⚗ Chemical Reactions and Equations

Science — Chemistry | Chapter 1 | NCERT Class 10

1. Chemical Reactions — Introduction

CHEMICAL REACTION → A process in which one or more substances are converted into one or more new substances with different properties. The original substances are called **Reactants** and the new substances are called **Products**.

Signs / Evidences of a Chemical Reaction

① **Change in State** — e.g., solid + liquid → gas (wax burning)

② **Change in Colour** — e.g., copper turns green (basic copper carbonate forms)

③ **Evolution of Gas** — e.g., zinc + dilute H_2SO_4 → H_2 gas released with effervescence

④ **Change in Temperature** — heat released (exothermic) or absorbed (endothermic)

⑤ **Formation of Precipitate** — insoluble solid formed; e.g., $BaSO_4\downarrow$ (white ppt) when $BaCl_2$ + Na_2SO_4 react

⚠ **परीक्षा के लिए** | All 5 evidences must be remembered — frequently asked in board exams as "How do we know a chemical reaction has taken place?"

2. Chemical Equations

CHEMICAL EQUATION → A symbolic representation of a chemical reaction using chemical formulae of reactants and products. Reactants on left, products on right, separated by arrow (→).

Word Equation → Symbol Equation

→ Word equation example: Magnesium + Oxygen → Magnesium oxide

SYMBOL EQUATION →

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

→ **Skeletal / Unbalanced equation** — does not follow Law of Conservation of Mass

→ **Balanced equation** — number of atoms of each element equal on both sides

Writing a Chemical Equation — Steps

① Write word equation (reactants → products)

② Replace names with correct chemical formulae

③ Balance the equation by adjusting coefficients (never change subscripts)

④ Add state symbols: (s) solid, (l) liquid, (g) gas, (aq) aqueous

⑤ Add conditions above/below arrow: heat (Δ), catalyst, light (hv), pressure etc.

State Symbols

→ **(s)** = Solid | **(l)** = Liquid | **(g)** = Gas | **(aq)** = Aqueous solution

→ ↑ = gas evolved upward | ↓ = precipitate formed

→ Δ above arrow = heat required | **hv** = light required

⚠ **परीक्षा के लिए** | State symbols aur conditions — board mein equation likhte waqt ZAROOR daalo, marks milte hain

3. Balancing Chemical Equations

LAW OF CONSERVATION OF MASS → Mass can neither be created nor destroyed in a chemical reaction. Total mass of reactants = Total mass of products. (Given by **Antoine Lavoisier**, 1789)

Hit and Trial Method (Balancing by Inspection)

→ Change coefficients (numbers before formulae) only — never change subscripts inside formula

→ Start with the most complex formula, balance it first

→ Balance H and O atoms last (usually)

BALANCING EXAMPLE — $FE + H_2O \rightarrow$

Unbalanced: $Fe + H_2O \rightarrow Fe_3O_4 + H_2$

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

BALANCING EXAMPLE — $MG + O_2 \rightarrow$

Unbalanced: $Mg + O_2 \rightarrow MgO$

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

BALANCING EXAMPLE — $HNO_3 + CA(OH)_2 \rightarrow$

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

BALANCING EXAMPLE — $NAOH + H_2SO_4 \rightarrow$

$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

BALANCING EXAMPLE — $BACL_2 + H_2SO_4 \rightarrow$

$BaCl_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s)\downarrow + 2HCl(aq)$

4. Types of Chemical Reactions

4.1 Combination Reaction

COMBINATION REACTION → Two or more substances combine to form a single new substance. A + B → AB

→ Burning of coal: $C(s) + O_2(g) \rightarrow CO_2(g)$ — **exothermic**

REACTION 1 — BURNING OF MAGNESIUM

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$ [White powder, bright light]

REACTION 2 — QUICKLIME + WATER

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$$ [Slaked lime; heat released — exothermic]

REACTION 3 — H_2 + CL_2

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

★ **Most combination reactions are exothermic** — heat is released

4.2 Decomposition Reaction

DECOMPOSITION REACTION → A single compound breaks down into two or more simpler substances. AB → A + B. Opposite of combination.

