

C7 Alkenes and alcohols

Separate Chemistry Paper 2 extras | AQA 8462 | Core: Foundation + Higher

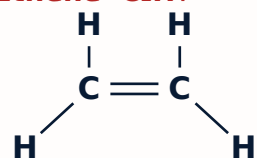
Supplement to shared topic notes: revise the main topic sheets as well.

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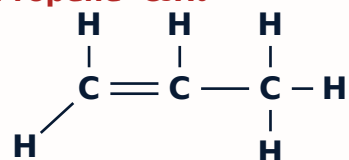
Recognise and draw alkenes

An alkene has a **C=C double bond**. Open-chain alkenes with one double bond follow C_nH_{2n} . They are unsaturated: more atoms can add across the double bond.

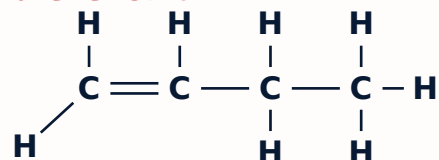
Ethene C_2H_4



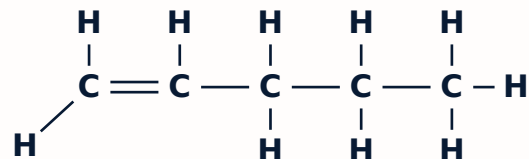
Propene C_3H_6



Butene C_4H_8



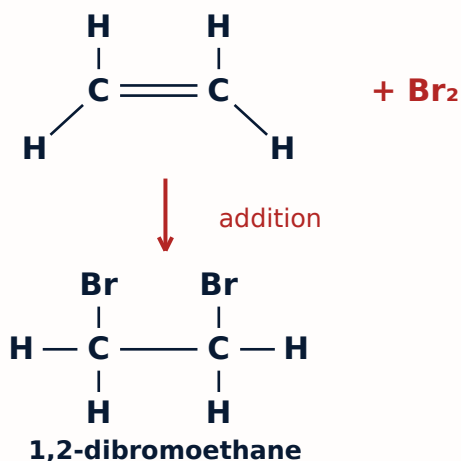
Pentene C_5H_{10}



The butene and pentene examples have the double bond at the end. Check every carbon has **four bonds** and every hydrogen has one.

Addition at the C=C bond

One bond of $C=C$ opens. Each carbon forms one new bond, leaving a C-C single bond. One organic product forms.



Add to alkene	Product and conditions
Hydrogen, H_2	Alkane; heated with a nickel catalyst.
Steam, H_2O	Alcohol; high temperature and pressure, acid catalyst.
Cl_2 , Br_2 or I_2	Two halogen atoms add; room temperature.

Bromine water changes from **orange to colourless**. Alkenes can burn with smoky flames in air because combustion is incomplete.

Alcohols: the -OH group

Name	Condensed formula
Methanol	CH_3OH
Ethanol	CH_3CH_2OH
Propanol	$CH_3CH_2CH_2OH$
Butanol	$CH_3CH_2CH_2CH_2OH$

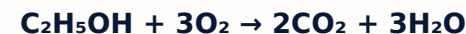
Alcohols are used as **fuels and solvents**. These first alcohols dissolve in water to form neutral solutions; longer chains are less soluble.

With sodium: hydrogen bubbles form and a salt is made.

In air: complete combustion makes carbon dioxide and water.

With an oxidising agent: these primary alcohols form carboxylic acids.

Ethanol combustion:



Fermentation produces ethanol

Yeast acts on a sugar solution in warm conditions, about **25-35°C**, without oxygen. Glucose produces ethanol and carbon dioxide. Too cold is slow; excessive heat denatures yeast enzymes.

Recognise the -OH group attached to carbon. The balanced combustion equation is the alcohol reaction equation you need to construct.

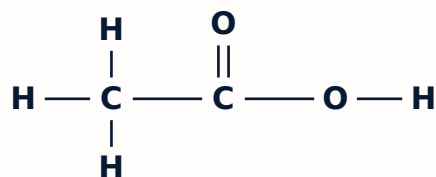
C7 Carboxylic acids and polymers

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Supplement to shared topic notes: revise the main topic sheets as well.

