for a longer time. **1 mark**

(b) To set as curd, the milk must become **acidic** — the bacteria have to produce enough lactic acid to bring the pH down. Since the milk has been made alkaline to begin with, the acid formed is first used up in neutralising that added base. Only after this does the pH start falling, so the milk **takes much longer to set** as curd. 1 mark

📌 Q11 and Q12 are a matched pair — one shows acid formation lowering pH, the other shows what happens when you deliberately work against it. Board papers often ask them together.

Q13. Plaster of Paris should be stored in a moisture-proof container. Explain why.

2 marks

SOLUTION:

Plaster of Paris, calcium sulphate hemihydrate **$CaSO_4 \cdot \frac{1}{2}H_2O$**, reacts readily with water. On contact with moisture it takes up water and sets into a **hard solid mass of gypsum**: 1 mark

$$CaSO_4 \cdot \tfrac{1}{2}H_2O + 1\tfrac{1}{2}H_2O \rightarrow CaSO_4 \cdot 2H_2O$$

(Plaster of Paris) *(Gypsum)*

Once this happens the plaster becomes useless for its purpose. Therefore it must be kept in a **moisture-proof container**, away from damp air. 1 mark

📌 Learn the numbers exactly: Plaster of Paris has **½** molecule of water, gypsum has **2**. It is made by heating gypsum to about **373 K (100 °C)** — heating beyond this makes it useless. Uses: plaster casts for fractured bones, making toys and decorative materials, smoothing walls.

Q14. What is a neutralisation reaction? Give two examples.

3 marks

SOLUTION:

Neutralisation reaction: the reaction in which an **acid reacts with a base** to form **salt and water only**, with the acidic and basic natures of the two cancelling each other out. 1 mark

$$\text{Acid} + \text{Base} \rightarrow \text{Salt} + \text{Water}$$

Example 1:

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

1 mark

Example 2:

$$Ca(OH)_2(aq) + H_2SO_4(aq) \rightarrow CaSO_4(aq) + 2H_2O(l)$$

1 mark

Everyday examples: taking an antacid for acidity in the stomach; applying baking soda on an ant sting (which injects formic acid); adding lime to acidic soil.

Q15. Give two important uses of washing soda and baking soda. 2 marks

SOLUTION:

Washing soda — $Na_2CO_3 \cdot 10H_2O$ 1 mark

• Used in the glass, soap and paper industries.

• Used for **removing the permanent hardness of water**.

(Also: as a cleaning agent for domestic purposes, and in the manufacture of borax.)

Baking soda — $NaHCO_3$ 1 mark

• Used in making **baking powder**, which makes cakes and bread soft and spongy (the CO_2 released causes the rising).

• Used as an **antacid** to neutralise excess acid in the stomach.

(Also: in soda-acid fire extinguishers.)

Common name	Chemical name	Formula
Baking soda	Sodium hydrogencarbonate	$NaHCO_3$
Washing soda	Sodium carbonate decahydrate	$Na_2CO_3 \cdot 10H_2O$
Bleaching powder	Calcium oxychloride	$CaOCl_2$
Plaster of Paris	Calcium sulphate hemihydrate	$CaSO_4 \cdot ½H_2O$
Common salt	Sodium chloride	$NaCl$

📌 This table is the highest-yield thing in the chapter. Five-mark questions regularly ask for the preparation, properties and uses of these salts, and one-mark questions ask only for a formula or chemical name.

— End of Chapter 2 Exercises —

⭐ Frequently Asked Board Questions — Chapter 2

📌 About this section

These questions are not from the NCERT exercise, but they appear repeatedly in CBSE board papers and sample papers from this chapter. They are worth preparing separately.

A. One-mark questions (MCQ / Very Short Answer)

Q. What is the chemical formula of bleaching powder, and how is it prepared?

$CaOCl_2$. It is prepared by passing chlorine gas over dry slaked lime:

> $Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$

Q. Why does dry HCl gas not change the colour of dry litmus paper?

Because in the absence of water the HCl molecules do not dissociate, so no H^+ ions are produced and no acidic behaviour is shown.

Q. What is the pH of a neutral solution? Name the ion responsible for the acidity of a solution.

pH = **7**. Acidity is due to the **hydrogen ion, H^+** (present as hydronium, H_3O^+).

Q. Which gas is usually liberated when an acid reacts with a metal? How would you test it?

Hydrogen gas. Bring a burning candle near the gas — it burns with a **pop sound**.

Q. What happens to the colour of copper sulphate crystals on heating?

Blue $CuSO_4{\cdot}5H_2O$ loses its water of crystallisation and turns **white**. Adding water back restores the blue colour.

B. Three-mark questions

Q. What is the chlor-alkali process? Write the equation and name the products with one use of each.

When electricity is passed through an aqueous solution of sodium chloride (called **brine**), it decomposes. The name comes from the two products — **chlor**ine and **alkali** (sodium hydroxide).

> $2NaCl(aq) + 2H_2O(l) \rightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$

Chlorine — at the anode; used for water treatment, PVC and bleaching powder.
Hydrogen — at the cathode; used as fuel and in making ammonia.
Sodium hydroxide — near the cathode; used for making soaps and detergents.

Q. What is water of crystallisation? Explain with an example.

It is the **fixed number of water molecules** chemically attached to one formula unit of a salt. For example, copper sulphate crystals contain five such molecules — $CuSO_4 \cdot 5H_2O$ (blue vitriol). On heating, the water is driven off and the blue crystals turn white.

Q. Why should curd and sour substances not be kept in brass and copper vessels?
Curd and sour foods contain **acids**. These acids react with the copper and zinc of the vessel to form toxic metal salts, which spoil the food and can cause food poisoning.

Q. How is the pH of the soil important for plant growth? How can acidic soil be treated?
Plants grow best in a narrow pH range, close to neutral. If the soil is too acidic or too alkaline, the plants cannot absorb nutrients properly. **Acidic soil is treated with quick lime (CaO), slaked lime $Ca(OH)_2$ or chalk ($CaCO_3$)**, which neutralise the excess acid.

C. Five-mark / case-study favourites

Q. Explain tooth decay in terms of pH. How can it be prevented?
Tooth enamel is made of **calcium phosphate**, the hardest substance in the body. It does not dissolve in water, but it is **corroded when the pH in the mouth falls below 5.5**. Bacteria in the mouth break down leftover sugar and food to produce acids, lowering the pH and starting decay. **Prevention:** clean the mouth after eating, and use **toothpaste, which is basic** — it neutralises the excess acid and keeps the pH above 5.5.

Q. Why does a bee sting cause pain, and what gives relief?
A bee sting injects an acid — **methanoic (formic) acid** — which causes pain and irritation. Rubbing a mild base such as **baking soda** on the stung area neutralises the acid and relieves the pain. Similarly, a nettle sting also injects methanoic acid, and rubbing the leaf of a dock plant gives relief.

Q. How does the pH of rain water relate to acid rain, and what is its effect?
When the pH of rain water falls **below 5.6**, it is called **acid rain**. It is caused by oxides of sulphur and nitrogen from burning fuels dissolving in rain. Acid rain flows into rivers and lakes and lowers their pH, which **threatens the survival of aquatic life**; it also damages buildings and monuments made of marble.

Q. Name the acid present in each: curd, lemon, vinegar, tamarind, ant sting, tomato.
Curd — **lactic acid**; Lemon/orange — **citric acid**; Vinegar — **acetic acid**; Tamarind — **tartaric acid**; Ant sting — **methanoic acid**; Tomato — **oxalic acid**.

— Chapter 2 Complete —

⭐ Frequently Asked Board Questions — Chapter 2

📌 **About this section**

Q. Why does dry HCl gas not change the colour of dry blue litmus paper?

Acidic behaviour is due to H^+ (H_3O^+) ions, which form only in the presence of **water**. Dry HCl does not ionise, so no H^+ ions are present and the litmus colour does not change.

Q. How is bleaching powder prepared? Give two uses.

By passing chlorine gas over dry slaked lime: $Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$. Uses: bleaching cotton and linen in textile industry and wood pulp in paper factories; disinfecting drinking water; oxidising agent in chemical industries.

Q. What is Plaster of Paris? How is it obtained and why must it be stored in a moisture-proof container?

$CaSO_4 \cdot \frac{1}{2}H_2O$. Gypsum is heated at **373 K**: $CaSO_4 \cdot 2H_2O \rightarrow CaSO_4 \cdot \frac{1}{2}H_2O + 1\frac{1}{2}H_2O$. With water it sets back into hard gypsum ($CaSO_4 \cdot \frac{1}{2}H_2O + 1\frac{1}{2}H_2O \rightarrow CaSO_4 \cdot 2H_2O$), so it is stored away from moisture. Used for plaster casts for fractured bones, toys, decoration.

Q. Write the chemical name and formula of washing soda. How is it obtained from baking soda?

Sodium carbonate decahydrate, $Na_2CO_3 \cdot 10H_2O$. Heating baking soda: $2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$; then recrystallisation: $Na_2CO_3 + 10H_2O \rightarrow Na_2CO_3 \cdot 10H_2O$. Uses: removing permanent hardness of water, glass/soap/paper industries, cleaning.

Q. A student adds zinc granules to dilute H_2SO_4. What gas is evolved and how is it tested?

$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$. Hydrogen gas — it burns with a **pop sound** when a burning candle is brought near.

Q. Why should water be added to acid and not acid to water?

Mixing concentrated acid with water is highly **exothermic**. If water is added to acid, the heat may cause the mixture to splash out and cause burns, and the glass container may break. So acid is added slowly to water with constant stirring.

Q. Solutions A, B, C have pH 3, 7 and 12. Arrange in increasing H^+ concentration and identify them.

H^+ concentration increases as pH decreases: **C (12) < B (7) < A (3)**. A — acidic, B — neutral, C — basic (alkaline).

— Chapter 2 Complete —

CHAPTER 3

Metals and Non-metals

Study Material · NCERT Solutions (16 Questions) · Board Questions

📋 SYLLABUS SCOPE — WHAT CBSE PRESCRIBES

UNIT I: CHEMICAL SUBSTANCES — NATURE AND BEHAVIOUR (25 marks). The scope is: **properties of metals and non-metals**; **reactivity series**; formation and properties of **ionic compounds**.

Unit	Marks in the theory paper
I — Chemical Substances: Nature and Behaviour	25 marks (Chapters 1–4)
II — World of Living	25 marks (Chapters 5–8)
III — Natural Phenomena	12 marks
IV — Effects of Current	13 marks
V — Natural Resources	05 marks
Theory total	**80 marks** + 20 internal assessment

⚠ **Three chapters are out of the syllabus altogether** for 2026–27: **Periodic Classification of Elements**, **Sources of Energy** and **Sustainable Management of Natural Resources**. The syllabus now runs to **13 chapters**.

A distinction that matters more than most students realise. The official Note for Teachers names three portions that stay **in the syllabus** but are assessed **only formatively** — they will not carry direct questions in the year-end paper: Periodic Classification of Elements, Heredity and Evolution, and the motor / electromagnetic induction / electric generator portion. These are *not* deleted from the textbook; they are removed from the summative exam only, and may still be asked in school periodic tests or portfolio work.

One more official instruction: the information printed inside **boxes** in the NCERT textbook is given for conceptual clarity and is **not assessed** in the year-end examination. Do not spend revision time memorising box content.

⚠ **Two portions of this chapter are outside the prescribed scope.** The syllabus line for this chapter names only properties, the reactivity series and ionic compounds. It does **not** name **basic metallurgical processes** (concentration of ore, roasting, calcination, reduction, refining) or **corrosion and its prevention** as part of this chapter's scope.

However, corrosion is very much examinable through **Chapter 1**, where it appears as an application of oxidation. So do not skip corrosion; study it as Chapter 1 material. As for extraction of metals, confirm against your school's scope circular before dropping it — several guidebooks still print the full metallurgy section.

📘 CHAPTER AT A GLANCE

Topic	What You Will Learn
1. Physical Properties	The full comparison table, with the exceptions that get asked
2. Chemical Properties of Metals	With oxygen, water, acids and salt solutions
3. Amphoteric Oxides	Al_2O_3 and ZnO — a favourite 2-mark question
4. The Reactivity Series	The ladder, and the three things it predicts
5. Reaction of Metals with Non-metals	How ions form; electron transfer
6. Ionic Compounds	Formation, structure and the five properties
7. Aqua Regia and Noble Metals	Why gold needs special treatment
8. Alloys	Definition and the standard examples
9. Common Mistakes	Where marks are lost even when the chemistry is right
10. Categorised Questions	Every type, sorted, with HOTS and starred favourites

1. PHYSICAL PROPERTIES

Property	Metals	Non-metals
Lustre	Shiny (lustrous)	Dull, except **iodine** which is lustrous
State at room temp.	Solid, except **mercury** (liquid)	Solid or gas, except **bromine** (liquid)
Malleability	**Malleable** — can be beaten into sheets	Brittle — break into pieces

Property	Metals	Non-metals
Ductility	**Ductile** — can be drawn into wires	Not ductile
Conduction	Good conductors of heat and electricity	Poor conductors, except **graphite**
Sonority	**Sonorous** — make a ringing sound	Not sonorous
Melting point	Generally high, except **gallium** and **caesium** which melt on the palm	Generally low
Hardness	Generally hard, except **sodium** and **potassium** which can be cut with a knife	Generally soft, except **diamond**, the hardest natural substance

📌 **The exceptions are the exam.** Mercury, bromine, iodine, graphite, diamond, sodium/potassium, gallium/caesium — almost every 1-mark question from this table asks for one of these, not for the general rule. Learn them as a list.

2. CHEMICAL PROPERTIES OF METALS

(i) Reaction with oxygen → metal oxide (basic in nature)

$$2Cu + O_2 \xrightarrow{\Delta} 2CuO \text{ (black)} \quad 4Al + 3O_2 \rightarrow 2Al_2O_3$$

Sodium and potassium react so vigorously with air that they catch fire, which is why they are stored under **kerosene oil**. Magnesium burns with a dazzling white flame. Aluminium forms a thin, protective oxide layer which prevents further corrosion.

(ii) Reaction with water

Metal	Behaviour with water	Equation
K, Na	React **violently** with cold water; the reaction is so exothermic that the hydrogen catches fire	$2Na + 2H_2O \rightarrow 2NaOH + H_2$ + heat
Ca, Mg	React with cold water **less violently**; calcium starts floating as bubbles stick to it	$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$
Al, Zn, Fe	Do **not** react with cold or hot water; react with **steam**	$3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$
Cu, Ag, Au	Do **not** react with water at all	—

(iii) Reaction with acids → salt + hydrogen

$$Fe + 2HCl \rightarrow FeCl_2 + H_2$$

⚠ **Why nitric acid is the exception.** Metals generally do not give hydrogen with **nitric acid**, because HNO_3 is a strong **oxidising agent** — it oxidises the hydrogen produced into water and is itself reduced to oxides of nitrogen. The only exceptions are **magnesium** and **manganese**, which give hydrogen with very dilute nitric acid.

(iv) Reaction with salt solutions — displacement

$$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$$

A more reactive metal displaces a less reactive one from its salt solution. This single idea is the basis of most numerical-reasoning questions in this chapter.

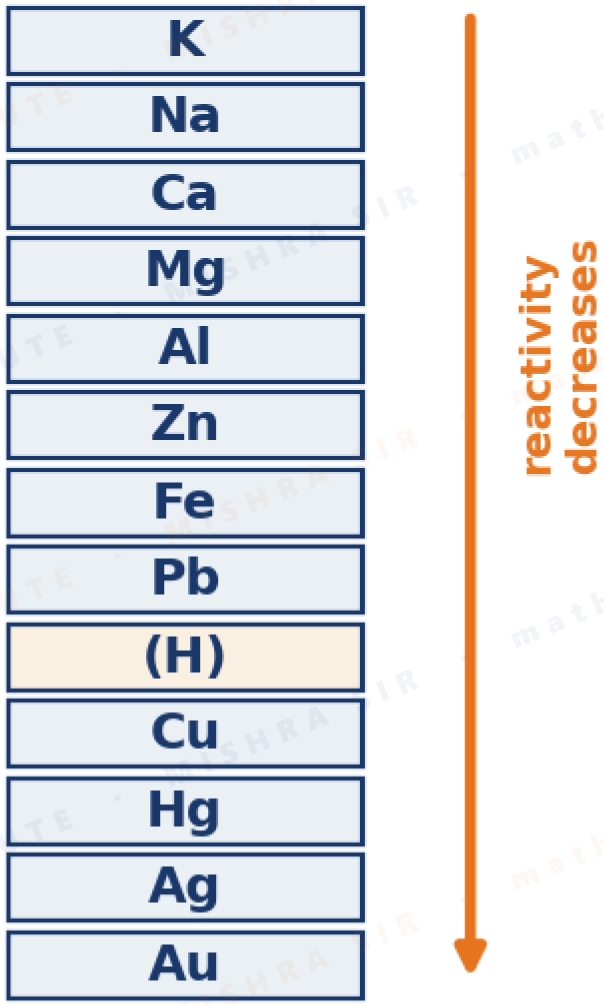
3. AMPHOTERIC OXIDES

Oxides that react with **both acids and bases** to give salt and water are called **amphoteric oxides**. The two examples to learn are **aluminium oxide (Al_2O_3)** and **zinc oxide (ZnO)**.

$$Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O \text{ (behaving as a base)}$$

$$Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O \text{ (behaving as an acid)}$$

4. THE REACTIVITY SERIES



The activity series — the most reactive metal at the top, the least at the bottom

The reactivity series is a list of metals arranged in order of decreasing reactivity. It tells you three things at a glance:

- **Which metal displaces which.** Any metal higher in the series displaces one lower down from its salt solution.
- **Which metals react with water or acids.** Metals **above hydrogen** displace hydrogen from dilute acids; those below (Cu, Hg, Ag, Au) do not.
- **How the metal occurs in nature.** Metals at the **bottom** (gold, silver, platinum) are so unreactive that they occur **free** in nature; those at the top are always found as compounds.

📌 **A mnemonic for the order:** *K, Na, Ca, Mg, Al, Zn, Fe, Pb, (H), Cu, Hg, Ag, Au.* Hydrogen is placed in the series even though it is not a metal, precisely so that you can read off which metals will react with acids.

5. HOW METALS AND NON-METALS COMBINE — IONIC BONDING

Metals **lose** electrons to become **positive ions (cations)**; non-metals **gain** electrons to become **negative ions (anions)**. Both do this to attain a stable, fully filled outermost shell like the nearest noble gas.

Formation of sodium chloride

- Sodium has 1 electron in its outermost shell. It **loses** that electron to become Na^+ (2, 8), the configuration of neon.
- Chlorine has 7 electrons in its outermost shell. It **gains** one electron to become Cl^- (2, 8, 8), the configuration of argon.
- The oppositely charged Na^+ and Cl^- ions are held together by strong **electrostatic force of attraction**, forming the ionic compound NaCl.
- **Note:** no sodium chloride *molecule* exists — the compound is a giant three-dimensional lattice of ions.

6. PROPERTIES OF IONIC COMPOUNDS

Property	Explanation
Physical nature	**Solid and hard**, because of the strong force of attraction between the ions. They are generally brittle and break into pieces on pressure.
Melting and boiling points	**Very high**, because a large amount of energy is needed to break the strong inter-ionic attraction.
Solubility	Generally **soluble in water**, and insoluble in solvents such as kerosene and petrol.
Conduction of electricity	**Conduct in the molten state and in aqueous solution, but not in the solid state.** In the solid, the ions are held in fixed positions and cannot move; on melting or dissolving, the ions become free to move and carry current.
Nature of the compound	Formed between a **metal and a non-metal**, by the complete transfer of electrons.

⚠ **The conduction question is asked almost every year.** The full answer needs both halves: ionic solids do **not** conduct because the ions cannot move; they **do** conduct when molten or dissolved because the ions become free. Writing only one half loses a mark.

7. NOBLE METALS AND AQUA REGIA

Gold and platinum are called **noble metals** because they are the least reactive and do not corrode. They are not attacked by any single acid.

Aqua regia (Latin for 'royal water') is a freshly prepared mixture of **concentrated hydrochloric acid and concentrated nitric acid in the ratio 3 : 1**. It is highly corrosive and fuming, and it is the only reagent that can **dissolve gold and platinum**, neither of which is attacked by either acid alone.

Alloys

An **alloy** is a homogeneous mixture of two or more metals, or of a metal with a non-metal. Alloying is done to improve hardness, strength or resistance to corrosion.

Alloy	Composition and note
Steel	Iron + carbon — much harder than pure iron
Stainless steel	Iron + chromium + nickel — does not rust
Brass	Copper + zinc
Bronze	Copper + tin
Solder	Lead + tin — a **low melting point**, so it is used for welding electrical wires
Amalgam	Any alloy in which one metal is **mercury**

8. COMMON MISTAKES THAT COST MARKS

- **Saying all non-metals are dull.** Iodine is lustrous; graphite conducts electricity; diamond is the hardest substance known.
- **Saying every metal reacts with acids to give hydrogen.** Copper, silver and gold do not, and **nitric acid** is an exception for almost all metals.
- **Writing only half the ionic-conduction answer.** State both the solid case and the molten/aqueous case, with the reason each time.
- **Forgetting why sodium is kept in kerosene** — it reacts so vigorously with air and moisture that it catches fire.
- **Getting the aqua regia ratio backwards.** It is **3 parts conc. HCl to 1 part conc. HNO_3**.

- **Calling an amphoteric oxide a basic oxide.** Al_2O_3 and ZnO react with **both** acids and bases.

CATEGORISED QUESTION BANK WITH SOLUTIONS

Sorted by Question Type — ⭐ marks CBSE's Frequently Asked Patterns

CATEGORY A

Properties and Exceptions (1–2 Marks)

Q1. Name a metal that is liquid at room temperature and a non-metal that is liquid at room temperature. [1 Mark] ⭐ FREQUENTLY ASKED

Ans. The metal is **mercury** and the non-metal is **bromine**.

Q2. Name a non-metal that is lustrous and one that conducts electricity. [1 Mark] ⭐ FREQUENTLY ASKED

Ans. Iodine is a lustrous non-metal, and **graphite** (a form of carbon) conducts electricity.

Q3. Why are sodium and potassium stored under kerosene oil? [2 Marks] ⭐ FREQUENTLY ASKED

Ans. Sodium and potassium are so **highly reactive** that they react vigorously with the **oxygen and moisture** of the air, and the reaction is so exothermic that they **catch fire** when kept in the open. Storing them under kerosene keeps air and moisture away and prevents accidental fires.

Q4. What is meant by malleability and ductility? [2 Marks]

Ans. Malleability is the property of a metal by which it can be beaten into **thin sheets** — gold and silver are the most malleable. **Ductility** is the property by which a metal can be drawn into **thin wires** — gold is the most ductile metal.

CATEGORY B

Reactivity Series and Displacement (2–3 Marks)

Q5. Why does copper not displace zinc from zinc sulphate solution, while zinc displaces copper from copper sulphate solution? [3 Marks] ⭐ FREQUENTLY ASKED

Ans. The answer depends on the relative positions in the reactivity series.

- **Zinc lies above copper** in the reactivity series, so zinc is the more reactive metal.
- A more reactive metal can displace a less reactive one from its salt solution.
- So zinc displaces copper: $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$, and the blue colour fades.
- Copper, being **less** reactive than zinc, cannot displace it, so **no reaction takes place** when copper is put into zinc sulphate solution.

Q6. Why do copper and silver not react with dilute hydrochloric acid? [2 Marks]

⭐ FREQUENTLY ASKED

Ans. Copper and silver lie **below hydrogen** in the reactivity series. Only metals placed **above hydrogen** can displace hydrogen from a dilute acid. Since copper and silver are less reactive than hydrogen, they cannot displace it, and so no reaction occurs.

Q7. Why does calcium start floating when it reacts with water? [2 Marks]

⭐ FREQUENTLY ASKED

Ans. Calcium reacts with cold water to give calcium hydroxide and **hydrogen gas**: $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$. The bubbles of hydrogen gas **stick to the surface** of the calcium metal, and this makes the calcium **float** on the water.

Q8. Metals generally do not give hydrogen when they react with nitric acid. Why? Name two exceptions. [3 Marks] ⭐ FREQUENTLY ASKED

Ans. Nitric acid behaves differently from other dilute acids.

- Nitric acid is a strong **oxidising agent**.
- It **oxidises** the hydrogen produced in the reaction into **water**, and is itself reduced to oxides of nitrogen such as N_2O, NO or NO_2.
- Because the hydrogen is used up as soon as it forms, no hydrogen gas is collected.
- **The two exceptions are magnesium (Mg) and manganese (Mn)**, which give hydrogen with **very dilute** nitric acid.

CATEGORY C

Amphoteric Oxides and Ionic Compounds (2–3 Marks)

Q9. What are amphoteric oxides? Give two examples with equations. [3 Marks]

⭐ FREQUENTLY ASKED

Ans. Oxides that react with **both acids and bases** to give salt and water are called amphoteric oxides.

- The two standard examples are **aluminium oxide (Al_2O_3)** and **zinc oxide (ZnO)**.
- **With an acid** (behaving as a base): $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$
- **With a base** (behaving as an acid): $Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O$
- Zinc oxide behaves in exactly the same way: $ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$ and $ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$

Q10. Why do ionic compounds conduct electricity in the molten state but not in the solid state? [3 Marks] ⭐ FREQUENTLY ASKED

Ans. The answer lies in whether the ions are free to move.

- An ionic compound is made of positive and negative **ions** held by strong electrostatic forces.

- **In the solid state**, these ions are locked in **fixed positions** in the crystal lattice and cannot move about, so no current flows.
- **In the molten state** (or in aqueous solution), the strong forces are overcome and the **ions become free to move**.
- These moving ions carry the electric current, so the compound conducts.

Q11. Explain the formation of sodium chloride from sodium and chlorine, showing the transfer of electrons. [3 Marks] ⭐ FREQUENTLY ASKED

Ans. It is formed by complete transfer of one electron.

- Sodium (2, 8, 1) **loses** its single outermost electron to become Na^+ with the configuration (2, 8), which is that of neon.
- Chlorine (2, 8, 7) **gains** that electron to become Cl^- with the configuration (2, 8, 8), which is that of argon.
- The oppositely charged ions are then held together by a strong **electrostatic force of attraction**.
- This gives the ionic compound **NaCl**, which exists as a giant lattice of ions and not as separate molecules.

Q12. Why do ionic compounds have high melting and boiling points? [2 Marks]

Ans. In an ionic compound the oppositely charged ions are held together by a **strong electrostatic force of attraction**. A **large amount of heat energy** is needed to overcome this strong force and separate the ions, so the melting and boiling points are very high.

CATEGORY D

Assertion – Reason (1 Mark)

Choose: (i) Both A and R true, R is the correct explanation of A. (ii) Both true, R is not the correct explanation. (iii) A true, R false. (iv) A false, R true.

Q13. Assertion (A): Sodium is kept immersed in kerosene oil. Reason (R): Sodium reacts vigorously with oxygen and moisture of the air and catches fire. [1 Mark] ⭐ FREQUENTLY ASKED

Ans. Answer: (i) — Both are true and R correctly explains A. Kerosene keeps air and moisture away from the metal.

Q14. Assertion (A): Ionic compounds conduct electricity in the solid state. Reason (R): Ionic compounds are made up of ions. [1 Mark] ⭐ FREQUENTLY ASKED

Ans. Answer: (iv) — A is false but R is true. Ionic compounds are indeed made of ions, but in the **solid** state those ions are fixed in the lattice and cannot move, so the solid does **not** conduct.

Q15. Assertion (A): Aluminium oxide is an amphoteric oxide. Reason (R): It reacts with both acids and bases to give salt and water. [1 Mark]

Ans. Answer: (i) — Both are true and R is the correct explanation, since reacting with both acids and bases is precisely the definition of an amphoteric oxide.

CATEGORY E

Case Study (4 Marks)

A jeweller's workshop. A goldsmith needs to dissolve a small quantity of gold in order to purify it. He explains that no single acid will attack gold, and that he uses a freshly prepared mixture of two concentrated acids for the purpose.

Q16. Name the mixture used and give its composition. [2 Marks]

Ans. The mixture is **aqua regia**. It is a freshly prepared mixture of **concentrated hydrochloric acid and concentrated nitric acid in the ratio 3 : 1**.

Q17. Why is gold not attacked by a single acid? [1 Mark]

Ans. Gold is a **noble metal** — it lies at the very bottom of the reactivity series and is therefore extremely **unreactive**, so it does not react with any single acid.

Q18. Why is gold usually alloyed before being made into jewellery? [1 Mark]

Ans. Pure gold (24 carat) is **very soft**, so it cannot hold its shape. It is alloyed with **silver or copper** to make it harder and more durable — 22 carat gold is 22 parts gold to 2 parts of another metal.

CATEGORY F

HOTS — Higher Order Thinking (3–5 Marks)

Q19. A metal M does not react with cold or hot water but reacts with steam. It also reacts with dilute hydrochloric acid to give hydrogen. Identify the likely metal, write both equations, and place it correctly in the reactivity series. [5 Marks]

⭐ FREQUENTLY ASKED

Ans. The two clues together pin the metal down.

- Not reacting with cold or hot water, but reacting with **steam**, places the metal in the middle group: Al, Zn or **Fe**.
- Reacting with dilute HCl to give hydrogen confirms it lies **above hydrogen** in the series.
- Taking the metal as **iron**: $3Fe + 4H_2O(steam) \rightarrow Fe_3O_4 + 4H_2$
- With dilute acid: $Fe + 2HCl \rightarrow FeCl_2 + H_2$
- **Position:** iron lies **below** aluminium and zinc but **above** hydrogen, lead and copper in the reactivity series.
- (Aluminium and zinc also fit the description, so any one of the three, argued correctly, is acceptable.)

Q20. An element X forms an oxide that dissolves in both hydrochloric acid and sodium hydroxide. X is also used for making cooking utensils and does not corrode easily. Identify X, explain the corrosion resistance, and write both equations of its oxide. [5 Marks] ⭐ FREQUENTLY ASKED

Ans. The amphoteric behaviour identifies the element.

- **X is aluminium.** Its oxide, Al_2O_3, is **amphoteric**, which is why it dissolves in both an acid and a base.
- $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$ (acting as a base)
- $Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O$ (acting as an acid)
- **Why it does not corrode:** aluminium is in fact a reactive metal, but on exposure to air it forms a **thin, tough, protective layer of aluminium oxide** on its surface.
- This layer is impervious and sticks firmly to the metal, so it prevents air and moisture from reaching the aluminium underneath. Further corrosion is therefore stopped.
- This is also why aluminium is safe and long-lasting for cooking utensils.

Q21. Why is sodium chloride solid at room temperature and a good conductor when dissolved in water, while it does not conduct as a solid? Answer with reference to its structure. [4 Marks] ⭐ FREQUENTLY ASKED

Ans. All three observations follow from the ionic lattice.

- Sodium chloride is an **ionic compound** made of Na^+ and Cl^- ions arranged in a giant three-dimensional lattice.
- **Why it is solid:** the ions are held by a very strong **electrostatic force of attraction**, so the substance is hard and solid at room temperature with a high melting point.
- **Why the solid does not conduct:** although ions are present, they are held in **fixed positions** and cannot move, so no charge can flow.
- **Why the solution conducts:** water separates the ions from the lattice, and the **free-moving ions** carry the current through the solution.
- The same reasoning explains why molten sodium chloride also conducts.

Q22. Two students each place an iron nail in a test tube. Student A adds copper sulphate solution; student B adds zinc sulphate solution. Predict and explain the observations in both cases. [4 Marks] ⭐ FREQUENTLY ASKED

Ans. Compare the reactivity of iron with each of the other metals.

- **Student A:** iron lies **above copper** in the reactivity series, so a displacement reaction occurs.
- $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$. The **blue** solution fades to **light green**, and a **reddish-brown deposit** of copper appears on the nail.
- **Student B:** iron lies **below zinc** in the reactivity series, so iron cannot displace zinc.
- **No reaction takes place.** The solution remains colourless and the nail is unchanged.

- **Conclusion:** displacement occurs only when the metal added is more reactive than the metal in the salt.

⭐ THE SIX MOST FREQUENTLY ASKED PATTERNS

Pattern	How to handle it
1. Name the exception	Mercury, bromine, iodine, graphite, diamond, sodium/potassium — learn these as a list.
2. Will a displacement occur?	Compare positions in the reactivity series; higher displaces lower.
3. Why sodium is kept in kerosene	Reacts vigorously with air and moisture, and catches fire.
4. Ionic conduction	Answer both halves: fixed ions in solid, free ions when molten or dissolved.
5. Amphoteric oxides	Al_2O_3 and ZnO, with one equation for the acid and one for the base.
6. Nitric acid exception	HNO_3 is an oxidising agent; Mg and Mn are the two exceptions.

✅ FINAL CHECK BEFORE THE EXAM

- Can you list all eight exceptions in the physical-properties table from memory?
- Do you know the reactivity series in order, with **hydrogen in its correct place**?
- Can you write both amphoteric equations for Al_2O_3 without hesitating?
- Do you always give **both halves** of the ionic-conduction answer?
- Do you know the aqua regia ratio — **3 : 1, conc. HCl to conc. HNO_3**?
- Have you confirmed with the school whether the metallurgy section is in your scope?

🧪 NCERT Solutions — Chapter 3 Exercises (16 Questions)

🔑 How to approach this chapter

Three things carry almost every mark here: the **reactivity series**, the **chemical behaviour of metals** with oxygen, water, acids and salt solutions, and the **properties of ionic compounds**.

> **Reactivity series (most reactive → least):**
> K > Na > Ca > Mg > Al > Zn > Fe > Pb > **H** > Cu > Hg > Ag > Au
> Everything **above hydrogen** displaces H_2 from dilute acids; everything **below** does not. A metal higher in the series displaces any metal below it from its salt solution.

Exceptions worth memorising: mercury is a liquid metal; iodine is a lustrous non-metal; bromine is a liquid non-metal; carbon (graphite) conducts electricity; sodium and potassium are soft enough to cut with a knife.

Q1. Which of the following pairs will give displacement reactions? (a) NaCl solution and copper metal (b) $MgCl_2$ solution and aluminium metal (c) $FeSO_4$ solution and silver metal (d) $AgNO_3$ solution and copper metal 1 mark

SOLUTION:

Answer: (d) $AgNO_3$ solution and copper metal 1 mark

Reasoning. A displacement reaction happens only when the free metal is *more* reactive than the metal in the salt. Copper lies above silver in the reactivity series, so it displaces silver:

$$Cu(s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2Ag(s)$$

In (a) copper is below sodium, in (b) aluminium is below magnesium, and in (c) silver is below iron — so none of those react.

