Topic 10: Using resources

AQA GCSE Chemistry (8462), topic 4.10

Using resources: choose the route by the job it must do

- tell finite and renewable resources apart, and explain **sustainable development**;
- explain how **potable water** is produced from fresh water, sea water and waste water;
- (higher tier) describe **phytomining** and bioleaching for extracting copper;

Using resources: choose the route by the job it must do (2)

- carry out a **life cycle assessment** and compare reducing, reusing and recycling;
- (chemistry only) explain **corrosion** and its prevention, and choose alloys, ceramics, polymers and composites for a job;
- (chemistry only) describe the **Haber process** and the production of NPK fertilisers, and (higher tier) explain the choice of conditions.

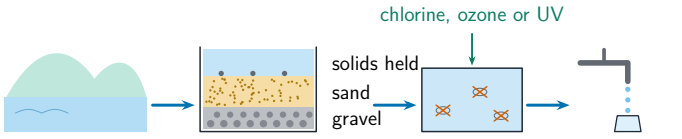
Resources and sustainable development

- We use Earth's resources for warmth, shelter, food and transport.
- Natural resources, supplemented by farming, give us food, timber, clothing and fuels.
- Chemistry also makes synthetic products, such as polyester fibres, that can replace natural ones.
- A **finite resource** will run out, because it is not replaced as fast as we use it: metal ores and fossil fuels are examples.

Potable water

- screening removes large objects, and grit settles out;
- **sedimentation** in large tanks separates it into **sludge**, which sinks, and **effluent**, the liquid on top;
- the **sludge** goes through **anaerobic digestion**: bacteria break it down without oxygen, producing methane gas that can be burned for energy;
- the **effluent** goes through **aerobic biological treatment**: air is bubbled through it so that other bacteria break down the remaining organic matter.

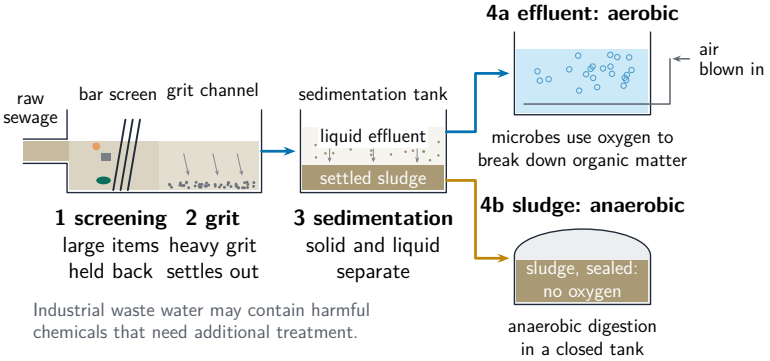
Figure: Potable water



salt water (sea water) is a different route: **distillation** or **reverse osmosis** removes the dissolved salts, but both need a lot of energy, so they are used only where fresh water is scarce.

- Fresh-water filtration and sterilisation, distinct from **desalination**.
- Match each part of the diagram to the text.

Figure: Potable water ·



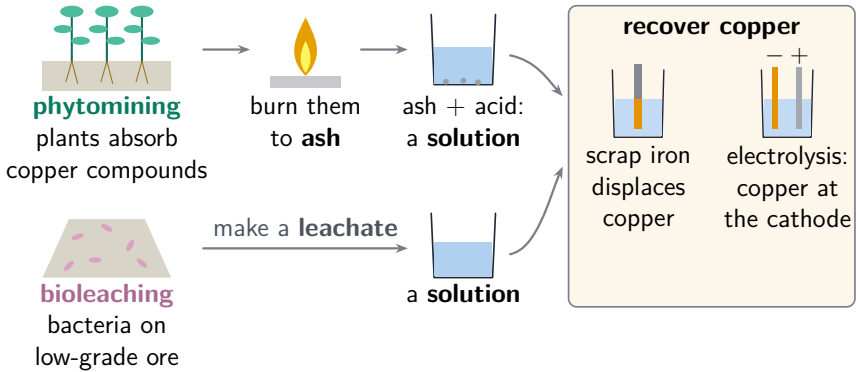
- **Sludge**: **anaerobic digestion**.
- **Effluent**: aerobic treatment.