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Carboxylic acids and esters



Ethanoic acid: -COOH group

Name	Condensed formula
Methanoic acid	HCOOH
Ethanoic acid	CH ₃ COOH
Propanoic acid	CH ₃ CH ₂ COOH
Butanoic acid	CH ₃ CH ₂ CH ₂ COOH

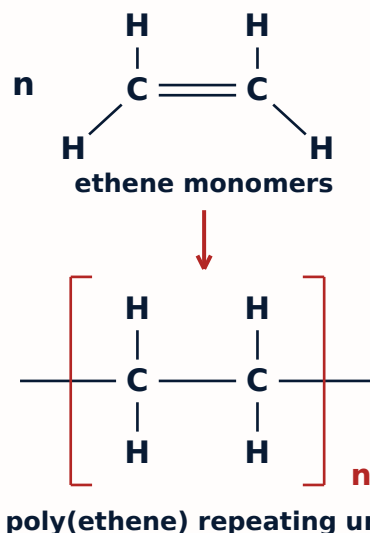
The **-COOH group** determines characteristic reactions. These acids dissolve in water to make acidic solutions.

With carbonates: a salt, water and carbon dioxide form. Fizzing is observed; the gas turns limewater cloudy.

With alcohols: an ester and water form. Warm with an acid catalyst. Ethanoic acid + ethanol form **ethyl ethanoate** + water.

Many esters have fruity smells and are used in perfumes or flavourings. Recognise ethyl ethanoate; further ester names are not required.

Addition polymerisation



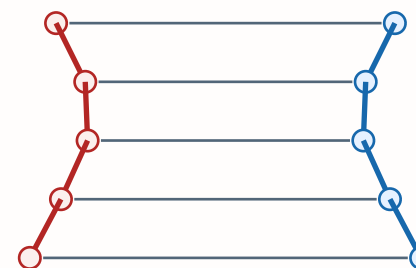
Many alkene **monomers** join to make one long polymer chain. The repeat unit contains the **same atoms** as the monomer: no small molecule is lost.

To draw a repeat unit: change C=C to C-C, retain the attached groups, show bonds continuing through both brackets, then add **n**.

To recover the monomer: remove the brackets and chain continuation bonds, then restore the C=C bond.

Poly(propene): the CH₃ side group stays attached to the same backbone carbon. Do not put it into the main chain or delete it.

Naturally occurring polymers



Untwisted DNA schematic

The molecule twists into a double helix

DNA stores genetic instructions. Most DNA molecules have two chains arranged as a double helix. Their monomers are **nucleotides**; four different nucleotide types are used.

Natural polymer	Monomers
DNA	Nucleotides
Protein	Amino acids
Starch	Glucose molecules
Cellulose	Glucose molecules

Different monomer sequences and structures give polymers different functions.

Tier boundary: addition polymers and this natural-polymer knowledge are core. Explaining amino-acid and condensation reactions belongs on the Higher page.

C7 Weak acids and condensation polymers

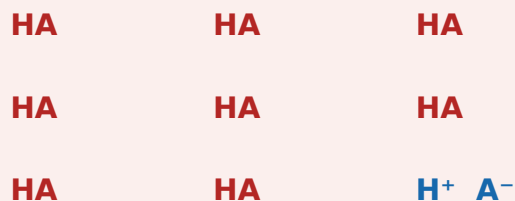
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Weak acids: partial ionisation

A carboxylic acid ionises only partly in water. Most acid particles remain molecules; only some release H^+ ions. Use a reversible arrow:



Mostly molecules; few ions

At the **same concentration**, a weak acid has fewer H^+ ions than a strong acid, so it has a **higher pH**. A strong acid is fully ionised in water.

Strength describes the fraction ionised.

Concentration describes the amount of acid per unit volume. A weak acid can be concentrated.

A decrease of one pH unit corresponds to a tenfold increase in hydrogen-ion concentration. For example, pH 3 has 100 times the H^+ concentration of pH 5.

The particle picture is schematic; its ionised fraction is not a measured value.

Condensation: two end groups

Monomers have **two functional groups**, so each molecule can link at both ends. When a link forms, a small molecule, often water, is eliminated.

A **diol** has two $-\text{OH}$ groups. A **dicarboxylic acid** has two $-\text{COOH}$ groups. Together they make a **polyester**.



Ester link: $-\text{C}(=\text{O})-\text{O}-$

At each ester link, $-\text{OH}$ from the acid group and H from the alcohol group leave as H_2O . R and R' represent the rest of the carbon-containing groups.