→ Requires energy input: heat (**thermal decomposition**), electricity (**electrolytic decomposition**), or light (**photolytic decomposition**)

THERMAL DECOMP — CALCIUM CARBONATE (LIMESTONE)

$$CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$$ [Used in cement industry]

THERMAL DECOMP — FERROUS SULPHATE

$$2FeSO_4(s) \xrightarrow{\Delta} Fe_2O_3(s) + SO_2(g) + SO_3(g)$$ [Brown residue + smell of burning sulphur]

THERMAL DECOMP — LEAD NITRATE

$$2Pb(NO_3)_2(s) \xrightarrow{\Delta} 2PbO(s) + 4NO_2(g) + O_2(g)$$ [Brown fumes of NO_2]

ELECTROLYTIC DECOMP — WATER

$$2H_2O(l) \xrightarrow{\text{electric current}} 2H_2(g) + O_2(g)$$ [H_2:O_2 = 2:1 by volume at electrodes]

PHOTOLYTIC DECOMP — SILVER CHLORIDE

$$2AgCl(s) \xrightarrow{\text{sunlight}} 2Ag(s) + Cl_2(g)$$ [White AgCl turns grey-black]

PHOTOLYTIC DECOMP — SILVER BROMIDE

$$2AgBr(s) \xrightarrow{\text{sunlight}} 2Ag(s) + Br_2(g)$$ [Used in black-and-white photography]

⚠ **परीक्षा के लिए** | Decomposition reactions are endothermic (energy is ABSORBED). AgCl/AgBr in photography — board favourite question!

4.3 Displacement Reaction

DISPLACEMENT REACTION → A more reactive element displaces a less reactive element from its compound. A + BC → AC + B

REACTION — IRON DISPLACES COPPER

$$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$$ [Blue solution fades; copper deposits on iron nail]

REACTION — ZINC DISPLACES IRON

$$Zn(s) + FeSO_4(aq) \rightarrow ZnSO_4(aq) + Fe(s)$$

REACTION — ZINC DISPLACES HYDROGEN

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

→ Reactivity order: **Zn > Fe > H > Cu** — more reactive displaces less reactive

→ Blue colour of $CuSO_4$ fades as Cu^{2+} is replaced by Fe^{2+} (light green)

4.4 Double Displacement Reaction

DOUBLE DISPLACEMENT → Two compounds react by exchanging ions to form two new compounds. Usually one product is a precipitate, gas, or water. AB + CD → AD + CB

REACTION — $BACL_2 + NA_2SO_4$

$$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s)\downarrow + 2NaCl(aq)$$ [White precipitate of $BaSO_4$]

REACTION — $PB(NO_3)_2 + KI$ (ACTIVITY 1.10)

$$Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s)\downarrow + 2KNO_3(aq)$$ [Yellow precipitate of PbI_2]

REACTION — NAOH + HCL (NEUTRALISATION)

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$ [Acid + Base → Salt + Water]

PRECIPITATION REACTION → A type of double displacement where an insoluble solid (precipitate ↓) is formed. Used to test for SO_4^{2-}, Cl^-, CO_3^{2-} ions.

⚠ **परीक्षा के लिए |** Neutralisation is a type of double displacement. Always write "salt + water" as products for acid-base reactions.

4.5 Oxidation and Reduction (Redox Reactions)

OXIDATION → Gain of oxygen OR loss of hydrogen OR loss of electrons. The substance oxidised is called the **reducing agent**.

REDUCTION → Loss of oxygen OR gain of hydrogen OR gain of electrons. The substance reduced is called the **oxidising agent**.

REDOX REACTION → Both oxidation AND reduction occur simultaneously. One substance gets oxidised while the other gets reduced.

REDOX EXAMPLE 1 — $CUO + H_2$

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

CuO: loses O → REDUCED (oxidising agent) | H_2: gains O → OXIDISED (reducing agent)

REDOX EXAMPLE 2 — ZNO + C

$$ZnO(s) + C(s) \xrightarrow{\Delta} Zn(s) + CO(g)$$

ZnO: loses O → REDUCED | C: gains O → OXIDISED

REDOX EXAMPLE 3 — MNO_2 + HCL

$$MnO_2(s) + 4HCl(aq) \rightarrow MnCl_2(aq) + 2H_2O(l) + Cl_2(g)$$

HCl: oxidised (loses H) | MnO_2: reduced (gains H / loses O)

→ **Oxidising agent**: gets reduced (gains electrons / adds O / removes H)

→ **Reducing agent**: gets oxidised (loses electrons / removes O / adds H)

→ Memory trick: **OIL RIG** — Oxidation Is Loss, Reduction Is Gain (of electrons)

⚠ **परीक्षा के लिए |** In CuO + H_2 reaction — identify oxidising and reducing agent separately. 2-mark question in board.