Extracting copper with living things (higher tier)

- **Phytomining** uses plants to absorb metal compounds from the soil. The plants are harvested and burned, and the ash contains the metal compounds.
- **Bioleaching** uses bacteria to produce a solution, called a **leachate** , that contains metal compounds.

$$\mathrm{Fe} + \mathrm{CuSO_4} \rightarrow \mathrm{FeSO_4} + \mathrm{Cu}$$

Figure: Extracting copper with living things (higher tier)

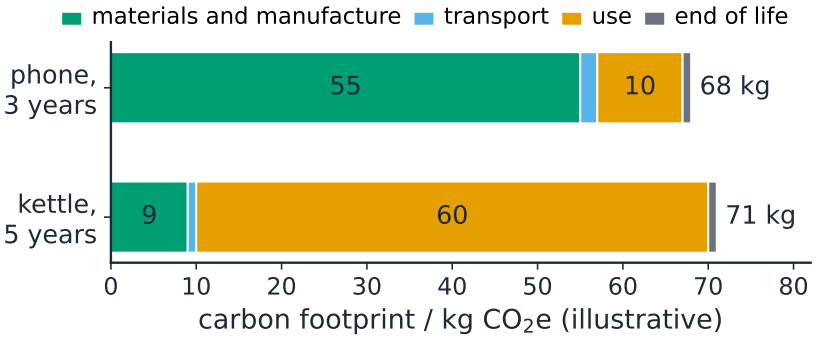


- Plants or bacteria collect copper compounds.
- Scrap iron or electrolysis recovers the copper.

Life cycle assessment

- A **life cycle assessment** (LCA) looks at the environmental impact of a product at every stage of its life:
- 1. extracting and processing the raw materials; 2. manufacturing and packaging; 3. use and operation during its lifetime; 4. disposal at the end of its life.
- Transport between stages is included too.
- The use of water, energy and resources, and the amount of some wastes, can be measured fairly easily.

Figure: Life cycle assessment



- Where the footprint comes from depends on the product (round numbers for teaching)
- Match each part of the diagram to the text.

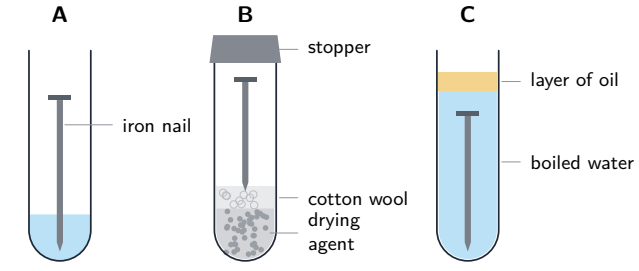
Reduce, reuse and recycle

- Using less material reduces the energy needed to extract and process it and the waste produced.
- Glass bottles can be reused after washing; or the glass can be crushed and melted to make new bottles.
- Metals can be melted and recycled; scrap steel is added to iron from the blast furnace, which reduces the amount of iron ore that must be mined.
- Recycling aluminium uses only about 5% of the energy needed to extract new aluminium from its ore.

Corrosion and its prevention (chemistry only)

- A barrier stops air and water reaching the metal: paint, oil or grease, or electroplating with another metal.
- **Sacrificial protection** uses a more reactive metal. Galvanised iron is coated with zinc. Zinc reacts in place of the iron, so even if the coating is scratched, the iron does not rust. Ships' hulls have blocks of zinc or magnesium fixed to them for the same reason.

Figure: Corrosion and its prevention (chemistry only)

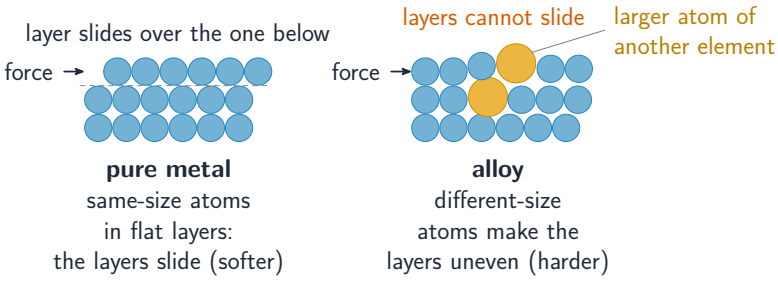


- Rusting needs both water and oxygen.
- Only tube A, with both, rusts.