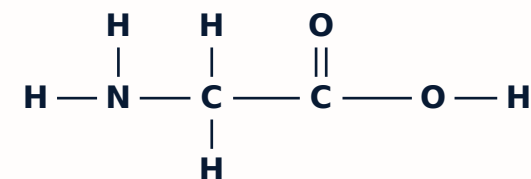
Example monomers:



A repeat unit contains residues of both monomers joined by ester links. Account for the atoms lost as water; do not copy both monomers unchanged.

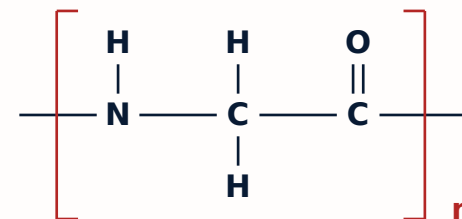
Compare: addition keeps all monomer atoms in the polymer. Condensation produces a small-molecule by-product; its monomers need not contain $\text{C}=\text{C}$.

Amino acids and polypeptides



Glycine: $\text{H}_2\text{NCH}_2\text{COOH}$

An amino acid has an **amino group**, $-\text{NH}_2$, and a **carboxyl group**, $-\text{COOH}$. These two different groups let amino acids join by condensation.



Polypeptide made from glycine

A peptide link is $-\text{C}(=\text{O})-\text{NH}-$. Water is released when the carboxyl group of one amino acid joins the amino group of another.

Many amino acids form a **polypeptide**.

Different amino acids can join in the same chain to produce proteins; their sequence affects the protein produced.

Check bonds: carbon has four, neutral nitrogen three, oxygen two and hydrogen one. The repeat-unit bonds pass through the brackets.

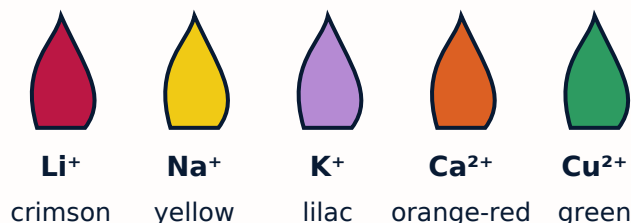
C8 Identify metal ions

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Flame tests



A clean wire loop is dipped into the sample and placed in a **non-luminous blue flame**. Observe the flame colour. Clean the loop between samples until it gives no colour.

Metal ion	Flame colour
Lithium	Crimson
Sodium	Yellow
Potassium	Lilac
Calcium	Orange-red
Copper	Green

A contaminated loop can give a false result. In a **mixture**, one flame colour may mask another; a visible colour does not prove only one metal ion is present.

Use the colour **names** as well as the illustrations: printers and screens reproduce colours differently.

For supervised school work: follow the teacher's method and wear eye protection.

Sodium hydroxide tests



Add sodium hydroxide solution to a fresh portion of the sample, then add **excess**. A precipitate is an insoluble solid formed in the liquid.

Ion	Precipitate	In excess NaOH
Al ³⁺	White	Dissolves
Ca ²⁺	White	Remains
Mg ²⁺	White	Remains
Cu ²⁺	Blue	Remains
Fe ²⁺	Green	Remains
Fe ³⁺	Brown	Remains

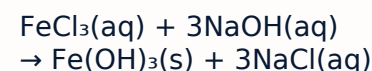
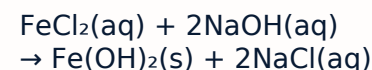
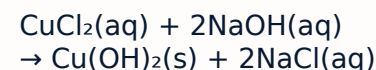
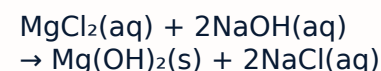
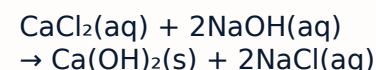
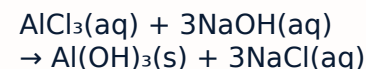
A white precipitate alone cannot distinguish aluminium, calcium and magnesium. Use the excess-NaOH result and, where useful, a flame test.

A calcium flame is orange-red. Magnesium is not one of the five specified diagnostic flame colours.

Balanced hydroxide equations

Balance every element on both sides. Change the large numbers in front of formulae, **not subscripts**. Hydroxide precipitates have state symbol (**s**).

