4.10 Using Resources

Humans use the Earth's resources to provide warmth, shelter, food and transport.

Natural resources, supplemented by agriculture, provide food, timber, clothing and fuels.
Finite resources from the Earth, oceans and atmosphere are processed to provide energy and materials.

Chemistry plays an important role in improving agricultural and industrial processes to provide new products and in sustainable development, which is development that **meets the needs** of **current generations** without compromising the **ability of future generations** to meet their own needs.

Water

Water of the correct quality is essential for life. For humans, drinking water should have sufficiently low levels of dissolved salts and microbes

Water that is safe to drink is called **potable water**. Potable water is not **pure water** in the chemical sense because it contains **dissolved solid** substances.
Pure water would contain no dissolved solids.

The methods used to produce potable water depend on available supplies of water and local conditions.

Turning fresh water into drinking water
In the UK, rain provides water with low levels of dissolved substances (fresh water) that collects in the ground and in lakes and rivers and most potable water is produced by:

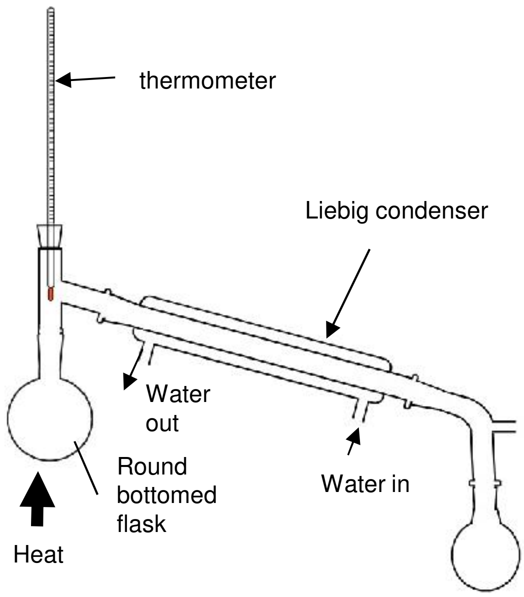
- choosing an appropriate source of fresh water
- passing the water through **filter beds** to remove any **solids**
- **sterilising** to kill **microbes**.

Sterilising agents
Sterilising agents used for potable water include **chlorine, ozone** or **ultra-violet light.**

- *Chlorine is a toxic gas so the amount added to water has to be carefully monitored.*
- *Using ultraviolet light to kill microbes avoids adding chemicals to the water but is more expensive.*

Turning sea water into drinking water
If supplies of fresh water are limited, desalination of salty water or sea water may be required. Desalination can be done by **distillation** or by processes that use membranes such as **reverse osmosis**. These processes require large amounts of energy.

Reverse Osmosis
Sea water is passed through a membrane that only allows through the water molecules. It needs high pressure to push the water through the membrane. The high pressure requires a lot of energy to produce.



Distillation has high energy costs because it requires heat to boil the water

Waste Water treatment

- Urban lifestyles and industrial processes produce large amounts of waste water that require treatment before being released into the environment.
- **Sewage and agricultural waste** water require removal of **organic matter** and **harmful microbes**.
- **Industrial waste** water may require removal of **organic matter** and **harmful chemicals**.

Sewage treatment includes:

- screening and grit removal
- sedimentation to produce sewage sludge and effluent
- anaerobic digestion of sewage sludge
- aerobic biological treatment of effluent

Extracting Copper

The Earth's resources of metal ores are limited. Copper ores are becoming scarce

New ways of extracting copper from low-grade ores include **phytomining**, and **bioleaching** can be used.

Phytomining uses plants to absorb metal compounds from the soil. The plants are harvested and then burned to produce ash that contains the metal compounds.
Bioleaching uses bacteria to produce leachate solutions that contain metal compounds.

The metal compounds formed in phytomining and bioleaching can be processed to obtain the metal. For example, copper can be obtained from solutions of copper compounds by displacement using scrap iron or by electrolysis

Equation for Displacement reaction using scrap iron: $Fe + CuSO_4 \rightarrow Cu + FeSO_4$

Advantages of these methods

- need less energy than traditional methods
- can extract from low grade/ concentration ores
- mining not required
- avoid the disadvantages of traditional mining methods of digging, moving and disposing of large amounts of rock.

