## Using Earth’s resources

Chemistry has replaced natural resources with synthetic resources such as (rubber).

Natural rubber comes from tree sap but synthetic rubber comes from crude oil

**Finite resources**

- Fossil fuels
- Metals

**Renewable resources**

- Wood

Sustainable = meet our needs without comprising the future generations needs

## Potable water

Drinking water has to have low levels of dissolved salts (e.g sodium chloride) and cannot have high levels of microbes

Potable water = Drinkable water

Pure water contains no dissolved substances

Potable water contains dissolved substances such as minerals

**How to produce potable water**

1. We choose a good source of fresh water (e.g river)
2. Pass water through filter beds to remove materials such as leaves and suspended particles
3. Water is sterilised to kill microbes (chlorine in UK but ozone and ultraviolet in other parts)

Desalination used for water which has very high levels of dissolved minerals

**Ways we can do desalination**

- Distillation
- Reverse osmosis
    - Pass water through membrane

Both processes require a lot of energy → expensive

**<u>Required practical: Water</u>**

1. Check pH of water by adding a drop of universal indicator
2. Use a balance to find the mass of an empty evaporating basin and record the mass
3. Fill the evaporating basin with water sample and place on tripod and gauze
4. Use a Bunsen burner to gently heat water until all of it has evaporated
5. Once the evaporating basin has cooled, weigh it again using the balance

- If water contained any dissolved solids, mass would have increased
- If water didn't contain any dissolved solids, mass would have stayed same

**Purify water by distillation**

1. Gently heat the water in the beaker using a Bunsen burner
2. Vapour is produced and passes through the collecting tube
3. Vapour condenses when it enters the cold test tube it condenses back into a liquid

- This is distilled water (pure)

## Waste water

### How waste is treated

1. Sewage is screened by passing through a mesh which removes solids and pieces of grit
2. Sewage settles in sedimentation tanks which produces liquid effluent and semi-solid sludge which sinks
3. Sludge is taken away and digested by anaerobic bacteria. When there is no oxygen, bacteria produces biogas which can be burned for electricity
4. The digested sludge can be used as fertilisers and farming at the end
5. Air is bubbled through liquid effluent which allows aerobic bacteria to multiply. With oxygen, they digest organic molecules and harmful microorganisms
6. Liquid effluent can be safely discharged into nearby rivers and seas

In chemical industry, harmful chemicals need to be removed first and then treated

Easiest way to produce potable water is to use ground water from aquifers

Salt water needs to be desalinated to produce potable water

## <u>Alternative methods of extracting metals</u>

Metal ore = Contains enough metal to make it economical to extract the metal

Copper is running out meaning that we have to extract copper ores from low grade ores

**Phytomining**

1. Plants are grown on land containing metal compound that we want
2. Plants absorb metal compound and they concentrate it in their tissue
3. Plants are then harvested and burned
4. Ash contains relatively high concentration of metal compound

**Bioleaching**

1. Bacteria are mixed with low grade ore
2. Bacteria carry out chemical reactions and they produce solution called a leachate
3. Leachate contains metal compound we want

At the end of both processes, phytomining and bioleaching has extracted metal compound from ore

Both methods allow us to economically extract metals from low grade ores

These methods don't involve digging, transporting, disposing large amount of rocks

**Extraction methods**

- Displace copper using iron from compound (use scrap iron which is cheap)
- Extract copper using electrolysis

## Life cycle assessment

Polymers such as plastics comes from crude oil

Oil has to be extracted from the ground and then transported to oil refineries

Hydrocarbons have to be separated and then cracked and then the polymer has to be produced

This takes a lot of energy which is generated by burning fossil fuels leading to climate change

**Extracting metals**

- Ore has to be dug out of the mine and transported for processing
- Metal has to be extracted from ore which can produce large amounts of toxins
- Once material is produced our raw materials, they can be manufactured, packaged and transported

Assess environmental impact of product during its life – e.g. batteries

Assess environmental impact of product at the end – e.g. contains harmful chemicals or has to be transported to the landfill

| **Plastic bag** | **Paper bag** |
|---|---|

| | |
|---|---|
| Comes from crude oil (non renewable) – can be harmful to habitats if there is an oil leak | Made from wood and trees (renewable) – Felling trees for wood is also very harmful and destructive to habitats |
| Needs to be chemically processed (requires energy and | Needs to be chemically processed |
| | Making paper requires a lot of water |
| Plastic bags are strong and can be reused (reused) | Paper bags are weak and they tear (thrown away) |
| At the end of their life, has to be transported to landfill | At the end of life, has to be transported to recycling |
| | Paper bags are more heavier so more energy needed to transport them |
| Plastic is non biodegradable (doesn't break down) – Fill up landfill sites | Biodegradable |

We can measure the use of water and energy and the production of some water products

We cannot be certain how damaging it is to the environment so we have to make estimates which is not accurate