Full formula equation: chloride examples



Each starting salt here is a soluble chloride. Sodium chloride remains dissolved, while the metal hydroxide forms a precipitate.

Equations for aluminium hydroxide dissolving in excess NaOH are not required. The equations above are suitable for both tiers.

C8 Anions, practical work and instruments

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Supplement to shared topic notes: revise the main topic sheets as well.

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Tests for negative ions

Ion	Reagent and positive result
Carbonate, CO_3^{2-}	Add dilute acid. CO_2 bubbles form; the gas turns limewater cloudy.
Chloride, Cl^-	Dilute nitric acid, then silver nitrate: white precipitate.
Bromide, Br^-	Dilute nitric acid, then silver nitrate: cream precipitate.
Iodide, I^-	Dilute nitric acid, then silver nitrate: yellow precipitate.
Sulfate, SO_4^{2-}	Dilute hydrochloric acid, then barium chloride: white precipitate.

Acid removes carbonate ions that could otherwise form a misleading precipitate. For halides, **do not use hydrochloric acid**: it adds chloride ions.

Silver halide precipitates: AgCl , AgBr and AgI . The sulfate precipitate is **BaSO_4** . Record both the reagent and the observation.

Fizzing alone does not identify CO_2 ; include the limewater result.

RP7: identify an unknown salt

1. Label clean test tubes and prepare a solution if needed.
2. Use **fresh, separate portions** for different tests.
3. Record observations before naming ions.
4. Combine cation and anion evidence.

Observation	Conclusion
Blue solid with NaOH	Copper(II) ions present
White solid with acidified BaCl_2	Sulfate ions present
Both in a single ionic compound	Copper(II) sulfate

Use clean apparatus and separate droppers to prevent contamination. Repeat doubtful tests; compare with known samples when available.

8462 Paper 2 practical numbers

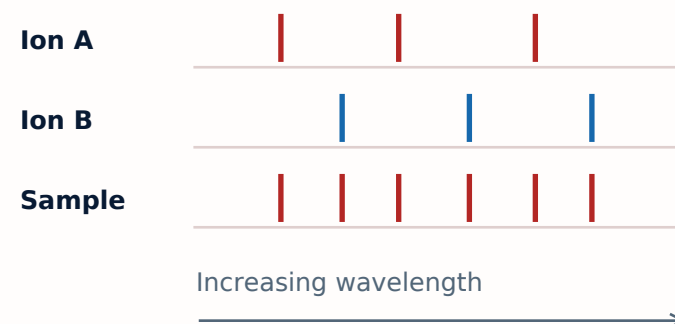
Number	Focus
RP5	Concentration and reaction rate
RP6	Paper chromatography and R_f
RP7	Identify ions in unknown salts
RP8	Water analysis and purification

The other practical methods are covered in shared notes. All ion-test content on these two pages is core.

Flame emission spectroscopy

A solution enters a flame. A spectroscope separates the emitted light into a **line spectrum**. Compare the pattern with reference spectra to identify metal ions.

Illustrative line patterns



The sample contains both A and B: its lines match both reference patterns. Match **positions**, not just the number of lines.

Measure emission intensity and compare with calibration data to determine **concentration**. A larger calibrated signal can indicate more of that ion in solution.

Instrumental methods are **rapid, sensitive and accurate**. They can detect small quantities and identify mixtures that a simple flame colour may not resolve.

Use the reference data supplied in a question. The illustrative spectra above are not real spectra for named elements.

C10 Corrosion, alloys and ceramics

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Supplement to shared topic notes: revise the main topic sheets as well.

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Corrosion and protection

Corrosion is chemical attack on a material by its surroundings. Iron rusts when both **oxygen and water** are available.

Air + water



rust

Dry air



no rust

No oxygen



no rust

Compare identical clean iron nails. Dry air is kept dry using a drying agent. To exclude oxygen, use boiled water with an oil layer. Only air plus water gives rust.

Barrier protection: paint, grease or electroplating blocks air and water. A damaged non-sacrificial barrier can allow iron to rust.

Sacrificial protection: a more reactive metal oxidises in preference to iron. Zinc galvanising gives a barrier and protection even when scratched, while zinc remains electrically connected.

Aluminium forms a thin, adherent oxide layer that prevents further attack. Rust is not an equivalent protective layer.