Disadvantages of these methods
Reactions slow to carry out.
Will produce small amounts of metal

Life Cycle Assessments (LCAs)

Life Cycle Assessments (LCAs) are carried out to assess the environmental impact of products in each of these stages:

- extracting and processing raw materials
- manufacturing and packaging
- use and operation during its lifetime
- disposal at the end of its useful life, including transport and distribution at each stage.

Energy, water, resource consumption and production of some wastes can be fairly easily quantified.
Allocating numerical values to pollutant effects is less straightforward and requires value judgements, so LCA is not a purely objective process.
Selective or abbreviated LCAs can be devised to evaluate a product but these can be misused to reach pre-determined conclusions, e.g. in support of claims for advertising purposes

Ways of reducing the use of resources
The reduction in use, reuse and recycling of materials by end users reduces the use of limited resources, energy consumption, waste and environmental impacts.
Metals, glass, building materials, clay ceramics and most plastics are produced from limited raw materials.
Much of the energy used in the processes comes from limited resources. Obtaining raw materials from the Earth by quarrying and mining causes environmental impacts.

Questions on LCAs will generally involve using data given in a table. Use the data given and combine with your knowledge about areas like pollution and waste

Reusing or recycling?
Some products, such as glass bottles, can be reused.
Other products cannot be reused and so are recycled for a different use. Glass bottles can be crushed and melted to make different glass products.
Metals can be recycled by melting and recasting or reforming into different products.
The amount of separation required for recycling depends on the material and the properties required of the final product. For example, some scrap steel can be added to iron from a blast furnace to reduce the amount of iron that needs to be extracted from iron ore.

Advantages of recycling:

- less acid rain (pollution)
- metal ore reserves last longer / conserved
- energy for extraction saved
- less mining / quarrying
- less waste
- less landfill
- creates local employment

Disadvantages of recycling

- collection problems
- transport problems/ cost of transport
- difficult to separate metal from appliances/sort

Corrosion and its Prevention

Chemistry only

Corrosion is the destruction of materials by chemical reactions with substances in the environment.

Rusting is an example of corrosion. Both **air** and **water** are necessary for iron to rust. *The iron forms rust which is hydrated iron oxide, which flakes off allowing more iron to corrode*

Iron + oyxgen + water → hydrated iron oxide

Preventing Corrosion

Corrosion can be prevented by applying a coating that acts as a barrier, such as greasing, painting or electroplating. These methods stop the air or water coming into contact with the metal.

Aluminium has an oxide coating that protects the metal from further corrosion.

Sacrificial protection

Some coatings are reactive and may contain corrosion inhibitors or a **more reactive metal**.

If two metals are in contact the more reactive metal will corrode instead of the less reactive one.

Zinc is used to galvanise iron and when scratched provides sacrificial protection because zinc is more reactive than iron. (*When the zinc reacts the zinc oxide tends to stick to its surface and does not flake off)*

Magnesium blocks can be attached to steel ships to provide sacrificial protection. *The magnesium blocks can be replaced from time to time which is cheaper than replacing the steel on the ships*.

Alloys as useful materials

Chemistry only

Most metals in everyday use are alloys. Pure copper, gold, iron and aluminium are too soft for many uses and so are mixed with other metals to make them harder for everyday use.

Pure metals have a regular arrangement of atoms, with layers that can slide over each other, and so are soft and easily shaped, but generally are too soft for many uses.

Alloys are mixtures of different metals

Brass is an alloy of copper and zinc used to make water taps and door fittings.

Bronze is an alloy of copper and tin and is used to make statues and decorative objects.

Aluminium-magnesium alloys are low density and used in aerospace manufacturing

Gold used as jewellery is usually an alloy with silver, copper and zinc

The proportion of gold in the alloy is measured in carats, with pure gold being 24 carat. 18 carat gold is 75% gold.

Steels are alloys of iron that contain specific amounts of carbon and other metals. High carbon steel is strong but brittle. Low carbon steel is softer and more easily shaped.