> 📌 The blue colour appearing in (d) is due to copper nitrate; shining silver settles out. Colour changes are asked as separate one-mark questions.

Q2. Which of the following methods is suitable for preventing an iron frying pan from rusting?
(a) Applying grease (b) Applying paint (c) Applying a coating of zinc (d) All of the above

1 mark

SOLUTION:

Answer: (c) Applying a coating of zinc 1 mark

Reasoning. A frying pan is heated and used for food. Grease and paint would burn off and contaminate the food. A zinc coating — **galvanisation** — survives heating and protects the iron because zinc is more reactive and corrodes in place of the iron beneath.

Q3. An element reacts with oxygen to give a compound with a high melting point. This compound is also soluble in water. The element is likely to be
(a) calcium (b) carbon (c) silicon (d) iron

1 mark

SOLUTION:

Answer: (a) calcium 1 mark

Calcium is a metal, and metal oxides are **ionic** — they have high melting points. CaO also dissolves in water to give calcium hydroxide (lime water):

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$$

Carbon and silicon give oxides that are not ionic in this way, and iron oxide is insoluble in water.

Q4. Food cans are coated with tin and not with zinc because
(a) zinc is costlier than tin (b) zinc has a higher melting point than tin (c) zinc is more reactive than tin (d) zinc is less reactive than tin

1 mark

SOLUTION:

Answer: (c) zinc is more reactive than tin 1 mark

Being more reactive, zinc would react with the acids in the food and form compounds that are poisonous. Tin is far less reactive, so it does not attack the food. This is why tin plating (*tinning*) is used for cans and zinc plating for buckets and pipes.

Q5. You are given a hammer, a battery, a bulb, wires and a switch. **3 marks**

(a) How could you use them to distinguish between samples of metals and non-metals?

(b) Assess the usefulness of these tests in distinguishing between metals and non-metals.

SOLUTION:

(a) Two tests. **2 marks**

Hammering test. Beat the sample with the hammer. A **metal** flattens into a sheet — it is malleable. A **non-metal** breaks into pieces — it is brittle.

Conductivity test. Put the sample in a circuit made of the battery, bulb, switch and wires, so that the current must pass through the sample. If the bulb **glows**, the sample conducts electricity and is a metal; if it does not, the sample is a non-metal.

(b) Usefulness. **1 mark** The tests are useful and quick, because malleability and electrical conductivity are the two most general physical properties of metals. But they are not foolproof: **graphite**, a non-metal, conducts electricity, and some metals such as **sodium and potassium** are too soft while zinc is brittle at room temperature. So physical tests should be confirmed by chemical behaviour.

> 📌 Mentioning graphite as the exception is what usually earns the assessment mark.

Q6. What are amphoteric oxides? Give two examples. **2 marks**

SOLUTION:

Amphoteric oxides: metal oxides that react **both with acids and with bases** to produce salt and water. **1 mark**

Examples: Al_2O_3 and ZnO. **1 mark**

$Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$ *(behaving as a base)*

$Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O$ *(behaving as an acid)*

> 📌 Write one equation with an acid and one with a base — a single equation does not show "amphoteric".

Q7. Name two metals which will displace hydrogen from dilute acids, and two metals which will not. **2 marks**

SOLUTION:

Will displace hydrogen: zinc and magnesium (any metal above hydrogen — K, Na, Ca, Mg, Al, Zn, Fe, Pb). **1 mark**

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

Will not displace hydrogen: copper and silver (metals below hydrogen — Cu, Hg, Ag, Au, Pt). **1 mark**

📌 Nitric acid is the exception for every metal: being a strong oxidising agent, HNO_3 normally gives oxides of nitrogen instead of hydrogen. Only Mg and Mn with *very dilute* HNO_3 give H_2.

Q8. In the electrolytic refining of a metal M, what would you take as the anode, the cathode and the electrolyte? **3 marks**

SOLUTION:

Anode: the impure sample of metal M. **1 mark**
Cathode: a thin strip of pure metal M. **1 mark**
Electrolyte: a water-soluble salt of the metal M (its sulphate or chloride) acidified with a little acid. **1 mark**

On passing current, pure M dissolves from the anode into the solution and an equal amount of pure M is deposited on the cathode. The insoluble impurities settle below the anode as **anode mud**.

Q9. Pratyush took sulphur powder on a spatula and heated it. He collected the gas evolved by inverting a test tube over it, as shown in the figure.
(a) What will be the action of the gas on (i) dry litmus paper and (ii) moist litmus paper?
(b) Write a balanced chemical equation for the reaction taking place. **3 marks**

SOLUTION:

(a) Burning sulphur gives **sulphur dioxide**, a non-metal oxide, which is acidic in nature.

(i) On **dry** blue litmus paper — **no change**, because without water no H^+ ions are produced.

1 mark

(ii) On **moist** blue litmus paper — it **turns red**, because SO_2 dissolves in the water to form sulphurous acid. 1 mark

(b) 1 mark

$S(s) + O_2(g) \rightarrow SO_2(g)$

$SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$ *(sulphurous acid)*

📌 The general rule being tested: **non-metal oxides are acidic, metal oxides are basic**.

Q10. State two ways to prevent the rusting of iron. 2 marks

SOLUTION:

Rusting needs **both air (oxygen) and moisture**, so every method works by keeping one of them away from the iron surface. 1 mark

1. Painting, oiling or greasing — a physical barrier that stops air and water from touching the metal.
2. Galvanisation — coating the iron with a layer of zinc; since zinc is more reactive, it corrodes first and protects the iron even if the coating is scratched. 1 mark

(Other accepted answers: chrome plating, tinning, and making an alloy such as stainless steel with chromium and nickel.)

Q11. What type of oxides are formed when non-metals combine with oxygen? 1 mark

SOLUTION:

Non-metals form **acidic oxides** — for example CO_2, SO_2, NO_2 and P_2O_5. They dissolve in water to give acids and turn moist blue litmus red. 1 mark

Neutral oxides such as CO, N_2O and H_2O are the exception — they are neither acidic nor basic.

Q12. Give reasons. 4 marks
(a) Platinum, gold and silver are used to make jewellery.

(b) Sodium, potassium and lithium are stored under oil.

(c) Aluminium is a highly reactive metal, yet it is used to make utensils for cooking.

(d) Carbonate and sulphide ores are usually converted into oxides during the process of extraction of metal.

SOLUTION:

(a) They are **noble metals** — lowest in the reactivity series, so they do not corrode or tarnish in air and moisture and keep their lustre. They are also highly malleable and ductile, so they can be shaped into fine ornaments. **1 mark**

(b) These alkali metals are so reactive that they catch fire on contact with air and react violently — even explosively — with water at room temperature. Storing them under kerosene keeps air and moisture away and prevents accidental fires. **1 mark**

(c) Aluminium reacts with the oxygen of the air at once, but the product, a thin layer of **aluminium oxide**, sticks firmly to the surface and is impervious. This layer protects the metal underneath from further reaction. Aluminium is also a good conductor of heat and has a low density, which makes it ideal for utensils. **1 mark**

(d) It is **easier to reduce an oxide** to the metal than a carbonate or a sulphide. So sulphide ores are **roasted** (heated strongly in excess air) and carbonate ores are **calcined** (heated strongly in limited air) to convert them to the oxide first. **1 mark**

> $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$ *(roasting)*
>
> $ZnCO_3 \rightarrow ZnO + CO_2$ *(calcination)*

Q13. You must have seen tarnished copper vessels being cleaned with lemon or tamarind juice. Explain why these sour substances are effective in cleaning the vessels. **2 marks**

SOLUTION:

Copper vessels exposed to moist air develop a dull green coating of **basic copper carbonate**, $CuCO_3{\cdot}Cu(OH)_2$. This coating is **basic** in nature. **1 mark**

Lemon and tamarind juice contain **citric acid** and **tartaric acid**. The acid neutralises and dissolves the basic coating, leaving the shining copper surface exposed again. **1 mark**

Q14. Differentiate between metal and non-metal on the basis of their chemical properties. 5 marks

SOLUTION:

Property	Metals	Non-metals
Nature	Electropositive — lose electrons to form **positive** ions	Electronegative — gain electrons to form **negative** ions
With oxygen	Form **basic** oxides (Na_2O, MgO); some are amphoteric (Al_2O_3, ZnO)	Form **acidic** oxides (CO_2, SO_2); a few are neutral (CO, N_2O)
With water	Reactive metals give hydroxide/oxide + H_2	Do not react with water
With dilute acids	Metals above hydrogen displace H_2	Do not displace hydrogen from acids
With salt solutions	Displace a less reactive metal from its salt	Generally no such displacement
With chlorine	Form ionic chlorides ($NaCl$, $MgCl_2$) — solids with high m.p.	Form covalent chlorides (CCl_4, PCl_3) — liquids or gases
With hydrogen	Only the most reactive form hydrides (NaH, CaH_2)	Form stable covalent hydrides (H_2O, NH_3, CH_4)
As agents	Act as **reducing** agents	Act as **oxidising** agents

Any five well-stated differences earn full marks. 5 marks

Q15. A man went door to door posing as a goldsmith. He promised to bring back the glitter of old and dull gold ornaments. An unsuspecting lady gave a set of gold bangles to him which he dipped in a particular solution. The bangles sparkled like new, but their weight was reduced drastically. The lady was upset. After a futile argument the man beat a hasty retreat. Can you play the detective to find out the nature of the solution he had used? 2 marks

SOLUTION:

The solution was **aqua regia** — a freshly prepared mixture of **concentrated hydrochloric acid and concentrated nitric acid in a 3 : 1 ratio**. 1 mark

Aqua regia is a strong, fuming, highly corrosive liquid and is one of the very few reagents that can dissolve gold. When the bangles were dipped in it, the outer layer of gold dissolved away. That removed the dull tarnished surface, so the bangles looked bright and new — but a real part of the gold had gone into the solution, which is why they weighed much less. **1 mark**

📌 Learn the name, the 3 : 1 ratio and the words "dissolves gold and platinum". All three are asked.

Q16. Give reasons why copper is used to make hot water tanks and not steel (an alloy of iron). **2 marks**

SOLUTION:

Copper **does not react with cold water, hot water or steam**, so a copper tank is not corroded from the inside by the hot water it holds. **1 mark**

Iron, on the other hand, reacts with steam to form iron oxide and hydrogen, so a steel tank would corrode and become useless:

$$3Fe(s) + 4H_2O(g) \rightarrow Fe_3O_4(s) + 4H_2(g)$$

Copper is also an excellent conductor of heat, which helps the water heat up quickly. **1 mark**

— End of Chapter 3 Exercises —

PART C — FREQUENTLY ASKED BOARD QUESTIONS

⭐ Frequently Asked Board Questions — Chapter 3

📌 **About this section**

These do not appear in the NCERT exercise, but they recur in CBSE board and sample papers from this chapter.

Q. Why do ionic compounds have high melting and boiling points?

Ionic compounds are made of oppositely charged ions held together by **strong electrostatic forces of attraction** throughout the crystal lattice. A large amount of heat energy is needed to break these forces, so their melting and boiling points are high.

Q. Why do ionic compounds conduct electricity in the molten state but not in the solid state?

Conduction needs **free ions**. In the solid state the ions are locked in fixed positions in the lattice and cannot move. On melting (or dissolving in water) the lattice breaks down, the ions become free to move, and the compound conducts.

Q. Explain the formation of sodium chloride from sodium and chlorine in terms of electron transfer.

Sodium (2,8,1) loses its one outer electron to become Na^+ (2,8). Chlorine (2,8,7) gains that electron to become Cl^- (2,8,8). Both attain a stable noble-gas configuration, and the oppositely charged ions are held together by strong electrostatic attraction as NaCl.

Q. What is an alloy? Name the constituents of brass, bronze and solder.

An **alloy** is a homogeneous mixture of two or more metals, or of a metal with a non-metal. **Brass** = copper + zinc; **bronze** = copper + tin; **solder** = lead + tin (a low melting point, so it is used for welding electrical wires). **Amalgam** is any alloy in which one metal is mercury.

Q. Why is sodium kept immersed in kerosene oil, while phosphorus is kept in water?

Sodium reacts vigorously with the oxygen and moisture of air and can catch fire, but it does not react with kerosene. White phosphorus catches fire in air at room temperature but is insoluble in and unreactive towards water, so water keeps air away from it.

Q. What happens when calcium reacts with water? Why does the collected gas not catch fire, though hydrogen is produced?

$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$. Calcium reacts less violently than sodium, so the heat evolved is not enough to ignite the hydrogen. The bubbles of hydrogen stick to the surface of the metal and make the calcium float.

Q. Why does aluminium oxide react with both HCl and NaOH? What is such an oxide called?

Because it is an **amphoteric oxide** — it can behave as a base towards an acid and as an acid towards a base, giving salt and water in both cases. ZnO behaves the same way.

Q. A metal X is used in thermite welding. Identify X, write the reaction, and state why it is used.

X is **aluminium**. $Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe$ + heat. The reaction is so strongly exothermic that the iron formed is molten, and this molten iron is run into the gap to join cracked machine parts and railway tracks.

— Chapter 3 Complete —

CHAPTER 4

Carbon and its Compounds

Study Material · NCERT Solutions (15 Questions) · Board Questions

📋 SYLLABUS SCOPE — WHAT CBSE PRESCRIBES

UNIT I: CHEMICAL SUBSTANCES — NATURE AND BEHAVIOUR (25 marks). The scope is: **carbon compounds** — covalent bonding in carbon compounds; **versatile nature of carbon**; **homologous series**; **nomenclature** of carbon compounds containing functional groups (halogens, alcohol, ketones, aldehydes, alkanes, alkenes, alkynes); **chemical properties** of carbon compounds (combustion, oxidation, addition and substitution reactions); **ethanol and ethanoic acid** (only properties and uses); **soaps and detergents**.

Unit	Marks in the theory paper
I — Chemical Substances: Nature and Behaviour	25 marks (Chapters 1–4)
II — World of Living	25 marks (Chapters 5–8)
III — Natural Phenomena	12 marks
IV — Effects of Current	13 marks
V — Natural Resources	05 marks
Theory total	**80 marks** + 20 internal assessment

⚠ **Three chapters are out of the syllabus altogether** for 2026–27: **Periodic Classification of Elements**, **Sources of Energy** and **Sustainable Management of Natural Resources**. The syllabus now runs to **13 chapters**.

A distinction that matters more than most students realise. The official Note for Teachers names three portions that stay **in the syllabus** but are assessed **only formatively** — they will not carry direct questions in the year-end paper: Periodic Classification of Elements, Heredity and Evolution, and the motor / electromagnetic induction / electric generator portion. These are *not* deleted from the textbook; they are removed from the summative exam only, and may still be asked in school periodic tests or portfolio work.

One more official instruction: the information printed inside **boxes** in the NCERT textbook is given for conceptual clarity and is **not assessed** in the year-end examination. Do not spend revision time memorising box content.

📌 **A scope note for this chapter.** Ethanol and ethanoic acid are prescribed for their **properties and uses only** — you are not required to study their industrial preparation. Two of the fourteen practicals come from here: the properties of acetic acid, and the cleaning capacity of soap in soft and hard water.

📘 CHAPTER AT A GLANCE

Topic	What You Will Learn
1. Covalent Bonding	Why carbon shares rather than transfers electrons
2. Versatile Nature of Carbon	Catenation and tetravalency — the two reasons
3. Allotropes	Diamond, graphite and fullerene
4. Saturated and Unsaturated	Alkanes, alkenes and alkynes
5. Homologous Series	The definition and the four features
6. Functional Groups	The full table with formulae and prefixes/suffixes
7. Nomenclature	The four-step method for naming any compound
8. Chemical Properties	Combustion, oxidation, addition and substitution
9. Ethanol and Ethanoic Acid	Properties and uses, plus the standard reactions
10. Soaps and Detergents	Micelle formation, hard water, and the difference

1. COVALENT BONDING IN CARBON

Carbon has **atomic number 6**, so its configuration is (2, 4) — four electrons in the outermost shell. To attain the noble gas configuration it would have to either lose four electrons or gain four.

- **Losing 4 electrons** would need a very large amount of energy and would leave a C^{4+} ion with six protons holding only two electrons — not possible.
- **Gaining 4 electrons** would give a C^{4-} ion with ten electrons held by only six protons — also not possible.
- So carbon **shares** its four electrons with other atoms. A bond formed by the **sharing of a pair of electrons** between two atoms is called a **covalent bond**.

Properties of covalent compounds

Property	Reason
Melting and boiling points	**Low**, because the force of attraction **between the molecules** is weak (though the bond within a molecule is strong).
Conduction of electricity	**Poor conductors**, because they do not contain ions or free electrons.
Solubility	Generally insoluble in water; soluble in organic solvents.

2. THE VERSATILE NATURE OF CARBON

Carbon forms an enormous number of compounds — far more than all other elements put together. There are **two reasons**, and CBSE expects both by name:

Reason	What it means	Why it matters
Catenation	The ability of carbon atoms to link with one another to form long **chains, branched chains and rings**.	Because the C—C bond is very strong and stable, unlike in silicon.
Tetravalency	Carbon has a **valency of four**, so one carbon atom can bond with four other atoms.	It bonds with carbon, hydrogen, oxygen, nitrogen, sulphur, halogens — giving huge variety.

3. ALLOTROPES OF CARBON

Allotrope	Structure	Property and use
Diamond	Each carbon is bonded to **four** others in a rigid three-dimensional structure.	**Hardest natural substance**; used in cutting tools and jewellery. Does **not** conduct.
Graphite	Each carbon is bonded to **three** others in hexagonal sheets; the sheets slide over one another.	**Soft and slippery**; a **good conductor** because the fourth electron is free. Used as a lubricant and in electrodes.
Fullerene (C_{60})	Carbon atoms arranged like a football (a buckyball).	Named after the architect Buckminster Fuller.

📌 **The classic 2-mark question:** diamond and graphite are both pure carbon, yet diamond is the hardest substance and graphite is soft and conducts electricity. The whole difference lies in the **arrangement of atoms** — four bonds in a rigid 3-D network versus three bonds in sliding sheets with one free electron per atom.

4. SATURATED AND UNSATURATED COMPOUNDS

Family	General formula	Nature	Example
Alkanes	C_nH_{2n+2}	Only **single** bonds — **saturated**	Methane CH_4, ethane C_2H_6
Alkenes	C_nH_{2n}	At least one **double** bond — unsaturated	Ethene C_2H_4
Alkynes	C_nH_{2n-2}	At least one **triple** bond — unsaturated	Ethyne C_2H_2

⚠ **Saturated compounds burn with a clean blue flame; unsaturated compounds burn with a yellow, sooty flame.** The reason is the higher percentage of carbon in unsaturated compounds, which does not burn completely. This is asked as a reasoning question every year.

5. HOMOLOGOUS SERIES

Family	General formula	First three members
Alkanes (single bonds)	C_nH_{2n+2}	CH_4 methane · C_2H_6 ethane · C_3H_8 propane
Alkenes (one double bond)	C_nH_{2n}	C_2H_4 ethene · C_3H_6 propene · C_4H_8 butene
Alkynes (one triple bond)	C_nH_{2n-2}	C_2H_2 ethyne · C_3H_4 propyne · C_4H_6 butyne

Each member differs from the next by $-CH_2-$ (mass difference 14 u).

The three hydrocarbon families — each member differs from the next by a $-CH_2-$ unit

A **homologous series** is a series of organic compounds having the **same functional group**, in which each successive member differs from the previous one by a **$-CH_2-$ unit**.

Four characteristics you should be able to state

- All members have the **same general formula** and the same functional group.
- Successive members differ by **$-CH_2-$**, that is, by a molecular mass of **14 u**.

- All members show **similar chemical properties**, because chemical behaviour is decided by the functional group.
- **Physical properties change gradually** with increasing molecular mass — melting and boiling points rise steadily down the series.

6. FUNCTIONAL GROUPS

Functional group	Formula	How it is named	Example
Halo — chloro, bromo	—Cl, —Br	**Prefix:** chloro- / bromo-	Chloroethane C_2H_5Cl
Alcohol	—OH	**Suffix:** -ol	Ethanol C_2H_5OH
Aldehyde	—CHO	**Suffix:** -al	Ethanal CH_3CHO
Ketone	—CO—	**Suffix:** -one	Propanone CH_3COCH_3
Carboxylic acid	—COOH	**Suffix:** -oic acid	Ethanoic acid CH_3COOH

How to name a compound — four steps

- **Step 1:** count the carbon atoms and write the root word — meth (1), eth (2), prop (3), but (4), pent (5), hex (6).
- **Step 2:** add the ending for the bond type — **-ane** for single, **-ene** for double, **-yne** for triple.
- **Step 3:** add the **suffix** of the functional group, dropping the final 'e' of the root if the suffix begins with a vowel. So eth + ane + ol becomes **ethanol**, not ethaneol.
- **Step 4:** if the group is named by a **prefix** (chloro, bromo), place it in front instead.

7. CHEMICAL PROPERTIES OF CARBON COMPOUNDS

(i) Combustion

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

All carbon compounds burn in oxygen to give carbon dioxide, water, heat and light.

(ii) Oxidation

Alcohols can be oxidised to carboxylic acids using **alkaline potassium permanganate** or **acidified potassium dichromate**. These are called **oxidising agents**.

$$CH_3CH_2OH \xrightarrow{\text{(alkaline } KMnO_4 \text{ + heat)}} CH_3COOH$$

📌 **Why $KMnO_4$ is said to lose its colour.** When alkaline potassium permanganate is added drop by drop to ethanol and warmed, its **purple colour disappears** as it is used up in oxidising the alcohol. Once the alcohol is fully converted, the purple colour persists. This is a favourite observation question.

(iii) Addition reaction — only for unsaturated compounds

$$CH_2{=}CH_2 + H_2 \xrightarrow{\text{Ni catalyst}} CH_3{-}CH_3$$

Hydrogenation of oils: vegetable oils are unsaturated and liquid. Adding hydrogen in the presence of a **nickel catalyst** converts them into saturated **vanaspati ghee**, which is solid. Health note: unsaturated (vegetable) oils are healthier than saturated fats.

(iv) Substitution reaction — characteristic of saturated compounds

$$CH_4 + Cl_2 \xrightarrow{\text{sunlight}} CH_3Cl + HCl$$

One atom or group is replaced by another. Saturated hydrocarbons are otherwise fairly unreactive, so substitution needs sunlight.

8. ETHANOL AND ETHANOIC ACID

Property	Ethanol	Ethanoic acid
Formula	C_2H_5OH	CH_3COOH
Common name	Alcohol / grain alcohol	Acetic acid; 5–8% solution is **vinegar**
Physical state	Liquid at room temperature	Freezes in cold climates like ice, hence **glacial acetic acid** (freezing point 290 K)
With sodium	$2Na + 2C_2H_5OH \rightarrow 2C_2H_5ONa + H_2$	$2Na + 2CH_3COOH \rightarrow 2CH_3COONa + H_2$
With $NaHCO_3$	No reaction	$CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2$ — **brisk effervescence**
Litmus test	No change (neutral)	Turns **blue litmus red**
Uses	In medicines, as a solvent, in tinctures; an important industrial solvent	As a preservative in pickles, as vinegar, in making esters and dyes

📌 **How to distinguish ethanol from ethanoic acid — the standard 2-mark answer.** Add **sodium hydrogencarbonate** to each. Ethanoic acid gives **brisk effervescence** of carbon dioxide, which turns lime water milky; ethanol gives **no reaction**. (Litmus is also acceptable: ethanoic acid turns blue litmus red, ethanol does not.)

Esterification

$$CH_3COOH + C_2H_5OH \xrightarrow{\text{conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$$

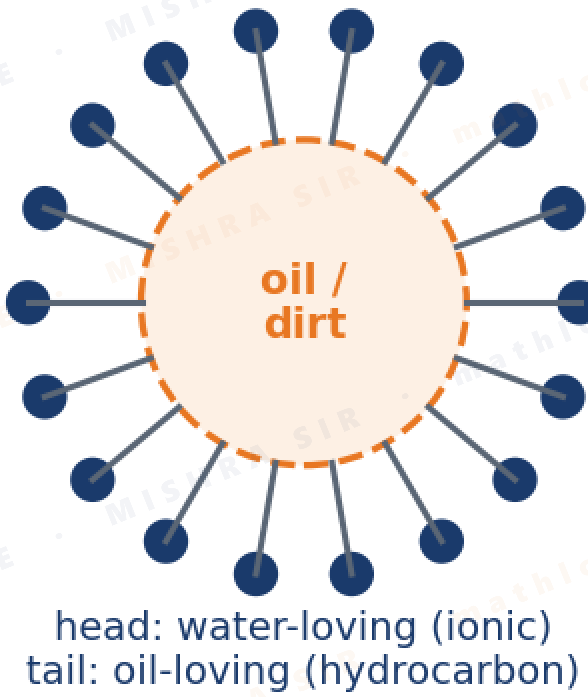
An acid and an alcohol give an **ester**, which has a **sweet fruity smell** and is used in perfumes and flavouring agents. On treating an ester with sodium hydroxide, the reverse happens — this is **saponification**, the reaction used to make soap.

Why ethanol is called a dehydrating agent's substrate

Heating ethanol with excess **concentrated sulphuric acid at 443 K** removes a water molecule and gives ethene:

$$C_2H_5OH \xrightarrow{\text{conc. } H_2SO_4,\ 443\text{ K}} CH_2{=}CH_2 + H_2O$$

9. SOAPS AND DETERGENTS



A micelle — the oil-loving tails point inwards to the dirt, the water-loving heads point outwards

A **soap** molecule has two very different ends, and this is the whole basis of cleaning:

- The **ionic head** (—COONa) is **hydrophilic** — water-loving, so it dissolves in water.

- The long **hydrocarbon tail** is **hydrophobic** — water-hating but oil-loving, so it dissolves in grease.
- When soap is added to dirty cloth, the tails stick into the oil and dirt while the heads face the water.
- This forms a spherical cluster called a **micelle**, which traps the dirt inside and is then washed away with the water.

Soap versus detergent in hard water

Term	Explanation
Hard water	Water containing salts of **calcium and magnesium**.
Problem with soap	Soap reacts with these calcium and magnesium salts to form an **insoluble curdy white precipitate called scum**. The soap is wasted, and washing becomes difficult.
Why detergents work	Detergents are **ammonium or sulphonate salts** of long-chain carboxylic acids. Their calcium and magnesium salts remain **soluble**, so they do not form scum and clean effectively even in hard water.
Environmental note	Detergents with branched chains are **not biodegradable** and cause water pollution; soaps are biodegradable.

CATEGORISED QUESTION BANK WITH SOLUTIONS

Sorted by Question Type — ⭐ marks CBSE's Frequently Asked Patterns

CATEGORY A

Bonding and Versatility (2–3 Marks)

Q1. Why does carbon form covalent compounds rather than ionic ones? [3 Marks]

⭐ FREQUENTLY ASKED

Ans. The reason lies in its electronic configuration (2, 4).

- Carbon has **four electrons** in its outermost shell, so it needs to gain or lose four to become stable.
- **Losing four electrons** would require a huge amount of energy, and the resulting C^{4+} ion, with six protons holding only two electrons, would be unstable.
- **Gaining four electrons** would give a C^{4-} ion in which six protons must hold ten electrons — also unstable.
- So carbon **shares** its four electrons with other atoms, forming **covalent bonds**.

Q2. What is catenation? Why does carbon show it to such a large extent? [2 Marks]

⭐ FREQUENTLY ASKED

Ans. Catenation is the ability of an element's atoms to link with one another to form long chains, branched chains and rings. Carbon shows it to an exceptional degree because the **carbon–carbon bond is very strong and stable**. Silicon also shows catenation, but its chains are limited to about eight atoms because Si—Si bonds are much weaker.

Q3. Diamond and graphite are both made only of carbon, yet their properties are completely different. Explain. **[3 Marks]** ⭐ FREQUENTLY ASKED

Ans. The difference is entirely in the arrangement of the atoms.

- **In diamond**, each carbon atom is bonded to **four** other carbon atoms in a rigid three-dimensional structure. This makes diamond the **hardest natural substance**, and it does **not conduct** electricity as all four electrons are used in bonding.
- **In graphite**, each carbon is bonded to only **three** others in flat hexagonal sheets, and the sheets can slide over one another. This makes graphite **soft and slippery**, so it is used as a lubricant.
- The **fourth electron** of each carbon in graphite is **free**, which is why graphite is a **good conductor** of electricity and is used to make electrodes.
- Compounds with the same formula but different structures and properties are called **allotropes**.

CATEGORY B

Homologous Series and Nomenclature (2–3 Marks)

Q4. Define a homologous series and state any two of its characteristics. **[3 Marks]** ⭐ FREQUENTLY ASKED

Ans. A series of organic compounds having the **same functional group**, in which each successive member differs from the previous one by a **$-CH_2-$ unit**.

- **Characteristic 1:** all members have the **same general formula** and show **similar chemical properties**, because the functional group is the same.
- **Characteristic 2:** successive members differ by a molecular mass of **14 u**.
- **Characteristic 3:** physical properties such as melting and boiling point **change gradually** as the molecular mass increases.
- Example: CH_4, C_2H_6, C_3H_8, C_4H_{10} form the alkane homologous series.

Q5. Write the name and formula of the next two members after C_2H_6 in its homologous series. **[2 Marks]**

Ans. The series is that of alkanes (general formula C_nH_{2n+2}). The next two members are **C_3H_8, propane** and **C_4H_{10}, butane**. Each differs from the one before it by a $-CH_2-$ unit.

Q6. Name the following: (i) CH_3CH_2OH (ii) CH_3COOH (iii) CH_3CHO (iv) CH_3CH_2Cl **[2 Marks]** ⭐ FREQUENTLY ASKED

Ans. (i) **Ethanol** (two carbons, alcohol group, suffix -ol). (ii) **Ethanoic acid** (two carbons, —COOH, suffix -oic acid). (iii) **Ethanal** (two carbons, —CHO, suffix -al). (iv) **Chloroethane** (two carbons, chlorine named as a prefix).

CATEGORY C

Chemical Reactions (2–3 Marks)

Q7. Why do unsaturated hydrocarbons burn with a yellow sooty flame while saturated ones burn with a clean blue flame? [2 Marks] ⭐ FREQUENTLY ASKED

Ans. Unsaturated hydrocarbons contain a **higher percentage of carbon** in proportion to hydrogen. This carbon does not burn completely in the air available, and the unburnt carbon particles glow and escape as **soot**, giving a yellow, sooty flame. **Saturated** hydrocarbons have relatively less carbon and burn completely, giving a clean **blue** flame.

Q8. What is a substitution reaction? Give one example with the equation. [2 Marks]
⭐ FREQUENTLY ASKED

Ans. A reaction in which one atom or group of atoms of a compound is **replaced** by another atom or group is called a substitution reaction. It is characteristic of **saturated** hydrocarbons. Example: $CH_4 + Cl_2 \xrightarrow{\text{sunlight}} CH_3Cl + HCl$. Sunlight is needed because saturated hydrocarbons are otherwise fairly unreactive.

Q9. What is hydrogenation? State its industrial application. [3 Marks]
⭐ FREQUENTLY ASKED

Ans. It is an addition reaction in which hydrogen is added to an unsaturated compound.

- An **unsaturated** hydrocarbon adds hydrogen in the presence of a **nickel catalyst** to become **saturated**.
- $CH_2{=}CH_2 + H_2 \xrightarrow{\text{Ni}} CH_3{—}CH_3$
- **Industrial application:** vegetable oils, which are unsaturated and liquid, are hydrogenated to give **vanaspati ghee**, which is saturated and solid.
- **Health note:** unsaturated vegetable oils are healthier for consumption than saturated fats.

Q10. What happens when ethanol is warmed with alkaline potassium permanganate? State the observation. [2 Marks] ⭐ FREQUENTLY ASKED

Ans. Ethanol is **oxidised** to ethanoic acid: $CH_3CH_2OH \xrightarrow{\text{alkaline } KMnO_4\text{, heat}} CH_3COOH$. **Observation:** the **purple colour of the potassium permanganate disappears** as long as ethanol is present to be oxidised. Alkaline $KMnO_4$ acts as an **oxidising agent**.

CATEGORY D

Ethanol, Ethanoic Acid and Esters (2–3 Marks)

Q11. How would you distinguish between ethanol and ethanoic acid using a chemical test? [2 Marks] ⭐ FREQUENTLY ASKED

Ans. Add **sodium hydrogencarbonate** to each in a test tube. **Ethanoic acid** gives **brisk effervescence** of carbon dioxide, which turns lime water milky: $CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2$. **Ethanol gives no reaction.** (Alternatively, ethanoic acid turns blue litmus red while ethanol has no effect.)

Q12. Why is ethanoic acid called glacial acetic acid? [2 Marks] ⭐ FREQUENTLY ASKED

Ans. Pure ethanoic acid has a freezing point of **290 K (about 17°C)**. In cold climates this is above room temperature, so the pure acid **freezes into an ice-like solid**. Because of this glacier-like appearance it is called **glacial acetic acid**.

Q13. What is esterification? Write the equation and state one use of esters. [3 Marks] ⭐ FREQUENTLY ASKED

Ans. The reaction of a carboxylic acid with an alcohol to form an ester.

- $CH_3COOH + C_2H_5OH \rightarrow$(conc. H_2SO_4) $CH_3COOC_2H_5 + H_2O$
- Concentrated sulphuric acid acts as the **catalyst and dehydrating agent**.
- Esters have a **sweet, fruity smell**.
- **Uses:** in making **perfumes** and as **flavouring agents** in the food industry.

CATEGORY E

Soaps and Detergents (2–3 Marks)

Q14. Explain the cleansing action of soap. [3 Marks] ⭐ FREQUENTLY ASKED

Ans. It works because a soap molecule has two chemically different ends.

- The **ionic end (—COONa)** is **hydrophilic**, that is water-loving, while the long **hydrocarbon tail** is **hydrophobic** and dissolves in oil and grease.
- When soap is added to dirty cloth, the **tails attach to the oil and dirt**, while the ionic heads face outwards into the water.
- The soap molecules arrange themselves in a spherical cluster called a **micelle**, with the dirt trapped inside.
- On agitating the cloth, these micelles are carried away with the water, and the cloth is cleaned.

Q15. Why does soap not work well in hard water, while detergent does? [3 Marks] ⭐ FREQUENTLY ASKED

Ans. The difference is in what each forms with calcium and magnesium salts.