Alloys: composition and use

Alloy	Composition / useful property / use
Bronze	Copper + tin; hard; statues and medals.
Brass	Copper + zinc; workable; fittings and musical instruments.
Gold alloy	Gold with silver, copper or zinc; harder jewellery.
High-carbon steel	Iron + more carbon; strong, brittle; cutting tools.
Low-carbon steel	Iron + less carbon; easily shaped; car bodies.
Stainless steel	Iron with chromium and nickel; resists corrosion; cutlery.
Aluminium alloy	Low density; aircraft bodies.

Different-sized atoms disrupt regular metal layers, making it harder for the layers to slide.

Gold percentage = carats ÷ 24 × 100.
18 carat = 75% gold. A 12 g piece of 18-carat gold alloy contains 9 g of gold.

Glass and clay ceramics

Material	Raw materials and manufacture
Soda-lime glass	Heat sand, sodium carbonate and limestone.
Borosilicate glass	Made using sand and boron trioxide; higher melting temperature than soda-lime glass.
Clay ceramics	Shape wet clay, then fire it at high temperature in a furnace.

Glass can be transparent, chemically resistant and easy to shape while hot. Uses include windows and containers. Choose heat-resistant glass for hot laboratory apparatus.

Clay ceramics include **bricks and pottery**. They are hard and resist heat, but can be brittle: they fracture instead of bending far.

Selecting a material from data

Link a property to the job: low density reduces mass; strength resists loading; corrosion resistance improves durability. Use figures if supplied, then consider cost and disadvantages.

Do not claim one material is universally best. The best choice depends on the required properties and the conditions of use.

C10 Polymers, ammonia and fertilisers

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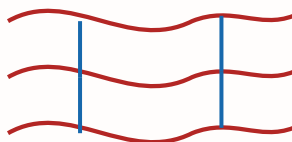
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Polymers and composites

Thermosoftening



Thermosetting



Blue lines = covalent cross-links

Thermosoftening: intermolecular forces hold separate chains together. Heating overcomes these forces, allowing chains to move; the material melts.

Thermosetting: covalent cross-links connect chains into a network. Chains cannot move past one another, so heating does not melt the material.

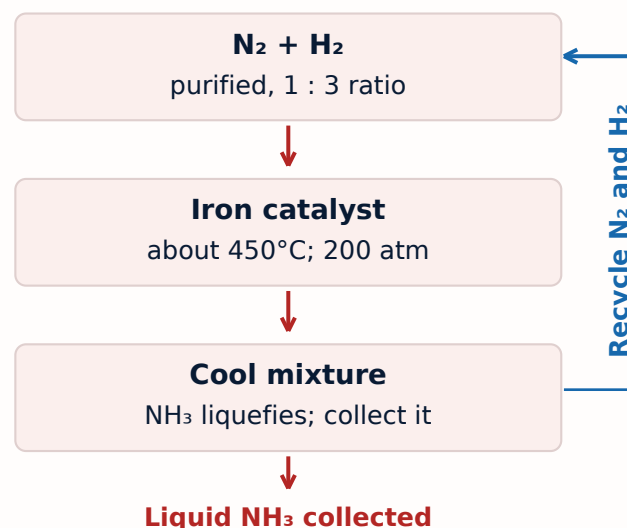
Both **LD and HD poly(ethene)** use ethene. LD is made at high temperature and pressure; HD uses lower temperature and pressure with a catalyst. Branched LD chains pack less closely; less-branched HD chains pack more closely.

Properties depend on the **monomers and manufacturing conditions**. LD poly(ethene) suits flexible bags; HD poly(ethene) suits rigid containers.

A **composite** combines a matrix or binder with reinforcement. Fibreglass: glass fibres in a polymer matrix. Concrete: aggregate bound by cement. Steel reinforcement improves concrete's tensile strength.

The Haber process

Ammonia is made from **nitrogen from air** and **hydrogen commonly obtained from natural gas**. Ammonia is used to make nitrogen fertilisers.



The reaction is **reversible**. Only some nitrogen and hydrogen react on each pass. Cooling removes liquid ammonia; unused gases return to the reactor.

The catalyst is **iron**. Learn the operating conditions: about **450°C** and **200 atmospheres**.