5. Effects of Oxidation in Everyday Life

5.1 Corrosion

CORROSION → Slow deterioration of metals by reaction with moisture, oxygen, acids, or other substances in their environment. Results in undesirable compounds forming on the metal surface.

→ **Rusting of Iron**: $4Fe + 3O_2 + xH_2O \rightarrow 2Fe_2O_3.xH_2O$ (Hydrated iron(III) oxide — reddish brown)

→ **Tarnishing of Silver**: $Ag + H_2S$ (in air) $\rightarrow Ag_2S$ (black tarnish)

→ **Copper Corrosion**: $Cu + H_2O + CO_2 \rightarrow CuCO_3.Cu(OH)_2$ (green patina — basic copper carbonate)

→ Corrosion causes huge economic loss — bridges, ships, vehicles, railway tracks affected

→ Prevention: painting, oiling, galvanising, alloying, electroplating, chrome plating

5.2 Rancidity

RANCIDITY → Oxidation of fats and oils in food, making them smell and taste unpleasant (stale/off). The food becomes unfit for consumption. Scientific term for food "going rancid."

→ Causes: prolonged exposure to oxygen, moisture, heat, and light

→ **Methods to prevent rancidity:**

① **Antioxidants added** — e.g., BHA, BHT in packaged chips; Vitamin C (ascorbic acid)

② **Nitrogen flushing** — chips packets filled with N_2 gas instead of air (no O_2)

③ **Refrigeration** — slows down oxidation rate

④ **Airtight containers** — less contact with oxygen

⑤ **Dark containers** — less light exposure

⚠ **परीक्षा के लिए** | Why are chips packets filled with nitrogen? — Rancidity prevention. Very commonly asked board question!

6. Exothermic and Endothermic Reactions

EXOTHERMIC REACTION → Chemical reaction in which **heat is released** to the surroundings. Products have less energy than reactants. Temperature of surroundings INCREASES.

ENDOTHERMIC REACTION → Chemical reaction in which **heat is absorbed** from the surroundings. Products have more energy than reactants. Temperature of surroundings DECREASES.

Property	Exothermic	Endothermic
Heat	Released	Absorbed
Temp change	Surroundings heat up	Surroundings cool down
Example	Burning, respiration, $CaO+H_2O$	Photosynthesis, decomposition, dissolving NH_4Cl
Energy of products	Less than reactants	More than reactants

EXOTHERMIC — NATURAL GAS BURNING

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) + \text{Heat}$$

EXOTHERMIC — RESPIRATION

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

ENDOTHERMIC — PHOTOSYNTHESIS

$$6CO_2(aq) + 6H_2O(l) \xrightarrow{\text{sunlight}} C_6H_{12}O_6(aq) + 6O_2(g)$$

★ **Decomposition reactions are endothermic** (energy needed to break bonds)

★ **Combination reactions are mostly exothermic** (energy released when bonds form)

7. Summary Table — Types of Reactions

Type	Pattern	Key Example	Energy
Combination	A + B → AB	$2Mg + O_2 \rightarrow 2MgO$	Exothermic
Decomposition	AB → A + B	$CaCO_3 \rightarrow CaO + CO_2$	Endothermic
Displacement	A + BC → AC + B	$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$	Varies
Double Displacement	AB + CD → AD + CB	$BaCl_2 + Na_2SO_4 \rightarrow BaSO_4\downarrow + 2NaCl$	Varies
Oxidation	Gain of O / Loss of H	$2Mg + O_2 \rightarrow 2MgO$	Usually exo

Reduction	Loss of O / Gain of H	$CuO + H_2 \rightarrow Cu + H_2O$	Varies

8. Important NCERT Activities — Summary

Activity	Observation	Inference
1.1 Magnesium ribbon burns	Bright white light; white powder (MgO) formed	Chemical change; combination rxn
1.2 $CuSO_4$ + Fe nail	Blue solution fades; brown copper deposits on nail	Displacement rxn; Fe > Cu in reactivity
1.3 $BaCl_2$ + Na_2SO_4	White precipitate ($BaSO_4$) forms immediately	Double displacement; precipitation rxn
1.4 CaO + H_2O	Heat released; $Ca(OH)_2$ (slaked lime) formed	Combination rxn; exothermic
1.5 AgCl in sunlight	White AgCl → grey-black (Ag forms)	Photolytic decomposition
1.6 $CuSO_4$ electrolysis	Cu deposits at cathode; O_2 at anode	Electrolytic decomposition
1.7 $FeSO_4$ heated	Green crystals → brown Fe_2O_3; SO_2 smell	Thermal decomposition
1.8 $Pb(NO_3)_2$ + KI	Yellow precipitate (PbI_2)	Double displacement; precipitation
1.9 CuO + H_2	Black CuO → reddish Cu; water droplets on tube wall	Redox rxn; CuO reduced, H_2 oxidised
1.10 Rancid butter smell	Smell of old/stale butter	Oxidation of fats = rancidity

⚠ **परीक्षा के लिए** | Activity-based questions carry 2–3 marks. Learn observation + inference for each NCERT activity above.