- Hard water contains **calcium and magnesium salts**.
- Soap reacts with these salts to form an **insoluble curdy white precipitate called scum**, so a large part of the soap is wasted and the cloth is not cleaned properly.
- **Detergents** are ammonium or sulphonate salts of long-chain carboxylic acids.

- Their calcium and magnesium salts are **soluble in water**, so no scum is formed and detergents clean effectively even in hard water.

Q16. Why are detergents preferred for washing machines but criticised on environmental grounds? [2 Marks]

Ans. Detergents work well in **hard water** without forming scum, which makes them convenient for machine washing where water quality varies. However, detergents with **branched hydrocarbon chains are not biodegradable** — they are not broken down by micro-organisms and accumulate in rivers, causing **water pollution**. Soaps, by contrast, are biodegradable.

CATEGORY F

Assertion – Reason (1 Mark)

Choose: (i) Both A and R true, R is the correct explanation of A. (ii) Both true, R is not the correct explanation. (iii) A true, R false. (iv) A false, R true.

Q17. Assertion (A): Graphite conducts electricity but diamond does not. Reason (R): In graphite each carbon atom is bonded to three others, leaving one free electron. [1 Mark] ⭐ FREQUENTLY ASKED

Ans. Answer: (i) — Both are true and R correctly explains A. In diamond all four electrons of each carbon are used in bonding, so none is free to carry current.

Q18. Assertion (A): Soap forms scum with hard water. Reason (R): Hard water contains calcium and magnesium salts. [1 Mark] ⭐ FREQUENTLY ASKED

Ans. Answer: (i) — Both are true and R correctly explains A. Soap reacts with those salts to give an insoluble precipitate called scum.

Q19. Assertion (A): Ethanoic acid gives brisk effervescence with sodium hydrogencarbonate. Reason (R): Carboxylic acids react with hydrogencarbonates to release carbon dioxide. [1 Mark]

Ans. Answer: (i) — Both are true and R correctly explains A. The equation is $CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2$. Ethanol, being an alcohol, gives no such reaction, which is why this serves as the distinguishing test.

CATEGORY G

Case Study (4 Marks)

Washing clothes in a village. A family living near a limestone region finds that their soap produces very little lather and leaves a sticky white deposit on the clothes. On shifting to a packaged washing powder, the clothes come clean easily.

Q20. What kind of water is being used, and what is the white deposit called? [2 Marks]

Ans. The water is **hard water**, because it contains **calcium and magnesium salts** (limestone regions are rich in these). The white deposit is **scum**, an insoluble precipitate formed when soap reacts with those salts.

Q21. Why does the washing powder work where the soap failed? [1 Mark]

Ans. Washing powders are **detergents**, whose calcium and magnesium salts are **soluble in water**, so no scum forms and cleaning is effective even in hard water.

Q22. State one disadvantage of using the detergent instead. [1 Mark]

Ans. Detergents with **branched chains are not biodegradable**, so they persist in water bodies and cause **water pollution**.

CATEGORY H

HOTS — Higher Order Thinking (4–5 Marks)

Q23. An organic compound A with the molecular formula C_2H_6O reacts with sodium to give hydrogen, and on oxidation with alkaline $KMnO_4$ gives compound B, which turns blue litmus red. Identify A and B, and write all the equations. [5 Marks]

⭐ FREQUENTLY ASKED

Ans. The clues identify an alcohol and the acid formed from it.

- C_2H_6O with two carbons that reacts with sodium releasing hydrogen indicates an **alcohol**, so **A is ethanol, C_2H_5OH**.
- $2Na + 2C_2H_5OH \rightarrow 2C_2H_5ONa + H_2$
- On oxidation, an alcohol gives a carboxylic acid, and turning blue litmus red confirms an acid. **B is ethanoic acid, CH_3COOH**.
- $CH_3CH_2OH \rightarrow$(alkaline $KMnO_4$, heat) CH_3COOH
- **Confirming test for B:** it gives brisk effervescence with sodium hydrogencarbonate: $CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2$
- A and B together also give a sweet-smelling **ester** on warming with conc. H_2SO_4.

Q24. A student is given two liquids, one saturated and one unsaturated hydrocarbon, and no labels. Describe two different tests to tell them apart, with reasons. [4 Marks]

⭐ FREQUENTLY ASKED

Ans. Both tests exploit the presence of the double or triple bond.

- **Test 1 — the flame test.** Burn a small sample of each. The **unsaturated** compound burns with a **yellow, sooty flame**, because its higher carbon content does not burn completely. The **saturated** compound burns with a clean **blue flame**.
- **Test 2 — bromine water test.** Add bromine water drop by drop. The **unsaturated** compound **decolourises** the brown bromine water, because bromine is used up in an **addition reaction** across the double bond.
- The **saturated** compound does **not** decolourise bromine water, as it can undergo only substitution, and that requires sunlight.

- **Conclusion:** the compound that gives a sooty flame and decolourises bromine water is the unsaturated one.

Q25. Explain why the same soap that cleans cotton clothes well in one town works poorly in another, even though the same quantity is used. What single change would you suggest, and what is the trade-off? [4 Marks] ⭐ FREQUENTLY ASKED

Ans. The variable is the water, not the soap.

- The soap works well where the water is **soft**, and poorly where the water is **hard**.
- Hard water contains **calcium and magnesium salts** which react with the soap to form insoluble **scum**, so most of the soap is consumed before any cleaning can take place.
- **Suggested change:** use a **detergent** instead, since the calcium and magnesium salts of detergents are **soluble** and no scum forms.
- **The trade-off:** detergents with branched chains are **not biodegradable**, so switching to them adds to **water pollution**. Softening the water first would be the environmentally better solution.

Q26. Carbon has a valency of four and shows catenation. Explain how these two properties together account for the very large number of carbon compounds, and why silicon does not form nearly as many. [4 Marks] ⭐ FREQUENTLY ASKED

Ans. The two properties reinforce each other.

- **Tetravalency** means one carbon atom can form **four** bonds, so it can attach to four other atoms — carbon, hydrogen, oxygen, nitrogen, sulphur or a halogen.
- **Catenation** means carbon atoms can join to one another in **long chains, branched chains and closed rings**.
- Combining the two, a skeleton of any length or shape can be built, and at every free position a different atom or functional group can be attached. The number of possible arrangements is therefore enormous.
- **Why silicon falls short:** silicon also shows catenation, but the **Si—Si bond is much weaker** than the C—C bond. Silicon chains therefore become unstable beyond about eight atoms, which limits the compounds it can form.

⭐ THE SEVEN MOST FREQUENTLY ASKED PATTERNS

Pattern	How to handle it
1. Why carbon forms covalent bonds	Configuration (2,4); losing or gaining four electrons is not possible.
2. Diamond versus graphite	Four bonds rigid 3-D versus three bonds in sliding sheets with a free electron.

Pattern	How to handle it
3. Define homologous series	Same functional group, successive members differ by $–CH_2–$ (14 u).
4. Name the compound	Root word + bond ending + functional group suffix; drop the ‘e’ before a vowel.
5. Sooty versus blue flame	Higher carbon percentage in unsaturated compounds burns incompletely.
6. Ethanol versus ethanoic acid	Sodium hydrogencarbonate test — brisk effervescence with the acid only.
7. Cleansing action of soap	Hydrophilic head, hydrophobic tail, micelle formation, dirt washed away.

✅ FINAL CHECK BEFORE THE EXAM

- Can you explain covalent bonding in carbon starting from its configuration (2, 4)?
- Can you name the **two** reasons for carbon's versatility, using the words **catenation** and **tetravalency**?
- Do you know all five functional groups with formula, prefix or suffix, and one example each?
- Can you write one equation each for combustion, oxidation, addition and substitution?
- Do you know the **two** tests that distinguish ethanol from ethanoic acid?
- Can you draw and explain a **micelle**, and say why soap fails in hard water?

PART B — NCERT SOLUTIONS

🧪 NCERT Solutions — Chapter 4 Exercises (15 Questions)

🔑 How to approach this chapter

Carbon forms four bonds (**tetravalency**) and joins to itself endlessly (**catenation**) — every other idea in the chapter follows from those two.

> **The functional groups you must recognise:**
> Alcohol — **–OH** (ethanol, C_2H_5OH)
> Aldehyde — **–CHO** (ethanal)
> Ketone — **>C=O** in the middle (propanone)
> Carboxylic acid — **–COOH** (ethanoic acid, CH_3COOH)
> Alkene — **C=C**; Alkyne — **C≡C** (both unsaturated, both give **addition** reactions)

Saturated (single bonds only) compounds give **substitution** reactions and burn with a clean blue flame; **unsaturated** compounds give **addition** reactions and burn with a yellow sooty flame. Counting bonds in a dot structure is worth easy marks: a C–H bond is one shared pair, a double bond two.

Q1. Ethane, with the molecular formula C_2H_6, has (a) 6 covalent bonds (b) 7 covalent bonds (c) 8 covalent bonds (d) 9 covalent bonds 1 mark

SOLUTION:

Answer: (b) 7 covalent bonds 1 mark

Six C–H bonds (three on each carbon) plus one C–C bond = 7 bonds in all.

Q2. Butanone is a four-carbon compound with the functional group (a) carboxylic acid (b) aldehyde (c) ketone (d) alcohol 1 mark

SOLUTION:

Answer: (c) ketone 1 mark

The suffix **-one** always indicates a ketone. Butanone is $CH_3{-}CO{-}CH_2{-}CH_3$; the carbonyl group lies inside the chain, which is what distinguishes a ketone from an aldehyde.

Q3. While cooking, if the bottom of the vessel is getting blackened on the outside, it means that
(a) the food is not cooked completely (b) the fuel is not burning completely (c) the fuel is wet (d) the fuel is burning completely **1 mark**

SOLUTION:

Answer: (b) the fuel is not burning completely **1 mark**

Incomplete combustion, caused by an insufficient supply of oxygen, leaves unburnt carbon particles which deposit as soot on the vessel. Cleaning the air holes of the burner restores the blue flame.

Q4. Explain the nature of the covalent bond using the bond formation in CH_3Cl. **3 marks**

SOLUTION:

A **covalent bond** is formed by the **mutual sharing of electron pairs** between two atoms, so that each atom completes its outermost shell. No electrons are transferred, so no ions are formed. **1 mark**

In CH_3Cl: carbon has 4 valence electrons and needs 4 more; each hydrogen has 1 and needs 1 more; chlorine has 7 and needs 1 more. **1 mark**
Carbon shares one electron pair with each of the three hydrogen atoms and one electron pair with the chlorine atom. Carbon thus completes its octet, each hydrogen completes its duplet, and chlorine completes its octet. **1 mark**

```
H
|
H — C — Cl
|
H
```
(four single covalent bonds around carbon)

📌 Because carbon cannot lose or gain 4 electrons (either would need far too much energy), it must share — that single sentence is the reason all carbon compounds are covalent.

Q5. Draw the electron dot structures for
(a) ethanoic acid (b) H_2S (c) propanone (d) F_2 **4 marks**

SOLUTION:

(a) Ethanoic acid, CH_3COOH **1 mark**

The CH_3 carbon shares one pair with each of 3 hydrogens and one pair with the second carbon. The second carbon shares **two pairs** with one oxygen (double bond) and one pair with the −O−H oxygen; that oxygen shares one pair with hydrogen. Each oxygen also carries lone pairs.

```
H : Ö :
   ‖
H : C : C : Ö : H
   H
```

(b) H_2S **1 mark** — sulphur (6 valence electrons) shares one pair with each hydrogen; two lone pairs remain on sulphur. Bent shape, like water.

(c) Propanone, CH_3COCH_3 **1 mark** — the middle carbon shares two pairs with oxygen (C=O) and one pair with each of the two CH_3 carbons; each CH_3 carbon shares one pair with each of its three hydrogens.

(d) F_2 **1 mark** — each fluorine has 7 valence electrons; the two atoms share **one pair** to form a single bond, and each keeps three lone pairs.

> 📌 Marks are lost for forgetting the **lone pairs** on O, S and F. Show every dot, not just the bonding pairs.

Q6. What is a homologous series? Explain with an example. **3 marks**

SOLUTION:

Homologous series: a series of organic compounds having the **same functional group**, in which each successive member differs from the previous one by a **$-CH_2-$ unit** (a difference of 14 u in molecular mass). **1 mark**

Example — the alkanes (general formula C_nH_{2n+2}): **1 mark**

> CH_4 (16 u) → C_2H_6 (30 u) → C_3H_8 (44 u) → C_4H_{10} (58 u)

Characteristics of a homologous series: 1 mark

• All members can be represented by one general formula.

• Consecutive members differ by CH_2 (14 u).

• All members show **similar chemical properties**, because the functional group is the same.

• Physical properties (melting point, boiling point, density) **change gradually** as the molecular mass increases.

Q7. How can ethanol and ethanoic acid be differentiated on the basis of their physical and chemical properties? 3 marks

SOLUTION:

Basis	Ethanol (C_2H_5OH)	Ethanoic acid (CH_3COOH)
Smell	Pleasant smell	Smell of vinegar
State in winter	Liquid	Freezes into an ice-like solid (glacial acetic acid, m.p. 290 K)
Litmus test	No effect on blue litmus	Turns blue litmus **red**
With $NaHCO_3$ / Na_2CO_3	No reaction — no gas	Brisk **effervescence** of CO_2, which turns lime water milky
With sodium metal	Hydrogen gas evolved	Hydrogen gas evolved (so this test cannot distinguish them)

The reliable chemical test is the sodium hydrogencarbonate test: 3 marks

$$CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2\uparrow$$

📌 When asked for "one test", always give the $NaHCO_3$ test — the litmus test alone is often considered incomplete, and the sodium test is common to both.

Q8. Why does micelle formation take place when soap is added to water? Will a micelle be formed in other solvents such as ethanol also? 3 marks

SOLUTION:

A soap molecule has **two ends of opposite nature**: a long hydrocarbon tail that is **hydrophobic** (water-repelling but oil-loving) and an ionic head ($-COO^-Na^+$) that is

hydrophilic (water-loving). 1 mark

In water, the ionic heads cannot be avoided by the water and the tails cannot mix with it. The molecules therefore arrange themselves in a cluster with all the **tails pointing inward** and all the **heads pointing outward** into the water. This spherical cluster is a **micelle**; the oily dirt is trapped in its centre. 1 mark

In ethanol — no. Ethanol is an organic solvent in which the hydrocarbon tail dissolves freely. Since there is nothing for the tails to escape from, there is no reason for the molecules to cluster, and micelles are not formed. 1 mark

Q9. Why are carbon and its compounds used as fuels for most applications? 2 marks

SOLUTION:

Carbon and its compounds burn in air to give **carbon dioxide, water and a large amount of heat and light** — they have a high calorific value. 1 mark

They are also easy to handle: most are liquids or gases that can be stored and transported, they burn without leaving much ash, and their combustion can be controlled by regulating the air supply. This is why coal, petrol, diesel, kerosene, LPG and CNG are all carbon-based. 1 mark

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) + \text{heat and light}$$

Q10. Explain the formation of scum when hard water is treated with soap. 2 marks

SOLUTION:

Hard water contains dissolved salts of **calcium and magnesium**. 1 mark

The sodium (or potassium) soap reacts with these Ca^{2+} and Mg^{2+} ions to form **insoluble calcium and magnesium salts of the fatty acid**, which separate out as a curdy white solid — the **scum** that sticks to clothes and the vessel. Because the soap is used up in this way, it does not lather and cleaning is wasteful. 1 mark

$$2C_{17}H_{35}COONa + CaCl_2 \rightarrow (C_{17}H_{35}COO)_2Ca\downarrow + 2NaCl$$

📌 Detergents do not form scum, because their calcium and magnesium salts are soluble in water — that is why they work in hard water.

Q11. What change will you observe if you test soap with litmus paper (red and blue)? **1 mark**

SOLUTION:

Soap is the sodium salt of a weak acid (a long-chain fatty acid) and a strong base, so its solution is **basic**. It turns **red litmus blue**, and there is **no change** in blue litmus. **1 mark**

Q12. What is hydrogenation? What is its industrial application? **2 marks**

SOLUTION:

Hydrogenation: the addition of hydrogen to an **unsaturated** hydrocarbon in the presence of a catalyst such as nickel or palladium, converting it into a **saturated** compound. **1 mark**

$$R{-}CH{=}CH{-}R' + H_2 \xrightarrow{\text{Ni, heat}} R{-}CH_2{-}CH_2{-}R'$$

Industrial application: it is used to convert liquid vegetable oils, which contain unsaturated fatty acids, into solid fats — **vanaspati ghee**. **1 mark**

From a health point of view, vegetable oils are the better choice; animal fats and hydrogenated fats contain saturated fatty acids, which are harmful to health.

Q13. Which of the following hydrocarbons undergo addition reactions? C_2H_6, C_3H_8, C_3H_6, C_2H_2 and CH_4 **2 marks**

SOLUTION:

Answer: C_3H_6 and C_2H_2. **1 mark**

Reasoning. Only **unsaturated** hydrocarbons give addition reactions. Test each against the saturated formula C_nH_{2n+2}:

• C_2H_6, C_3H_8, CH_4 fit C_nH_{2n+2} — saturated (alkanes), so they give **substitution** reactions.

• C_3H_6 is C_nH_{2n} — an alkene, with a double bond.

• C_2H_2 is C_nH_{2n-2} — an alkyne, with a triple bond. **1 mark**

Q14. Give a test that can be used to differentiate chemically between butter and cooking oil. 2 marks

SOLUTION:

Butter contains mainly **saturated** fats; cooking oil contains **unsaturated** fats. Only the unsaturated one will add bromine across its double bonds. 1 mark

Bromine water test. Add bromine water drop by drop to each sample.
• With **cooking oil**, the reddish-brown colour of bromine water is **decolourised** — an addition reaction takes place.
• With **butter**, the colour **persists**. 1 mark

(The same conclusion follows from an alkaline $KMnO_4$ test: the purple colour is discharged by the unsaturated oil.)

Q15. Explain the mechanism of the cleaning action of soaps. 3 marks

SOLUTION:

Most dirt on clothes is **oily or greasy**, and oil does not dissolve in water — which is why water alone cannot clean it. 1 mark

Step 1. A soap molecule has a hydrophobic hydrocarbon tail and a hydrophilic ionic head. When soap is added, the **tails attach themselves to the oily dirt** while the heads stay in the water. 1 mark
Step 2. The molecules surround the droplet of dirt, forming a **micelle** with the dirt trapped inside and the ionic heads facing outward.
Step 3. Since all the micelles carry the same negative charge on the outside, they **repel one another** and stay suspended in the water instead of joining up again (they form an emulsion).
Step 4. Agitating or scrubbing the cloth lifts the micelles off the fabric, and rinsing with water carries the dirt away with them. 1 mark

— End of Chapter 4 Exercises —

PART C — FREQUENTLY ASKED BOARD QUESTIONS

⭐ Frequently Asked Board Questions — Chapter 4

📌 About this section

Repeatedly asked in CBSE board and sample papers.

Q. Why does carbon form a very large number of compounds?

Two reasons. **Catenation** — carbon atoms link with one another through strong covalent bonds to form long chains, branched chains and rings. **Tetravalency** — each carbon has four valence electrons, so it can bond with four other atoms of carbon or of other elements such as O, N, S, H and the halogens. The small size of the carbon atom makes these bonds exceptionally strong and stable.

Q. What is denatured alcohol, and why is ethanol denatured?

Ethanol made for industrial use is mixed with poisonous substances such as methanol, along with dyes to colour it blue. This is **denatured alcohol**. It is done to make the ethanol unfit for drinking, so that it can be sold without the tax levied on potable alcohol.

Q. What is esterification? Write the reaction and state one use of esters.

An alcohol reacts with a carboxylic acid in the presence of a few drops of concentrated H_2SO_4 to give a sweet-smelling **ester**: $CH_3COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O$. Esters are used in perfumes and as flavouring agents.

Q. What is saponification?

The hydrolysis of an ester with an alkali (NaOH) to give back the alcohol and the sodium salt of the acid. When the ester is a fat or an oil, that sodium salt is **soap** — hence the name.

Q. Why does ethanoic acid react with sodium hydrogencarbonate but ethanol does not?

Only an acid liberates CO_2 from a hydrogencarbonate. Ethanoic acid releases H^+ ions in solution and is acidic; ethanol does not ionise in this way and is neutral.

Q. Name the products formed when ethanol is heated with excess concentrated H_2SO_4 at 443 K.

Ethene and water. Concentrated sulphuric acid acts as a dehydrating agent: C_2H_5OH —(conc. H_2SO_4, 443 K)→ $C_2H_4 + H_2O$.

Q. Why is the conversion of ethanol to ethanoic acid called an oxidation reaction?

Because oxygen is added to the ethanol. Alkaline $KMnO_4$ or acidified $K_2Cr_2O_7$ supplies this oxygen and is therefore called an **oxidising agent**; the purple colour of $KMnO_4$ disappears as it is used up.

Q. Give the structural formula and the IUPAC name of the compound obtained when ethanol is treated with sodium metal.

$2Na + 2C_2H_5OH \rightarrow 2C_2H_5ONa + H_2$. The product is **sodium ethoxide**, CH_3CH_2ONa, and hydrogen gas is evolved — this is itself a test for the −OH group.

Q. Distinguish between soaps and detergents.

Soap is the sodium or potassium salt of a long-chain fatty acid; it is biodegradable but forms scum with hard water. **Detergent** is the ammonium or sulphonate salt of a long-chain hydrocarbon; it works well even in hard water because its calcium and magnesium salts are soluble, but many detergents are not easily biodegradable and cause water pollution.

— Chapter 4 Complete —

CHAPTER 5

Life Processes

Study Material · NCERT Solutions (13 Questions) · Board Questions

📋 SYLLABUS SCOPE — WHAT CBSE PRESCRIBES

UNIT II: WORLD OF LIVING (25 marks). The scope for this chapter is: **'Life processes'** — the basic concept of **nutrition, respiration, transport and excretion** in plants and animals.

Unit	Marks in the theory paper
I — Chemical Substances: Nature and Behaviour	25 marks (Chapters 1–4)
II — World of Living	25 marks (Chapters 5–8)
III — Natural Phenomena	12 marks
IV — Effects of Current	13 marks
V — Natural Resources	05 marks
Theory total	**80 marks** + 20 internal assessment

⚠ **Three chapters are out of the syllabus altogether** for 2026–27: **Periodic Classification of Elements**, **Sources of Energy** and **Sustainable Management of Natural Resources**. The syllabus now runs to **13 chapters**.

A distinction that matters more than most students realise. The official Note for Teachers names three portions that stay **in the syllabus** but are assessed **only formatively** — they will not carry direct questions in the year-end paper: Periodic Classification of Elements, Heredity and Evolution, and the motor / electromagnetic induction / electric generator portion. These are *not* deleted from the textbook; they are removed from the summative exam only, and may still be asked in school periodic tests or portfolio work.

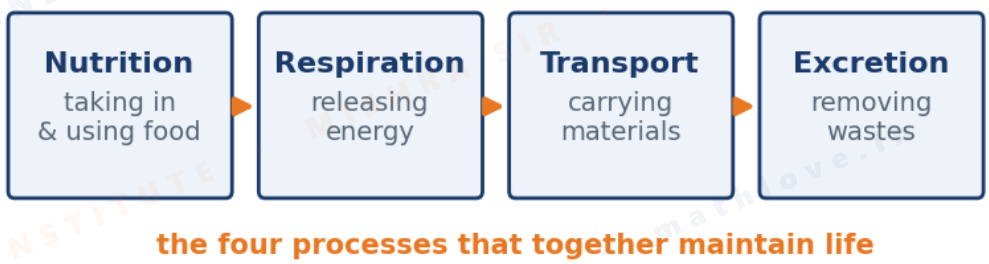
One more official instruction: the information printed inside **boxes** in the NCERT textbook is given for conceptual clarity and is **not assessed** in the year-end examination. Do not spend revision time memorising box content.

📌 **A scope note for this chapter.** Three of the prescribed practicals come from Unit II and are worth revising alongside this chapter: preparing a **temporary mount of a leaf peel to show stomata**, showing that **carbon dioxide is released during respiration**, and identifying the **parts of a dicot seed embryo**. Diagram-based questions from this chapter are almost guaranteed, so practise the four standard diagrams by hand.

📘 CHAPTER AT A GLANCE

Topic	What You Will Learn
1. What are Life Processes	The four processes and why they are needed
2. Autotrophic Nutrition	Photosynthesis — equation, steps and the role of stomata
3. Heterotrophic Nutrition	The three types, with examples
4. Nutrition in Human Beings	The alimentary canal from mouth to anus, with all the enzymes
5. Respiration	Aerobic and anaerobic; the three pathways of glucose breakdown
6. Transportation in Humans	Heart, blood vessels, double circulation, lymph
7. Transportation in Plants	Xylem and phloem; transpiration and translocation
8. Excretion in Humans	The nephron and how urine is formed
9. Excretion in Plants	How plants get rid of their wastes
10. Categorised Questions	Every type, sorted, with HOTS and starred favourites

1. WHAT ARE LIFE PROCESSES?



The four life processes that together maintain life

The processes that together perform the **maintenance function** of a living organism, and which go on even when the organism is not doing anything in particular, are called **life processes**.

Even a resting or sleeping organism must keep repairing and replacing its broken-down structures. This needs energy, and energy needs a supply of food and oxygen — which is why all four processes are essential.

2. AUTOTROPHIC NUTRITION — PHOTOSYNTHESIS

$6CO_2 + 6H_2O \xrightarrow{\text{sunlight, chlorophyll}} C_6H_{12}O_6 + 6O_2$

The three events of photosynthesis

- **Absorption of light energy** by chlorophyll.
- **Conversion of light energy to chemical energy**, and the **splitting of water molecules** into hydrogen and oxygen.
- **Reduction of carbon dioxide to carbohydrates.**
- These three steps need not happen one immediately after the other — a point CBSE sometimes tests.

Raw materials and where they come from

Requirement	Source
Carbon dioxide	From the air, through the **stomata** in leaves
Water	From the soil, absorbed by roots and carried up by **xylem**
Sunlight	The source of energy
Chlorophyll	The green pigment in **chloroplasts** that traps light

Stomata

Stomata are tiny pores, mostly on the lower surface of a leaf, through which **gaseous exchange** takes place and **water is lost as vapour** (transpiration). Each pore is guarded by two **guard cells**.

- When the guard cells take in water they **swell**, become curved, and the pore **opens**.
- When they lose water they **shrink**, become straight, and the pore **closes**.
- **Stomata close mainly at night** and when there is a risk of excessive water loss — this prevents the plant from drying out.

3. HETEROTROPHIC NUTRITION

Type	How it works	Examples
Saprophytic	The organism feeds on **dead and decaying** matter, secreting digestive juices onto it and absorbing the digested food.	Fungi, bread mould, yeast, mushroom
Parasitic	The organism lives on or inside another living organism (the host) and takes its food **without killing** it.	Cuscuta (amarbel), ticks, lice, leeches, tapeworm
Holozoic	The organism takes in **whole food** and then digests it inside the body.	Amoeba, human beings, most animals

Nutrition in Amoeba — the five steps

Amoeba is the standard example asked for holozoic nutrition in a unicellular organism:

- **Ingestion** — Amoeba pushes out **pseudopodia** (finger-like projections) which surround the food particle and engulf it, forming a **food vacuole**.
- **Digestion** — enzymes are secreted into the food vacuole and break the food into simpler substances.
- **Absorption** — the digested food is absorbed into the cytoplasm.
- **Assimilation** — the absorbed food is used for energy, growth and repair.
- **Egestion** — the undigested material is thrown out when the vacuole touches the cell surface.

4. NUTRITION IN HUMAN BEINGS

Part	Juice or enzyme	What happens there
Mouth	Salivary amylase (ptyalin) in saliva	**Starch → maltose**; teeth chew the food and the tongue mixes it
Oesophagus	None	**Peristaltic movement** pushes food down to the stomach
Stomach	Pepsin, in the presence of **hydrochloric acid**	**Proteins → peptides**. HCl makes the medium acidic for pepsin to work, and kills bacteria. Mucus protects the stomach lining from the acid.

Part	Juice or enzyme	What happens there
Small intestine	Bile from the liver; pancreatic juice (trypsin, amylase, lipase); intestinal juice	**The main site of complete digestion and of absorption.** Bile makes the medium alkaline and **emulsifies fats** into small globules.
Large intestine	None	Absorbs **water**; the rest is passed out

📌 **Villi — a guaranteed question.** The inner lining of the small intestine has millions of tiny finger-like projections called **villi**. They **increase the surface area** for absorption enormously, and each villus is richly supplied with **blood vessels** which carry the absorbed food to every cell of the body.

⚠ **Two roles of bile, both needed for full marks.** (1) It makes the acidic food coming from the stomach **alkaline**, so that pancreatic enzymes can act. (2) It **emulsifies fats** — breaks large fat globules into smaller ones so that lipase can act on them efficiently. Note that **bile contains no enzyme**.

5. RESPIRATION

Respiration is the process of **breaking down food to release energy**, which is stored in the form of **ATP** (adenosine triphosphate), the energy currency of the cell.

The three pathways of glucose breakdown

Pathway	What happens	Where
Step 1 — in the cytoplasm (all cases)	Glucose (6C) → **Pyruvate** (3C)	—
Aerobic — in the mitochondria, with oxygen	Pyruvate → CO_2 + H_2O + **a large amount of energy**	In our cells, normally
Anaerobic — in yeast, without oxygen	Pyruvate → **Ethanol + CO_2** + a little energy	Fermentation
Anaerobic — in our muscles, lack of oxygen	Pyruvate → **Lactic acid** + a little energy	Cramps during heavy exercise

📌 **Why muscle cramps occur — the standard 3-mark answer.** During heavy exercise the supply of oxygen to the muscles falls short of the demand. The muscle cells then respire **anaerobically**, and pyruvate is converted into **lactic acid**. The accumulation of lactic acid in the muscles causes **cramps and pain**. Hot water bath or massage improves circulation, removes the lactic acid, and gives relief.

Respiration in plants and in fish

- **Plants** exchange gases through **stomata** in leaves and **lenticels** in stems. The direction of exchange depends on the time of day — at night, only respiration occurs, so carbon dioxide is given out.
- **Fish** breathe through **gills**, taking dissolved oxygen from water. Since water contains far less dissolved oxygen than air, fish have a **faster breathing rate** than land animals — a favourite reasoning question.

6. TRANSPORTATION IN HUMAN BEINGS

📖 **Diagram: please refer to the NCERT textbook figure (Schematic sectional view of the human heart / double circulation) in the chapter *Life Processes*.**

Pulmonary circulation: Right ventricle → pulmonary artery → **lungs** (blood gets O_2) → pulmonary vein → left atrium

Systemic circulation: Left ventricle → aorta → **body organs** (O_2 used) → vena cava → right atrium → right ventricle

Double circulation — blood passes through the heart twice in one complete cycle

The heart

The human heart has **four chambers** — two upper **atria** and two lower **ventricles**. This separation is essential:

- The **right side** carries **deoxygenated** blood; the **left side** carries **oxygenated** blood.
- The four chambers prevent the two kinds of blood from mixing, which allows a **highly efficient supply of oxygen** to the body.
- This matters because birds and mammals are **warm-blooded** and need a great deal of energy to maintain their body temperature.
- **Ventricles have thicker walls than atria**, because they must pump blood out of the heart with much greater force. The **left ventricle** has the thickest wall of all, as it pumps blood to the whole body.

Double circulation

Blood passes through the heart **twice** in one complete cycle: once through the **pulmonary circulation** (heart → lungs → heart) and once through the **systemic circulation** (heart → body → heart). This is called **double circulation**.

Blood vessels

Vessel	Function	Structure
Arteries	Carry blood **away from** the heart	Thick, elastic walls; no valves; blood flows under high pressure
Veins	Carry blood **towards** the heart	Thin walls; **valves** present to stop backflow; low pressure
Capillaries	Connect arteries to veins	**One-cell-thick** walls, so that materials can be exchanged with the surrounding cells

Lymph

Lymph is a colourless fluid similar to plasma but containing **less protein**. It escapes from the capillaries into the intercellular spaces, drains into lymphatic vessels, and returns to the blood. It carries **digested and absorbed fat** from the intestine and drains excess fluid back into the blood.

7. TRANSPORTATION IN PLANTS

Tissue	What it carries	Direction	Driving force
Xylem	**Water and dissolved minerals**	From roots **upwards** to leaves	Transpiration pull; root pressure at night
Phloem	**Food** (products of photosynthesis), also amino acids	**Both up and down** the plant	Translocation, using energy from **ATP**

Transpiration — and why it matters

Transpiration is the loss of water as vapour from the aerial parts of a plant, mainly through the stomata. It has three functions:

- It creates the **transpiration pull**, which draws water upwards from the roots — the main force for water transport in tall plants during the day.
- It helps in the **absorption and upward movement of minerals** dissolved in the water.
- It **regulates temperature** by cooling the plant.

8. EXCRETION IN HUMAN BEINGS

Excretion is the biological process of removing harmful nitrogenous wastes from the body. The **excretory system** consists of two **kidneys**, two **ureters**, a **urinary bladder** and a

urethra.

The nephron — the functional unit of the kidney

- **Filtration** — blood enters the **glomerulus**, a cluster of capillaries inside **Bowman's capsule**, under pressure. Water, glucose, amino acids, salts and urea are filtered out.
- **Selective reabsorption** — as the filtrate moves along the tubule, useful substances such as **glucose, amino acids, most salts and most water** are reabsorbed into the blood.
- **Collection** — the remaining fluid, now **urine**, passes into the collecting duct, then to the ureter, and is stored in the urinary bladder until it is passed out.

📌 **What decides the amount of urine?** Mainly the **amount of excess water** in the body and the **amount of dissolved waste** to be excreted. On a hot day, much water is lost as sweat, so less urine is formed and it is more concentrated.

Artificial kidney — dialysis

When the kidneys fail, blood is purified by an artificial kidney using **dialysis**. Blood is passed through tubes made of a **selectively permeable membrane**, surrounded by **dialysing fluid** which has the same concentration of glucose and salts as normal plasma but **no nitrogenous waste**. The waste therefore passes out of the blood into the fluid, and the cleaned blood is returned to the body. **Note: there is no reabsorption step in dialysis**, unlike in a real nephron.

9. EXCRETION IN PLANTS

- **Oxygen and carbon dioxide** are removed through the **stomata** and lenticels.
- **Excess water** is removed by **transpiration**.
- Many wastes are stored in **cell vacuoles**, or as **resins and gums** in old xylem.
- Some wastes are stored in **leaves that fall off**, and some are excreted into the **soil** around the plant.