Core: know the feedstocks, conditions, reaction and recycling. Higher: explain why these conditions balance rate, equilibrium and cost.

NPK fertilisers

N, P and K are nitrogen, phosphorus and potassium. Formulations supply these elements in suitable proportions to replace nutrients removed from soil by crops.

Ammonia makes **ammonium salts** and **nitric acid**. For example:



Potassium chloride, potassium sulfate and phosphate rock are mined. Phosphate rock is not directly useful as fertiliser; acid treatment makes soluble phosphate salts.

Acid added to phosphate rock	Products
Nitric acid	Calcium nitrate and phosphoric acid
Sulfuric acid	Calcium sulfate + calcium phosphate: single superphosphate
Phosphoric acid	Calcium phosphate: triple superphosphate

Here, calcium phosphate means the soluble fertiliser salt **calcium dihydrogen phosphate**. Compare lab and industrial methods using scale, purity, speed, energy and cost.

In a lab, use measured neutralisation, then concentrate and crystallise an ammonium salt. Industry operates at larger scale with process controls and heat recovery.

C10 Haber process: the commercial trade-off

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Equilibrium and temperature



The forward reaction is **exothermic**. At equilibrium in a closed system, forward and reverse reactions have equal rates.

Lower temperature favours the exothermic direction, increasing the equilibrium proportion of ammonia. But particles react more slowly, so output per hour may be too low.

Higher temperature increases reaction rates, but favours the endothermic reverse reaction and reduces ammonia yield at equilibrium.

About 450°C is a compromise: a useful rate with an acceptable yield. Maximum equilibrium yield is not the same as maximum profitable production.

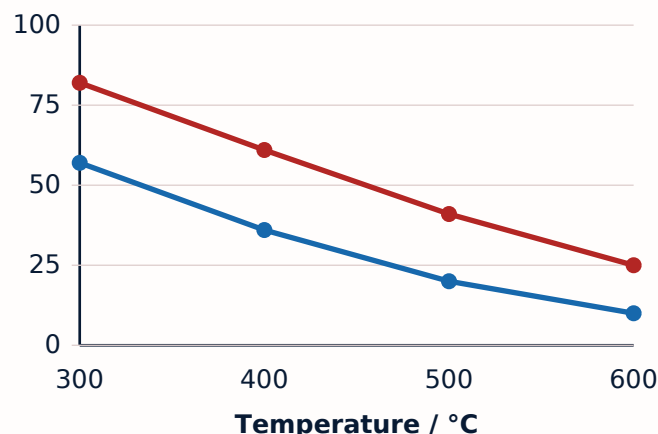
The iron catalyst

Iron lowers the activation energy for both directions. Equilibrium is reached faster, but the catalyst **does not change its position** or the equilibrium yield.

A catalyst can allow a commercially useful rate at a lower temperature, reducing energy costs. Do not describe it as increasing the equilibrium amount of ammonia.

Read yield and rate evidence

Equilibrium NH_3 / % (illustrative)



Red: higher pressure

Blue: lower pressure

At either pressure, equilibrium yield decreases as temperature rises. At the same temperature, higher pressure gives a larger equilibrium yield.

These are illustrative **equilibrium** curves, not measurements of rate. You cannot infer output per hour from yield alone.

For a rate graph, a steeper gradient means faster reaction. Compare the same time interval and use axis units. A plateau may show the final amount produced.

Choose conditions using both yield and rate data, then consider operating costs.

Pressure, recycling and cost

There are **four gas molecules** on the left of the equation for every **two** on the right. Higher pressure favours the side with fewer gas molecules, so ammonia yield increases.

Higher pressure also increases collision frequency and rate. However, compressing gases costs energy and strong pressure vessels cost more. About **200 atm** balances these benefits and costs.

Cooling the exit mixture liquefies ammonia so it can be removed. Recycling unreacted nitrogen and hydrogen improves the overall use of raw materials.

Read percentages carefully

If 20% of a reactant is converted on a pass, 80% remains. A second identical pass converts 20% of that remainder: $0.20 \times 80 = 16\%$ of the original amount. Total converted = **36%**.

This simple calculation assumes identical conversion each pass and no losses. Real plants manage flow, cooling, recycling and impurities.

A justified decision links **rate + equilibrium yield + energy and equipment costs + raw-material supply**. State which benefit is gained and what must be paid for it.