

AQA GCSE Combined Science: Trilogy — Chemistry

Topic 17

Using resources

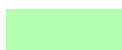
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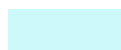
Revision notes for one topic, free to download.

These are the summary notes only. The full edition of this booklet also carries the worked examples, the required practicals and the formula sheets, with every topic in one place.

Colour Codes



Definitions



Diagrams



Notes and warnings



Sub-topic headings

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Define Finite resource

- a resource being used up faster than it is replaced, so supplies will run out.

Define Sustainable development

- development that meets the needs of current generations without compromising the ability of future generations to meet their own needs.

Define Desalination

- removing dissolved salts from salty or sea water, by distillation or membranes.

Define Sewage sludge

- the solids that settle out during sedimentation, broken down by anaerobic digestion.

HIGHER TIER

Define Bioleaching HT ONLY

- using bacteria to produce leachate solutions containing metal compounds.

Define Life cycle assessment (LCA)

- an assessment of a product's environmental impact across raw materials, manufacture, use and disposal.

Define Renewable resource

- a resource replaced at the same rate as, or faster than, it is used.

Define Potable water

- water safe to drink, with sufficiently low levels of dissolved salts and microbes.

Define Sterilisation

- killing microbes in water using chlorine, ozone or ultraviolet light.

Define Effluent

- the liquid left above the sludge after sedimentation of sewage.

HIGHER TIER

Define Phytomining HT ONLY

- using plants to absorb metal compounds; they are harvested and burned to give an ash containing metal compounds.

HIGHER TIER

Define Low-grade ore HT ONLY

- an ore containing only a small percentage of the metal compound.

17.1 Using the Earth's resources and obtaining potable water

17.1.1 Using the Earth's resources and sustainable development

Humans use the Earth's resources for **warmth, shelter, food and transport**. **Natural resources**, supplemented by agriculture, provide food, timber, clothing and fuels, and **finite resources** from the Earth, oceans and atmosphere are processed to provide energy and materials.

Chemistry improves agricultural and industrial processes and contributes to **sustainable development** — development that meets the needs of current generations without compromising the ability of future generations to meet their own needs.

Natural products supplemented or replaced by agricultural and synthetic products: natural rubber by synthetic rubber; cotton and wool by nylon and polyester; wood as a fuel by fossil fuels; wild-caught food by farmed crops.

Finite or renewable? Ask: *is it replaced as fast as we take it?*

- **Finite** — crude oil, natural gas, coal, metal ores, limestone: formed over millions of years, used far faster than replaced.
- **Renewable** — timber, cotton, wool, biofuels, fresh water from rainfall: replaced within a human lifetime if managed.

You should also be able to extract and interpret information about resources from charts, graphs and tables, and use **orders of magnitude** to judge how significant a set of data is.

ANALOGY

Finite resources are a savings account with no income paid in — every withdrawal shrinks the balance and it never refills. Renewable resources are a monthly wage: you can spend from it forever, but only if you spend no faster than it arrives.

17.1.2 Potable water

Water of appropriate quality is essential for life. For humans, drinking water should have sufficiently low levels of dissolved salts and microbes. Water safe to drink is **potable water**.

WATCH OUT

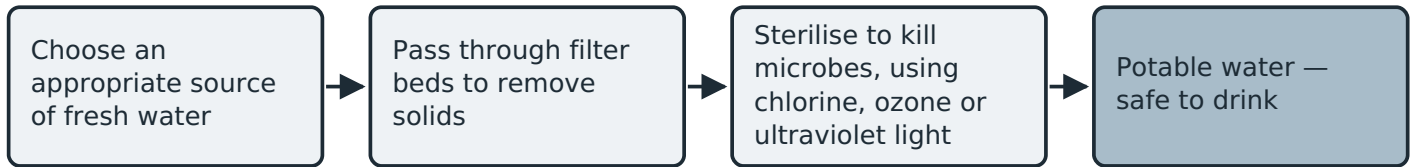
Potable water is **not** pure water in the chemical sense. Pure water contains only H₂O; potable water still contains dissolved substances — just few enough to be safe.