CATEGORISED QUESTION BANK WITH SOLUTIONS

Sorted by Question Type — ⭐ marks CBSE's Frequently Asked Patterns

CATEGORY A

Photosynthesis and Plant Nutrition (2–3 Marks)

Q1. Write the balanced equation for photosynthesis and name the three events that occur during it. [3 Marks] ⭐ FREQUENTLY ASKED

Ans. $6CO_2 + 6H_2O \rightarrow$(sunlight, chlorophyll) $C_6H_{12}O_6 + 6O_2$

- **Event 1:** absorption of light energy by chlorophyll.

- **Event 2:** conversion of light energy into chemical energy, and the **splitting of water** molecules into hydrogen and oxygen.
- **Event 3:** reduction of carbon dioxide into carbohydrates.
- These three steps need not take place immediately one after the other.

Q2. Describe how the opening and closing of stomata is controlled. [3 Marks]
⭐ FREQUENTLY ASKED

Ans. It is controlled by the water content of the two guard cells surrounding each pore.

- When the **guard cells take in water**, they **swell up** and become curved in shape.
- This curving pulls the pore **open**, allowing gaseous exchange.
- When the guard cells **lose water**, they **shrink** and become straight, and the pore **closes**.
- Stomata generally close at **night** and when water loss must be prevented, since large amounts of water can be lost through them.

Q3. Why do stomata close at night in most plants? [2 Marks] ⭐ FREQUENTLY ASKED

Ans. At night there is no sunlight, so **photosynthesis does not take place** and carbon dioxide is not needed. Keeping the stomata open would only cause a needless **loss of water** by transpiration. So the guard cells lose water, shrink, and the pores close, conserving the plant's water.

CATEGORY B

Human Digestive System (2–5 Marks)

Q4. What is the role of hydrochloric acid in the stomach? [2 Marks]
⭐ FREQUENTLY ASKED

Ans. Hydrochloric acid makes the medium in the stomach **acidic**, which is necessary for the enzyme **pepsin** to act on proteins. It also **kills harmful bacteria** that enter with the food. The stomach lining is protected from this acid by a layer of **mucus**.

Q5. What are the two functions of bile in digestion? [2 Marks] ⭐ FREQUENTLY ASKED

Ans. First, bile makes the acidic food coming from the stomach **alkaline**, so that the pancreatic enzymes can work on it. **Second**, bile salts **emulsify fats** — they break large fat globules into small ones, increasing the surface area so that the enzyme **lipase** can digest them efficiently. Note that bile itself contains **no enzyme**.

Q6. What are villi? State their function. [3 Marks] ⭐ FREQUENTLY ASKED

Ans. Villi are tiny finger-like projections on the inner lining of the small intestine.

- There are millions of them, and they project into the cavity of the small intestine.
- **Function 1:** they enormously **increase the surface area** available for the absorption of digested food.

- **Function 2:** each villus is richly supplied with **blood vessels**, which take the absorbed food to every cell of the body.
- This is why the **small intestine** is the main site of absorption.

Q7. Name the enzyme in saliva and state what it acts upon. [1 Mark]

Ans. The enzyme is **salivary amylase (ptyalin)**, and it breaks down **starch into maltose**, a simpler sugar.

CATEGORY C

Respiration (2–3 Marks)

Q8. Why do we get muscle cramps after heavy exercise? [3 Marks]

⭐ FREQUENTLY ASKED

Ans. The cramps are caused by anaerobic respiration in the muscles.

- During heavy exercise the **demand for oxygen exceeds the supply** reaching the muscle cells.
- The muscle cells then respire **anaerobically**, and the pyruvate formed is converted into **lactic acid** instead of carbon dioxide and water.
- The **accumulation of lactic acid** in the muscles causes cramps and pain.
- **Relief:** a hot water bath or a massage improves the blood circulation, which carries the lactic acid away.

Q9. Write the three pathways for the breakdown of glucose in a living cell. [3 Marks]

⭐ FREQUENTLY ASKED

Ans. All three begin with the same first step in the cytoplasm.

- **Common first step (cytoplasm):** glucose, a six-carbon molecule, is broken into **pyruvate**, a three-carbon molecule.
- **Aerobic respiration (mitochondria, with oxygen):** pyruvate → carbon dioxide + water + **a large amount of energy**.
- **Anaerobic respiration in yeast (no oxygen):** pyruvate → **ethanol + carbon dioxide** + a little energy. This is **fermentation**.
- **Lack of oxygen in our muscles:** pyruvate → **lactic acid** + a little energy.

Q10. Why is the rate of breathing in aquatic organisms much faster than in terrestrial organisms? [2 Marks] ⭐ FREQUENTLY ASKED

Ans. Aquatic organisms take in the oxygen **dissolved in water**. The amount of dissolved oxygen in water is **much lower** than the amount of oxygen available in air. To obtain enough oxygen for their needs, aquatic organisms must therefore pass a large volume of water over their gills, which means a **much faster breathing rate**.

CATEGORY D

Q11. Why is the separation of oxygenated and deoxygenated blood necessary in birds and mammals? [3 Marks] ⭐ FREQUENTLY ASKED

Ans. The separation makes the oxygen supply highly efficient.

- The four-chambered heart keeps **oxygenated blood on the left** and **deoxygenated blood on the right**, so the two never mix.
- This allows a **highly efficient supply of oxygen** to all parts of the body.
- Birds and mammals are **warm-blooded**, that is, they must maintain a constant body temperature.
- This requires a great deal of **energy**, which in turn requires a great deal of oxygen. Mixing the two kinds of blood would reduce the oxygen supply and make this impossible.

Q12. Why are the walls of the ventricles thicker than those of the atria? [2 Marks]
⭐ FREQUENTLY ASKED

Ans. The **atria** only receive blood and pass it to the ventricles below, which is a short distance requiring little force. The **ventricles** must pump blood **out of the heart** to the lungs and to the whole body, which needs much greater force. Their walls are therefore **thicker and more muscular**, the left ventricle having the thickest wall of all.

Q13. Differentiate between xylem and phloem transport. [3 Marks]
⭐ FREQUENTLY ASKED

Ans. The two tissues differ in what they carry, in direction, and in the force used.

- **Xylem** carries **water and dissolved minerals**; **phloem** carries **food** made in the leaves, and also amino acids.
- **Xylem** transport is **upwards only**, from roots to leaves; **phloem** transport, called **translocation**, goes **both upwards and downwards**.
- **Xylem** uses the **transpiration pull** (and root pressure at night) and needs no energy from the plant; **phloem** transport **uses energy from ATP**.
- Xylem consists of dead tissue at maturity, while phloem is living tissue.

Q14. What is lymph? State two of its functions. [2 Marks]

Ans. Lymph is a colourless fluid similar to blood plasma but containing **less protein**. It escapes from the capillaries into the intercellular spaces and drains into lymphatic vessels. **Function 1:** it carries **digested and absorbed fat** from the small intestine. **Function 2:** it drains **excess fluid** from the tissue spaces back into the blood.

CATEGORY E

Excretion (2–5 Marks)

Q15. Describe how urine is formed in a nephron. [5 Marks] ⭐ FREQUENTLY ASKED

Ans. Urine formation takes place in three stages.

- **Stage 1 — Filtration:** blood enters the **glomerulus**, a cluster of capillaries enclosed in **Bowman's capsule**, under pressure. Water, glucose, amino acids, salts and urea are filtered out of the blood.
- **Stage 2 — Selective reabsorption:** as this filtrate flows along the long tubule, the substances the body still needs are taken back into the blood — **glucose, amino acids, most salts and most of the water**.
- **Stage 3 — Collection:** the fluid that remains is **urine**. It passes into the collecting duct and then into the **ureter**.
- Urine is carried to the **urinary bladder**, where it is stored until it is passed out through the **urethra**.
- **The amount of urine formed** depends on the excess water in the body and the amount of dissolved waste that must be removed.

Q16. What is dialysis? How does an artificial kidney differ from a real one? [3 Marks]

FREQUENTLY ASKED

Ans. Dialysis is the process used to purify the blood when the kidneys fail.

- Blood from the patient is passed through tubes made of a **selectively permeable membrane**, placed in a tank of **dialysing fluid**.
- The dialysing fluid has the **same concentration of glucose and salts** as normal plasma but contains **no nitrogenous waste**.
- So the waste products pass out of the blood into the fluid by diffusion, and the cleaned blood is returned to the patient.
- **The key difference:** in a real nephron there is a stage of **selective reabsorption**, in which useful substances are taken back. **There is no reabsorption in an artificial kidney** — the fluid's composition alone prevents useful substances from being lost.

Q17. How do plants get rid of their waste products? [3 Marks]

Ans. Plants use several different routes rather than a single excretory organ.

- **Gaseous wastes** — oxygen and carbon dioxide — are released through the **stomata** in leaves and **lenticels** in stems.
- **Excess water** is removed by **transpiration**.
- Many wastes are stored in the **cell vacuoles**, or as **resins and gums** in old xylem.
- Some wastes are stored in **leaves that later fall off**, and some are excreted into the **soil** around the plant.

CATEGORY F

Assertion – Reason (1 Mark)

Choose: (i) Both A and R true, R is the correct explanation of A. (ii) Both true, R is not the correct explanation. (iii) A true, R false. (iv) A false, R true.

Q18. Assertion (A): The small intestine is the main site of absorption of digested food. Reason (R): Its inner lining bears villi, which greatly increase the surface area. [1 Mark] ⭐ FREQUENTLY ASKED

Ans. Answer: (i) — Both are true and R correctly explains A. The villi also carry a rich supply of blood vessels to take the food away.

Q19. Assertion (A): Bile contains digestive enzymes. Reason (R): Bile emulsifies fats into smaller globules. [1 Mark] ⭐ FREQUENTLY ASKED

Ans. Answer: (iv) — A is false but R is true. Bile does **not** contain any enzyme; it works by making the medium alkaline and by emulsifying fats so that lipase can act.

Q20. Assertion (A): Arteries have thick elastic walls. Reason (R): Blood flows through arteries under high pressure. [1 Mark]

Ans. Answer: (i) — Both are true and R correctly explains A. Veins, carrying blood at low pressure, have thin walls and valves instead.

CATEGORY G

Case Study (4 Marks)

A patient in a hospital. A man is admitted with badly damaged kidneys. His blood urea level is very high, and he passes very little urine. The doctor puts him on a machine through which his blood is passed for four hours, twice a week.

Q21. Name the process and the machine used. [1 Mark]

Ans. The process is **dialysis** and the machine is an **artificial kidney** (haemodialysis machine).

Q22. Explain how the machine removes the waste from his blood. [2 Marks]

Ans. The blood is passed through tubes made of a **selectively permeable membrane**, surrounded by **dialysing fluid** which contains glucose and salts at the same concentration as normal plasma but **no nitrogenous waste**. Because of this difference in concentration, **urea and other wastes diffuse out** of the blood into the fluid, while the useful substances stay in the blood.

Q23. Name the structural and functional unit of the kidney that this machine replaces. [1 Mark]

Ans. The **nephron**. A healthy kidney contains about a million of them.

CATEGORY H

HOTS — Higher Order Thinking (4–5 Marks)

Q24. A potted plant is kept in a dark cupboard for two days, then one leaf is partly covered with black paper and the plant is placed in sunlight for six hours. On testing

the leaf with iodine, only the uncovered part turns blue-black. Explain each step of this experiment. [5 Marks] ⭐ FREQUENTLY ASKED

Ans. The experiment proves that sunlight is essential for photosynthesis.

- **Why the plant is kept in the dark for two days:** to **destarch** the leaf, that is, to use up all the starch already stored in it. Without this step, old starch would give a false positive.
- **Why one part is covered with black paper:** to keep **sunlight** away from that part while everything else — carbon dioxide, water, chlorophyll, temperature — stays the same. The covered part is the **control**.
- **Why the plant is put in sunlight:** so that photosynthesis can take place in the exposed part.
- **Why iodine is used:** iodine turns **blue-black** in the presence of **starch**, the product of photosynthesis.
- **Conclusion:** only the exposed part turned blue-black, so starch was made only where sunlight fell. This proves that **sunlight is essential for photosynthesis**.

Q25. An athlete finishes a race and feels a sharp pain in his legs. A friend suggests a hot water bath. Explain the biology behind both the pain and the remedy. [4 Marks]

⭐ FREQUENTLY ASKED

Ans. The pain is a direct result of anaerobic respiration.

- During the race the athlete's muscles needed far more oxygen than the blood could supply, so the **supply fell short of the demand**.
- The muscle cells therefore switched to **anaerobic respiration**, in which pyruvate is converted into **lactic acid** rather than carbon dioxide and water.
- The **build-up of lactic acid** in the muscle fibres causes the cramping pain he feels.
- **Why the hot water bath helps:** it improves the **blood circulation** to the muscles, so more oxygen reaches them and the accumulated lactic acid is carried away and broken down. A massage works in the same way.

Q26. Why is a four-chambered heart an advantage to a mammal but not necessary for a fish? Explain with reference to circulation. [5 Marks] ⭐ FREQUENTLY ASKED

Ans. The difference is in how many times blood passes through the heart and in the animal's energy needs.

- A **fish has a two-chambered heart** with **single circulation** — blood passes through the heart only **once** in a complete cycle. Blood goes from the heart to the gills, is oxygenated there, and then travels straight to the body.
- This is sufficient for a fish because it is **cold-blooded** and does not need to spend energy maintaining a constant body temperature.
- A **mammal has a four-chambered heart** with **double circulation** — blood passes through the heart **twice** in one cycle.

- The four chambers keep **oxygenated and deoxygenated blood completely separate**, which gives a highly efficient oxygen supply.
- This is essential because mammals are **warm-blooded** and need a great deal of energy, and therefore oxygen, to maintain their body temperature.

Q27. Both the lungs and the kidneys are called organs of excretion by some students. Comment on this statement, and explain what happens to carbon dioxide and to urea in the body. [4 Marks] FREQUENTLY ASKED

Ans. The statement is partly right but needs care.

- **Excretion** is defined as the removal of harmful **metabolic wastes** from the body, so any organ removing such waste can be called excretory.
- **The kidneys** remove **nitrogenous wastes** such as urea and uric acid, formed when excess amino acids are broken down in the **liver**. This is excretion in the strict sense.
- **The lungs** remove **carbon dioxide**, a waste product of respiration. Since carbon dioxide is a metabolic waste, the lungs do perform an excretory function.
- However, the lungs are studied as part of the **respiratory system** and the kidneys as the **excretory system**, so in an examination answer name the kidneys as the excretory organs and mention the lungs only as an additional route.

THE EIGHT MOST FREQUENTLY ASKED PATTERNS

Pattern	How to handle it
1. Photosynthesis equation + three events	Write the balanced equation, then name the three events in order.
2. Opening and closing of stomata	Guard cells swell → open; shrink → close.
3. Role of HCl in the stomach	Acidic medium for pepsin, and kills bacteria.
4. Two functions of bile	Makes medium alkaline; emulsifies fats. No enzyme in bile.
5. Villi	Increase surface area; rich blood supply.
6. Muscle cramps	Anaerobic respiration → lactic acid accumulation.
7. Four-chambered heart	No mixing of blood → efficient oxygen supply → warm-blooded needs.
8. Urine formation	Filtration, selective reabsorption, collection — in that order.

✅ FINAL CHECK BEFORE THE EXAM

- Can you write the photosynthesis equation **balanced**, with the conditions above the arrow?
- Can you draw and label the **human digestive system**, the **heart**, and a **nephron** from memory?
- Do you know which enzyme acts where, and on what, all the way from mouth to small intestine?
- Can you write all **three** pathways of glucose breakdown, starting from the common first step?
- Do you know the **three** stages of urine formation in the correct order?
- Can you explain why an artificial kidney has **no reabsorption** stage?

THE HUMAN DIGESTIVE SYSTEM (ALIMENTARY CANAL AND GLANDS)

> 📖 **Diagram: please refer to the NCERT textbook figure in the chapter *Life Processes*.** Practise drawing it from the textbook; the detailed explanation of every labelled part is given below.

Detailed explanation (label-wise)

- **Mouth & salivary glands** — teeth chew food; saliva contains **salivary amylase** which breaks starch into sugar (maltose).
- **Oesophagus (food pipe)** — carries food to the stomach by **peristalsis** (rhythmic contraction of muscles).
- **Stomach** — gastric glands release **HCl** (acidic medium, kills germs, activates pepsin), **pepsin** (digests proteins) and **mucus** (protects inner lining from acid). Sphincter muscle controls exit into small intestine.
- **Liver** — largest gland; secretes **bile**, stored in the **gall bladder**. Bile has no enzyme: it makes food alkaline and **emulsifies fats** (breaks big globules into small ones).
- **Pancreas** — pancreatic juice: **trypsin** (proteins), **lipase** (emulsified fats), **amylase** (starch).
- **Small intestine** — longest part; site of **complete digestion** (intestinal juice converts proteins → amino acids, carbohydrates → glucose, fats → fatty acids + glycerol). **Villi** increase surface area for absorption into blood.
- **Large intestine** — absorbs excess **water**; the rest is removed through the **anus**, controlled by the anal sphincter.

✏️ **How to draw it in the exam:** Draw a long tube from mouth to anus; put the stomach as a J-shaped bag on the left, liver as a large lobe on the right above it with the gall bladder beneath; pancreas as a leaf-like gland below the stomach; coiled small intestine in the middle, framed by the large intestine. Label at least 8 parts.

HUMAN HEART — FOUR CHAMBERS AND DOUBLE CIRCULATION

📖 **Diagram: please refer to the NCERT textbook figure in the chapter *Life Processes*.** Practise drawing it from the textbook; the detailed explanation of every labelled part is given below.

Detailed explanation (label-wise)

- Four chambers: **right atrium, right ventricle** (deoxygenated blood) and **left atrium, left ventricle** (oxygenated blood). A wall (septum) keeps the two sides separate.
- **Vena cava** brings deoxygenated blood from the body → right atrium → right ventricle → **pulmonary artery** → lungs.
- **Pulmonary vein** brings oxygenated blood from lungs → left atrium → left ventricle → **aorta** → whole body.
- **Left ventricle has the thickest wall** because it pumps blood to the whole body.
- **Valves** between atria and ventricles prevent backflow.
- **Double circulation**: blood passes through the heart **twice** in one cycle — pulmonary (heart↔lungs) + systemic (heart↔body). This gives an efficient supply of oxygen, needed by warm-blooded animals.

✏️ **How to draw it in the exam:** Draw the heart as a rounded shape; divide into four chambers (atria small on top, ventricles larger below; left ventricle wall thickest). Show vena cava entering right atrium, aorta arching out of left ventricle, pulmonary artery and veins. Use arrows for blood flow.

THE NEPHRON — STRUCTURAL AND FUNCTIONAL UNIT OF THE KIDNEY

📖 **Diagram: please refer to the NCERT textbook figure in the chapter *Life Processes*.** Practise drawing it from the textbook; the detailed explanation of every labelled part is given below.

Detailed explanation (label-wise)

- Nephron = **structural and functional unit of the kidney**; each kidney has about a million nephrons.

- **Glomerulus** — a cluster of thin-walled capillaries; blood arrives by the **afferent arteriole** and leaves by the (narrower) **efferent arteriole**. Filtration occurs here under pressure.
- **Bowman's capsule** — cup-shaped end of the tubule that collects the filtrate (water, glucose, amino acids, salts, urea).
- **Tubule** (proximal part, loop, distal part) — **selective reabsorption** of glucose, amino acids, salts and a major amount of water back into the surrounding capillaries.
- **Collecting duct** — carries urine to the ureter → **urinary bladder** → urethra.
- Amount of water reabsorbed depends on how much excess water is in the body and how much dissolved waste has to be excreted.

> ✏️ **How to draw it in the exam:** Draw Bowman's capsule as a cup around a ball of capillaries (glomerulus); from it a coiled tubule, a U-shaped loop, and another coil joining the straight collecting duct. Show capillaries wrapped around the tubule.

ALVEOLI — HOW THEY MAXIMISE THE EXCHANGE OF GASES

> 📖 **Diagram: please refer to the NCERT textbook figure in the chapter *Life Processes*.** Practise drawing it from the textbook; the detailed explanation of every labelled part is given below.

Detailed explanation (label-wise)

- Air path: nostrils → pharynx → larynx → **trachea** (rings of cartilage prevent collapse) → **bronchi** → **bronchioles** → **alveoli**.
- **Alveoli** are tiny balloon-like air sacs; their walls are **one cell thick** and covered by an extensive network of blood capillaries.
- O_2 diffuses from alveolar air into blood; CO_2 diffuses from blood into alveoli to be breathed out.
- Huge total surface (~80 m^2 if spread out) maximises gas exchange; moist surface helps gases dissolve.
- Haemoglobin in RBCs carries oxygen; CO_2 is mostly carried dissolved in plasma.

> ✏️ **How to draw it in the exam:** Draw the trachea branching into two bronchi and finer bronchioles, each ending in a bunch of grape-like alveoli; show one enlarged alveolus surrounded by a capillary network with arrows for O_2 in and CO_2 out.

PART B — NCERT SOLUTIONS

NCERT Solutions — Chapter 5 Exercises (13 Questions)

How to approach this chapter

Four life processes, four systems: **nutrition** (how food is taken and broken down), **respiration** (how energy is released from it), **transportation** (how it reaches every cell) and **excretion** (how wastes leave). Almost every long answer is a description of a structure followed by how that structure suits its function.

> **Facts that are asked again and again:**
> Saliva — the enzyme **salivary amylase** digests starch into sugar.
> Stomach — **HCl** (acidic medium, kills germs), **pepsin** (protein), **mucus** (protects the lining).
> Small intestine — **bile** (emulsifies fat, makes the medium alkaline), **pancreatic juice** (trypsin, lipase, amylase); it is the site of **complete digestion and absorption**, through **villi**.
> Breakdown of glucose: cytoplasm → pyruvate; then **mitochondria** (aerobic, CO_2 + H_2O + 38 ATP), or ethanol + CO_2 (yeast), or lactic acid (muscle cramps).
> Transport: **xylem** — water and minerals, upward only, dead tissue, driven by **transpiration pull**. **Phloem** — food, both directions, living tissue, needs **ATP** (translocation).
> Excretion: **nephron** is the filtration unit — filtration in the glomerulus, selective reabsorption in the tubule.

Q1. The kidneys in human beings are a part of the system for (a) nutrition (b) respiration (c) excretion (d) transportation 1 mark

SOLUTION:

Answer: (c) excretion 1 mark

The kidneys filter nitrogenous waste — chiefly urea — out of the blood and remove it as urine.

Q2. The xylem in plants is responsible for (a) transport of water (b) transport of food (c) transport of amino acids (d) transport of oxygen 1 mark

SOLUTION:

Answer: (a) transport of water 1 mark

Xylem carries water and dissolved minerals from the roots upward to the leaves. Food is carried by the **phloem**.

Q3. The autotrophic mode of nutrition requires
(a) carbon dioxide and water (b) chlorophyll (c) sunlight (d) all of the above

1 mark

SOLUTION:

Answer: (d) all of the above **1 mark**

Photosynthesis needs the raw materials (CO_2 and water), the pigment that traps the energy (chlorophyll) and the energy source itself (sunlight).

Q4. The breakdown of pyruvate to give carbon dioxide, water and energy takes place in
(a) cytoplasm (b) mitochondria (c) chloroplast (d) nucleus

1 mark

SOLUTION:

Answer: (b) mitochondria **1 mark**

Glucose is first broken down to pyruvate in the **cytoplasm**; the pyruvate then enters the mitochondria, where aerobic respiration completes the breakdown. This is why mitochondria are called the powerhouse of the cell.

Q5. How are fats digested in our bodies? Where does this process take place?

3 marks

SOLUTION:

Fats are digested entirely in the **small intestine**. **1 mark**

Step 1 — emulsification. Fats enter the small intestine as large globules. **Bile juice** from the liver breaks these globules into fine droplets. This increases the surface area on which enzymes can act, and also makes the acidic food coming from the stomach alkaline, which the pancreatic enzymes need. **1 mark**
Step 2 — enzyme action. Lipase in the pancreatic juice, and again in the intestinal juice, breaks the emulsified fat into **fatty acids and glycerol**, which are then absorbed by the villi. **1 mark**

📌 Bile contains **no enzyme**. Its job is emulsification plus changing the medium to alkaline — saying "bile digests fat" loses the mark.

Q6. What is the role of saliva in the digestion of food?

2 marks

SOLUTION:

Saliva is secreted by the salivary glands in the mouth and has three roles: 1 mark

• It contains the enzyme **salivary amylase (ptyalin)**, which begins the digestion of **starch** and converts it into simple sugar (maltose).
• It **moistens and softens** the food, so that it can be chewed by the teeth and swallowed easily.
• It helps the tongue to mix the food thoroughly, and so lets the enzyme act uniformly on it. 1 mark

📌 Chewing a piece of roti for a while makes it taste sweet — the amylase has turned starch into sugar. That observation is a favourite one-mark question.

Q7. What are the necessary conditions for autotrophic nutrition, and what are its by-products?

2 marks

SOLUTION:

Necessary conditions: carbon dioxide, water, **chlorophyll** and **sunlight**. 1 mark

$$6CO_2 + 6H_2O \xrightarrow{\text{sunlight, chlorophyll}} C_6H_{12}O_6 + 6O_2$$

By-products: oxygen, which is released through the stomata, and **water**. The glucose formed is stored as **starch**. 1 mark

Q8. What are the differences between aerobic and anaerobic respiration? Name some organisms that use the anaerobic mode of respiration.

3 marks

SOLUTION:

Basis	Aerobic respiration	Anaerobic respiration
Oxygen	Takes place in the presence of oxygen	Takes place in the absence of oxygen

Site	Cytoplasm, then **mitochondria**	Only in the **cytoplasm**
End products	Carbon dioxide and water	Ethanol + CO_2 (yeast), or lactic acid (muscle cells)
Energy released	Much more — about 38 ATP per glucose	Much less — about 2 ATP per glucose
Breakdown	Complete breakdown of glucose	Incomplete breakdown of glucose

2 marks

Organisms respiring anaerobically: yeast (fermentation — the basis of brewing and baking), and many bacteria such as those that turn milk into curd. Our own **muscle cells** respire anaerobically for short periods during vigorous exercise, and the lactic acid built up causes cramps. 1 mark

Q9. How are the alveoli designed to maximise the exchange of gases? 2 marks

SOLUTION:

The alveoli are balloon-like sacs at the ends of the finest bronchioles, and every feature of theirs serves gas exchange: 1 mark

• They are extremely **numerous**, giving a total surface area of about **80 m^2** — roughly the size of a tennis court — packed inside the chest.
• Their walls are **only one cell thick**, so gases diffuse across very quickly.
• They are covered by an **extensive network of blood capillaries**, which carries the oxygen away at once and keeps the concentration difference high.
• Their surface is **moist**, and gases must dissolve before they can diffuse. 1 mark

Q10. What would be the consequences of a deficiency of haemoglobin in our bodies? 2 marks

SOLUTION:

Haemoglobin is the respiratory pigment in the red blood cells that binds oxygen and carries it to every tissue. 1 mark

If it is deficient, the blood cannot carry enough oxygen. The cells cannot respire properly, so less energy is released. The person suffers from **anaemia** — tiredness and weakness, breathlessness on slight exertion, pale skin, headache and poor growth. 1 mark

Q11. Describe double circulation in human beings. Why is it necessary? 3 marks

SOLUTION:

Double circulation means that the blood passes through the heart **twice** in one complete round of the body. 1 mark

Pulmonary circulation. Deoxygenated blood from the body enters the right atrium, passes into the right ventricle, and is pumped to the **lungs**. There it is oxygenated and returns to the left atrium. 1 mark

Systemic circulation. From the left atrium the oxygenated blood goes into the left ventricle and is pumped through the aorta to **all parts of the body**, returning as deoxygenated blood to the right atrium.

Why it is necessary. The four-chambered heart keeps oxygenated and deoxygenated blood completely separated, so that the body receives blood with the **highest possible oxygen content**. This is essential for warm-blooded animals such as birds and mammals, which need a great deal of energy to maintain a constant body temperature. 1 mark

Q12. What are the differences between the transport of materials in xylem and phloem? 3 marks

SOLUTION:

Basis	Xylem	Phloem
Material carried	Water and dissolved minerals	Food — mainly sucrose — and amino acids
Direction	Upward only, roots → leaves	Both directions, from leaves to storage organs and back
Tissue	Mainly dead tissue (vessels, tracheids)	Living tissue (sieve tubes with companion cells)
Energy	No energy spent; driven by **transpiration pull**	Energy from **ATP** is used — the process is called **translocation**
Force involved	Root pressure and suction from transpiration	Osmotic pressure created after ATP moves sugar into the sieve tube

3 marks

Q13. Compare the functioning of alveoli in the lungs and nephrons in the kidneys with respect to their structure and functioning. 3 marks

SOLUTION:

What they have in common: both are the basic functional units of their organ, both are present in very large numbers, both have extremely thin walls in close contact with a network of blood capillaries, and both work by exchanging materials with the blood over a large surface area. 1 mark

Basis	Alveoli	Nephron
Location	Lungs	Kidneys
Structure	Balloon-like air sacs, one-cell-thick walls, surrounded by capillaries	A cup-shaped Bowman's capsule holding a capillary bundle (glomerulus), continuing into a long coiled tubule
Function	Exchange of gases — O_2 into the blood, CO_2 out of it	Filtration of blood and removal of nitrogenous waste as urine
Process	Simple **diffusion**, no energy spent	Pressure **filtration** followed by **selective reabsorption** of glucose, amino acids, salts and water

2 marks

— End of Chapter 5 Exercises —

⭐ Frequently Asked Board Questions — Chapter 5

📌 **About this section**

Standard board favourites from Life Processes.

Q. Why is the small intestine long in herbivores and shorter in carnivores?

Herbivores eat grass and leaves, which are rich in **cellulose** — a material that takes a long time to digest. A longer small intestine gives that time. Meat is digested far more easily, so carnivores such as the tiger have a much shorter small intestine.

Q. What is the advantage of having four-chambered heart?

The four chambers keep oxygenated blood in the left side and deoxygenated blood in the right side completely separate, so the two never mix. Tissues therefore get blood rich in oxygen, allowing the high rate of respiration that warm-blooded animals need to maintain body temperature.

Q. Explain the structure and working of stomata.

A stoma is a tiny pore in the leaf surface bounded by two bean-shaped **guard cells**. When water enters the guard cells they swell, become turgid and bend apart, opening the pore; when they lose water they shrink and the pore closes. Stomata allow the exchange of CO_2 and O_2 and are also the main route for transpiration. They stay mostly closed when the plant does not need CO_2, to reduce water loss.

Q. What is the role of HCl in the stomach? Why does the stomach not digest itself?

HCl makes the medium acidic so that the enzyme **pepsin** can act on proteins, and it kills bacteria that come with the food. The stomach lining is protected by a thick layer of **mucus**, which prevents the acid from damaging it — when this protection fails, ulcers result.

Q. What is translocation? Why is it essential for plants?

The transport of the food made in the leaves to all other parts of the plant, through the **phloem**. It is essential because roots, stems, fruits and seeds cannot make their own food, and food has to be delivered both upward to growing tips and downward to storage organs.

Q. How is urine produced in the nephron, and how is the amount of water in it regulated?

Blood is filtered under pressure in the **glomerulus**; the filtrate collects in Bowman's capsule. As it passes down the tubule, useful substances — glucose, amino acids, salts and most of the water — are **selectively reabsorbed** into the surrounding capillaries. The amount of water finally left depends on how much excess water the body has and how much dissolved waste has to be excreted.

Q. What is the function of the lymph?

Lymph is a colourless fluid formed from the plasma that escapes the capillaries into the intercellular spaces. It carries digested and absorbed **fat** from the intestine, drains excess fluid from the tissues back into the blood, and plays a part in the body's defence — it contains lymphocytes.

Q. Why are rings of cartilage present in the throat?

The rings of cartilage in the trachea keep the air passage permanently open. Without them the trachea would collapse when the air pressure inside fell during breathing.

— Chapter 5 Complete —

CHAPTER 6

Control and Coordination

Study Material · NCERT Solutions (16 Questions) · Board Questions

PART A — STUDY MATERIAL

📘 Study Material — Chapter 6: Control and Coordination

🔑 The spine of this chapter

Every living body must respond to changes around it (stimuli) in a controlled, coordinated way. Animals use two systems together — the fast, short-lived **nervous system** and the slow, long-lasting **endocrine (hormonal) system**. Plants have no nervous or muscle tissue, so they respond through **chemical messengers (plant hormones)**, either by **growth** (tropic movements) or by **changes in water content of cells** (nastic movements).

📘 CHAPTER AT A GLANCE

Topic	What You Will Learn
1. Nervous tissue	Receptors, neuron, synapse, how an impulse travels
2. Reflex action	Reflex arc — the favourite 3/5-mark diagram question
3. Human brain	Fore, mid and hind brain — what each part controls
4. Protection & action	Cranium, CSF, vertebral column; how muscles contract
5. Coordination in plants	Touch-me-not, tropisms, plant hormones
6. Hormones in animals	Endocrine glands table, feedback mechanism

1. RECEPTORS AND THE NEURON

Receptors are specialised tips of nerve cells that detect information from the environment. They are located in sense organs.

Receptor	Location	Detects
Photoreceptors	Eye	Light
Phonoreceptors	Inner ear	Sound (the ear also detects balance)
Olfactory receptors	Nose	Smell
Gustatory receptors	Tongue	Taste

Thermo-/touch receptors	Skin	Heat, cold, touch, pain

Neuron (nerve cell) — the structural and functional unit of the nervous system.
Path of impulse: Dendrite → Cell body (cyton) → Axon → Nerve ending → (chemical released) → Synapse → next neuron.
Synapse: the tiny gap between the nerve ending of one neuron and the dendrite of the next. At the nerve ending the **electrical impulse** causes release of **chemicals**; these cross the gap and start a new electrical impulse in the next neuron. Because the chemicals are released only at the axon end, the impulse travels in **one direction only**.

STRUCTURE OF A NEURON

📖 **Diagram: please refer to the NCERT textbook figure (Structure of neuron) in the chapter *Control and Coordination*.**

Labels you must show (4): Dendrite, Cell body (with nucleus), Axon, Nerve ending. Add an arrow showing direction of impulse.

✏️ **How to draw:** a star-shaped cell body with a nucleus and many short branches (dendrites) → one long thin tube (axon) → branched ends (nerve endings).

