

C10 Corrosion, alloys and ceramics

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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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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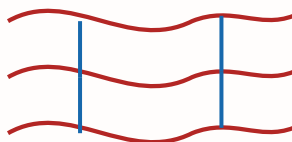
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Polymers and composites

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.

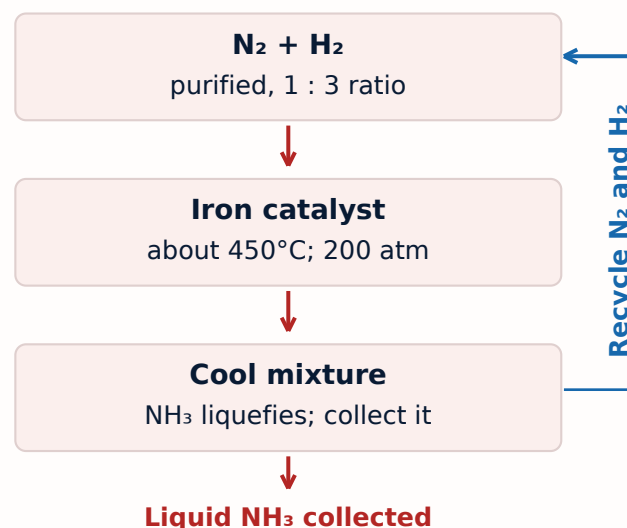
Both **LD and HD poly(ethene)** use ethene. LD is made at high temperature and pressure; HD uses lower temperature and pressure with a catalyst. Branched LD chains pack less closely; less-branched HD chains pack more closely.

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

Separate Chemistry Paper 2 extras | AQA 8462 | Higher Tier only

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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.

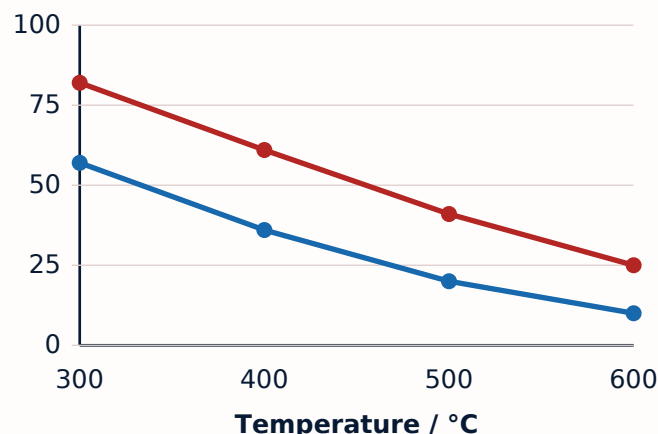
The iron catalyst

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.