Alloys (chemistry only)

- Most metals we use are alloys.
- In an **alloy** , atoms of different sizes distort the layers of metal atoms, so they slide over each other less easily.
- This makes alloys harder than pure metals.
- The purity of gold is measured in carats. 24 **carat** gold is pure gold, so 18 **carat** gold is $18/24 = 75\%$ gold. **Worked example 4.** A 12 g ring of 18 carat gold contains $12 \times 18/24 = 9$ g of gold.

Figure: Alloys (chemistry only)

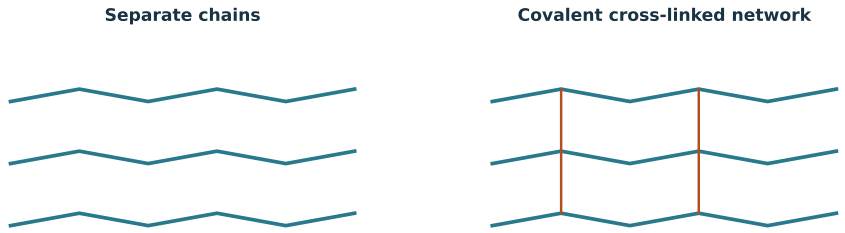


- Different-sized atoms disrupt the layers, so they slide less easily: one reason many alloys are harder than the pure metal
- Match each part of the diagram to the text.

Ceramics, polymers and composites (chemistry only)

- **Ceramics.** Most glass is soda-lime glass, made by heating sand, sodium carbonate and limestone.
- Borosilicate glass, made from sand and boron trioxide, melts at a higher temperature, so it is used for oven dishes and laboratory glassware.
- Clay ceramics, such as pottery and bricks, are made by shaping wet clay and heating it in a furnace.
- **Polymers.** The properties of a polymer depend on its monomer and on the conditions used to make it.

Figure: Ceramics, polymers and composites (chemistry only)



- Separate polymer chains and a covalent cross-linked network.
- Match each part of the diagram to the text.

The Haber process (chemistry only)

- Nitrogen comes from the air; hydrogen is made from natural gas.
- The purified gases are passed over an iron catalyst at about 450 °C and 200 atmospheres pressure.
- The reaction is reversible: $\mathrm{N_2} + 3\mathrm{H_2} \rightleftharpoons 2\mathrm{NH_3}$.

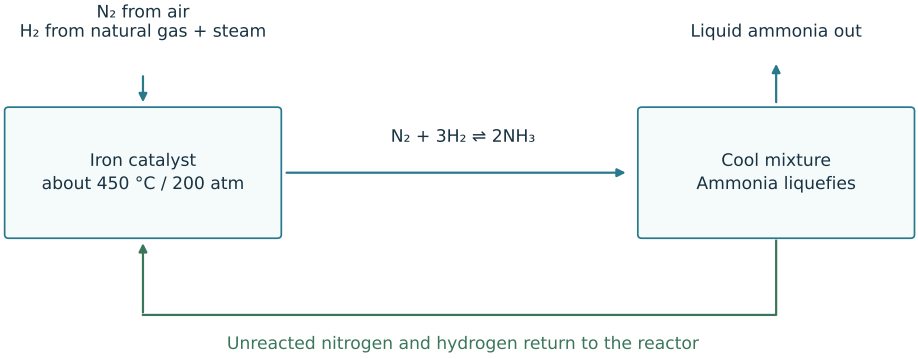
The Haber process (chemistry only) (2)

- The gas mixture is cooled, so the ammonia liquefies and is removed. The unreacted nitrogen and hydrogen are recycled back to the reactor.
- A low temperature would give a higher yield, but the reaction would be too slow. 450 °C is a compromise between a reasonable yield and a fast rate.