The methods used depend on the available supplies of water and local conditions. In the **UK**, rain provides water with low levels of dissolved substances (**fresh water**) that collects in the ground and in lakes and rivers; most potable water is produced as below.

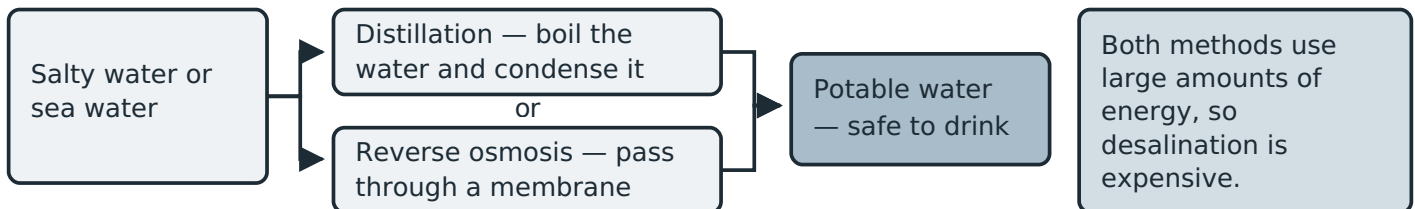
Step	What happens	Why
Choose an appropriate source of fresh water	Water low in dissolved substances	Less treatment needed, so cheaper
Pass through filter beds	Water passes through sand and gravel	Removes insoluble solids
Sterilise	Chlorine, ozone or ultraviolet light	Kills microbes, so it does not cause disease

Producing potable water

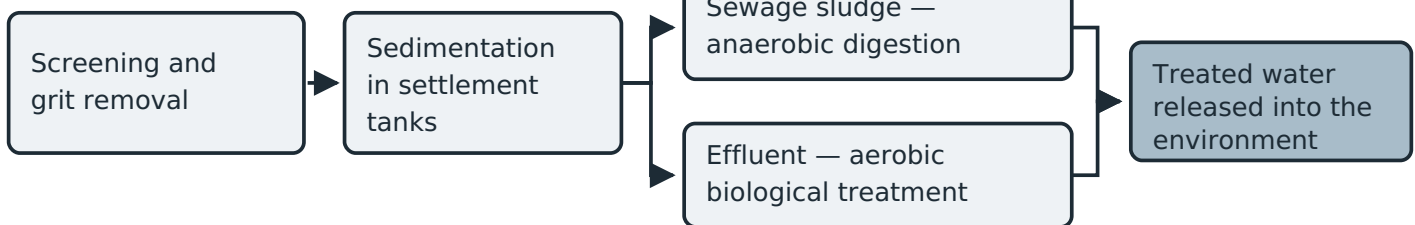
Potable water from fresh water (ground water, lakes and rivers)



Potable water from salty water or sea water — desalination



Waste water (sewage) treatment



Potable water is not pure water in the chemical sense — it still contains dissolved substances.

Ease of obtaining potable water: fresh water is easiest, then waste water; salty water is hardest because desalination needs the most energy.

Desalination. If supplies of fresh water are limited, desalination of salty or sea water may be required:

- **distillation** — boil the water and condense the steam, leaving the salts behind
- **membrane processes such as reverse osmosis** — water is forced at high pressure through a membrane that holds back dissolved ions.

Both **require large amounts of energy**, so they are expensive. Sea water is therefore not used routinely in the UK: fresh water is plentiful, and filtering plus sterilising it needs far less energy than removing dissolved salts.

Relative ease of obtaining potable water: ground/fresh water is easiest (filter and sterilise only); **waste water** is harder (organic matter, harmful microbes and sometimes harmful chemicals must be removed); **salt water** is hardest (large amounts of energy).

17.1.3 Waste water treatment

Urban lifestyles and industrial processes produce large amounts of **waste water** requiring treatment before release 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**.