Steels containing chromium and nickel (stainless steels) are hard and resistant to corrosion.

Alloys can be designed to have properties for specific uses. Low carbon steels are easily shaped (used in car bodies/ reinforcing concrete), high carbon steels are hard, and stainless steels are resistant to corrosion (used in cutlery).

Properties of Polymers

Chemistry only

Different polymers have different properties

The properties of polymers depend on what monomers they are made from and the conditions under which they are made. For example, **low density (LD) and high density (HD) poly(ethene)** are produced from ethene, using different catalysts and reaction conditions.

Thermosoftening and Thermosetting Polymers

Thermosetting polymers do not melt on heating. The polymer molecules are linked to each other by **strong cross-links**.

Thermosoftening polymers soften easily on heating and can then be remoulded, keeping the new shape on cooling. The polymer molecules are attracted to each other by **weak intermolecular forces of attraction.**

Ceramics and Composites

Glass
Most of the glass we use is **soda-lime glass**, made by heating a mixture of **sand, sodium carbonate and limestone. Borosilicate glass**, made from **sand and boron trioxide**, melts at **higher temperatures** than soda-lime glass.

Chemistry only

Clay ceramics, including pottery and bricks, are made by shaping wet clay and then heating in a furnace.

Composites
Most composites are made of two materials, a **matrix** or binder surrounding and binding together **fibres** or fragments of the other material, which is called the **reinforcement**. Examples of composites include reinforced concrete (fibre= steel bar, matrix= concrete) and carbon fibre composites.

Haber Process

Chemistry only

The Haber process is used to manufacture ammonia, which can be used to produce nitrogen-based fertilisers.

The raw materials for the Haber process are nitrogen and hydrogen. Nitrogen is obtained from the air and hydrogen may be obtained from natural gas or other sources.

The purified gases are passed over **a catalyst of iron** at a high temperature (about 450°C) and a high pressure (about 200 atmospheres). Some of the hydrogen and nitrogen reacts to form ammonia.
$N_2 + 3\,H_2 \rightleftharpoons 2NH_3$
The reaction is reversible so ammonia breaks down again into nitrogen and hydrogen:

The reaction conditions are chosen to produce a **reasonable yield** of ammonia **quickly**.
The effect of temperature and pressure on yield and the rate of reaction are important when determining the optimum conditions in industrial processes, including the Haber process.

On **cooling**, the ammonia liquefies and is removed. The remaining hydrogen and nitrogen is **re-cycled**.

See chapter 4.6 for explanations of how temperature and pressure change yield and rate of reaction

For the Haber process
- An optimum temperature of $450^{O}C$ is used. **Using a lower temperature would give a higher yield but the rate would be too slow**
- A pressure of 200atm is used. **Using a higher pressure would give a higher yield but would be too expensive because the cost of energy to produce the pressure would be high**.
- The catalyst speeds up the rate of reaction and saves money by allowing a lower temperature to be used.
- The recycle saves money because no raw materials are wasted.

Chemistry only

Production and uses of NPK Fertilisers

Compounds of nitrogen, phosphorus and potassium are used as fertilisers to improve agricultural productivity. NPK fertilisers contain compounds of all three elements.

Industrial production of NPK fertilisers can be achieved using a variety of raw materials in several integrated processes. NPK fertilisers are formulations of various salts containing appropriate percentages of the elements.

Ammonia can be used to manufacture ammonium salts and nitric acid.

$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

Ammonia + sulfuric acid → ammonium sulfate

$NH_3 + HNO_3 \rightarrow NH_4NO_3$

Ammonia + nitric acid → ammonium nitrate

Potassium chloride, potassium sulfate and phosphate rock are obtained by mining, but phosphate rock cannot be used directly as a fertiliser.

Phosphate rock is treated with nitric acid or sulfuric acid to produce soluble salts that can be used as fertilisers

- Phosphate rock is reacted with nitric acid to produce phosphoric acid and calcium nitrate.
- Phosphate rock can be reacted with sulfuric acid to produce a mixture of calcium phosphate and calcium sulfate
- Phosphate rock can be reacted with phosphoric acid to produce calcium phosphate.