The Haber process (chemistry only) (3)

- A high pressure gives a higher yield, because there are 4 molecules of gas on the left and 2 on the right. It also increases the rate. But very high pressures need expensive, thick-walled equipment and a lot of energy, so 200 atmospheres is a compromise with cost and safety.
- The iron catalyst speeds up the reaction but does not change the yield.

Figure: The Haber process (chemistry only)

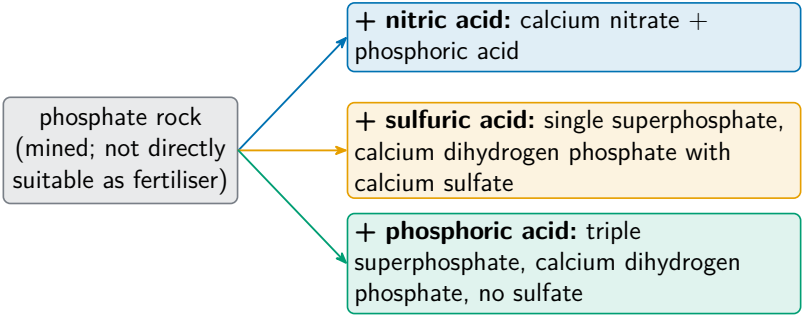


- Haber conditions, ammonia removal and a connected recycle loop.
- Match each part of the diagram to the text.

NPK fertilisers (chemistry only)

- Nitrogen: ammonia from the **Haber process** is used to make nitric acid and ammonium salts. Ammonia reacts with nitric acid to make ammonium nitrate: $\mathrm{NH_3} + \mathrm{HNO_3} \rightarrow \mathrm{NH_4NO_3}$.
- Potassium: potassium chloride and potassium sulfate are mined.
- Phosphorus: phosphate rock is mined, but it cannot be used directly because it does not dissolve. It is treated with acid to make soluble salts.

Figure: NPK fertilisers (chemistry only)



- Three acid treatments of phosphate rock and what each gives
- Match each part of the diagram to the text.

Sources for this lesson

- AQA, *GCSE Chemistry (8462) specification*, section 4.10, and the required practicals handbook (Required practical 8).
- PUB, Singapore's National Water Agency, "NEWater" (first plants opened February 2003; up to 40% of current demand).
- F. Haber, Nobel Lecture, "The synthesis of ammonia from its elements" (2 June 1920).

Sources for this lesson (2)

- V. Smil, *Enriching the Earth: Fritz Haber, Carl Bosch, and the Transformation of World Food Production* (2001).
- International Aluminium Institute, on the energy saving of recycling aluminium.

Common errors

- Saying **potable water** is pure water; it contains dissolved substances at safe levels.
- Saying filtration removes dissolved salts or kills microbes; it removes solid particles only.
- Saying iron rusts in water alone or in air alone; it needs both.

Common errors (2)

- Saying a scratched painted surface still protects iron; only **sacrificial protection** keeps working at a scratch.
- Saying thermosoftening polymers have no forces between chains; they have weak intermolecular forces, which are overcome on heating.
- Saying the **Haber process** uses the conditions for maximum yield; the conditions are a compromise with rate and cost.
- Saying **phytomining** produces pure copper directly; the ash must still be processed.

Key terms

- **Finite resource**: a resource that will run out because it is not replaced as fast as it is used.
- **Sustainable development**: meeting the needs of the present without harming the ability of future generations to meet theirs.
- **Potable water**: water that is safe to drink.

Key terms (2)

- **Life cycle assessment**: an assessment of the environmental impact of a product at each stage of its life.
- **Corrosion**: the destruction of a material by chemical reactions with its environment.
- **Sacrificial protection**: protecting a metal by attaching a more reactive metal that corrodes instead.

Key terms (3)

- **Composite**: a material made of a **reinforcement** held in a **matrix**.
- **Haber process**: the industrial manufacture of ammonia from nitrogen and hydrogen.

Check yourself

- 1.
- Is wood a finite or a **renewable resource**?
- Explain. 2.
- Why is sea water not made potable in the UK, even though there is plenty of it? 3.