Stage of sewage treatment	What happens
Screening and grit removal	Large solids and grit are physically removed
Sedimentation	Solids settle as sewage sludge ; liquid effluent stays above
Anaerobic digestion of sludge	Microorganisms break it down without oxygen , giving biogas to burn for energy and a solid usable as fertiliser
Aerobic biological treatment of effluent	Air is pumped through so aerobic bacteria multiply and break down remaining organic matter and microbes

17.1.4 Alternative methods of extracting metals **HT ONLY**

HT ONLY The Earth's resources of metal ores are limited and **copper ores are becoming scarce**, so new ways of extracting copper from **low-grade ores** have been developed. These avoid traditional mining methods of digging, moving and disposing of large amounts of rock.

- **HT ONLY Phytomining** — plants absorb metal compounds; the plants are harvested and **burned** to produce **ash containing metal compounds**.
- **HT ONLY Bioleaching** — **bacteria** produce **leachate solutions containing metal compounds**.

HT ONLY The metal compounds are then processed to obtain the metal: copper is obtained from solutions of copper compounds by **displacement using scrap iron** or by **electrolysis**.

HT ONLY Evaluating these methods. Advantages: far less rock dug, moved and dumped, so less landscape damage and waste; they work on ores too poor for traditional extraction. Disadvantages: both are **slow**; bioleaching can produce toxic substances.

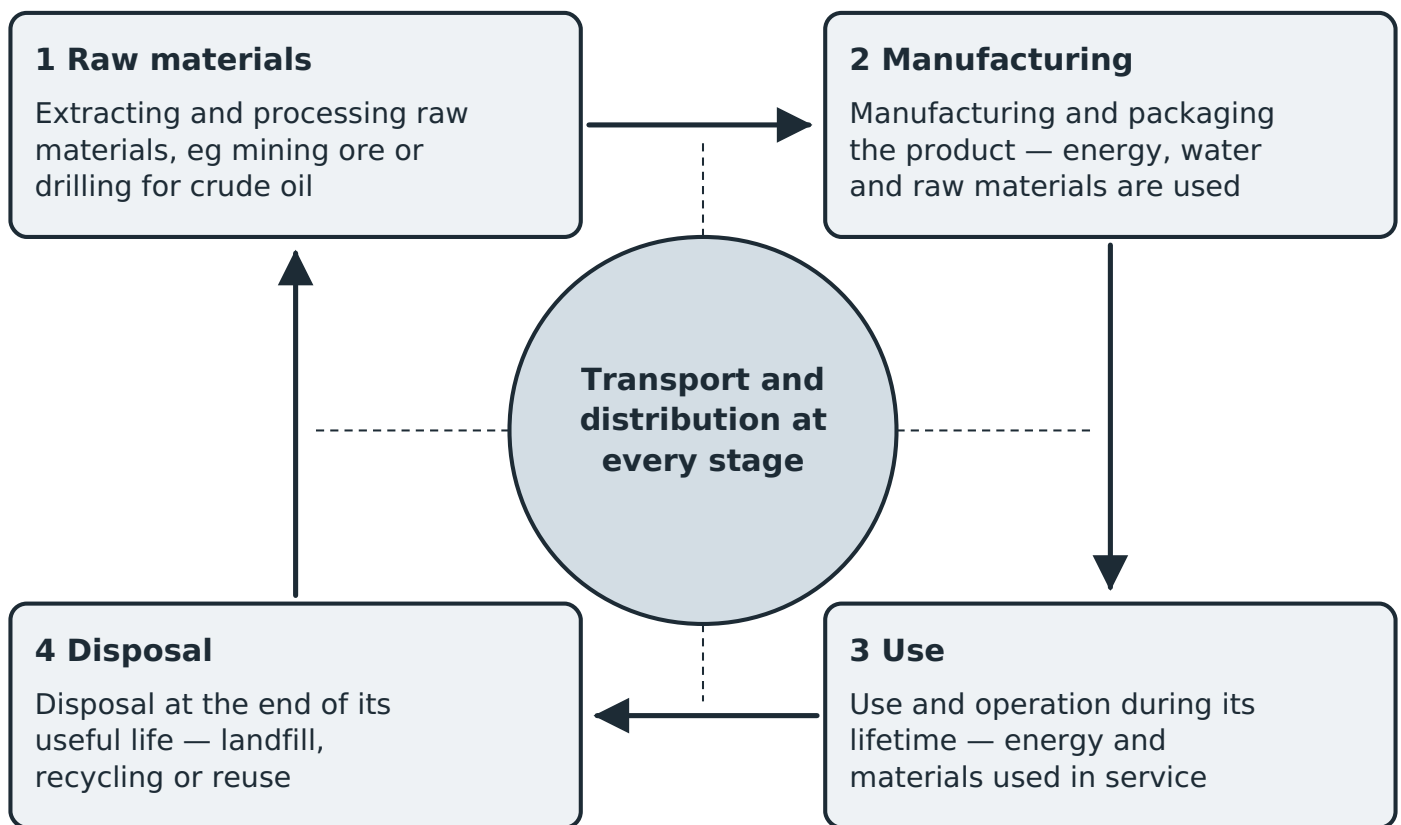
17.2 Life cycle assessment and recycling