Life cycle assessments can be biased to support claims of advertisers

**Recycling**

Reduce need for raw materials (reusing/recycling)

Help to save limited resources and energy and reduce amount of waste and have a less harmful effect on the environment

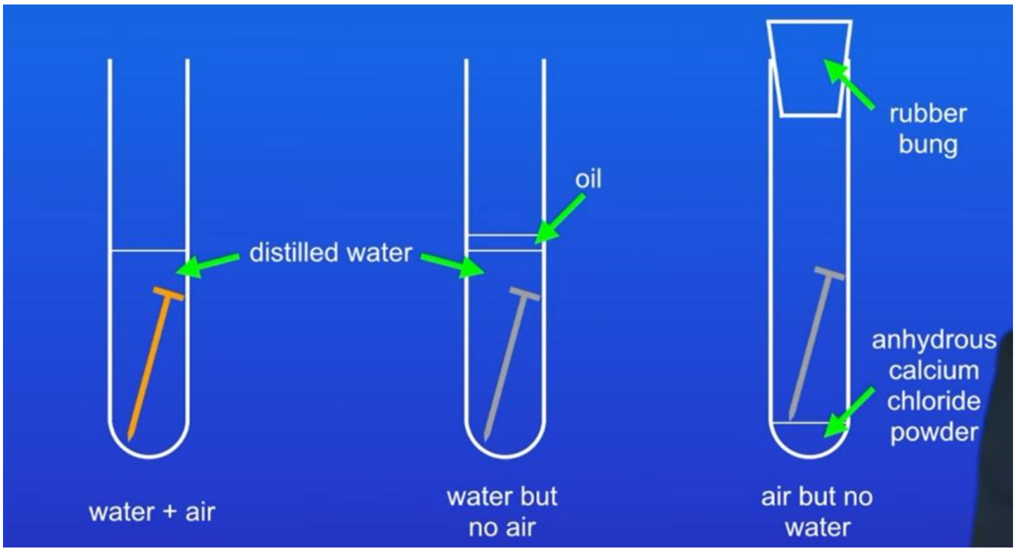
Glass bottles can be reused

To recycle metals, we melt them and recast them into different products but some metals need to be separated before recycling

## Corrosion

Corrosion = Destruction of materials by chemical reactions with substances in the environment

Rusting is an example of corrosion (only applies to iron and alloys of iron)




**Practical – Rusting**

1. Add an iron nail and distilled water to a test tube and make sure it is open to air
2. Add an iron nail, boiled distilled water (removes air), and add oil over the water (prevents air in test tube from dissolving in water)

3. Add anhydrous calcium chloride powder (removes any water from air in test tube) and place a rubber bung
4. Leave for a few days

- Test tube 1 will have rust
- Test tube 2,3 will have no rust
- This tells us both air and water are required for rusting

**Stop corrosion by putting barrier between environment and materials**

- Grease
- Paint
- Electroplating (coat material with another metal)
- Coating metal with zinc (galvanising)
    - layer of zinc acts as barrier between air and metal
    - If zinc gets scratched then it still prevents corrosion (because zinc is more reactive than iron) → zinc corrodes instead
    - Using more reactive metal is called sacrificial protection

## <u>Alloys</u>

Alloy = Metal blended with other elements

**Alloys**

- Bronze is an alloy of copper and tin
    - Bronze is hard and tends not to corrode so it is used for statues
- Brass is an alloy of copper and zinc
    - Can still be formed into different shapes
- Gold mixed with silver, copper and zinc
    - Stops it from changing shape
- Steel is alloy of iron containing non metal carbon and other metals

  - High carbon steel is hard but also brittle
  - Stainless steel contains chromium and nickel (resistant to corrosion)
- Aluminium alloys
  - Low density (good for aeroplanes)

## Ceramics and composites

### To make soda lime glass

- Mix sand, sodium carbonate and limestone together
- Heat this mixture in a furnace until it melts
- When it cools, it solidifies into any shape we want

Problem – Soda lime glass has a low melting point

### Borosilicate glass

- High melting point → useful for objects the need heating
- Made by melting mixture of sand and boron trioxide

When clay is wet it can be shaped and then heated to harden it

### Composites – Combining two different materials

- Reinforcement which consists of fibres/fragments of one material
- Reinforcement is then surrounded by matrix/ binder material

Concrete is useful for making concrete

## Thermosofting and thermosetting

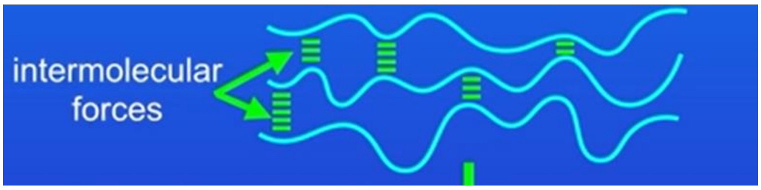
**Conditions to change properties of polymer**