2. REFLEX ACTION AND REFLEX ARC

Reflex action: a sudden, automatic, involuntary response to a stimulus, done without conscious thinking of the brain. Examples: pulling the hand away from a hot object, blinking when an object comes near the eye, sneezing, coughing, watering of the mouth at the smell of food.
Reflex arc: the pathway followed by the impulse in a reflex action.
Receptor → Sensory neuron → Relay neuron (in spinal cord) → Motor neuron → Effector (muscle/gland)
Why reflex arcs are formed in the spinal cord: the brain's thinking takes time; in danger, a quick response is needed. The spinal cord connects input and output nerves directly, so the response is immediate. The information **also goes to the brain**, which becomes aware of the event afterwards.
Why reflex arcs evolved: in animals whose thinking process is slow, reflex arcs give an efficient, quick response — they persist even in complex animals.

REFLEX ARC

📖 **Diagram: please refer to the NCERT textbook figure (Reflex arc) in the chapter *Control and Coordination*.**

Labels (5): Receptor (in skin), Sensory neuron, Relay neuron in spinal cord (grey matter), Motor neuron, Effector (muscle). Show arrows from receptor → spinal cord → muscle.

Voluntary vs involuntary vs reflex

Voluntary action	Involuntary action	Reflex action
Under our will; controlled by **cerebrum**	Not under our will; controlled by **mid-brain and hind-brain (medulla)**	Sudden response; controlled mainly by **spinal cord**
Writing, talking, walking	Heartbeat, breathing, peristalsis, blood pressure	Withdrawing hand from a hot plate, knee jerk

3. HUMAN NERVOUS SYSTEM AND BRAIN

Central nervous system (CNS): brain + spinal cord.
Peripheral nervous system (PNS): cranial nerves (arising from the brain) + **spinal nerves** (arising from the spinal cord). They carry messages between the CNS and all parts of the body.
Brain — three regions:

Region	Part	Function
Fore-brain	Cerebrum	Main thinking part; memory, reasoning, intelligence; voluntary actions; separate areas for hearing, smell, sight, taste; sensation of hunger/fullness
Mid-brain	—	Involuntary actions: reflex movements of head, neck, eyes; change in pupil size
Hind-brain	Cerebellum	Posture and balance; precision of voluntary actions (walking in a straight line, riding a bicycle, picking up a pencil)
	Pons	Regulates respiration
	Medulla	Blood pressure, salivation, vomiting, heartbeat

HUMAN BRAIN

📖 **Diagram: please refer to the NCERT textbook figure (Human brain) in the chapter *Control and Coordination*.**

Labels: Fore-brain (cerebrum), Mid-brain, Hind-brain — Cerebellum, Pons, Medulla; Pituitary gland, Hypothalamus; Spinal cord.

Protection: brain lies in a bony box — the **cranium (skull)** — inside a fluid-filled balloon (**cerebrospinal fluid**, which acts as a shock absorber). The spinal cord is protected by the **vertebral column (backbone)**.
How nervous tissue causes action: a nerve impulse reaching a muscle makes the muscle cells change shape. Muscle cells contain special **proteins** that change their shape and arrangement in response to the electrical impulse, so the muscle **shortens (contracts)** and movement occurs.

Limitations of electrical impulses (why hormones are also needed): (i) they reach only cells connected to nervous tissue, not every cell; (ii) after generating an impulse, a cell needs time to reset before the next — so continuous impulses are not possible. Hence animals also use **chemical communication (hormones)**, which reach all cells through blood.

4. COORDINATION IN PLANTS

(A) Immediate response — not growth-related (nastic): the leaves of the **sensitive plant (touch-me-not, *Mimosa pudica*)** fold on touch. Plant cells change shape by **changing the amount of water** in them — they swell or shrink. Information passes from cell to cell by electrical-chemical means, but there is no specialised tissue for it.
(B) Movement due to growth (tropic): directional, slow.

Tropism	Stimulus	Example
Phototropism	Light	Shoot bends towards light (+ve), root away (−ve)
Geotropism	Gravity	Root grows downwards (+ve), shoot upwards (−ve)
Hydrotropism	Water	Roots grow towards water
Chemotropism	Chemicals	Pollen tube grows towards ovule
Thigmotropism*	Touch/support	Tendrils of pea coil around a support

*Tendril: the part of the tendril away from the support grows faster than the part in contact, so it coils around.

Plant hormones (phytohormones)

Hormone	Type	Function
Auxin	Growth promoter	Synthesised at shoot tip; causes cell elongation. When light falls from one side, auxin diffuses to the **shaded side** → cells there elongate more → shoot bends **towards light**

Gibberellins	Growth promoter	Growth of the stem
Cytokinins	Growth promoter	Promote cell division; present in high amounts in fruits and seeds
Abscisic acid (ABA)	Growth inhibitor	Inhibits growth; causes wilting of leaves; "stress hormone"

5. HORMONES IN ANIMALS

Hormones are chemical messengers secreted by **endocrine (ductless) glands** directly into the blood, act on target organs, and are needed in very small amounts.

Gland	Location	Hormone	Function / disorder
Hypothalamus	Brain	Releasing hormones	Stimulates pituitary (e.g. growth-hormone-releasing factor)
Pituitary ("master gland")	Below brain	Growth hormone	Growth and development; deficiency in childhood → **dwarfism**; excess → gigantism
Thyroid	Neck	Thyroxine	Regulates carbohydrate, protein, fat metabolism; needs **iodine** → deficiency causes **goitre** (swollen neck) — hence iodised salt
Adrenal	Above kidneys	Adrenaline	Emergency ("fight or flight") — faster heartbeat, more O_2 to muscles, blood diverted from digestive system and skin, faster breathing (diaphragm and rib muscles contract)
Pancreas	Below stomach	Insulin	Regulates blood sugar; deficiency → **diabetes**
Testes	Males	Testosterone	Changes at puberty in boys
Ovaries	Females	Oestrogen	Changes at puberty in girls; development of female organs

Feedback mechanism controls the timing and amount of hormone released. Example: when blood sugar rises, cells of the pancreas detect it and secrete more insulin; as the sugar level falls, insulin secretion is reduced.

ENDOCRINE GLANDS IN THE HUMAN BODY

📖 **Diagram: please refer to the NCERT textbook figure (Endocrine glands in human beings — male and female) in the chapter *Control and Coordination*.** Labels: Pineal, Hypothalamus, Pituitary, Thyroid, Parathyroid, Thymus, Pancreas, Adrenal, Testes (male), Ovaries (female).

Nervous vs hormonal control

Nervous system	Endocrine system
Message as electrical impulse + chemicals at synapse	Message as chemical (hormone) in blood
Very fast, short-lived response	Slow, long-lasting response
Reaches only cells connected to nerves	Reaches all cells through blood

6. COMMON MISTAKES THAT COST MARKS

- Writing that reflex actions are controlled by the **brain** — say **spinal cord**.
- Confusing **cerebrum** (thinking) with **cerebellum** (balance).
- Saying auxin moves towards light — it moves to the **shaded side**.
- Calling touch-me-not movement a tropism — it is **nastic** and not growth-related.
- Forgetting "iodine" in the goitre answer.

⭐ THE SIX MOST FREQUENTLY ASKED PATTERNS

Pattern	How to handle it
1. Reflex arc (define + diagram + why spinal cord)	Flow chart + 5 labels + two lines on speed
2. Brain parts & functions	Use the three-region table
3. Synapse / neuron	Dendrite → cyton → axon → ending; electrical → chemical → electrical
4. Phototropism & auxin	Light one side → auxin to shade → elongation → bending

Pattern	How to handle it
5. Hormone table / goitre / diabetes / adrenaline	Gland–hormone–function–disorder
6. Nervous vs hormonal	Three-point comparison table

✅ FINAL CHECK BEFORE THE EXAM

- Can you draw a neuron and a reflex arc with all labels in under 3 minutes?
- Can you name the part of brain for: balance, heartbeat, thinking, pupil size?
- Can you explain bending of a shoot towards light using auxin?
- Do you know seven glands with their hormone and one disorder?
- Can you explain feedback mechanism with the insulin example?

PART B — NCERT SOLUTIONS

NCERT Solutions — Chapter 6 Exercises

Q1. Which of the following is a plant hormone?
(a) Insulin (b) Thyroxin (c) Oestrogen (d) Cytokinin 1 mark

SOLUTION:

Answer: (d) Cytokinin 1 mark

Insulin, thyroxin and oestrogen are animal hormones. Cytokinin is a plant hormone that promotes cell division.

Q2. The gap between two neurons is called a
(a) dendrite (b) synapse (c) axon (d) impulse 1 mark

SOLUTION:

Answer: (b) synapse 1 mark

Q3. The brain is responsible for
(a) thinking (b) regulating the heart beat (c) balancing the body (d) all of the above 1 mark

SOLUTION:

Answer: (d) all of the above 1 mark

Thinking is the work of the cerebrum, the heartbeat is regulated by the medulla, and balance is maintained by the cerebellum — all three are parts of the brain.

Q4. What is the function of receptors in our body? Think of situations where receptors do not work properly. What problems are likely to arise? 3 marks

SOLUTION:

Function. Receptors are specialised cells, located in the sense organs, that **detect a particular stimulus** from the environment and pass the information on to the sensory nerves. 1 mark

• **Gustatory receptors** — taste (tongue)
• **Olfactory receptors** — smell (nose)
• **Photoreceptors** — light (eye)
• **Phonoreceptors** — sound and balance (ear)
• **Thermoreceptors** — heat and cold (skin) 1 mark

When receptors fail. The information never reaches the brain, so the body cannot respond appropriately, and this can be dangerous. Someone whose thermoreceptors are damaged — as happens in diabetes — may touch a hot object and not pull the hand away in time. Damaged photoreceptors or phonoreceptors cause blindness or deafness, and the person cannot be warned by sight or sound of an approaching danger. 1 mark

Q5. Draw the structure of a neuron and explain its function. 3 marks

SOLUTION:

A **neuron** (nerve cell) is the structural and functional unit of the nervous system and the longest cell in the body. 1 mark

> dendrites → cell body (cyton) → axon → nerve endings / synapse

How the impulse travels: 1 mark
• The **dendrites** pick up the information from a receptor; this sets off a chemical reaction that creates an **electrical impulse**.
• The impulse travels through the **cell body** and along the **axon** to its end.
• At the nerve ending the electrical impulse causes the release of **chemicals**, which cross the **synapse** — the tiny gap — and set up a similar impulse in the dendrite of the next neuron. 1 mark
• In this way the message is carried from the receptor to the central nervous system, and from there along a motor neuron to a muscle or gland, which acts as the **effector**.

Q6. How does phototropism occur in plants? 3 marks

SOLUTION:

Phototropism is the directional growth movement of a plant part in response to light — a shoot bends **towards** light (positive) and a root **away** from it (negative). 1 mark

Mechanism. When light falls on one side of a shoot tip, the hormone **auxin**, made at the tip, diffuses towards the **shaded** side. 1 mark
Auxin stimulates the **elongation of cells**. Since there is now more auxin on the shaded side,

the cells there grow longer than those on the lighted side. The unequal growth makes the shoot **bend towards the light**. 1 mark

> 📌 The answer must contain the word **auxin** and the phrase **unequal growth**. "The plant likes light" earns nothing.

Q7. Which signals will get disrupted in case of a spinal cord injury? 2 marks

SOLUTION:

The spinal cord carries two kinds of traffic, and both are disrupted: 1 mark

• **Reflex signals**, since the reflex arc is completed in the spinal cord itself — reflex actions below the level of the injury are lost.
• The **signals travelling between the body and the brain** — sensory information going up to the brain, and instructions for voluntary movement coming down from it. The result is loss of sensation and paralysis of the parts below the injury. 1 mark

Q8. How does chemical coordination occur in plants? 3 marks

SOLUTION:

Plants have neither a nervous system nor muscles, so all their coordination is **chemical**. It is carried out by **plant hormones (phytohormones)**, which are made in one part of the plant and **diffuse** to the area where they are needed. 1 mark

Hormone	Effect
Auxin	Cell elongation; responsible for bending towards light
Gibberellin	Promotes the growth of the stem
Cytokinin	Promotes cell division; abundant in fruits and seeds
Abscisic acid	Inhibits growth; causes wilting and shedding of leaves

1 mark

By controlling growth in this way, hormones produce the **tropic movements** of the plant — towards light, water, gravity or chemicals. 1 mark

Q9. What is the need for a system of control and coordination in an organism? **2 marks**

SOLUTION:

A multicellular organism is made of many organs, each doing a different job. For the organism to work as one unit, these organs must **act together, in the right order and at the right time**. **1 mark**

A control and coordination system also lets the organism **respond to changes in its environment** — moving away from danger, obtaining food, and keeping conditions inside the body (temperature, blood sugar, water) steady. Without it, the parts would work at cross purposes and the organism could not survive. **1 mark**

Q10. How are involuntary actions and reflex actions different from each other? **2 marks**

SOLUTION:

Basis	Reflex action	Involuntary action
Meaning	A sudden, automatic response to a stimulus that could harm us	An action that goes on continuously without our being aware of it
Controlled by	Mainly the **spinal cord** (the reflex arc)	Mainly the **medulla** of the hind-brain
Stimulus	Needs a sudden external stimulus	Does not need any external stimulus
Examples	Pulling the hand back from a hot plate; blinking; sneezing	Heartbeat, breathing, peristalsis, the working of the intestines

2 marks

Q11. Compare and contrast nervous and hormonal mechanisms for control and coordination in animals. **3 marks**

SOLUTION:

Basis	Nervous system	Hormonal (endocrine) system
Message carried by	An electrical impulse along neurons	Chemicals (hormones) carried in the **blood**

Speed	Very fast	Slow
Duration of effect	Short-lived	Long-lasting
Reach	Only where nerve fibres reach	Every cell that the blood reaches, but acts only on target organs
Return path	Information travels back to the brain	There is no such return; control is by **feedback** on the secreting gland

2 marks

What they share: both coordinate the activities of the body, both work through chemical messengers at some stage (neurons release chemicals at the synapse), and both keep the internal conditions of the body stable. 1 mark

Q12. What is the difference between a reflex action and walking? 2 marks

SOLUTION:

Reflex action is **involuntary and automatic**. It happens at once, without any thinking, and is controlled by the **spinal cord** through a reflex arc — for example, jerking the hand away from a flame. 1 mark

Walking is a **voluntary** action. It is decided upon and controlled by the **cerebrum**, and it has to be learnt; we can start, stop or change it at will. (Once learnt it becomes so practised that it needs little conscious attention, but it is still under the control of the will.) 1 mark

Q13. What happens at the synapse between two neurons? 2 marks

SOLUTION:

The **synapse** is the microscopic gap between the nerve ending of one neuron and the dendrite of the next. 1 mark

The electrical impulse cannot jump across this gap. On arriving at the nerve ending, it causes the release of a **chemical (neurotransmitter)**, which crosses the gap and starts a fresh electrical impulse in the next neuron. In this way the synapse also makes the impulse travel in **one direction only**. The same thing happens at the junction between a neuron and a muscle cell. 1 mark

Q14. Which part of the brain maintains posture and equilibrium of the body? 1 mark

SOLUTION:

The **cerebellum**, a part of the hind-brain. 1 mark It also makes voluntary actions precise — walking in a straight line, riding a bicycle or picking up a pencil all depend on it.

Q15. How do we detect the smell of an agarbatti (incense stick)? 2 marks

SOLUTION:

The smell is detected by the **olfactory receptors** in the lining of the nose, which respond to the chemicals given off by the burning agarbatti. 1 mark

These receptors set up an impulse that travels along the olfactory nerve to the **olfactory lobe of the fore-brain**, where the sensation of smell is interpreted. The fore-brain may then send instructions for a response — for instance, the mouth may water if the smell is of food. 1 mark

Q16. What is the role of the brain in reflex action? 2 marks

SOLUTION:

A reflex action itself is completed by the **spinal cord**, not by the brain — the reflex arc runs receptor → sensory neuron → spinal cord → motor neuron → effector. Routing it this way makes the response fast enough to prevent injury. 1 mark

The brain's role is that the information is **simultaneously passed on to it**. The brain becomes aware of what happened, records the experience, and may then direct further, considered action. So the brain is informed of the reflex but is not responsible for it. 1 mark

> 📌 Why is the reflex arc needed at all? Because the thinking process of the brain is not fast enough for an emergency — and in simple animals, reflex arcs evolved before true brains did.

— End of Chapter 6 Exercises —

PART C — FREQUENTLY ASKED BOARD QUESTIONS

⭐ Frequently Asked Board Questions — Chapter 6

📌 **About this section**

Q. Why is the use of iodised salt advisable?

The thyroid gland needs iodine to make **thyroxine**, the hormone that regulates carbohydrate, protein and fat metabolism. If the diet lacks iodine, the gland enlarges and the person develops **goitre**. Iodised salt supplies the small amount needed.

Q. When a person is suddenly frightened, what changes take place in the body and which hormone causes them?

Adrenaline, from the adrenal glands, is poured into the blood. The heartbeat and breathing rate rise, blood is diverted away from the skin and digestive system towards the skeletal muscles, and the liver releases extra glucose. All this readies the body to fight or run — which is why adrenaline is called the emergency hormone.

Q. What is a reflex arc? Draw and label it.

The pathway taken by the nerve impulse in a reflex action: **receptor** → **sensory neuron** → **spinal cord (relay neuron)** → **motor neuron** → **effector (muscle)**. It bypasses the thinking part of the brain, which makes the response almost instantaneous.

Q. How does feedback control the secretion of a hormone? Explain with insulin.

The secretion is regulated by the very condition that the hormone controls. When the sugar level in the blood rises, the cells of the pancreas detect it and secrete more **insulin**. As the sugar level falls back, the stimulus weakens and less insulin is secreted. This is a feedback mechanism, and it keeps the level within a narrow range.

Q. Name the plant hormone that (i) promotes cell division (ii) inhibits growth (iii) helps in cell elongation.

(i) Cytokinin (ii) Abscisic acid (iii) Auxin.

Q. Why is the flow of signals in a synapse from axon to dendrite and not the other way round?

Because the chemical (neurotransmitter) is stored in and released only from the axon endings, and the receptors for it are present only on the dendrite of the next neuron. So the transmission can happen in one direction only.

— Chapter 6 Complete —

CHAPTER 7

How do Organisms Reproduce?

Study Material · NCERT Solutions (11 Questions) · Board Questions

PART A — STUDY MATERIAL

📘 Study Material — Chapter 7: How do Organisms Reproduce?

🔑 **The spine of this chapter**

Reproduction is not needed for the survival of an individual, but it is essential for the survival of the **species**. The basic event is **DNA copying**. Copying is never perfect — the small **variations** produced are the raw material for survival in changing environments and for evolution. Asexual reproduction uses one parent and gives near-identical offspring; sexual reproduction uses two parents and creates more variation.

📘 CHAPTER AT A GLANCE

Topic	What You Will Learn
1. DNA copying & variation	Why variation is useful
2. Asexual modes	Fission, fragmentation, regeneration, budding, vegetative propagation, spores
3. Sexual reproduction in plants	Flower, pollination, fertilisation, seed & fruit
4. Human reproduction	Puberty, male & female systems, menstruation
5. Reproductive health	STDs, contraception, female foeticide

1. DNA COPYING AND VARIATION

DNA in the nucleus carries the information for making proteins; this is the **blueprint** of body design. During reproduction a cell makes a copy of its DNA through biochemical reactions, and creates an additional cellular apparatus, then divides into two. Copying reactions are not 100% accurate → slight **variations**.

Importance of variation: (i) helps the species survive if the environment changes drastically (e.g. a rise in water temperature — bacteria with a heat-resistant variation survive); (ii) forms the basis of evolution.

Importance of accurate copying: keeps the body design stable, suited to the niche (the specific place/role of the organism in the ecosystem).

2. ASEXUAL REPRODUCTION — MODES

Mode	How it happens	Example
Binary fission	Parent cell divides into two equal halves; in *Leishmania* the split is along a definite plane (because of its whip-like structure)	*Amoeba*, *Leishmania*
Multiple fission	Parent divides into many daughter cells simultaneously	*Plasmodium* (malaria parasite)
Fragmentation	Mature body breaks into pieces; each piece grows into a new individual	*Spirogyra*
Regeneration	Body cut into pieces; each piece regrows the whole organism by specialised cells that divide and differentiate	*Planaria*, *Hydra*
Budding	An outgrowth (bud) develops due to repeated cell division at one site; it detaches when mature	*Hydra*, yeast
Vegetative propagation	New plants from root, stem or leaf	Bryophyllum (leaf-margin buds), sugarcane, rose, grapes, banana, orange (layering / grafting)
Spore formation	Sporangia produce spores with thick walls; spores germinate in moist conditions	*Rhizopus* (bread mould)

Why regeneration is not the same as reproduction: most organisms do not normally depend on being cut up to reproduce; regeneration is repair ability.
Advantages of vegetative propagation: (i) plants that have lost the capacity to produce seeds (banana, orange, rose, jasmine) can be grown; (ii) plants bear flowers and fruits earlier than from seed; (iii) all plants are genetically identical to the parent — desirable features are preserved.
Tissue culture: cells from the growing tip are grown in an artificial medium → callus → transferred

to hormone medium for growth and differentiation → plantlets. Used for ornamental plants (orchids, carnation).

BINARY FISSION IN AMOEBA · MULTIPLE FISSION IN PLASMODIUM · BUDDING IN HYDRA · REGENERATION IN PLANARIA · RHIZOPUS

📖 **Diagrams: please refer to the NCERT textbook figures in the chapter *How do Organisms Reproduce?*** For Rhizopus label: Hyphae, Sporangia, Spores. For budding: Tentacles, Bud, Parent Hydra. For Amoeba: nucleus dividing → two daughter cells.

3. SEXUAL REPRODUCTION IN FLOWERING PLANTS

Why sexual mode: combines DNA from two individuals → more variation. Germ cells contain **half** the number of chromosomes (formed by reduction), so the number is restored in the zygote and DNA content stays constant across generations.

Parts of a flower: Sepals, Petals, **Stamen** (male: anther + filament; anther makes pollen grains), **Pistil / carpel** (female: stigma, style, ovary; ovary contains ovules with egg cell).

Unisexual flower: either stamens or pistil (papaya, watermelon). **Bisexual**: both (Hibiscus, mustard).

Pollination: transfer of pollen from anther to stigma. **Self-pollination** — same flower; **cross-pollination** — different flower, by wind, water, animals.

Fertilisation: pollen grain on stigma → pollen tube grows through style → reaches ovule → male germ cell fuses with female germ cell (egg) → **zygote**.

After fertilisation: zygote → embryo; ovule → **seed**; ovary → **fruit**; petals, sepals, stamens, style and stigma shrivel and fall off.

Seed = embryo (future plant) + seed coat. Germination: plumule (future shoot), radicle (future root), cotyledon (stored food).

LONGITUDINAL SECTION OF A FLOWER · GERMINATION OF POLLEN ON STIGMA · GERMINATION (PLUMULE/RADICLE)

📖 **Diagrams: please refer to the NCERT textbook figures in this chapter.** Flower labels: Sepal, Petal, Stamen (anther, filament), Stigma, Style, Ovary, Ovule. Pollen germination labels: Pollen grain, Stigma, Pollen tube, Style, Ovary, Ovule, Female germ cell, Male germ cell.

4. REPRODUCTION IN HUMAN BEINGS

Puberty: the period when reproductive tissues mature. Common changes: thick hair in armpits and genital area, oilier skin, pimples. Boys: facial hair, cracking voice, enlargement of penis. Girls: breast enlargement, start of menstruation.

Male reproductive system

Organ	Function
Testes (in scrotum)	Produce sperms and testosterone. Located outside the abdomen because sperm formation needs a temperature **lower than body temperature**
Vas deferens	Carries sperms from testis; unites with a tube from the urinary bladder
Urethra	Common passage for sperms and urine
Seminal vesicles & prostate	Add secretions — make transport easier and provide nutrition; sperms + secretions = semen

Female reproductive system

Organ	Function
Ovaries	Produce eggs (one egg per month from one ovary) and hormones (oestrogen)
Oviduct (fallopian tube)	Carries egg to uterus; **site of fertilisation**
Uterus	Elastic bag-like structure; the embryo implants here and develops
Cervix & vagina	Uterus opens into the vagina through the cervix

After fertilisation: zygote → embryo → implants in the thickened uterine lining. **Placenta:** a disc-shaped tissue embedded in the uterine wall with **villi** on the embryo's side (large surface area). Glucose and oxygen pass from mother to embryo; wastes pass from embryo to mother's blood. Development inside the mother takes about **nine months** (gestation).
Menstruation: if the egg is not fertilised, it lives about one day. The thick, spongy uterine lining (prepared every month) is no longer needed, so it breaks down and comes out through the vagina as blood and mucus. Cycle ≈ once every month; lasts about 2–8 days.

HUMAN MALE AND FEMALE REPRODUCTIVE SYSTEMS

📖 **Diagrams: please refer to the NCERT textbook figures in this chapter.** Male labels: Testis, Scrotum, Vas deferens, Seminal vesicle, Prostate gland, Urethra, Penis, Ureter, Urinary bladder. Female labels: Ovary, Oviduct (fallopian tube), Funnel, Uterus, Cervix, Vagina.

5. REPRODUCTIVE HEALTH

Sexually transmitted diseases (STDs): Bacterial — gonorrhoea, syphilis. Viral — warts, HIV-AIDS. Using a covering (condom) on the penis helps prevent transmission.

Contraceptive methods:

Method	Examples / how	Note
Barrier (mechanical)	Condom, diaphragm	Also prevents STDs
Chemical (hormonal)	Oral pills	Change hormonal balance so eggs are not released; may have side effects
Intrauterine devices	Loop, Copper-T	Placed in uterus; may cause irritation
Surgical	Vasectomy (vas deferens blocked), tubectomy (fallopian tube blocked)	Permanent

Female foeticide — illegal sex-selective abortion; leads to a falling male–female ratio. Prenatal sex determination is prohibited by law in India.

6. COMMON MISTAKES THAT COST MARKS

- Writing "fertilisation takes place in the uterus" — it takes place in the **oviduct**.
- Confusing fragmentation (natural breaking) with regeneration (cut pieces regrow).
- Saying "ovary becomes seed" — ovary → **fruit**, ovule → **seed**.
- Forgetting that the placenta also removes **waste** from the embryo.
- Calling Copper-T a barrier method.

⭐ THE SIX MOST FREQUENTLY ASKED PATTERNS

Pattern	How to handle it
1. Importance of DNA copying / variation	Stability of body design + survival + evolution
2. Asexual modes with example / diagram	Use the mode table; Amoeba, Plasmodium, Hydra, Rhizopus
3. LS of flower & pollen germination	Label all parts; describe pollen tube path

Pattern	How to handle it
4. Changes after fertilisation	Zygote→embryo, ovule→seed, ovary→fruit
5. Human reproductive organs / placenta / menstruation	Function table + placenta villi
6. Contraception & STDs	Four method types; bacterial vs viral STDs

✅ FINAL CHECK BEFORE THE EXAM

- Can you draw and label the LS of a flower and a germinating pollen grain?
- Can you name one organism for each asexual method?
- Can you give three advantages of vegetative propagation?
- Do you know why testes lie outside the abdomen?
- Can you explain the role of the placenta and the reason for menstruation?

PART B — NCERT SOLUTIONS

NCERT Solutions — Chapter 7 Exercises

Q1. Asexual reproduction takes place through budding in
(a) amoeba (b) yeast (c) plasmodium (d) leishmania 1 mark

SOLUTION:

Answer: (b) yeast 1 mark

Amoeba and Leishmania reproduce by **binary fission**; Plasmodium by **multiple fission**. In yeast a small bud grows out of the parent cell, may itself bud further, and finally detaches.

Q2. Which of the following is not a part of the female reproductive system in human beings?
(a) Ovary (b) Uterus (c) Vas deferens (d) Fallopian tube 1 mark

SOLUTION:

Answer: (c) Vas deferens 1 mark — it is part of the **male** system, carrying sperms from the testis.

Q3. The anther contains
(a) sepals (b) ovules (c) carpel (d) pollen grains 1 mark

SOLUTION:

Answer: (d) pollen grains 1 mark — the anther is the swollen top of the stamen, the male part of the flower.

Q4. What are the advantages of sexual reproduction over asexual reproduction? 3 marks

SOLUTION:

• **It creates variation.** The offspring receives DNA from **two** parents, so it is never identical to either. Asexual reproduction produces near-identical copies. 1 mark

• **Variation gives the species a better chance of survival.** If the environment changes drastically, at least some of the varied individuals are likely to be suited to the new conditions, so the species is not wiped out. 1 mark

• **It drives evolution.** The accumulation of useful variations over generations is the basis of the evolution of new species.

• The mixing of DNA also lets harmful mutations be masked by a healthy copy from the other parent. 1 mark

Q5. What are the functions performed by the testis in human beings? 2 marks

SOLUTION:

The testes perform **two** functions: 1 mark

• They produce the male gametes, the **sperms**.

• They secrete the male sex hormone **testosterone**, which brings about the changes of puberty — the deepening of the voice, growth of facial and body hair — and which also regulates the production of sperms. 1 mark

The testes lie in the **scrotum**, outside the abdominal cavity, because sperm formation requires a temperature lower than the normal body temperature.

Q6. Why does menstruation occur? 3 marks

SOLUTION:

Each month one egg is released from an ovary, and at the same time the lining of the **uterus becomes thick and spongy**, richly supplied with blood, ready to receive and nourish a fertilised egg. 1 mark

If the egg is **not fertilised**, this preparation is no longer needed. The thickened lining breaks down and is shed, along with blood and the unfertilised egg, through the vagina. 1 mark

This shedding is **menstruation**. It lasts about 2–8 days and the cycle repeats roughly every **28 days** from puberty until menopause. 1 mark

Q7. Draw a labelled diagram of the longitudinal section of a flower. 3 marks

SOLUTION:

The labels the examiner looks for, from the outside inward: 1 mark

> Sepal · Petal · **Stamen** (anther + filament) · **Carpel/Pistil** (stigma + style + ovary) · Ovule · Receptacle

Sequence of events to mark on it: 1 mark

Pollen from the anther lands on the **stigma** (pollination). A **pollen tube** grows down through the style into the ovary and reaches an **ovule**. The male germ cell fuses with the egg cell — **fertilisation** — to form the **zygote**. 1 mark

Afterwards the ovule becomes the **seed**, the ovary becomes the **fruit**, and the petals, sepals, stamens and stigma usually fall off.

Q8. What are the different methods of contraception? 3 marks

SOLUTION:

Contraception means preventing pregnancy. The methods fall into four groups: 1 mark

1. Barrier methods. Condoms for the male, and the cervical cap or diaphragm for the female, physically prevent the sperm from reaching the egg. Condoms also protect against sexually transmitted diseases. 1 mark

2. Chemical / hormonal methods. Oral pills change the hormonal balance so that no egg is released. They are effective but may have side effects.

3. Intra-uterine devices (IUDs) such as the copper-T or loop, placed in the uterus, prevent pregnancy; they may cause irritation or side effects in some women.

4. Surgical methods. Vasectomy — the vas deferens is blocked in the male; **tubectomy** — the fallopian tube is blocked in the female. These are permanent methods. 1 mark

Q9. How are the modes for reproduction different in unicellular and multicellular organisms? 2 marks

SOLUTION:

In a **unicellular** organism the single cell divides, and that division is itself reproduction — the whole body is copied. The modes are fission (Amoeba, Plasmodium), budding (yeast) and regeneration-like division. No specialised reproductive organs exist. 1 mark

In a **multicellular** organism, especially a complex one, the body is made of specialised tissues and cannot simply split in two. Reproduction is carried out by **specialised cells (gametes)** made in **specialised organs**, usually involving the fusion of two gametes. Simpler multicellular organisms such as *Hydra* and *Planaria* can still reproduce by budding, fragmentation or regeneration. 1 mark

Q10. How does reproduction help in providing stability to populations of species? **2 marks**

SOLUTION:

Individuals in a population are constantly dying — of age, disease, predation or accident. Reproduction **replaces them**, so the number of individuals stays roughly steady from generation to generation. **1 mark**

Reproduction also passes on the **body design** of the species faithfully enough for it to remain recognisable, while the small variations it introduces allow the population to adapt if conditions change. Birth rate and death rate balancing each other is precisely what gives a population its stability. **1 mark**

Q11. What could be the reasons for adopting contraceptive methods? **3 marks**

SOLUTION:

• **To space or limit the number of children**, so that the health of the mother is protected and each child can be brought up and educated properly. **1 mark**

• **To control the growth of population.** A rapidly rising population strains the supply of food, housing, water, jobs and education, and lowers the standard of living. **1 mark**

• **To prevent sexually transmitted diseases** such as syphilis, gonorrhoea, HIV–AIDS and warts; barrier methods such as the condom give protection against them. **1 mark**

— End of Chapter 7 Exercises —

PART C — FREQUENTLY ASKED BOARD QUESTIONS

⭐ Frequently Asked Board Questions — Chapter 7

📌 **About this section**

Q. What is vegetative propagation? State two advantages.

Growing a new plant from a vegetative part — root, stem or leaf — of the parent plant, without seeds. **Advantages:** plants such as banana, orange, rose and jasmine that have lost the capacity to produce viable seeds can still be grown; the new plants are genetically identical to the parent, so a desirable variety is preserved exactly; and they bear flowers and fruit much earlier than plants grown from seed.

Q. What is the significance of DNA copying in reproduction?

DNA carries the information for the body design. Copying it is what makes the offspring resemble the parent, so the species is maintained. Because the copying is similar but **not identical**, it also generates variations — and these variations are the basis of evolution and of the survival of the species when the environment changes.

Q. Explain the term "placenta". State its functions.

A disc-shaped tissue embedded in the uterine wall, connecting the embryo to the mother. It has **villi** on the embryo's side and blood spaces on the mother's side, giving a large surface for exchange. Through it the embryo receives **glucose and oxygen** from the mother's blood and passes its **waste products** back into it for removal.

Q. What happens when a Planaria is cut into many pieces?

Each piece grows into a complete new Planaria by **regeneration**. Specialised cells proliferate and make large numbers of cells, which then differentiate into the various tissues and organs in an organised sequence.

Q. Why cannot fertilisation take place in flowers if pollination does not occur?

Fertilisation is the fusion of the male germ cell with the egg cell inside the ovule. The male germ cell is carried in the **pollen grain**, and it can only reach the ovule if the pollen first lands on the stigma and grows a pollen tube down the style. No pollination, therefore no pollen tube, and no fertilisation.