17.2.1 Life cycle assessment

Life cycle assessments (LCAs) assess a product's **environmental impact** in four stages. **Transport and distribution** must be included at every stage.

Stage	What is assessed
Extracting and processing raw materials	Finite resources and energy used; land damage from mining and quarrying
Manufacturing and packaging	Energy and water used; wastes; packaging
Use and operation during its lifetime	Energy or fuel used; how long it lasts
Disposal at the end of its useful life	Landfill space; recyclability; pollution from incineration

The stages of a life cycle assessment



Use of water, resources, energy sources and production of some wastes can be quantified fairly easily. Allocating numerical values to pollutant effects requires value judgements, so an LCA is not a purely objective process. Selective or abbreviated LCAs can be misused, eg for advertising claims.

How objective is an LCA?

- Use of water, resources, energy sources 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, but can be **misused to reach pre-determined conclusions**, eg for advertising claims.

	Plastic bag	Paper bag
Raw material	Crude oil (finite)	Timber (renewable)
Energy per bag / kJ	210	900
Water per bag / dm ³	1	20
Number of uses	4	1
Disposal	Not biodegradable	Biodegradable, recyclable

17.2.2 Ways of reducing the use of resources

Reduction in use, reuse and recycling by end users reduces the use of limited resources, use of energy sources, waste and environmental impacts.

- Metals, glass, building materials, clay ceramics and most plastics come from **limited raw materials**, and much of the **energy** used also comes from limited resources.
- Obtaining raw materials by **quarrying and mining** causes environmental impacts.
- **Reuse**: **glass bottles** can be reused, or **crushed and melted** to make different glass products.
- **Recycling**: products that cannot be reused are **recycled for a different use**. **Metals** are recycled by **melting and recasting or reforming**.
- The amount of separation needed depends on the material and the properties required of the final product — eg some scrap steel can be added to iron from a blast furnace, reducing the iron that must be extracted from ore.

17.3 Key ideas in chemistry

Specification reference 5.11. These ideas are of universal application, are embedded throughout the subject content and are **assessed across all papers**.

- Matter is composed of tiny particles called **atoms**; there are about **100 naturally occurring types of atom**, called **elements**.
- Elements show **periodic relationships** in their chemical and physical properties.
- These periodic properties can be explained in terms of the **atomic structure** of the elements.
- Atoms bond either by **transferring electrons** from one atom to another or by **sharing electrons**.
- The **shapes of molecules** (groups of atoms bonded together) and the arrangement of **giant structures** are of great importance in the way they behave.
- There are **barriers to reaction**, so reactions occur at **different rates**.
- Chemical reactions take place in only **three ways**: **proton transfer**, **electron transfer** and **electron sharing**.
- **Energy is conserved** in chemical reactions, so it can be neither created nor destroyed.