- Temperature
- Catalyst
- Pressure

Thermsoftening polymers melt when we heat them

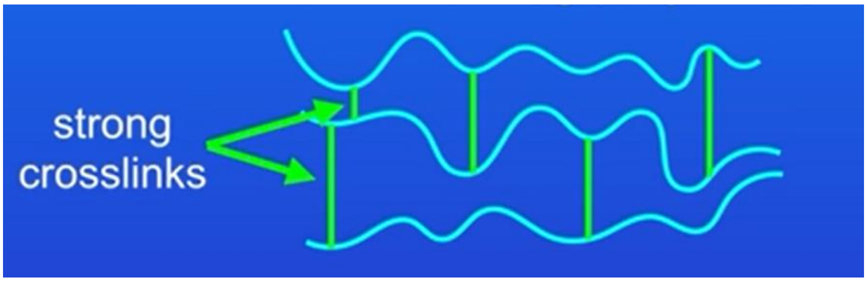
Can be reshaped while soft

Goes back to solid when we cool them down




Heating this would break intermolecular forces which separates the polymer strands

Cooling the melted polymer would reform intermolecular forces




Thermosetting polymers are connected by strong crosslinks which are not broken by heat so polymer doesn't melt when heated

**<u>Haber process</u>**

nitrogen + hydrogen $\xrightleftharpoons{\text{iron catalyst}}$ ammonia

$$N_{2(g)} + 3H_{2(g)} \xrightleftharpoons{\text{iron catalyst}} 2NH_{3(g)}$$

Nitrogen can be extracted from air

Hydrogen can be produced by reacting methane with steam

Reaction happens at 450$^{O}$C and 200 atmospheres pressure

To increase yield, you can cool ammonia to turn it into a liquid which is then removed

You can then recycle the unreacted hydrogen and nitrogen back over the catalyst

Le Chatelier’s principle = If system is at equilibrium and a change is made to any of conditions then system responds to counteract the change

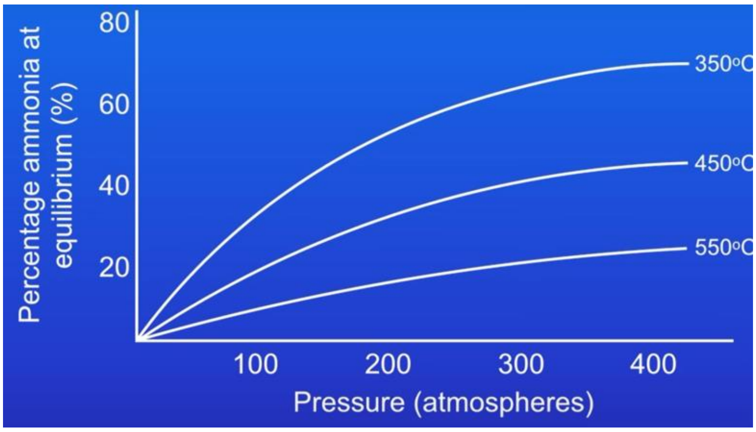
You can adjust the temperature and pressure to shift position of equilibrium towards right side (produce more ammonia)

Haber process – Forward reaction is exothermic

Cool temperature will shift equilibrium to right side but reaction is slow

450$^{O}$C is a compromise temperature (high yield and fast reaction)

High pressure will push equilibrium to right side




Increasing temperature will increase rate but lowers yield

High temperatures require more energy

% of ammonia increases at high pressure but it is very expensive and dangerous working with high pressure so use compromise pressure (250 atm)

Catalyst has no effect on equilibrium

## NPK fertilisers

NPK contains nitrogen, phosphorous and potassium – Helps boost agricultural productivity (make plants grow larger and faster)

NPK fertilisers are formulations of different salts

Main compound in NPK fertilisers is ammonium nitrate ($NH_4NO_3$) – Made by ammonia produced by Haber process. Ammonia can produce nitric acid

You can react nitric acid with more ammonia to make ammonium nitrate

Salts come from – potassium chloride or potassium sulfate which is mined from ground and can be used without processing

Phosphate rock has to be chemically processed before used

Phosphate rock + nitric acid → phosphoric acid + calcium nitrate

Phosphoric acid contains phosphorous but cannot be added to plants so neutralised with ammonia so ammonium phosphate is produced which can be used in NPK fertilisers

Phosphate rock + sulfuric acid → calcium phosphate + calcium sulfate (mixture called single superphosphate)

Phosphate rock + phosphoric acid → triple superphosphate

| **In lab** | **In school** |
|---|---|
| Ammonia is used as a gas and nitric acid is concentrated (more dangerous because reaction is very exothermic) heat produced has to be safely removed which is used in later stages | Use dilute solutions of ammonia and nitric acid so it is safe to work with |
| Energy for evaporation is provided by exothermic reaction | Produce crystals using water bath and Bunsen burner which uses a lot of energy |
| Chemical produced through flow production | Only produce small amount of ammonium nitrate in one go (batch process) |