Q. What are STDs? Name two bacterial and two viral ones.

Diseases that spread through sexual contact. **Bacterial:** gonorrhoea and syphilis. **Viral:** warts and HIV–AIDS. The use of a condom during sexual intercourse gives considerable protection.

— Chapter 7 Complete —

CHAPTER 8

Heredity

Study Material · NCERT Solutions (8 Questions) · Board Questions

PART A — STUDY MATERIAL

📘 Study Material — Chapter 8: Heredity

🔑 **The spine of this chapter**

Offspring resemble parents because they inherit **genes** (segments of DNA) from both parents. Mendel's pea-plant experiments showed that traits are controlled by pairs of factors, one from each parent, and that one factor can be **dominant** over the other (**recessive**). Sex in humans is decided by the **sex chromosome inherited from the father**. *Note: questions in this chapter are mostly 2–3 mark cross-based or reasoning questions; always show the cross in a checkerboard / flow form.*

📘 CHAPTER AT A GLANCE

Topic	What You Will Learn
1. Variation	Accumulation of variation in reproduction
2. Mendel's experiments	Monohybrid (3:1) and dihybrid (9:3:3:1) crosses
3. How traits are expressed	Gene → protein → trait (plant height example)
4. Sex determination	XX / XY; role of father

1. KEY TERMS

Term	Meaning
Heredity	Transmission of traits from parents to offspring
Variation	Differences among individuals of the same species; more in sexual reproduction
Gene	A segment of DNA that provides information for one protein, and hence controls a trait
Alleles	Two alternative forms of a gene (e.g. T and t)
Dominant trait	The trait that is expressed in F_1 (T — tall)

Term	Meaning
Recessive trait	The trait that is hidden in F_1 and reappears in F_2 (t — dwarf)
Genotype / Phenotype	Genetic make-up (TT, Tt, tt) / visible character (tall, dwarf)
Homozygous / Heterozygous	Both alleles same (TT, tt) / different (Tt)

2. MENDEL'S EXPERIMENTS

Why Mendel chose garden pea (*Pisum sativum*): (i) many clear contrasting traits (tall/dwarf, round/wrinkled seed, violet/white flower, green/yellow seed); (ii) short life cycle; (iii) self-pollinating but can be cross-pollinated easily; (iv) large number of seeds.

Monohybrid cross (one pair of traits — tall × dwarf)
P: TT (tall) × tt (dwarf)
Gametes: T and t
F_1: **Tt — all tall** (dwarf trait hidden → tall is dominant)
F_1 self-crossed: Tt × Tt

♂ / ♀	T	t
T	TT (tall)	Tt (tall)
t	Tt (tall)	tt (dwarf)

Phenotypic ratio 3 : 1 (tall : dwarf) | **Genotypic ratio 1 : 2 : 1** (TT : Tt : tt)
Conclusion: (i) traits are controlled by a pair of factors (genes); (ii) one form can be dominant; (iii) the recessive factor is not lost — it reappears in F_2; (iv) each parent passes on one copy.

Dihybrid cross (two pairs — round yellow × wrinkled green)
P: RRYY × rryy → F_1: **RrYy — all round yellow**
F_2 phenotypes: Round Yellow **9** : Round Green **3** : Wrinkled Yellow **3** : Wrinkled Green **1**
Conclusion: new combinations (round green, wrinkled yellow) appear → the two traits are **inherited independently** of each other.

MONOHYBRID AND DIHYBRID CROSSES

📖 **Refer to the NCERT textbook figures for the cross diagrams.** In the exam a clearly written cross (as above, with P, gametes, F_1, F_2 and ratio) earns full marks — a picture of plants is not required.

3. HOW DO TRAITS GET EXPRESSED?

DNA → gene → **protein (enzyme)** → trait. Example: plant height depends on a **growth hormone**. The amount of hormone made depends on the efficiency of the enzyme that makes it. If the gene for the enzyme is efficient → more hormone → **tall** plant; if the gene is altered and the enzyme less efficient → less hormone → **short** plant.

Germ cells carry only **one set** of genes (one chromosome of each pair). On fusion, the full set is restored.

4. SEX DETERMINATION IN HUMANS

Humans have 23 pairs of chromosomes: 22 pairs of autosomes + 1 pair of sex chromosomes.

Female: **XX**; male: **XY**.

All eggs carry X. Half the sperms carry X and half carry Y.

Egg	Sperm	Child
X	X	XX — girl
X	Y	XY — boy

So the **sex of the child is decided by the father** (by whether the sperm carries X or Y); probability of a boy or a girl is **50 : 50**.

In some animals, sex is decided by environment — e.g. in some reptiles, by the **temperature** at which fertilised eggs are kept; snails can change sex.

SEX DETERMINATION IN HUMAN BEINGS

📖 **Refer to the NCERT textbook figure.** Draw it as a flow chart: Mother (XX) → eggs X, X; Father (XY) → sperms X, Y → XX (girl), XY (boy).

5. COMMON MISTAKES THAT COST MARKS

- Writing 3:1 as the genotypic ratio — it is the **phenotypic** ratio; genotypic is 1:2:1.
- Not writing the gametes step in a cross.
- Saying the mother decides the sex of the child.
- Forgetting "independent inheritance" as the conclusion of the dihybrid cross.

⭐ THE FIVE MOST FREQUENTLY ASKED PATTERNS

Pattern	How to handle it
1. Monohybrid cross + ratio	P → gametes → F_1 → checkerboard → 3:1 / 1:2:1
2. Dihybrid cross + conclusion	9:3:3:1 → independent inheritance
3. Dominant vs recessive (identify from data)	The trait visible in F_1 is dominant
4. Sex determination	Flow chart; father decides; 50% chance
5. Gene → protein → trait	Plant-height hormone example

✅ FINAL CHECK BEFORE THE EXAM

- Can you write a complete monohybrid cross from memory with both ratios?
- Can you list the four F_2 phenotypes of the dihybrid cross in order?
- Can you explain why a child's sex is determined by the father?
- Can you explain how a gene controls plant height?

PART B — NCERT SOLUTIONS

NCERT Solutions — Chapter 8 Exercises

Q1. A Mendelian experiment consisted of breeding tall pea plants bearing violet flowers with short pea plants bearing white flowers. The progeny all bore violet flowers, but almost half of them were short. This suggests that the genetic make-up of the tall parent can be depicted as
(a) TTWW (b) TTww (c) TtWW (d) TtWw 1 mark

SOLUTION:
Answer: (c) TtWW 1 mark

Reasoning. All the progeny are violet, so the violet parent must carry **WW** — if it were Ww, some white-flowered progeny would appear. But **half the progeny are short**, which is the result of a test-cross ratio 1 : 1; that happens only if the tall parent is **heterozygous, Tt**, crossed with the short tt parent. Hence TtWW.

Q2. A study found that children with light-coloured eyes are likely to have parents with light-coloured eyes. On this basis, can we say anything about whether the light eye colour trait is dominant or recessive? Why? 2 marks

SOLUTION:
No, we cannot decide from this information alone. 1 mark

The observation only tells us that the trait is **inherited** — it passes from parents to children. To call a trait dominant or recessive, we would need to know what happens in the **next generation**: whether the trait disappears in the F_1 progeny of a cross between light-eyed and dark-eyed parents and then reappears in F_2, and in what ratio. Without data across generations, the same pattern fits either possibility. 1 mark

Q3. Outline a project which aims to find the dominant coat colour in dogs. 3 marks

SOLUTION:
Step 1. Select pure-breeding dogs of the two coat colours to be compared — say pure black

and pure white — and confirm that each has bred true for several generations. 1 mark

Step 2. Cross them and observe the coat colour of the whole $\mathbf{F_1}$ litter. Whichever colour appears in **all** the F_1 puppies is the **dominant** trait; the one that disappears is recessive. 1 mark

Step 3. Confirm by crossing two F_1 dogs with each other. If the hidden colour **reappears in the $\mathbf{F_2}$ generation in about 1 out of 4 puppies (a 3 : 1 ratio)**, the conclusion is confirmed. 1 mark

Note. Since a dog litter is small, the ratio will only show up clearly if the records of **many litters** are pooled — a genuine project would also use pedigree records already maintained by breeders.

Q4. How is the equal genetic contribution of male and female parents ensured in the progeny? 3 marks

SOLUTION:

Every body cell of an organism contains **two copies** of each chromosome — one inherited from the mother and one from the father. 1 mark

When gametes are made, the number is **halved**: an egg or a sperm carries only **one** chromosome of each pair. In human beings each gamete carries 23 chromosomes instead of 46. 1 mark

At fertilisation the egg and the sperm fuse, and the zygote again has the full number — with exactly **half the chromosomes from the mother and half from the father**. This is how the genetic contribution of the two parents is kept equal. 1 mark

Q5. Only variations that confer an advantage to an individual organism will survive in a population. Do you agree with this statement? Why or why not? 3 marks

SOLUTION:

No — the statement is not entirely correct. 1 mark

It is true that a variation giving an advantage in the **present** environment is more likely to be selected and to spread. But many variations are **neutral**: they neither help nor harm, and they are carried along in the population without being eliminated. 1 mark

More importantly, whether a variation is an advantage **depends on the environment, which**

changes. A trait that is useless today may become the very thing that saves the species tomorrow — heat-resistant bacteria in a population survive a rise in temperature that kills the rest. Variations are also passed on through individuals that reproduce successfully for reasons unconnected with that particular trait. **1 mark**

Q6. How do Mendel's experiments show that traits may be dominant or recessive? **3 marks**

SOLUTION:

Mendel crossed a **pure tall** pea plant (TT) with a **pure short** one (tt). **1 mark**

Every plant of the $\mathbf{F_1}$ generation was **tall** — the short character had vanished completely, and no plant was of medium height. **1 mark**

He then self-pollinated the F_1 plants. In the $\mathbf{F_2}$ generation the short plants **reappeared**, in a ratio of about **3 tall : 1 short**. **1 mark**

Since the short character was hidden in F_1 but not lost — it came back unchanged in F_2 — both factors must have been present together in the F_1 plant, with one expressing itself over the other. The expressed one is **dominant** (tallness), the hidden one **recessive** (shortness).

Q7. How do Mendel's experiments show that traits are inherited independently? **3 marks**

SOLUTION:

Mendel made a **dihybrid cross**: a pea plant with **round, yellow** seeds (RRYY) was crossed with one having **wrinkled, green** seeds (rryy). **1 mark**

The whole F_1 generation had **round yellow** seeds (RrYy), showing that round and yellow are the dominant traits. **1 mark**

On self-pollinating the F_1, the F_2 generation gave four types in the ratio **9 round-yellow : 3 round-green : 3 wrinkled-yellow : 1 wrinkled-green**. **1 mark**

The crucial point is that **round-green** and **wrinkled-yellow** are **new combinations** that were present in neither parent. They could only arise if the seed-shape gene and the seed-colour gene were passed on **independently of each other**.

Q8. How is the sex of a child determined in human beings? **3 marks**

SOLUTION:

Human beings have 23 pairs of chromosomes, of which one pair decides the sex. A female has two X chromosomes (**XX**); a male has one X and one Y (**XY**). **1 mark**

Since the mother is XX, **every egg carries an X**. The father is XY, so **half his sperms carry X and half carry Y**. **1 mark**

> X (egg) + X (sperm) → **XX — girl**
> X (egg) + Y (sperm) → **XY — boy**

Therefore the sex of the child depends entirely on **which type of sperm from the father** happens to fertilise the egg. The mother can never determine it, and the chance of a boy or a girl is 50 : 50 in each pregnancy. **1 mark**

> 📌 This question is regularly set as a 3- or 5-mark value-based question, ending with "comment on the practice of blaming the mother for the sex of the child." The scientific answer above is the whole of the reply.

— End of Chapter 8 Exercises —

PART C — FREQUENTLY ASKED BOARD QUESTIONS

⭐ Frequently Asked Board Questions — Chapter 8

📌 **About this section**

Q. Why did Mendel choose the garden pea for his experiments?

It has clearly contrasting pairs of characters (tall/short, round/wrinkled, yellow/green), it is normally self-pollinating but can easily be cross-pollinated by hand, it has a short life cycle so many generations can be studied quickly, and it produces a large number of seeds in each generation, which makes the ratios reliable.

Q. Define: (i) gene (ii) genotype (iii) phenotype (iv) heterozygous.

(i) A section of DNA on a chromosome that carries the information for one trait. (ii) The genetic make-up of an organism, written as TT, Tt or tt. (iii) The observable appearance — tall or short. (iv) Having two different alleles for a trait, such as Tt.

Q. What is a test cross? What is it used for?

Crossing an individual showing the dominant trait with a **homozygous recessive** individual. If all the progeny show the dominant trait, the tested individual was homozygous (TT); if about half are recessive — a **1 : 1** ratio — it was heterozygous (Tt). It is the standard way to find out an unknown genotype.

Q. A woman has only daughters. Is she responsible for it? Explain.

No. She contributes an X chromosome to every child, without exception. Whether the child is a girl (XX) or a boy (XY) depends on whether an X-bearing or a Y-bearing sperm from the father fertilises the egg. Blaming the mother has no scientific basis whatever.

Q. If a trait A exists in 10% of a population and trait B in 60%, which is likely to have arisen earlier?

Trait **B**. A trait spreads gradually through a population over generations, so the one present in a much larger fraction has almost certainly been there longer. (Trait A, at 10%, appears to be the more recent variation.)

Q. A tall pea plant is crossed with a short one and half the progeny are short. What are the genotypes of the parents?

The tall parent must be heterozygous **Tt** and the short parent **tt**. Tt × tt gives 50% Tt (tall) and 50% tt (short) — a 1 : 1 ratio, which is exactly what is observed.

— **Chapter 8 Complete** —

CHAPTER 9

Light — Reflection and Refraction

Study Material · NCERT Solutions (17 Questions) · Board Questions

PART A — STUDY MATERIAL

📘 Study Material — Chapter 9: Light — Reflection and Refraction

🔑 **The spine of this chapter**

This is the highest-scoring physics chapter. Marks come from three things: (1) **ray diagrams** drawn with the correct rules and arrows; (2) the **image-formation tables** for concave mirror and convex lens; (3) **numericals** using the mirror/lens formula with the **New Cartesian sign convention**. Learn the sign convention first — most numerical mistakes are sign mistakes.

📘 CHAPTER AT A GLANCE

Topic	What You Will Learn
1. Reflection	Laws; plane mirror image
2. Spherical mirrors	Terms, rules for rays, image table, uses
3. Sign convention & mirror formula	$1/v + 1/u = 1/f$; $m = -v/u$
4. Refraction	Laws, Snell's law, refractive index, glass slab
5. Lenses	Rules, image table, lens formula, power

1. REFLECTION OF LIGHT

Laws of reflection: (i) angle of incidence = angle of reflection ($\angle i = \angle r$); (ii) incident ray, reflected ray and normal at the point of incidence all lie in the same plane. These laws hold for all reflecting surfaces, including spherical ones.
Plane mirror image: virtual, erect, same size, as far behind the mirror as the object is in front, laterally inverted.

2. SPHERICAL MIRRORS

Term	Meaning
Pole (P)	Centre of the reflecting surface

Term	Meaning
Centre of curvature (C)	Centre of the sphere of which the mirror is a part
Radius of curvature (R)	Radius of that sphere
Principal axis	Line through P and C
Principal focus (F)	Concave: point where rays parallel to axis meet after reflection (real). Convex: point from which they appear to diverge (virtual)
Focal length (f)	Distance PF; **R = 2f** (for small aperture)
Aperture	Diameter of the reflecting surface

Rules for drawing ray diagrams (use any two):

1. A ray **parallel to the principal axis** passes through F (concave) / appears to come from F (convex) after reflection.
2. A ray **through F** (concave) / directed towards F (convex) becomes parallel to the axis.
3. A ray **through C** (concave) / directed towards C (convex) returns along the same path.
4. A ray incident **at the pole** obliquely reflects making an equal angle with the axis.

Image formation by a CONCAVE mirror

Object at	Image at	Size	Nature
Infinity	F	Highly diminished, point-sized	Real, inverted
Beyond C	Between F and C	Diminished	Real, inverted
At C	At C	Same size	Real, inverted
Between C and F	Beyond C	Enlarged	Real, inverted
At F	Infinity	Highly enlarged	Real, inverted
Between P and F	Behind mirror	Enlarged	Virtual, erect

CONVEX mirror: object anywhere → image behind the mirror between P and F, **diminished, virtual, erect** (at infinity: at F, point-sized).

Uses

Concave: torches, searchlights and vehicle headlights (bulb at F → parallel beam); shaving mirrors (enlarged erect image); dentists' mirrors; solar furnaces (concentrate sunlight).

Convex: rear-view mirrors in vehicles — always give an **erect** image and have a **wider field of view** as they curve outwards.

RAY DIAGRAMS — CONCAVE MIRROR (SIX POSITIONS) AND CONVEX MIRROR (TWO POSITIONS)

📖 **Diagrams: please refer to the NCERT textbook figures (Ray diagrams for image formation by a concave mirror / convex mirror) in this chapter.** Practise every case at least twice.

✏️ **How to draw:** use a sharp pencil and scale; mark P, F, C on the axis; draw object as an upward arrow; use two rules; put arrow-heads on every ray; show virtual rays as **dotted** lines; draw the image where the rays meet (or appear to meet).

3. SIGN CONVENTION AND MIRROR FORMULA

New Cartesian sign convention: (i) object always on the **left**; (ii) all distances measured from the **pole** (mirror) / **optical centre** (lens); (iii) distances along the direction of incident light (to the right) are **+ve**, against it (left) **−ve**; (iv) heights above the axis +ve, below −ve.

Results to remember: u is always −ve. Concave mirror f is −ve; convex mirror f is +ve. Convex lens f +ve; concave lens f −ve.

Mirror formula: $1/v + 1/u = 1/f$ **Magnification:** $m = h'/h = \mathbf{-v/u}$

m −ve → real, inverted; m +ve → virtual, erect; $|m| > 1$ enlarged, < 1 diminished.

Worked example: An object is 10 cm from a convex mirror of f = 15 cm. Find image position and nature.

$u = -10$ cm, $f = +15$ cm. $1/v = 1/f - 1/u = 1/15 + 1/10 = (2+3)/30 = 5/30$ → **$v = +6$ cm** (behind mirror).

$m = -v/u = -6/(-10) = +0.6$ → virtual, erect, diminished.

4. REFRACTION OF LIGHT

Refraction: bending of light when it passes obliquely from one medium to another, because the **speed of light changes**.

Rarer → denser: bends **towards** the normal. Denser → rarer: bends **away** from the normal.

Laws: (i) incident ray, refracted ray and normal lie in the same plane; (ii) **Snell's law**: sin i / sin r = constant (= refractive index of the second medium w.r.t. the first), for a given pair of media and a given colour.

Refractive index: $n_{21} = v_1/v_2$. Absolute: **$n = c/v$** ($c = 3\times10^8$ m/s). Water 1.33, glass (crown) 1.52, diamond 2.42 (highest in the NCERT table). Optically denser medium = higher refractive index (not the same as mass density; kerosene is optically denser than water though lighter).

Glass slab: emergent ray is **parallel** to the incident ray but shifted sideways (lateral displacement), because refraction at the two parallel faces is equal and opposite.

Everyday examples: a pencil appears bent in water; a tank appears shallower; letters appear raised under a glass slab.

REFRACTION THROUGH A RECTANGULAR GLASS SLAB

📖 **Diagram: please refer to the NCERT textbook figure.** Labels: incident ray, normal, ∠i, ∠r, refracted ray, emergent ray, ∠e, lateral displacement. Note ∠i = ∠e.

5. SPHERICAL LENSES

Convex (converging) — thicker at the middle. Concave (diverging) — thicker at the edges. Terms: optical centre (O), principal axis, two foci F_1 and F_2, $2F_1$ and $2F_2$.
Rules: (1) ray parallel to axis → through F_2 (convex) / appears to come from F_1 (concave); (2) ray through F_1 (convex) / towards F_2 (concave) → emerges parallel; (3) ray through O → goes **undeviated**.

Image formation by a CONVEX lens

Object at	Image at	Size	Nature
Infinity	F_2	Point-sized	Real, inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real, inverted
At $2F_1$	At $2F_2$	Same size	Real, inverted
Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real, inverted
At F_1	Infinity	Highly enlarged	Real, inverted
Between F_1 and O	Same side as object	Enlarged	Virtual, erect (magnifying glass)

CONCAVE lens: image always between F_1 and O, same side as object, **virtual, erect, diminished**.

Lens formula: $1/v - 1/u = 1/f$ **Magnification:** $m = h'/h =$ **v/u**
Power: $P = 1/f$ (f in metres); unit **dioptre (D)**. Convex lens → +ve power, concave → −ve. For lenses in contact: $P = P_1 + P_2 + \dots$
Worked example: A convex lens of f = 10 cm; object at 15 cm. $u = -15$, $f = +10$. $1/v = 1/f + 1/u = 1/10 - 1/15 = 1/30$ → **$v = +30$ cm**; $m = v/u = 30/(-15) = -2$ → real, inverted, twice the size.

RAY DIAGRAMS — CONVEX LENS (SIX POSITIONS) AND CONCAVE LENS

📖 **Diagrams: please refer to the NCERT textbook figures in this chapter.** Mark O, F_1, $2F_1$, F_2, $2F_2$ on the axis before drawing.

6. COMMON MISTAKES THAT COST MARKS

- Using the mirror formula for a lens (lens: 1/v − 1/u; mirror: 1/v + 1/u).
- Mixing magnification formulas (mirror −v/u; lens +v/u).
- Forgetting to convert f to metres when finding power.
- No arrow-heads on rays; virtual rays drawn solid.
- Taking u as positive.

⭐ THE SEVEN MOST FREQUENTLY ASKED PATTERNS

Pattern	How to handle it
1. Draw ray diagram for a given position	Two rules + arrows + nature of image
2. Mirror/lens numericals	Write data with signs → formula → substitute → v and m → interpret
3. Uses of concave/convex mirrors	Headlights, shaving, dentist, solar furnace; rear-view
4. Refractive index & speed of light	n = c/v; higher n → slower light
5. Glass slab — lateral shift	∠i = ∠e; emergent ray parallel
6. Power of lens / combination	P = 1/f(m); $P = P_1+P_2$
7. Identify mirror/lens from image nature	Always erect & diminished → convex mirror / concave lens

✅ FINAL CHECK BEFORE THE EXAM

- Can you reproduce both six-row image tables from memory?
- Can you draw all 6 concave-mirror and 6 convex-lens ray diagrams?

- Do you know the sign of f for all four (concave/convex mirror, convex/concave lens)?
- Can you solve a numerical in 4 clean lines, stating the nature of the image?
- Can you state both laws of refraction and Snell's law?

PART B — NCERT SOLUTIONS

NCERT Solutions — Chapter 9 Exercises (17 Questions)

Q1. Which one of the following materials cannot be used to make a lens? **1 mark**
(a) Water (b) Glass (c) Plastic (d) Clay

SOLUTION:

Answer: (d) Clay **1 mark**

A lens works by refracting light that passes *through* it. Clay is opaque — light cannot pass through it at all.

Q2. The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should be the position of the object? **1 mark**
(a) Between the principal focus and the centre of curvature (b) At the centre of curvature (c) Beyond the centre of curvature (d) Between the pole of the mirror and its principal focus

SOLUTION:

Answer: (d) Between the pole of the mirror and its principal focus **1 mark**

This is the only position for which a concave mirror gives a virtual image — which is why a concave mirror is used as a shaving mirror and by dentists, with the face or tooth held closer than F.

Q3. Where should an object be placed in front of a convex lens to get a real image of the size of the object? **1 mark**
(a) At the principal focus (b) At twice the focal length (c) At infinity (d) Between the optical centre and the principal focus

SOLUTION:

Answer: (b) At twice the focal length **1 mark**

With the object at $2F_1$, the image is formed at $2F_2$ on the other side, real, inverted and of the **same size**.

Q4. A spherical mirror and a thin spherical lens have each a focal length of −15 cm. The mirror and the lens are likely to be
(a) both concave (b) both convex (c) the mirror is concave and the lens is convex (d) the mirror is convex but the lens is concave

1 mark

SOLUTION:

Answer: (a) both concave 1 mark

By the sign convention, a negative focal length belongs to a **concave mirror** and to a **concave lens**. (Convex mirror and convex lens both have positive f.)

Q5. No matter how far you stand from a mirror, your image appears erect. The mirror is likely to be
(a) plane (b) concave (c) convex (d) either plane or convex

1 mark

SOLUTION:

Answer: (d) either plane or convex 1 mark

A plane mirror always gives an erect image of the same size, and a convex mirror always gives an erect, diminished image — at every distance. A concave mirror would give an inverted image once the object went beyond F.

Q6. Which of the following lenses would you prefer to use while reading small letters found in a dictionary?
(a) A convex lens of focal length 50 cm (b) A concave lens of focal length 50 cm (c) A convex lens of focal length 5 cm (d) A concave lens of focal length 5 cm

1 mark

SOLUTION:

Answer: (c) A convex lens of focal length 5 cm 1 mark

A magnifying glass must be a **convex** lens, which rules out (b) and (d). Between the two convex lenses, magnification is greater for the **shorter** focal length, so the 5 cm lens is the better magnifier.

Q7. We wish to obtain an erect image of an object, using a concave mirror of focal length 15 cm. What should be the range of distance of the object

3 marks

from the mirror? What is the nature of the image? Is the image larger or smaller than the object? Draw a ray diagram.

SOLUTION:

Range of object distance: anywhere **between the pole and the focus**, that is, less than **15 cm** from the mirror. 1 mark

Nature of the image: virtual and erect, formed **behind** the mirror. 1 mark

Size: larger than the object — the image is magnified. 1 mark

Ray diagram. Draw the object between P and F. One ray parallel to the principal axis reflects through F; a second ray directed towards C is reflected back along itself. The reflected rays **diverge**, so produce them backwards — they meet behind the mirror, giving an enlarged, erect, virtual image.

Q8. Name the type of mirror used in the following situations. Support your answer with reason.
(a) Headlights of a car (b) Side/rear-view mirror of a vehicle (c) Solar furnace 3 marks

SOLUTION:

(a) Headlights — concave mirror. The bulb is placed at the **focus** of the mirror. Rays from the focus are reflected as a **parallel beam**, which travels a long distance and lights up the road far ahead. 1 mark

(b) Rear-view mirror — convex mirror. It always gives an **erect, diminished** image and has a much **wider field of view** than a plane mirror, so the driver can see a large area of traffic behind in a small mirror. 1 mark

(c) Solar furnace — concave mirror. A large concave reflector **converges** the parallel rays of the sun to its focus, concentrating a great deal of heat at one small point and producing a very high temperature. 1 mark

Q9. One-half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object? Verify your answer experimentally. Explain your observations. 3 marks

SOLUTION:

Yes — a complete image is still formed. 1 mark

Reason. Every part of a lens refracts light from every point of the object. Even the uncovered half receives rays from the whole object and bends them to converge at the same image position, so the full image is formed. 1 mark

Experiment. Place a lighted candle in front of the lens and obtain its image on a screen. Now cover the upper half of the lens with black paper and look again. The image is **complete but fainter**, because only half as many rays now reach it — the **brightness** falls, not the shape. The same happens when the lower half is covered. 1 mark

Q10. An object 5 cm in length is held 25 cm away from a converging lens of focal length 10 cm. Draw the ray diagram and find the position, size and nature of the image formed. 3 marks

SOLUTION:

Given: h = +5 cm, u = **−25 cm**, f = **+10 cm** (converging = convex). 1 mark

$$1/v - 1/u = 1/f$$
$$1/v = 1/f + 1/u = 1/10 + 1/(-25) = (5 - 2)/50 = 3/50$$
$$\mathbf{v = +16.7\ cm}$$

The image is formed **16.7 cm on the other side** of the lens. Since v is positive, it is **real**.

1 mark

$$m = v/u = 16.7/(-25) = \mathbf{-0.67}$$
$$h' = m \times h = -0.67 \times 5 = \mathbf{-3.3\ cm}$$

Nature: real, **inverted** (the minus sign), and **diminished** — 3.3 cm tall against the object's 5 cm. 1 mark

Q11. A concave lens of focal length 15 cm forms an image 10 cm from the lens. How far is the object placed from the lens? Draw the ray diagram. 3 marks

SOLUTION:

Given: f = **−15 cm** (concave), v = **−10 cm** (a concave lens always forms a virtual image on the same side as the object). 1 mark

$1/v - 1/u = 1/f$

$1/u = 1/v - 1/f = (-1/10) - (-1/15) = -1/10 + 1/15 = (-3 + 2)/30 = -1/30$

$u = -30$ cm

The object is placed **30 cm in front of the lens**. 1 mark

Ray diagram. A ray parallel to the axis diverges after refraction as if coming from F_1 on the object side; a ray through the optical centre goes straight on. Extended backwards, the two meet 10 cm from the lens, giving a **virtual, erect and diminished** image. 1 mark

Q12. An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image. 3 marks

SOLUTION:

Given: $u = -10$ cm, $f = +15$ cm (convex mirror). 1 mark

$1/v + 1/u = 1/f$

$1/v = 1/f - 1/u = 1/15 - (-1/10) = 1/15 + 1/10 = (2 + 3)/30 = 5/30$

$v = +6$ cm

The image is formed **6 cm behind the mirror**. 1 mark

$m = -v/u = -6/(-10) = +0.6$

Nature: virtual, erect and diminished (m is positive and less than 1) — as is always the case with a convex mirror. 1 mark

Q13. The magnification produced by a plane mirror is +1. What does this mean? 2 marks

SOLUTION:

The **magnitude 1** means the image is exactly the **same size** as the object — a plane mirror neither enlarges nor diminishes. 1 mark

The **positive sign** means the image is **virtual and erect**, formed behind the mirror, as far behind it as the object is in front. 1 mark

Q14. An object of size 5.0 cm is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30 cm. Find the position of the 3 marks

image, its nature and size.

SOLUTION:

Given: $h = +5$ cm, $u =$ **−20 cm**, $R = +30$ cm, so $f = R/2 =$ **+15 cm**. 1 mark

$1/v = 1/f - 1/u = 1/15 + 1/20 = (4 + 3)/60 = 7/60$

$v = +8.6$ cm

The image is **8.6 cm behind the mirror**. 1 mark

$m = -v/u = -8.6/(-20) =$ **+0.43**

$h' = m \times h = 0.43 \times 5 =$ **+2.2 cm**

Nature: virtual, erect and diminished, about **2.2 cm** tall. 1 mark

Q15. An object of size 7.0 cm is placed at 27 cm in front of a concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed so that a sharp focused image can be obtained? Find the size and the nature of the image. 3 marks

SOLUTION:

Given: $h = +7$ cm, $u =$ **−27 cm**, $f =$ **−18 cm** (concave). 1 mark

$1/v = 1/f - 1/u = (-1/18) - (-1/27) = -1/18 + 1/27 = (-3 + 2)/54 = -1/54$

$v = -54$ cm

The screen must be placed **54 cm in front of the mirror**, on the same side as the object. A real image can be caught on a screen; a virtual one cannot. 1 mark

$m = -v/u = -(-54)/(-27) =$ **−2**

$h' = -2 \times 7 =$ **−14 cm**

Nature: real, inverted and enlarged, 14 cm tall — twice the size of the object. 1 mark

📌 The object here is between C (36 cm) and F (18 cm), and the table predicts exactly this: image beyond C, real, inverted, enlarged. Always check your answer against the table.

Q16. Find the focal length of a lens of power −2.0 D. What type of lens is this? 2 marks

SOLUTION:

$P = 1/f \Rightarrow f = 1/P = 1/(-2.0) =$ **-0.5 m $= -50$ cm**

1 mark

A **negative** focal length (and negative power) means this is a **concave — diverging — lens**.

1 mark

📌 Keep f in **metres** when using $P = 1/f$. Substituting centimetres is the commonest mistake in this question.

Q17. A doctor has prescribed a corrective lens of power +1.5 D. Find the focal length of the lens. Is the prescribed lens diverging or converging? 2 marks

SOLUTION:

$f = 1/P = 1/(+1.5) =$ **$+0.67$ m $= +67$ cm**

1 mark

Since both the power and the focal length are **positive**, the lens is a **convex — converging — lens**. It would be prescribed for **hypermetropia** (long-sightedness). 1 mark

— End of Chapter 9 Exercises —

PART C — FREQUENTLY ASKED BOARD QUESTIONS

⭐ Frequently Asked Board Questions — Chapter 9

📌 **About this section**

Q. Define refractive index. What does a refractive index of 1.5 for glass mean?

The refractive index of a medium is the ratio of the speed of light in vacuum to its speed in that medium: $n = c/v$. A value of 1.5 means light travels 1.5 times faster in vacuum than in glass — that is, its speed in glass is $c/1.5 = 2 \times 10^8$ m/s.

Q. Why does a pencil placed slantwise in a glass of water appear bent at the surface?

Light from the immersed part of the pencil travels from water into air, a rarer medium, and so **bends away from the normal** as it emerges. The eye traces these bent rays back in straight lines, so the submerged part appears raised, and the pencil looks broken at the water surface. This is refraction, not reflection.

Q. State the laws of refraction of light.

(i) The incident ray, the refracted ray and the normal to the interface at the point of incidence all lie in the same plane. (ii) The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant for a given pair of media — **Snell's law**, $\sin i / \sin r = n_{21}$.

Q. Why does a ray of light falling normally on a surface pass undeviated?

Because the angle of incidence is 0°, and by Snell's law sin r is then also 0, so r = 0. The ray travels along the normal and is not bent, though its speed does change.

Q. Two lenses of power +2.0 D and −3.5 D are placed in contact. Find the power and focal length of the combination.

$P = P_1 + P_2 = 2.0 + (-3.5) =$ **−1.5 D**. Hence $f = 1/P = -0.67$ m = **−67 cm**; the combination behaves as a diverging lens.

Q. Why is a convex mirror preferred as a rear-view mirror although it makes objects look smaller?

Because it always gives an erect image and, above all, covers a much **wider field of view** — it shows the whole road behind in a small mirror. The reduced size is the price of that wide view, and drivers are trained to allow for it.

Q. An object is placed at the centre of curvature of a concave mirror. State the position, size and nature of the image.

The image is formed **at the centre of curvature itself**, is of the **same size** as the object, and is **real and inverted**.

