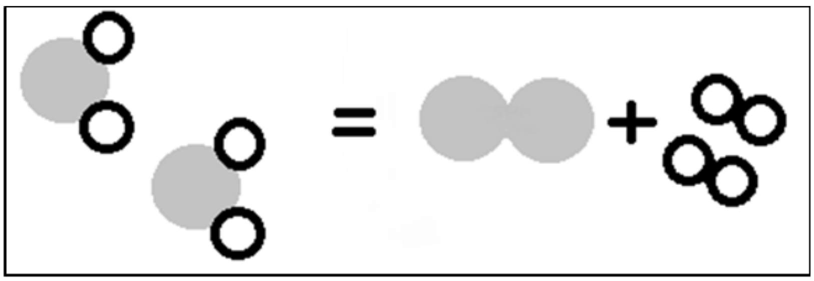
Chemical reactions

Observations that may indicate that a reaction has occurred include:

- New substance (product) is formed
- Reactants consumed
- Formation of a gas or precipitate
- Colour change
- Involvement of energy (gets hot or cold, light, etc…)

When a reaction occurs, bonds between atoms break and new bonds form

Ex. Water → hydrogen + oxygen



$$2\ H_2O_{(l)} \rightarrow O_{2\,(g)} + 2\ H_{2\,(g)}$$

The law of conservation of mass

- The total mass of all reactants before a chemical reaction equals the total mass of all products after the reaction
- Must include gases in a closed system (sealed container)

Components of a chemical reaction

Reactants: all chemicals consumed in a reaction
Products: any substance formed in a reaction

Word Equations

Reactants → Products

Ex. Ethanol burns in air to produce carbon dioxide and water vapour

Chemical Equations

The same number and kinds of atoms must be shown before and after a reaction.

a) Write correct formulae for all reactants and products
b) Once correct formulae are written, you **cannot change the subscripts**
c) Use **coefficients** in front of the formulae until each side is equal

Ex. $H_2 + O_2 \rightarrow H_2O$

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$Na + H_2O \rightarrow NaOH + H_2$

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$NH_3 + O_2 \rightarrow NO_2 + H_2O$

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Coefficients are related to the relative numbers of molecules or moles of molecules, of reactants and products in the reaction.

This is the **mole ratio**

Ex. $2C + O_2 \rightarrow 2CO$

For every mole of O_2 there are 2 moles of C used, and 2 moles of CO produced. For every C used, 1 CO is produced.

Show your Phases

$$2\ C_{(s)} + O_{2\ (g)} \rightarrow 2\ CO_{(g)}$$

s = solid g = gas aq = aqueous l = liquid al = alcohol

Types of Reactions (recall from sci 10)

Synthesis (or combination) reactions

A + B → AB

Ex. $CaO_{(s)} + CO_{2\ (g)} \rightarrow CaCO_{3\ (g)}$

Decomposition reactions

AB → A + B

Ex. $Ca(OH)_{2\ (s)} \rightarrow CaO_{\ (s)} + H_2O_{\ (g)}$

Combustion reactions

carbon source + oxygen → carbon dioxide + water

Ex. $CH_{4\ (g)} + 2\ O_{2\ (g)} \rightarrow CO_{2\ (g)} + 2\ H_2O_{(g)}$

Neutralization (acid-base) reactions

Acid + Base → salt + water
HA + BOH → BA + water

Ex. $HCl_{\ (aq)} + NaOH_{\ (aq)} \rightarrow NaCl_{\ (aq)} + H_2O_{\ (l)}$

Carbonate reactions

Carbonate salt + acid → salt + water + carbon dioxide

Ex. $CaCO_{3\ (s)} + 2\ HCl_{\ (aq)} \rightarrow CaCl_{2(aq)} + H_2O_{\ (l)} + CO_{2\ (g)}$

Single Replacement reactions

AB + C → AC + B or AB + C → CB + A

Ex. $Fe_{(s)} + CuCl_{2\,(aq)} \rightarrow FeCl_{2\,(aq)} + Cu_{(s)}$

Ex. $Br_{2\,(l)} + 2\,NaI_{(aq)} \rightarrow 2NaBr_{(aq)} + I_{2\,(s)}$

Double replacement reactions

AB + CD → AD + CB

Ex. $CuNO_{3\,(aq)} + NaCl_{(aq)} \rightarrow CuCl_{(s)} + NaNO_{3\,(aq)}$

- Not all replacement reactions which can be written will occur. The element displacing must be more active than the element being replaced (see activity series in data booklet)

**Single replacement reactions, check activity series of common metals and non-metals (generally higher up on periodic table = more reactive)

**Double replacement reactions, check solubility in water

Predicting Products of a Reaction

The regularity that allows you to classify reactions into the above reaction types allows you to predict the results of reactions

Ex. $Mg_{(s)} + I_{2\ (s)} \rightarrow$ it has two elements reacting together – synthesis

Ex. $C_6H_{14\ (l)} + O_{2\ (s)} \rightarrow$ it has oxygen and a carbon source – combustion

Ex. $FeSO_{4\ (aq)} + K_2CO_{3\ (aq)} \rightarrow$ it has two salts in solution – double replacement – but will it precipitate? (Check data booklet)

Ex. $Mg_{(s)} + AlCl_{3\ (aq)} \rightarrow$ a salt plus a metal – single replacement – but will there be a reaction? (Check data booklet)

Ex. $HCl_{(aq)} + Sr(OH)_{2\ (aq)} \rightarrow$ something with an "H" in front, and something with "OH" – neutralization

Energy relationships in Chemical Equations

Chemical reactions involve the breaking and formation of chemical bonds

Breaking bonds requires energy and **making** bonds releases energy

The symbol we use for energy change is ΔH – called **enthalpy.** Calculated as

$$\Delta H = H_{products} - H_{reactants}$$

And measured in joules (or sometimes in kilojoules)

Exothermic Reactions

More energy is released than is required to break the bonds, meaning that the products are more stable than the reactants. Energy is lost within the system

Energy is released to the surroundings – surroundings heat up, so exothermic reactions appear hot to observers

Have a negative enthalpy (ΔH = -)

Ex. $2\ H_{2\,(g)} + O_{2\,(g)} \rightarrow 2H_2O_{(l)} + 572\ kJ$

Or... $2\ H_{2\,(g)} + O_{2\,(g)} \rightarrow 2H_2O_{(l)} \quad \Delta H = -572\ kJ$

Endothermic Reactions

More energy is required to break the bonds than is released, meaning that the reactants are more stable than the products. Energy is gained within the system

Energy is taken from the surroundings – surroundings get cold, so endothermic reactions appear cold to observers

Have a positive enthalpy (ΔH = +)

Ex. $572\ kJ + 2H_2O_{(l)} \rightarrow 2\ H_{2\,(g)} + O_{2\,(g)}$

Or... $2H_2O_{(l)} \rightarrow 2\ H_{2\,(g)} + O_{2\,(g)} \quad \Delta H = +572\ kJ$

Potential Energy Diagrams