9. Important Formulae and Reactions — Quick Revision

KEY FORMULA — REACTANT → PRODUCT

Reactants (Left) → Products (Right) | Balanced using coefficients only

Decomposition Reactions

THERMAL

$$CaCO_3 \rightarrow CaO + CO_2$$

$$2FeSO_4 \rightarrow Fe_2O_3 + SO_2 + SO_3$$

$$2Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2 + O_2$$

ELECTROLYTIC

$$2H_2O \rightarrow 2H_2 + O_2$$

PHOTOLYTIC

$$2AgCl \rightarrow 2Ag + Cl_2$$

$$2AgBr \rightarrow 2Ag + Br_2$$

Combination Reactions

KEY COMBOS

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

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

$$H_2 + Cl_2 \rightarrow 2HCl$$

$$C + O_2 \rightarrow CO_2$$

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Displacement

DISPLACEMENT

$$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$$

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2\uparrow$$

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

Double Displacement — Key Reactions

NEUTRALISATION

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

PRECIPITATION

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

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

10. NCERT In-Text Q&A — Key Concepts

Section 1.1 — Chemical Equations (Pg 6)

Q1. Why should a balanced equation obey Law of Conservation of Mass? → Atoms are neither created nor destroyed; total atoms on both sides must be equal.

Q2. Write balanced equation for: Hydrogen + Chlorine → Hydrogen chloride

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

Q3. Barium Chloride + Aluminium Sulphate → Barium Sulphate + Aluminium Chloride

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

Section 1.2 — Types of Reactions (Pg 13)

Q1. A solution of substance X is used for whitewashing. Name X and write reaction with water.

X = CaO (Quicklime/Calcium oxide). $CaO + H_2O \rightarrow Ca(OH)_2$ (Slaked lime)

Q2. Why is decomposition reaction opposite to combination? → Combination: A+B → AB (merging). Decomposition: AB → A+B (breaking). Exactly opposite direction.

Section 1.3 — Oxidation (Pg 18)

Q1. Define the terms: Oxidation = gain of O / loss of H. Reduction = loss of O / gain of H.

Q2. What is a reducing agent? → Substance that reduces another (itself gets oxidised). E.g., H_2 in CuO + H_2 reaction.

11. What Have You Learnt — Chapter Summary

- ✔ A **chemical reaction** involves transformation of substances with evidence like colour change, gas evolution, precipitate, temperature/state change.
- ✔ Chemical equations use formulae; must be balanced to satisfy **Law of Conservation of Mass**.
- ✔ State symbols (s, l, g, aq) and condition symbols (Δ, light, catalyst) make equations more informative.
- ✔ **Combination**: A+B → AB (mostly exothermic). **Decomposition**: AB → A+B (endothermic).
- ✔ Decomposition types: **thermal** (heat), **electrolytic** (electricity), **photolytic** (light).
- ✔ **Displacement**: more reactive displaces less reactive element. **Double displacement**: exchange of ions; gives precipitate/water/gas.
- ✔ **Oxidation** = gain O/loss H. **Reduction** = loss O/gain H. Both happen simultaneously in **redox reactions**.
- ✔ **Exothermic**: heat released (combination, respiration, combustion). **Endothermic**: heat absorbed (decomposition, photosynthesis).
- ✔ **Corrosion**: metals reacting with environment (rusting of Fe, tarnishing of Ag, patina of Cu). Prevented by painting, alloying, galvanising.
- ✔ **Rancidity**: oxidation of fats/oils in food. Prevented by antioxidants, N_2 flushing, refrigeration, airtight containers.

⚠ **परीक्षा के लिए** | Most important reactions to memorise: $Mg+O_2$, $CaO+H_2O$, $CaCO_3 \rightarrow CaO+CO_2$, $Fe+CuSO_4$, $BaCl_2+Na_2SO_4$, $CuO+H_2$, $2AgCl \rightarrow sunlight \rightarrow 2Ag+Cl_2$