— Chapter 9 Complete —

CHAPTER 10

The Human Eye and the Colourful World

Study Material · NCERT Solutions (12 Questions) · Board Questions

PART A — STUDY MATERIAL

📘 Study Material — Chapter 10: The Human Eye and the Colourful World

🔑 **The spine of this chapter**

Three blocks carry almost every mark: (1) **parts of the eye and their functions**, including power of accommodation; (2) **defects of vision** — myopia and hypermetropia with causes, correction and ray diagrams; (3) **phenomena** — dispersion, atmospheric refraction (twinkling, early sunrise), scattering (blue sky, red sunset, danger signals).

📘 CHAPTER AT A GLANCE

Topic	What You Will Learn
1. Human eye	Parts, functions, accommodation, near/far point
2. Defects of vision	Myopia, hypermetropia, presbyopia
3. Prism	Refraction, angle of deviation, dispersion, spectrum
4. Atmospheric refraction	Twinkling of stars, advance sunrise / delayed sunset
5. Scattering of light	Tyndall effect, blue sky, reddish sun

1. THE HUMAN EYE

Part	Function
Cornea	Thin transparent membrane at the front; **most of the refraction** of light entering the eye happens here
Iris	Dark muscular diaphragm; controls the size of the pupil
Pupil	Opening that regulates the amount of light entering the eye (small in bright light, large in dim light)
Eye lens	Convex, made of jelly-like fibrous material; provides **fine adjustment** of focal length to focus on the retina

Part	Function
Ciliary muscles	Change the curvature and thus the focal length of the eye lens
Retina	Light-sensitive screen with rods and cones; forms a **real, inverted** image; electrical signals go via the **optic nerve** to the brain, which interprets them

Power of accommodation: the ability of the eye lens to adjust its focal length.
Distant object → ciliary muscles **relax** → lens thin → focal length **increases**.
Near object → ciliary muscles **contract** → lens thick → focal length **decreases**.
Near point (least distance of distinct vision) of a normal eye = **25 cm**. **Far point** = **infinity**. Normal eye sees clearly from 25 cm to infinity.
Cataract: the lens becomes milky and cloudy in old age → partial or complete loss of vision; restored by surgery.
Why two eyes: wider field of view (about 180° vs 150°), ability to judge depth / three-dimensional view.

THE HUMAN EYE

📖 **Diagram: please refer to the NCERT textbook figure (The human eye).** Labels: Cornea, Iris, Pupil, Eye lens, Ciliary muscles, Retina, Optic nerve, (aqueous humour, vitreous humour).

2. DEFECTS OF VISION AND THEIR CORRECTION

	Myopia (near-sightedness)	Hypermetropia (far-sightedness)
Can see	Near objects clearly, not distant ones	Distant objects clearly, not nearby ones
Defect in points	Far point comes closer than infinity	Near point moves farther than 25 cm
Image formed	In **front** of the retina	**Behind** the retina
Causes	(i) excessive curvature of eye lens; (ii) elongation of eyeball	(i) focal length of eye lens too long; (ii) eyeball too small
Correction	**Concave lens** of suitable power	**Convex lens** of suitable power

Presbyopia: in old age the power of accommodation decreases (ciliary muscles weaken, lens loses flexibility); near point recedes. Corrected by **convex** lens. If a person has both myopia and presbyopia → **bifocal lens**: upper part concave (distant vision), lower part convex (reading). Refractive defects can also be corrected by contact lenses or surgery.
Numerical idea: for a myopic eye with far point x, lens needed has $f = -x$ (concave). E.g. far point 80 cm → $f = -0.8$ m → $P = -1.25$ D.

MYOPIA AND HYPERMETROPIA — DEFECT AND CORRECTION

📖 **Diagrams: please refer to the NCERT textbook figures (a, b, c for each defect).** Show: (a) far point / near point, (b) defective eye with image in front of / behind retina, (c) correction with concave / convex lens.

3. REFRACTION THROUGH A PRISM AND DISPERSION

A glass prism has two triangular bases and three rectangular faces; the angle between two refracting faces is the **angle of prism (A)**. The emergent ray bends towards the base; the angle between the incident ray produced and the emergent ray is the **angle of deviation (D)**.
Dispersion: splitting of white light into its seven component colours — **VIBGYOR** — because different colours bend through different angles. **Violet bends the most, red the least.** The band of colours is the **spectrum**.
Newton's experiment: a second, inverted prism recombines the colours into white light → proves white light is made of seven colours.
Rainbow: a natural spectrum seen after a shower, always in the direction **opposite to the Sun**. Water droplets act like tiny prisms: **refraction + dispersion** on entering, **internal reflection**, and **refraction** again on leaving.

REFRACTION THROUGH A PRISM · DISPERSION · RAINBOW FORMATION

📖 **Diagrams: please refer to the NCERT textbook figures.** Prism labels: incident ray, ∠i, refracted ray, ∠r, emergent ray, ∠e, angle of prism A, angle of deviation D, normals.

4. ATMOSPHERIC REFRACTION

The air's refractive index changes with temperature and density, and air layers keep moving.
Twinkling of stars: starlight is refracted continuously as it passes through changing atmospheric layers; stars are point sources, so their apparent position and brightness keep fluctuating → twinkling. The star also appears **slightly higher** than its actual position.
Planets do not twinkle: they are much closer, so they act as **extended sources** (collection of many point sources); fluctuations average out.

Advance sunrise and delayed sunset: the Sun is visible about **2 minutes before** actual sunrise and 2 minutes after actual sunset due to atmospheric refraction → day is ~4 minutes longer. The Sun also appears flattened at sunrise/sunset.
Flickering of objects seen through hot air above a fire is also atmospheric refraction.

5. SCATTERING OF LIGHT

Tyndall effect: scattering of light by colloidal particles, making the path of a beam visible (sunlight through a canopy of trees in a dense forest; beam in a smoke-filled room).
Colour of scattered light depends on particle size: very fine particles scatter **shorter wavelengths (blue)** most; larger particles scatter longer wavelengths; very large particles make scattered light appear white.
Blue sky: air molecules are smaller than the wavelength of visible light, so they scatter blue light (short wavelength) much more than red → blue reaches our eyes from all directions.
Sky appears dark to astronauts / at great heights: no atmosphere → no scattering.
Reddish Sun at sunrise and sunset: sunlight travels a much longer path through the atmosphere near the horizon; most blue light is scattered away, and mainly red light (longest wavelength) reaches us.
Danger signals are red: red is least scattered by fog or smoke, so it can be seen from a distance.

6. COMMON MISTAKES THAT COST MARKS

- Saying the eye lens does most of the refraction — it is the **cornea**.
- Correcting myopia with a convex lens (wrong — use **concave**).
- Explaining rainbow without **internal reflection**.
- Saying blue sky is due to dispersion — it is **scattering**.
- Confusing twinkling (refraction) with red sunset (scattering).

⭐ THE SIX MOST FREQUENTLY ASKED PATTERNS

Pattern	How to handle it
1. Myopia/hypermetropia with diagrams	Causes (2) + image position + correction + 3 diagrams
2. Accommodation / near point / far point	Ciliary muscles relax/contract; 25 cm / infinity

Pattern	How to handle it
3. Dispersion & rainbow	VIBGYOR; violet most; refraction–dispersion–internal reflection–refraction
4. Twinkling of stars / planets	Point source vs extended source
5. Blue sky / red sun / danger signals	Scattering depends on wavelength and particle size
6. Prism diagram with angles	Mark i, r, e, A, D

✅ FINAL CHECK BEFORE THE EXAM

- Can you label a diagram of the eye and give the function of each part?
- Can you draw all three diagrams for myopia and for hypermetropia?
- Can you explain why stars twinkle but planets don't?
- Can you explain the blue sky and reddish sunrise with the word "scattering" and "wavelength"?

PART B — NCERT SOLUTIONS

🧪 NCERT Solutions — Chapter 10 Exercises

Q1. The human eye can focus on objects at different distances by adjusting the focal length of the eye lens. This is due to 1 mark

(a) presbyopia (b) accommodation (c) near-sightedness (d) far-sightedness

SOLUTION:

Answer: (b) accommodation 1 mark

Q2. The human eye forms the image of an object at its 1 mark

(a) cornea (b) iris (c) pupil (d) retina

SOLUTION:

Answer: (d) retina 1 mark — a real and inverted image; the brain interprets it as erect.

Q3. The least distance of distinct vision for a young adult with normal vision is about 1 mark

(a) 25 m (b) 2.5 cm (c) 25 cm (d) 2.5 m

SOLUTION:

Answer: (c) 25 cm 1 mark

Q4. The change in focal length of an eye lens is caused by the action of the 1 mark

(a) pupil (b) retina (c) ciliary muscles (d) iris

SOLUTION:

Answer: (c) ciliary muscles 1 mark

When they contract, the lens becomes thicker and its focal length decreases, letting us see nearby objects; when they relax, the lens thins and the focal length increases for distant objects.

Q5. A person needs a lens of power −5.5 D for correcting his distant vision. For correcting his near vision he needs a lens of power +1.5 D. What is the focal length of the lens required for correcting (i) distant vision and (ii) near vision? 2 marks

SOLUTION:

(i) Distant vision. 1 mark

> $f = 1/P = 1/(-5.5) =$ **-0.182 m = -18.2 cm**

Negative, so it is a **concave lens** — the correction for **myopia**.

(ii) Near vision. 1 mark

> $f = 1/P = 1/(+1.5) =$ **$+0.667$ m = $+66.7$ cm**

Positive, so it is a **convex lens** — the correction for **hypermetropia/presbyopia**. A person needing both would use **bifocal** lenses.

Q6. The far point of a myopic person is 80 cm in front of the eye. What is the nature and power of the lens required to correct the problem? 3 marks

SOLUTION:

In myopia, the correcting **concave lens** must form the image of an object at **infinity** at the person's **far point**, so that the eye can then see it. 1 mark

Given: u = infinity, v = **−80 cm = −0.8 m**.

> $1/v - 1/u = 1/f$
> $1/f = (1/-0.8) - 0 = -1.25$
> **$f = -0.8$ m** and **$P = 1/f = -1.25$ D**

1 mark

Nature: a **concave (diverging) lens** of power **−1.25 D**. 1 mark

> 📌 For myopia, the focal length of the required lens is simply the **distance of the far point**, taken as negative. You can quote the result, but show the formula for full marks.

Q7. Make a diagram to show how hypermetropia is corrected. The near point of a hypermetropic eye is 1 m. What is the power of the lens 3 marks

required to correct this defect? Assume that the near point of the normal eye is 25 cm.

SOLUTION:

Diagram. Rays from an object at 25 cm converge **behind the retina** in the uncorrected eye. Placing a **convex lens** before the eye converges them enough for the image to fall **on the retina**. 1 mark

The lens must take an object at the **normal near point, 25 cm**, and form its image at the person's own near point, **1 m**, on the same side.

Given: u = **−25 cm = −0.25 m**, v = **−100 cm = −1 m**.

> 1/f = 1/v − 1/u = (−1/1) − (−1/0.25) = −1 + 4 = **+3**
> **f = +0.33 m = +33.3 cm**

1 mark

Power: P = 1/f = +3.0 D — a **convex (converging) lens**. 1 mark

Q8. Why is a normal eye not able to see clearly the objects placed closer than 25 cm? 2 marks

SOLUTION:

To focus an object, the ciliary muscles contract and make the eye lens thicker, reducing its focal length. But this power of **accommodation has a limit**. 1 mark

At about 25 cm the lens has already been made as convergent as it can be. For anything nearer, the required focal length is shorter than the eye can produce, so the image falls **behind the retina** and looks blurred. Holding the object closer also strains the muscles, causing discomfort. 1 mark

Q9. What happens to the image distance in the eye when we increase the distance of an object from the eye? 2 marks

SOLUTION:

The **image distance does not change.** 1 mark

In a camera the lens moves to refocus, but in the eye the retina is at a fixed distance from the lens. Instead, the **focal length changes**: as the object moves away, the ciliary muscles relax, the lens becomes thinner, and its focal length increases just enough to keep the image on the retina. 1 mark

Q10. Why do stars twinkle? 3 marks

SOLUTION:

A star is so far away that it acts as a **point source** of light. 1 mark

Starlight entering the earth's atmosphere undergoes **atmospheric refraction**, and the atmosphere is not uniform — its density and temperature keep changing. So the path of the light keeps changing slightly, and the **apparent position of the star goes on shifting**. 1 mark

With it, the amount of starlight entering the eye also fluctuates — the star looks brighter at one moment and fainter at the next. That fluctuation is what we see as **twinkling**. 1 mark

Q11. Explain why the planets do not twinkle. 2 marks

SOLUTION:

Planets are much closer to the earth than the stars, so they are not point sources — each can be regarded as a **collection of a very large number of point sources**. 1 mark

The variation in light coming from the individual points averages out: when one point dims, another brightens. The **total light reaching the eye stays nearly constant**, and the planet shines steadily. 1 mark

Q12. Why does the sky appear dark instead of blue to an astronaut? 2 marks

SOLUTION:

The blue colour of our sky is due to the **scattering** of sunlight by the molecules of the atmosphere — blue, having a shorter wavelength, is scattered far more than red. 1 mark

At the height at which an astronaut travels there is **no atmosphere**, and so there is nothing to scatter the sunlight. Light reaches the eye only if it comes directly from a source, and the rest of the sky sends none. Hence the sky appears **dark**. 1 mark

— End of Chapter 10 Exercises —

PART C — FREQUENTLY ASKED BOARD QUESTIONS

⭐ Frequently Asked Board Questions — Chapter 10

📌 **About this section**

Q. Why does the sun appear reddish early in the morning?

At sunrise and sunset the sunlight has to travel through a much **greater thickness of atmosphere** before reaching us. Most of the blue and shorter wavelengths are scattered away along that long path, and the light that finally reaches the eye is mainly the least-scattered **red**. At noon the path is shortest, very little is scattered, and the sun appears white.

Q. Why is the colour of the clear sky blue?

The molecules of air are much smaller than the wavelength of visible light, and such fine particles scatter **short wavelengths much more strongly** than long ones. The blue end of the spectrum is therefore scattered all over the sky and reaches our eyes from every direction.

Q. What is dispersion of light? Why does a prism produce it?

The splitting of white light into its seven constituent colours, VIBGYOR. It happens because the **refractive index of the glass is different for each colour** — greatest for violet and least for red — so each colour is bent through a different angle and the colours emerge separated.

Q. Explain how a rainbow is formed.

It is formed by tiny water droplets suspended in the air after rain, each acting as a prism. Sunlight entering a droplet is first **refracted and dispersed**, then **internally reflected** at the back of the droplet, and finally **refracted again** as it emerges. A rainbow is always seen in the direction opposite to the sun.

Q. Why is red used for danger signals and traffic stop lights?

Red has the **longest wavelength** of the visible colours, so it is **scattered the least** by fog, smoke and dust. It therefore travels farthest without being dimmed and can be seen clearly from a long distance even in poor visibility.

Q. Why does the sun appear about 2 minutes before actual sunrise?

Because of **atmospheric refraction**. Light from the sun, still below the horizon, is bent as it passes through layers of air of increasing density, so the sun's apparent position is slightly higher than its real position. The same effect delays sunset, lengthening the day by about four minutes in all.

Q. What is the Tyndall effect? Give two examples.

The scattering of light by colloidal particles, which makes the path of a light beam visible. Examples: a beam of sunlight entering a smoke-filled room, and sunlight streaming through the canopy of a dense forest where tiny water droplets hang in the air.

— Chapter 10 Complete —

CHAPTER 11

Electricity

Study Material · NCERT Solutions (18 Questions) · Board Questions

PART A — STUDY MATERIAL

📘 Study Material — Chapter 11: Electricity

🔑 **The spine of this chapter**

Every question here is built from five formulas: **$Q = It$**, **$V = W/Q$**, **$V = IR$**, **$R = \rho l/A$** and **$P = VI = I^2R = V^2/R$**, plus the series and parallel rules. Numericals carry most marks: always write the given data with units, the formula, substitution, and the answer with unit.

📘 CHAPTER AT A GLANCE

Topic	What You Will Learn
1. Charge & current	$Q = It$; ampere; ammeter
2. Potential difference	$V = W/Q$; volt; voltmeter
3. Circuit symbols	Cell, battery, key, resistor, rheostat, ammeter, voltmeter
4. Ohm's law	$V = IR$; V–I graph
5. Resistance & resistivity	$R = \rho l/A$; factors
6. Series & parallel	Equivalent resistance; household wiring
7. Heating effect	$H = I^2Rt$; applications
8. Electric power	$P = VI$; kWh; cost

1. ELECTRIC CHARGE AND CURRENT

Electric current = rate of flow of charge: **$I = Q/t$**. SI unit **ampere (A)**; 1 A = 1 C/s. 1 mA = 10^{-3} A, 1 μA = 10^{-6} A.

Charge of an electron = 1.6×10^{-19} C, so 1 C ≈ 6.25×10^{18} electrons. $Q = ne$.

Conventional current flows from + to − terminal (opposite to the flow of electrons).

Current is measured by an **ammeter**, always connected in **series**; it has very low resistance.

2. POTENTIAL DIFFERENCE

Potential difference (V) between two points = work done to move a unit charge from one point to the other: **V = W/Q**. SI unit **volt (V)**; 1 V = 1 J/C.
A cell maintains a potential difference due to chemical action. Measured by a **voltmeter**, connected in **parallel**; it has very high resistance.

3. CIRCUIT SYMBOLS

SYMBOLS OF COMMONLY USED COMPONENTS

📖 **Refer to the NCERT textbook table of circuit symbols.** You must be able to draw: electric cell, battery, plug key (open/closed), wire joint, wires crossing without joining, bulb, resistor, rheostat (variable resistance), ammeter (A in a circle), voltmeter (V in a circle).

✏️ **Cell:** long thin line = positive terminal, short thick line = negative. **Resistor:** zig-zag line. **Rheostat:** zig-zag with an arrow across it.

4. OHM'S LAW

Statement: the current through a metallic conductor is directly proportional to the potential difference across its ends, provided the temperature remains the same. V ∝ I → **V = IR**.
R = resistance, unit **ohm (Ω)**; 1 Ω = 1 V/A.
V–I graph: a straight line through the origin; **slope = R** (steeper line → higher resistance). For I–V graph slope = 1/R.
Rheostat changes the current in a circuit by changing resistance.

CIRCUIT TO VERIFY OHM'S LAW AND V–I GRAPH

📖 **Diagram: please refer to the NCERT textbook figure.** Circuit: battery, plug key, ammeter (series), resistor/nichrome wire XY, voltmeter (parallel to XY), rheostat. Graph: V on y-axis, I on x-axis, straight line through origin.

5. RESISTANCE AND RESISTIVITY

Resistance of a conductor depends on: (i) **length** — R ∝ l; (ii) **area of cross-section** — R ∝ 1/A; (iii) **nature of material**; (iv) **temperature** (increases with temperature for metals).
R = ρ l / A, where ρ = **resistivity**, SI unit **Ω m**. Resistivity depends only on material and temperature, not on dimensions.
Metals/alloys: ρ ≈ 10^{-8}–10^{-6} Ω m (good conductors). Insulators: 10^{12}–10^{17} Ω m.
Alloys (nichrome, manganin, constantan) have higher resistivity than pure metals and do not oxidise (burn) readily at high temperature → used in heating elements (iron, toaster, heater).

Copper and aluminium are used for transmission wires — low resistivity.
Tungsten is used for bulb filaments — very high melting point (3380 °C).
If a wire is stretched to double length, its area halves → resistance becomes **4 times**.

6. RESISTORS IN SERIES AND PARALLEL

	Series	Parallel
Equivalent resistance	$\mathbf{Rs = R_1 + R_2 + R_3}$ (greater than the largest)	$\mathbf{1/Rp = 1/R_1 + 1/R_2 + 1/R_3}$ (less than the smallest)
Current	Same through every resistor	Divides; total $I = I_1 + I_2 + I_3$
Voltage	Divides; $V = V_1 + V_2 + V_3$	Same across every resistor
Effect of one failing	Whole circuit breaks	Others keep working

Why household appliances are connected in parallel: (i) each gets the full supply voltage (220 V); (ii) each can be switched on/off independently; (iii) if one fails the others work; (iv) total resistance decreases, so each appliance draws the current it needs.
Disadvantages of series for household: voltage is shared, current is the same for all though appliances need different currents; one fault breaks everything.
Worked example: 2 Ω, 3 Ω, 6 Ω in parallel: $1/Rp = 1/2 + 1/3 + 1/6 = (3+2+1)/6 = 1$ → **Rp = 1 Ω**. In series → 11 Ω.

RESISTORS IN SERIES AND IN PARALLEL

📖 **Refer to the NCERT textbook figures.** Series: resistors end to end with one ammeter and a voltmeter across the combination. Parallel: resistors between two common points X and Y, with ammeters in each branch.

7. HEATING EFFECT OF ELECTRIC CURRENT

When current flows through a resistor, part of the source energy is dissipated as heat. **Joule's law of heating: $H = I^2Rt$** (heat ∝ square of current, resistance and time). Also $H = VIt$.
Applications: electric iron, toaster, oven, kettle, heater; electric bulb (filament heated to glow); **electric fuse**.
Fuse: a wire of alloy with **low melting point** (aluminium, copper, iron, lead...) connected in **series**. If current exceeds the safe limit, it melts and breaks the circuit — protecting appliances. Common ratings: 1 A, 2 A, 3 A, 5 A, 10 A. For a 1 kW iron at 220 V, I ≈ 4.54 A → 5 A fuse.

Bulbs are filled with chemically inactive **nitrogen and argon** to prolong filament life.
Undesirable effects: wastage of energy, heating of components.

8. ELECTRIC POWER

Power = rate of consumption of electrical energy: **$P = VI = I^2R = V^2/R$**. SI unit **watt (W)**; 1 W = 1 V × 1 A.
Commercial unit of energy: **kilowatt hour (kWh) = 1 "unit"**. **1 kWh = 3.6×10^6 J**.
Energy = Power × time; Cost = units × rate.
Worked example: A 100 W bulb for 10 h a day for 30 days: 0.1 kW × 10 × 30 = 30 kWh. At ₹5/unit → ₹150.
Note: the "electricity bill" pays for **energy**, not power or current.

9. COMMON MISTAKES THAT COST MARKS

- Connecting ammeter in parallel / voltmeter in series.
- Forgetting to take the reciprocal at the end in parallel combinations.
- Writing kWh as a unit of power (it is **energy**).
- Not converting W to kW or minutes to hours.
- Saying resistivity depends on length.

⭐ THE SEVEN MOST FREQUENTLY ASKED PATTERNS

Pattern	How to handle it
1. Ohm's law + circuit + graph	Statement, V = IR, diagram, straight-line graph
2. R = ρl/A numericals / stretched wire	Stretch n times → R becomes n^2 times
3. Series–parallel combination numericals	Reduce step by step; then I = V/R
4. Why parallel in houses	Four advantages
5. Joule heating / fuse / filament	$H = I^2Rt$; low m.p. fuse; tungsten
6. Power & energy bill	P = VI; kWh; cost

Pattern	How to handle it
7. Comparing two bulbs	$R = V^2/P$ — higher power bulb has lower resistance

✅ FINAL CHECK BEFORE THE EXAM

- Can you write all five core formulas with SI units?
- Can you draw the Ohm's law circuit with correct symbols?
- Can you solve a mixed series–parallel numerical in under 4 minutes?
- Do you know 1 kWh = 3.6×10^6 J by heart?

PART B — NCERT SOLUTIONS

NCERT Solutions — Chapter 11 Exercises (18 Questions)

Q1. A piece of wire of resistance R is cut into five equal parts. These parts are then connected in parallel. If the equivalent resistance of this combination is R′, then the ratio R/R′ is
(a) 1/25 (b) 1/5 (c) 5 (d) 25 1 mark

SOLUTION:

Answer: (d) 25 1 mark

> Each part has resistance R/5.
> Five such parts in parallel: R′ = (R/5)/5 = R/25
> ⇒ **R/R′ = 25**

Q2. Which of the following terms does not represent electrical power in a circuit?
(a) I^2R (b) IR^2 (c) VI (d) V^2/R 1 mark

SOLUTION:

Answer: (b) IR^2 1 mark

P = VI, and substituting V = IR gives P = I^2R; substituting I = V/R gives P = V^2/R. There is no form IR^2.

Q3. An electric bulb is rated 220 V and 100 W. When it is operated on 110 V, the power consumed will be
(a) 100 W (b) 75 W (c) 50 W (d) 25 W 1 mark

SOLUTION:

Answer: (d) 25 W 1 mark

> R = $V^2/P = (220)^2/100 = 484\ \Omega$ (the resistance is fixed)
> At 110 V: P = $V^2/R = (110)^2/484$ = **25 W**

📌 Halving the voltage divides the power by **four**, since $P \propto V^2$.

Q4. Two conducting wires of the same material and of equal lengths and equal diameters are first connected in series and then in parallel in a circuit across the same potential difference. The ratio of heat produced in series and parallel combinations would be
(a) 1 : 2 (b) 2 : 1 (c) 1 : 4 (d) 4 : 1

1 mark

SOLUTION:

Answer: (c) 1 : 4 **1 mark**

Let each wire be R. Series: $R_s = 2R$. Parallel: $R_p = R/2$.
$H = V^2t/R$, so $H_s : H_p = (1/2R) : (2/R) =$ **1 : 4**

Q5. How is a voltmeter connected in the circuit to measure the potential difference between two points?

1 mark

SOLUTION:

A voltmeter is always connected **in parallel** across the two points between which the potential difference is to be measured. **1 mark**

It has a very **high resistance**, so that it draws almost no current and does not disturb the circuit. (An ammeter, by contrast, is connected in **series** and has very low resistance.)

Q6. A copper wire has a diameter 0.5 mm and resistivity of 1.6×10^{-8} Ω m. What will be the length of this wire to make its resistance 10 Ω? How much does the resistance change if the diameter is doubled?

3 marks

SOLUTION:

Area of cross-section: **1 mark**

$A = \pi d^2/4 = 3.14 \times (0.5 \times 10^{-3})^2 / 4 = \mathbf{1.96 \times 10^{-7}\ m^2}$

Length: **1 mark**

$R = \rho l/A \Rightarrow l = RA/\rho = (10 \times 1.96 \times 10^{-7}) / (1.6 \times 10^{-8}) \approx$ **122.7 m**

If the diameter is doubled: the area becomes **four times** as large, and since R ∝ 1/A, the resistance falls to **one-fourth**: 1 mark

R_{new} = 10/4 = **2.5 Ω**

Q7. The values of current I flowing in a given resistor for the corresponding values of potential difference V across the resistor are given below. Plot a graph between V and I and calculate the resistance of that resistor.

I (A): 0.5, 1.0, 2.0, 3.0, 4.0 | V (V): 1.6, 3.4, 6.7, 10.2, 13.2

2 marks

SOLUTION:

Plotting V on the y-axis against I on the x-axis gives a **straight line through the origin**, which verifies Ohm's law: V ∝ I. 1 mark

The **slope** of the line is the resistance. Taking each pair, V/I gives 3.2, 3.4, 3.35, 3.4, 3.3 — nearly constant. 1 mark

R = mean of V/I ≈ **3.4 Ω**

Q8. When a 12 V battery is connected across an unknown resistor, there is a current of 2.5 mA in the circuit. Find the value of the resistance of the resistor.

2 marks

SOLUTION:

Given: V = 12 V, I = 2.5 mA = **2.5×10^{-3} A**. 1 mark

R = V/I = 12 / (2.5×10^{-3}) = **4800 Ω = 4.8 kΩ**

1 mark

📌 Converting mA to A is where the mark is usually lost. 1 mA = 10^{-3} A.

Q9. A battery of 9 V is connected in series with resistors of 0.2 Ω, 0.3 Ω, 0.4 Ω, 0.5 Ω and 12 Ω. How much current would flow through the 12 Ω resistor?

2 marks

SOLUTION:

In a **series** circuit the same current flows through every resistor, so we need only the total resistance. 1 mark

$R_s = 0.2 + 0.3 + 0.4 + 0.5 + 12 =$ **$13.4\ \Omega$**

$I = V/R_s = 9/13.4 =$ **0.67 A**

The current through the 12 Ω resistor is therefore **0.67 A**, the same as everywhere else in the circuit. 1 mark

Q10. How many 176 Ω resistors (in parallel) are required to carry 5 A on a 220 V line? 2 marks

SOLUTION:

Required total resistance: 1 mark

$R = V/I = 220/5 =$ **$44\ \Omega$**

For n equal resistors of R each in parallel, $R_p = R/n$:

$44 = 176/n \Rightarrow$ **$n = 4$**

Hence **four** resistors of 176 Ω must be joined in parallel. 1 mark

Q11. Show how you would connect three resistors, each of resistance 6 Ω, so that the combination has a resistance of (i) 9 Ω, (ii) 4 Ω. 2 marks

SOLUTION:

(i) 9 Ω. Connect **two resistors in parallel** and the third **in series** with that pair. 1 mark

Parallel pair: $(6 \times 6)/(6 + 6) = 3\ \Omega$

Total: $3 + 6 =$ **$9\ \Omega$**

(ii) 4 Ω. Connect **two resistors in series** and the third **in parallel** with that combination. 1 mark

Series pair: $6 + 6 = 12\ \Omega$

Parallel with 6 Ω: $(12 \times 6)/(12 + 6) = 72/18 =$ **$4\ \Omega$**

Q12. Several electric bulbs designed to be used on a 220 V electric supply line are rated 10 W. How many lamps can be connected in parallel with each other across the two wires of a 220 V line if the maximum allowable current is 5 A? 3 marks

SOLUTION:

Resistance of one bulb: 1 mark

$R = V^2/P = (220)^2/10 = \mathbf{4840\ \Omega}$

Total resistance the line can carry: 1 mark

$R_p = V/I = 220/5 = \mathbf{44\ \Omega}$

Number of bulbs in parallel: 1 mark

$R_p = R/n \Rightarrow n = 4840/44 = \mathbf{110\ bulbs}$

📌 A quicker route: total power allowed = VI = 220 × 5 = 1100 W; each bulb takes 10 W; so 1100/10 = 110. Either method earns full marks.

Q13. A hot plate of an electric oven connected to a 220 V line has two resistance coils A and B, each of 24 Ω resistance, which may be used separately, in series, or in parallel. What are the currents in the three cases? 3 marks

SOLUTION:

(i) One coil used separately: 1 mark

$I = V/R = 220/24 = \mathbf{9.17\ A}$

(ii) Both coils in series: $R_s = 24 + 24 = 48\ \Omega$ 1 mark

$I = 220/48 = \mathbf{4.58\ A}$

(iii) Both coils in parallel: $R_p = 24/2 = 12\ \Omega$ 1 mark

$I = 220/12 = \mathbf{18.33\ A}$

The parallel setting draws the most current and gives the most heat — that is the “high” setting of the oven.

Q14. Compare the power used in the 2 Ω resistor in each of the following circuits: **3 marks**
(i) a 6 V battery in series with 1 Ω and 2 Ω resistors, and
(ii) a 4 V battery in parallel with 12 Ω and 2 Ω resistors.

SOLUTION:

(i) Series circuit. 1 mark

> $R_s = 1 + 2 = 3\ \Omega$, $I = 6/3 = 2$ A
> $P = I^2R = (2)^2 \times 2 =$ **8 W**

(ii) Parallel circuit. In parallel the full 4 V appears across the 2 Ω resistor. 1 mark

> $P = V^2/R = (4)^2/2 =$ **8 W**

Comparison: the power used in the 2 Ω resistor is **the same, 8 W, in both circuits**. 1 mark

Q15. Two lamps, one rated 100 W at 220 V and the other 60 W at 220 V, are connected in parallel to the electric mains supply. What current is drawn from the line if the supply voltage is 220 V? **2 marks**

SOLUTION:

Both lamps operate at their rated voltage, so each consumes its rated power, and in a parallel connection the powers simply add. 1 mark

> $P_{total} = 100 + 60 = 160$ W
> $I = P/V = 160/220 =$ **0.73 A**

1 mark

Q16. Which uses more energy: a 250 W TV set in 1 hour, or a 1200 W toaster in 10 minutes? **2 marks**

SOLUTION:

> TV: $E = P \times t = 250\ \text{W} \times 3600\ \text{s} =$ **9×10^5 J** (0.25 kWh)
> Toaster: $E = 1200\ \text{W} \times 600\ \text{s} =$ **7.2×10^5 J** (0.2 kWh)

1 mark

The **TV set uses more energy**, even though the toaster is the more powerful appliance —

because it runs for six times as long. 1 mark

Q17. An electric heater of resistance 8 Ω draws 15 A from the service mains for 2 hours. Calculate the rate at which heat is developed in the heater. 2 marks

SOLUTION:

The **rate** at which heat is developed is the **power**, so the 2 hours is not needed for this part.

1 mark

$P = I^2R = (15)^2 \times 8 = 225 \times 8 = \mathbf{1800\ J/s = 1800\ W}$

1 mark

📌 If the question had asked for the *heat produced*, you would multiply by the time: $H = 1800 \times 7200\ s = 1.296 \times 10^7$ J.

Q18. Explain the following. 5 marks

(a) Why is tungsten used almost exclusively for filaments of electric lamps?

(b) Why are the conductors of electric heating devices, such as toasters and electric irons, made of an alloy rather than a pure metal?

(c) Why is the series arrangement not used for domestic circuits?

(d) How does the resistance of a wire vary with its area of cross-section?

(e) Why are copper and aluminium wires usually employed for electricity transmission?

SOLUTION:

(a) Tungsten has a **very high melting point (3380 °C)** and a high resistivity, so it can be heated to a white-hot glow without melting or vaporising. It also retains most of the heat produced and emits light efficiently. 1 mark

(b) Alloys have a **higher resistivity** than pure metals, so they produce more heat for the same current, and — crucially — they **do not oxidise or burn readily** even when red hot. Nichrome is the standard choice. 1 mark

(c) In series the same current would flow through every appliance, which is impossible since a bulb and a heater need very different currents. The **voltage would be divided**, so no appliance would get the full 220 V it is rated for, and a break anywhere — or switching one appliance off

— would **cut off the whole circuit**. Parallel connection avoids all three problems. **1 mark**

(d) Resistance is **inversely proportional** to the area of cross-section: R = ρl/A. A thicker wire offers more room for the charges to flow and therefore lower resistance. Doubling the diameter quarters the resistance. **1 mark**

(e) Because copper and aluminium have **very low resistivity** — they are excellent conductors — so very little energy is lost as heat over long transmission lines. They are also ductile enough to be drawn into wires, and reasonably cheap. **1 mark**

— End of Chapter 11 Exercises —

⭐ Frequently Asked Board Questions — Chapter 11

📌 About this section

Q. State Ohm's law. Draw the V–I graph and state what its slope gives.

At constant temperature, the current flowing through a conductor is directly proportional to the potential difference across it: $V \propto I$, or $V = IR$. The V–I graph is a **straight line through the origin**, and its **slope gives the resistance** R of the conductor.

Q. Define resistivity. On what factors does the resistance of a conductor depend?

Resistivity ρ is the resistance of a conductor of unit length and unit area of cross-section; its SI unit is the **ohm metre (Ω m)**. The resistance of a wire depends on its **length** (directly), its **area of cross-section** (inversely), the **material** it is made of, and its **temperature**. Resistivity depends only on the material and the temperature, not on the dimensions.

Q. Why is the tungsten filament of a bulb enclosed in an inert gas?

At its working temperature tungsten would react rapidly with the oxygen of the air and burn out. Filling the bulb with an inert gas — nitrogen or argon — prevents this and also slows the evaporation of the filament, giving the bulb a longer life.

Q. State Joule's law of heating and name three appliances based on it.

The heat produced in a resistor is directly proportional to (i) the square of the current, (ii) the resistance, and (iii) the time for which the current flows: $\mathbf{H = I^2Rt}$. Appliances: the electric iron, the electric heater/toaster, and the filament bulb; the **fuse** also works on this principle.

Q. What is an electric fuse and how does it protect a circuit?

A short piece of wire of suitable rating, made of a material with a **low melting point and high resistivity**, connected in series with the circuit. If the current exceeds the safe value — because of overloading or a short circuit — the heat produced (I^2Rt) melts the fuse wire, the circuit breaks, and the appliances are saved from damage.

Q. Why are household appliances connected in parallel, and why is the switch placed in the live wire?

Parallel connection gives every appliance the full 220 V and lets each be operated independently; putting the switch in the **live** wire ensures that when it is off, the appliance is completely disconnected from the high-potential side and is safe to touch.

Q. An electric iron of 1 kW is used for 2 hours a day. Find the cost of running it for 30 days at ₹3.00 per unit.

Energy per day = 1 kW × 2 h = 2 kWh. For 30 days = 60 kWh (units). Cost = 60 × ₹3.00 = **₹180**.

— Chapter 11 Complete —

CHAPTER 12

Magnetic Effects of Electric Current

Study Material · NCERT Solutions (18 Questions) · Board Questions

PART A — STUDY MATERIAL

📘 Study Material — Chapter 12: Magnetic Effects of Electric Current

🔑 The spine of this chapter

A current-carrying conductor produces a **magnetic field**; a current-carrying conductor placed in a magnetic field experiences a **force**. Learn: field-line properties, field patterns (straight wire, loop, solenoid), the **right-hand thumb rule**, **Fleming's left-hand rule**, and **domestic electric circuits**. *(Check your school's scope circular for the motor / electromagnetic induction / generator portion — see the note in the Syllabus Scope above.)*

📘 CHAPTER AT A GLANCE

Topic	What You Will Learn
1. Magnetic field & field lines	Properties; compass
2. Field due to current	Straight wire, circular loop, solenoid; electromagnet
3. Force on a conductor	Fleming's left-hand rule
4. Domestic circuits	Live, neutral, earth; fuse; overloading; short-circuit

1. MAGNETIC FIELD AND FIELD LINES

Magnetic field: region around a magnet in which its force can be detected. It has both **magnitude and direction**. Direction = the direction in which the north pole of a compass needle moves inside it. SI unit: tesla (T).

Properties of magnetic field lines:

(i) They emerge from the **north pole** and merge at the **south pole** outside the magnet; inside the magnet they go from south to north — so they are **closed curves**.

(ii) Where lines are **crowded**, the field is **stronger** (near the poles).

(iii) **Two field lines never intersect** — if they did, the compass needle would point in two directions at that point, which is impossible.

(iv) The tangent at any point gives the direction of the field.

FIELD LINES AROUND A BAR MAGNET

📖 **Diagram: please refer to the NCERT textbook figure.** Show closed loops, arrows from N to S outside, crowded near the poles.

2. MAGNETIC FIELD DUE TO A CURRENT

Oersted's observation: a compass needle is deflected when placed near a current-carrying wire → electricity and magnetism are linked.
(a) Straight conductor: field lines are **concentric circles** centred on the wire, in a plane perpendicular to it. Field ∝ current; decreases as distance from the wire increases. Reversing current reverses the field direction.
Right-hand thumb rule: hold the current-carrying straight conductor in your right hand with the **thumb pointing along the current**; the direction in which the **fingers curl** gives the direction of the magnetic field lines.
(b) Circular loop: every part of the loop behaves like a straight wire; at the centre the lines are nearly **straight** and all point in the same direction, so their effects add up. Field ∝ current and ∝ number of turns n.
(c) Solenoid (coil of many circular turns of insulated copper wire wound close together, like a cylinder): the field pattern outside is like that of a **bar magnet** (one end N, other S). Inside, field lines are **parallel straight lines** → the field is **uniform** (same at all points).
Electromagnet: a soft-iron core inside a current-carrying solenoid becomes magnetised strongly; magnetism lasts only while current flows. Strength increases with number of turns, current, and soft-iron core.

Electromagnet	Permanent magnet
Temporary; magnetism only while current flows	Permanent
Strength can be changed	Fixed strength
Polarity can be reversed by reversing current	Polarity fixed
Soft iron core	Steel, alnico, etc.

FIELD LINES: STRAIGHT WIRE · CIRCULAR LOOP · SOLENOID

📖 **Diagrams: please refer to the NCERT textbook figures.** Straight wire: concentric circles on a cardboard. Loop: circles near the wire, straight lines at the centre. Solenoid: parallel lines inside, bar-magnet pattern outside with N and S marked.

3. FORCE ON A CURRENT-CARRYING CONDUCTOR

A current-carrying conductor placed in a magnetic field experiences a force (shown by André-Marie Ampère; aluminium-rod experiment). The force is **maximum** when current is **perpendicular** to the field, and **zero** when current is parallel to the field. Reversing either the current or the field reverses the force.

Fleming's left-hand rule: stretch the **thumb, forefinger and middle finger** of the left hand mutually perpendicular. If the **forefinger** points along the **field** and the **middle finger** along the **current**, the **thumb** gives the direction of **motion / force**.

Devices using this: electric motor, loudspeakers, electric fans, washing machines.

MRI: weak ionic currents in nerve cells produce magnetic fields inside the body; these are used for imaging (Magnetic Resonance Imaging). Heart and brain are the two main organs with significant magnetic fields.

4. DOMESTIC ELECTRIC CIRCUITS

Supply is through three wires:

Wire	Insulation colour	Role
Live (positive)	**Red**	At 220 V
Neutral (negative)	**Black**	At 0 V; potential difference between live and neutral = 220 V
Earth	**Green**	Connected to a metal plate deep in the earth near the house

In India, AC supply is **220 V, 50 Hz**. Main fuse → electricity meter → main switch → distribution box → separate circuits: 15 A for high-power appliances (geyser, AC), 5 A for bulbs and fans.

Earthing: used for appliances with metallic bodies (iron, toaster, fridge). If current leaks to the body, it flows to the earth through the low-resistance earth wire, keeping the body at earth's potential → the user does not get a severe shock.

Short circuit: live and neutral wires come into direct contact (damaged insulation or faulty appliance) → resistance becomes very small → current increases abruptly.

Overloading: too many appliances connected to a single socket, or a sudden rise in supply voltage → excessive current.

Protection: electric **fuse** (in series; melts), and **MCB** (miniature circuit breaker) which trips automatically.

A SCHEMATIC OF ONE COMMON DOMESTIC CIRCUIT

📖 **Diagram: please refer to the NCERT textbook figure.** Labels: Live, Neutral, Earth wires, Electricity meter, Fuse, Main switch, Distribution box, Appliances in parallel, 5 A and 15 A lines.

5. COMMON MISTAKES THAT COST MARKS

- Using the right-hand thumb rule for force — for force use **Fleming's left-hand rule**.
- Saying field lines go from S to N outside the magnet.
- Not giving the reason why two field lines cannot intersect.
- Writing "earth wire is black" — it is **green**.
- Confusing short circuit (live touches neutral) with overloading (too much load).

⭐ THE SIX MOST FREQUENTLY ASKED PATTERNS

Pattern	How to handle it
1. Properties of field lines	Four properties, with the "never intersect" reason
2. Right-hand thumb rule + straight-wire pattern	Diagram + rule + factors
3. Solenoid & electromagnet	Uniform field inside; bar-magnet pattern; uses
4. Fleming's left-hand rule / direction of force	Field – forefinger, current – middle, force – thumb
5. Domestic circuit, earthing, fuse	Three wires + colours + safety devices
6. Short circuit vs overloading	Cause + effect + prevention

✅ FINAL CHECK BEFORE THE EXAM

- Can you draw field lines of a bar magnet, straight wire and solenoid?
- Can you apply Fleming's left-hand rule to find the direction of force in a given figure?
- Do you know the three wire colours and the purpose of earthing?
- Can you explain why a fuse is connected in series?

PART B — NCERT SOLUTIONS

NCERT Solutions — Chapter 12 Exercises

Q1. Which of the following correctly describes the magnetic field near a long straight wire?
(a) The field consists of straight lines perpendicular to the wire (b) The field consists of straight lines parallel to the wire (c) The field consists of radial lines originating from the wire (d) The field consists of concentric circles centred on the wire

1 mark

SOLUTION:

Answer: (d) concentric circles centred on the wire 1 mark

The circles are closer together near the wire, where the field is strongest, and spread out farther away.

Q2. The phenomenon of electromagnetic induction is
(a) the process of charging a body (b) the process of generating magnetic field due to a current passing through a coil (c) producing induced current in a coil due to relative motion between a magnet and the coil (d) the process of rotating a coil of an electric motor

1 mark

SOLUTION:

Answer: (c) producing induced current in a coil due to relative motion between a magnet and the coil 1 mark

Q3. The device used for producing electric current is called a
(a) generator (b) galvanometer (c) ammeter (d) motor

1 mark

SOLUTION:

Answer: (a) generator 1 mark

A galvanometer *detects* current, an ammeter *measures* it, and a motor *uses* it.

Q4. The essential difference between an AC generator and a DC generator is that
(a) AC generator has an electromagnet while a DC generator has a permanent magnet (b) DC generator will generate a higher voltage (c) AC generator will generate a higher voltage (d) AC generator has slip rings while the DC generator has a commutator 1 mark

SOLUTION:
Answer: (d) AC generator has slip rings while the DC generator has a commutator 1 mark

The split-ring commutator reverses the connections every half rotation, so the current in the external circuit always flows the same way — that is what makes the output direct current.

Q5. At the time of short circuit, the current in the circuit
(a) reduces substantially (b) does not change (c) increases heavily (d) varies continuously 1 mark

SOLUTION:
Answer: (c) increases heavily 1 mark

When the live and neutral wires touch directly, the resistance of the circuit falls almost to zero, and by I = V/R the current becomes enormous.

Q6. State whether the following statements are true or false. 4 marks
(a) An electric motor converts mechanical energy into electrical energy.
(b) An electric generator works on the principle of electromagnetic induction.
(c) The field at the centre of a long circular coil carrying current will be parallel straight lines.
(d) A wire with a green insulation is usually the live wire of an electric supply.

SOLUTION:
(a) False. It is the other way round — a motor converts **electrical energy into mechanical energy**. 1 mark
(b) True. A changing magnetic field through the coil induces a current in it. 1 mark
(c) True. Inside a long coil (solenoid) the field is **uniform**, represented by parallel straight lines.

1 mark

(d) False. Green (or green-yellow) is the **earth** wire. The live wire is red or brown. 1 mark

Q7. List three sources of magnetic fields. 1 mark

SOLUTION:

• A **permanent magnet** (bar magnet, horseshoe magnet)

• A **current-carrying conductor** — a straight wire, a circular loop or a solenoid

• An **electromagnet**, and the **earth** itself, which behaves like a huge bar magnet 1 mark

Q8. How does a solenoid behave like a magnet? Can you determine the north and south poles of a current-carrying solenoid with the help of a bar magnet? Explain. 3 marks

SOLUTION:

A **solenoid** is a long coil of many circular turns of insulated wire. When current flows, the fields of the individual turns add up, and the pattern of field lines outside it is **exactly like that of a bar magnet** — the lines emerge from one end and enter the other, so one end behaves as a **north pole** and the other as a **south pole**. Inside, the field is uniform. 2 marks

Yes, the poles can be identified with a bar magnet. Suspend the current-carrying solenoid so that it can turn freely, and bring the known **north pole** of a bar magnet near one end. If that end is **repelled**, it is the north pole of the solenoid; if it is **attracted**, it is the south pole — since like poles repel and unlike poles attract. 1 mark

Q9. When is the force experienced by a current-carrying conductor placed in a magnetic field largest? 1 mark

SOLUTION:

The force is largest when the conductor is placed at **90° to the direction of the magnetic field** — that is, when the current and the field are mutually perpendicular. The force is **zero** when the conductor lies along the field. 1 mark

Q10. Imagine that you are sitting in a chamber with your back to one wall. An electron beam, moving horizontally from the back wall towards the front wall, is deflected by a strong magnetic field to your right side. What is the direction of the magnetic field? 2 marks

SOLUTION:

The magnetic field is directed vertically downwards. 1 mark

Reasoning. The beam consists of electrons moving from back to front, so the **conventional current is from front to back**. Apply Fleming's left-hand rule: the thumb (thrust) points to the right, the central finger (current) points backwards — the forefinger then points **downwards**, which is the direction of the field. 1 mark

Q11. Draw a labelled diagram of an electric motor. Explain its principle and working. What is the function of a split ring in an electric motor? 5 marks

SOLUTION:

Principle. When a rectangular coil carrying current is placed in a magnetic field, the two opposite arms of the coil experience **forces in opposite directions** (Fleming's left-hand rule). The pair of forces forms a couple that makes the coil **rotate**. 1 mark

Parts: a rectangular coil ABCD of insulated copper wire, a strong **permanent magnet** with curved pole pieces, a **split-ring commutator** (two halves of a ring), two **carbon brushes** pressing against it, a battery and a switch. 1 mark

Working. Current flows into the coil through the brushes and the split ring. In arm AB the current flows one way and in CD the opposite way, so AB is pushed down and CD is pushed up. The coil turns. 1 mark

After half a rotation, the two halves of the split ring **change contact** with the brushes, so the direction of current in the coil is reversed. The forces on AB and CD therefore also reverse, and the coil **keeps turning in the same direction**. 1 mark

Function of the split ring: it acts as a **commutator** — it reverses the direction of the current in the coil after every half rotation, so that the rotation continues in one direction instead of the coil oscillating back and forth. 1 mark

Q12. Name some devices in which electric motors are used. 1 mark

SOLUTION:

Electric fans, mixers and grinders, washing machines, refrigerators, water pumps, electric drills and other power tools, computer hard drives and CD players. **1 mark**

Q13. A coil of insulated copper wire is connected to a galvanometer. What will happen if a bar magnet is (i) pushed into the coil (ii) withdrawn from inside the coil (iii) held stationary inside the coil? **3 marks**

SOLUTION:

(i) Pushed in: the galvanometer needle **deflects momentarily to one side**. Moving the magnet changes the magnetic field through the coil, and this changing field **induces a current** in it. **1 mark**

(ii) Withdrawn: the needle deflects momentarily **in the opposite direction**, because the field through the coil is now changing the other way, so the induced current is reversed. **1 mark**

(iii) Held stationary: no deflection at all. There is no relative motion, so the field through the coil is not changing, and no current is induced. **1 mark**

> 📌 The single sentence to remember: induction needs a **change** in the magnetic field through the coil — motion alone is not the point, and a steady field does nothing.

Q14. Two circular coils A and B are placed close to each other. If the current in coil A is changed, will some current be induced in coil B? Give reason. **2 marks**

SOLUTION:

Yes, a current will be induced in coil B. **1 mark**

The current in A produces a magnetic field around it, and some of that field passes through B. Changing the current in A changes that field, and a **changing magnetic field through coil B induces a current in it** — exactly as a moving magnet would. This is **mutual induction**, and no physical movement is needed. **1 mark**

Q15. State the rule to determine the direction of (i) the magnetic field produced around a straight conductor carrying current (ii) the force experienced by a current-carrying straight conductor placed in a **3 marks**

magnetic field which is perpendicular to it (iii) the current induced in a coil due to its rotation in a magnetic field.

SOLUTION:

(i) Right-hand thumb rule. Hold the conductor in your right hand with the thumb pointing in the direction of the current; the way the fingers curl around it gives the direction of the magnetic field lines. **1 mark**

(ii) Fleming's left-hand rule. Stretch the thumb, forefinger and middle finger of the **left** hand mutually perpendicular. Forefinger → magnetic field, middle finger → current, and the **thumb then points along the force (motion)**. **1 mark**

(iii) Fleming's right-hand rule. With the three fingers of the **right** hand held mutually perpendicular: forefinger → field, thumb → motion of the conductor, and the **middle finger points along the induced current**. **1 mark**

Q16. Explain the underlying principle and working of an electric generator. What is the function of the brushes? **5 marks**

SOLUTION:

Principle — electromagnetic induction. When a conductor is moved in a magnetic field, or when the magnetic field through a coil is changed, an **electric current is induced** in the conductor. Its direction is given by Fleming's right-hand rule. **1 mark**

Parts: a rectangular coil ABCD rotating between the poles of a strong magnet, two **slip rings** attached to its ends (a **split ring** in a DC generator), and two **carbon brushes** resting on them, connected to the external circuit. **1 mark**

Working. The coil is rotated mechanically. Arm AB moves up while CD moves down, so an induced current flows through the coil in a definite direction — say A → B → C → D. **1 mark** After half a rotation the arms exchange places: AB now moves down and CD up, so the **induced current reverses**. This happens at every half rotation, producing **alternating current**. In India the direction reverses 100 times a second, giving a frequency of **50 Hz**. **1 mark**

Function of the brushes: they remain in sliding contact with the rotating rings and **transfer the current from the rotating coil to the stationary external circuit**. **1 mark**

Q17. When does an electric short circuit occur? **2 marks**

SOLUTION:

A short circuit occurs when the **live wire and the neutral wire come into direct contact** — usually through damaged insulation or a fault in an appliance. 1 mark

The current then bypasses the appliance and flows through a path of almost **zero resistance**, so it becomes enormously large. The heat produced can melt the wires and start a fire — which is why a fuse or a miniature circuit breaker (MCB) is placed in the circuit. Overloading, by drawing too many appliances from one socket, has a similar effect. 1 mark

Q18. What is the function of an earth wire? Why is it necessary to earth metallic appliances? 2 marks

SOLUTION:

The **earth wire** is a low-resistance conductor that connects the metal body of an appliance to a metal plate buried deep in the earth. It provides a **safe, low-resistance path** for the current. 1 mark

If the insulation inside an appliance fails and the live wire touches its metal casing, the casing would otherwise become live, and anyone touching it would receive a severe electric shock. With earthing, the leaked current runs harmlessly into the ground instead — and the large current usually blows the fuse, disconnecting the appliance. 1 mark

— End of Chapter 12 Exercises —

⭐ Frequently Asked Board Questions — Chapter 12

📌 **About this section**

Q. Why do two magnetic field lines never intersect each other?

If two field lines crossed, there would be **two directions of the magnetic field at that single point**, which is impossible — a compass needle placed there could point in only one direction.

Q. List the properties of magnetic field lines.

They are **closed continuous curves**, running from N to S outside the magnet and S to N inside it; the **tangent** at any point gives the direction of the field there; they are **crowded where the field is strong** and far apart where it is weak; and **no two lines intersect**.

Q. What is an electromagnet? How does it differ from a permanent magnet?

A solenoid wound on a **soft iron core**, which becomes a strong magnet only while current flows. Unlike a permanent magnet, its **strength can be varied** (by changing the current or the number of turns), its **polarity can be reversed**, and it can be **switched off**. It is used in electric bells, cranes for lifting scrap iron, loudspeakers and MRI machines.

Q. What precautions should be taken to avoid overloading of domestic circuits?

Do not connect too many high-power appliances to a single socket; use a fuse or MCB of the correct rating in each circuit; use good-quality wires of adequate thickness; and avoid using several appliances at the same time on one line.

Q. Name and state the rule used to find the direction of the induced current.

Fleming's right-hand rule. Hold the thumb, forefinger and middle finger of the right hand mutually perpendicular; if the forefinger points along the magnetic field and the thumb along the motion of the conductor, the middle finger gives the direction of the **induced current**.

— Chapter 12 Complete —

CHAPTER 13

Our Environment

Study Material · NCERT Solutions (9 Questions) · Board Questions

PART A — STUDY MATERIAL

📘 Study Material — Chapter 13: Our Environment

🔑 **The spine of this chapter**

Short but reliable scoring chapter (Unit V, 5 marks). Know: **ecosystem components**, **food chains and trophic levels**, the **10% law** of energy flow, **biological magnification**, the **ozone layer** and its depletion, and **biodegradable vs non-biodegradable** waste.

📘 CHAPTER AT A GLANCE

Topic	What You Will Learn
1. Ecosystem	Biotic & abiotic components; natural & artificial
2. Food chains & webs	Trophic levels; producers, consumers, decomposers
3. Energy flow	Unidirectional; 10% law
4. Biological magnification	Pesticides accumulate at higher trophic levels
5. Ozone layer	Formation, role, depletion by CFCs
6. Waste management	Biodegradable, non-biodegradable; disposable cups

1. ECOSYSTEM

Ecosystem: all the living organisms of an area together with the non-living components of their environment, interacting with each other.

Biotic components: plants, animals, microorganisms. **Abiotic:** temperature, rainfall, wind, soil, minerals, water.

Natural ecosystems: forests, ponds, lakes, grasslands. **Artificial (man-made):** gardens, crop fields, **aquarium**.

Producers: green plants and blue-green algae; make food by photosynthesis (autotrophs).

Consumers: depend on producers directly or indirectly — herbivores, carnivores, omnivores, parasites.

Decomposers: bacteria and fungi; break down dead remains and wastes into simple substances that go back to the soil → **replenish the soil** and recycle nutrients.

Why we don't clean ponds/lakes the way we clean an aquarium: natural ecosystems have decomposers that break down waste; an aquarium is artificial and lacks enough decomposers.

2. FOOD CHAINS, TROPHIC LEVELS AND FOOD WEBS

Food chain: a series of organisms taking part at various biotic levels, each eating the one before. Examples: Grass → Deer → Lion; Grass → Grasshopper → Frog → Snake → Eagle; Phytoplankton → Zooplankton → Fish → Shark.

Trophic level: each step or level of a food chain. T_1 producers, T_2 herbivores (primary consumers), T_3 small carnivores (secondary consumers), T_4 large carnivores (tertiary consumers).

Food web: network of interconnected food chains; more realistic because one organism is eaten by many.

TROPHIC LEVELS · FOOD WEB · ENERGY FLOW

📖 **Diagrams: please refer to the NCERT textbook figures.** A trophic-level pyramid can be drawn as four stacked boxes: Producers (bottom, widest) → Herbivores → Carnivores → Top carnivores.

3. FLOW OF ENERGY

(i) Green plants capture about **1% of the sunlight** falling on leaves and convert it into food energy.

(ii) **10% law:** only about **10%** of the energy at one trophic level is available to the next level as organic matter; the rest is used in life processes, lost as heat, or unused.

(iii) Energy flow is **unidirectional** — energy captured by autotrophs does not revert to the Sun, and energy passed to herbivores does not come back to autotrophs.

(iv) Because energy decreases at each level, food chains usually have only **3–4 trophic levels**. The number of individuals at lower levels is larger; producers are the most numerous.

Numerical: if producers have 10,000 J, herbivores get 1,000 J, carnivores 100 J, top carnivores 10 J.

Vegetarian food chains are more energy-efficient — fewer levels mean less energy loss.

4. BIOLOGICAL MAGNIFICATION

The **increase in concentration of harmful, non-biodegradable chemicals** (pesticides like DDT) at successive trophic levels of a food chain. These chemicals are washed into soil and water, absorbed by plants, and are **not degraded or excreted**, so they accumulate. **Human beings**, occupying the top level in many food chains, get the **maximum concentration**. This is why food grains, vegetables and fruits have been found with pesticide residues.

5. OZONE LAYER AND ITS DEPLETION

Ozone (O_3) — a molecule of three oxygen atoms; **deadly poisonous** at ground level but in the upper atmosphere it **shields** the Earth from harmful **ultraviolet (UV) radiation** of the Sun, which can cause skin cancer.
Formation: $O_2 \xrightarrow{(UV)} O + O$; $O + O_2 \rightarrow O_3$
Depletion: amount of ozone started dropping sharply in the 1980s; linked to synthetic chemicals like **chlorofluorocarbons (CFCs)** used as refrigerants and in fire extinguishers.
Action: in 1987, the United Nations Environment Programme (UNEP) got an agreement to freeze CFC production at 1986 levels; manufacturing companies now make CFC-free refrigerators.

6. WASTE AND ITS MANAGEMENT

Biodegradable	Non-biodegradable
Broken down by the action of bacteria or other decomposers	Cannot be broken down by biological processes; persist for a long time
Vegetable peels, paper, cotton, wood, leather, cow-dung	Plastics, polythene, glass, DDT, metal cans
Do not cause lasting harm; return to nature	Accumulate, harm organisms, enter food chains

Disposable cups: Indian Railways once replaced plastic cups with **kulhads** (disposable clay cups); but making them in large numbers would cause loss of fertile top-soil. Now **disposable paper cups** are used — they are biodegradable.
Our role: segregate waste at home (green bin — biodegradable, blue bin — non-biodegradable), follow the **3 Rs — Reduce, Reuse, Recycle**, use cloth/jute bags, compost kitchen waste.
Changes in lifestyle (packaging, disposables) have greatly increased waste generation.

7. COMMON MISTAKES THAT COST MARKS

- Starting a food chain with the Sun or an animal — always start with a **producer**.
- Writing that energy flow is cyclic — it is **unidirectional** (nutrients cycle, energy does not).
- Saying ozone is harmful in the upper atmosphere — it is protective there.
- Stating 10% is lost — actually 10% is **passed on**, 90% is lost.

⭐ THE SIX MOST FREQUENTLY ASKED PATTERNS

Pattern	How to handle it
1. Food chain with trophic levels	Producer first; label T_1–T_4
2. 10% law numerical	Divide by 10 at each step
3. Biological magnification	Define + DDT + humans at top
4. Ozone formation & depletion	Two equations + CFCs + UNEP 1987
5. Biodegradable vs non-biodegradable	Definition + 2 examples each
6. Role of decomposers	Recycle nutrients, clean environment

✅ FINAL CHECK BEFORE THE EXAM

- Can you write a four-step food chain and label each trophic level?
- Can you explain why energy flow is unidirectional?
- Can you write the equations for ozone formation?
- Can you give three steps you take at home to reduce waste?

PART B — NCERT SOLUTIONS

NCERT Solutions — Chapter 13 Exercises

Q1. Which of the following groups contain only biodegradable items?
(a) Grass, flowers and leather (b) Grass, wood and plastic (c) Fruit peels, cake and lime juice (d) Cake, wood and grass

1 mark

SOLUTION:

Answer: (a), (c) and (d) — all three contain only biodegradable items. 1 mark

Only **(b)** is ruled out, because **plastic** is non-biodegradable. Everything of plant or animal origin — grass, flowers, leather, wood, fruit peels, cake, lime juice — is broken down by the action of microorganisms.

Q2. Which of the following constitute a food chain?
(a) Grass, wheat and mango (b) Grass, goat and human (c) Goat, cow and elephant (d) Grass, fish and goat

1 mark

SOLUTION:

Answer: (b) Grass, goat and human 1 mark

A food chain must have organisms at **successive trophic levels**: grass is the producer, the goat is the herbivore that eats it, and the human is the consumer that eats the goat. In (a) and (c) all the members are at the same level, and in (d) a fish does not eat grass, nor a goat a fish.

Q3. Which of the following are environment-friendly practices?
(a) Carrying cloth bags to put purchases in while shopping (b) Switching off unnecessary lights and fans (c) Walking to school instead of getting your mother to drop you on her scooter (d) All of the above

1 mark

SOLUTION:

Answer: (d) All of the above 1 mark

Each avoids plastic waste, saves electricity or reduces the burning of fossil fuel.

Q4. What will happen if we kill all the organisms in one trophic level? 3 marks

SOLUTION:

The ecosystem would be thrown out of balance, because the organisms of one level control the numbers of those on either side of them. 1 mark

Example. If all the herbivores were killed, the producers would grow unchecked and overcrowd the area, while every carnivore above them would **starve and die** for want of food. 1 mark

The same logic applies at every level: removing the carnivores lets the herbivores multiply until they destroy all the vegetation, and removing the producers destroys the ecosystem altogether, since no other level can make its own food. Once a level is emptied, that gap in the food chain cannot be filled and the whole ecosystem may collapse. 1 mark

Q5. Will the impact of removing all the organisms in a trophic level be different for different trophic levels? Can the organisms of any trophic level be removed without causing any damage to the ecosystem? 3 marks

SOLUTION:

Yes, the impact differs from level to level. 1 mark

• Removing the **producers** is the most damaging of all — no other level can make food, so every organism above them dies.

• Removing the **herbivores** leaves the producers unchecked and starves all the carnivores.

• Removing the **top carnivores** lets the herbivore population explode, and overgrazing then destroys the vegetation. 1 mark

No trophic level can be removed without damage. Every level is linked to the ones above and below it, and each depends on the others for food and for the control of its numbers. Emptying any one of them upsets the balance of the whole ecosystem. 1 mark

Q6. What is biological magnification? Will the levels of this magnification be different at different levels of the ecosystem? 3 marks

SOLUTION:

Biological magnification is the progressive increase in the concentration of harmful, **non-biodegradable** chemicals — such as pesticides — in the bodies of organisms at **successively higher trophic levels** of a food chain. 1 mark

The pesticides sprayed on crops are washed into the soil and water, absorbed by plants, and eaten by herbivores. Since these chemicals **cannot be broken down or excreted**, they accumulate in the body of every organism that eats them. 1 mark

Yes, the levels differ. The concentration is **lowest in the producers and highest at the top of the chain**, because each consumer eats many organisms of the level below and takes in all their accumulated chemical. Human beings, occupying the topmost level, receive the greatest concentration of all. 1 mark

Q7. What are the problems caused by the non-biodegradable wastes that we generate? 3 marks

SOLUTION:

• They **persist in the environment for centuries**, since no microorganism can break them down, and they accumulate as ever-growing heaps of waste. 1 mark
• They enter food chains and cause **biological magnification**, poisoning organisms at the higher levels, including human beings.
• Plastics and similar wastes **clog drains and sewers**, causing water to stagnate, which becomes a breeding ground for mosquitoes and disease. 1 mark
• Animals swallow discarded plastic bags along with food and die; burning plastic releases **toxic fumes** that pollute the air.
• They damage the **fertility of the soil** and pollute groundwater, and pesticides among them kill useful soil organisms. 1 mark

Q8. If all the waste we generate is biodegradable, will this have no impact on the environment? 2 marks

SOLUTION:

It would have a far smaller impact — but not none at all. 1 mark

Biodegradable waste is broken down by microorganisms and returned to the nutrient cycle, so it does not accumulate. But if it is generated in very large quantities, decomposition cannot keep pace with it. The rotting heaps give off a **foul smell and harmful gases such as methane**, they attract flies and rats and become breeding grounds for disease, and the nutrients washed into ponds and lakes cause **excessive growth of algae**, which uses up the dissolved oxygen and kills the aquatic life. 1 mark

Q9. Why is damage to the ozone layer a cause for concern? What steps are being taken to limit this damage? 3 marks

SOLUTION:

What ozone does. A layer of ozone (O_3) in the upper atmosphere absorbs most of the harmful **ultraviolet radiation** coming from the sun, acting as a shield for life on earth. **1 mark**

Why the damage matters. UV radiation reaching the surface causes **skin cancer** in human beings, **cataract** and other damage to the eyes, and a weakening of the immune system. It also damages plants and reduces crop yields, and kills the plankton that form the base of ocean food chains. **1 mark**

Steps being taken. The main culprits are **CFCs** (chlorofluorocarbons), used in refrigerators, air conditioners and fire extinguishers. In **1987 the United Nations Environment Programme (UNEP)** secured an agreement — the **Montreal Protocol** — to freeze and then phase out CFC production. Manufacturers worldwide have switched to CFC-free refrigerants and propellants. **1 mark**

— End of Chapter 13 Exercises —

PART C — FREQUENTLY ASKED BOARD QUESTIONS

⭐ Frequently Asked Board Questions — Chapter 13

📌 **About this section**

Q. Define ecosystem. Name its biotic and abiotic components.

All the interacting organisms of an area together with the non-living components of their environment form an **ecosystem**. The **biotic** components are producers, consumers and decomposers; the **abiotic** components are temperature, rainfall, wind, soil, light and minerals. A forest, a pond and a lake are natural ecosystems; a garden, a crop field and an aquarium are artificial ones.

Q. What is the ten per cent law? Why are food chains limited to three or four trophic levels?

Only about **10%** of the energy available at one trophic level is transferred to the next; the remaining 90% is lost as heat and used up in life processes. Because so little energy is passed on, there is not enough left to support a fifth or sixth level, so food chains rarely go beyond three or four steps.

Q. Why is energy flow in an ecosystem said to be unidirectional?

Energy enters the ecosystem as sunlight captured by producers and moves from producers to herbivores to carnivores. At each step much of it is lost to the surroundings as heat, and that heat is never captured again by any organism. It therefore flows in **one direction only** and never returns to the sun — unlike nutrients, which are cycled.

Q. What is a food web? How is it different from a food chain?

In nature an organism is usually eaten by more than one kind of animal and itself eats several kinds of food, so the food chains interlink into a network — the **food web**. A food chain is a single straight-line sequence, while a food web shows all the possible feeding relationships in an ecosystem, and so is far more realistic and more stable.

Q. Why are decomposers important?

They break down the complex organic matter of dead plants and animals and their waste products into simple inorganic substances, which are returned to the soil and water to be used again by producers. Without them, nutrients would stay locked up in dead bodies and the nutrient cycle would come to a halt.

Q. What can we do to reduce the problem of waste disposal? Explain the three Rs.

Reduce — use less, and stop wasting electricity and water. **Reuse** — use an article again rather than throwing it away, as with envelopes and glass jars. **Recycle** — collect plastic, paper, glass and metal and send them to be made into fresh articles. Segregating biodegradable and non-biodegradable waste at home is the first practical step.

— Chapter 13 Complete —

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