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GCSE Chemistry

AQA Topic – Using Resources

Overview
Using Resources

Using the Earth's resources and obtaining potable water

- Using the Earth's resources and sustainable development
- Potable water
- Waste water treatment
- Alternative methods of extracting metals (HT only)

Life cycle assessment and recycling

- Life cycle assessment
- Ways or reducing the use of resources

Using materials (Chemistry)

- Corrosion and its prevention
- Alloys as useful materials
- Ceramics, polymers and composites

The Haber Process and NPK fertilisers (Chemistry)

- The Haber process
- Production and use of NPK fertilisers

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Using the Earth's resources and obtaining Potable water (part 1)

- Using the Earth's resources and sustainable development

Using the Earth's resources and sustainable development

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

These natural resources are supplemented by **agriculture, providing food, timber, clothing** and **fuels.**

Using the Earth's resources and sustainable development

Finite resources (**there is only a limited supply of them**) from the Earth, oceans and atmosphere are processed to provide energy and materials

Using the Earth's resources and sustainable development

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.

Farmers spray fertilisers onto crops so they can produce more food from less area of land.

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QuestionIT!

Using the Earth's resources and obtaining potable water (part 1)

- Using the Earth's resources and sustainable development

1. Describe two ways that humans use the Earth's natural resources.

2. Explain what the term finite means and give an example.

3. What three areas do humans process finite resources from?

4. What is meant by the term sustainable development?

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AnswerIT!

Using the Earth's resources and obtaining potable water (part 1)

- Using the Earth's resources and sustainable development

1. Describe two ways that humans use the Earth's natural resources.

   any two from ***warmth/ shelter/ food/ transport.***

2. Explain what the term finite means and give an example.

   finite – being used up faster than it is made, any suitable example.

3. What three areas do humans process finite resources from?

   Earth, oceans and the atmosphere.

4. What is meant by the term sustainable development?

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

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Using the Earth's resources and obtaining potable water (part 2)

- Potable water

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 that is **safe to drink is called potable water**.
Potable water is **not pure water** in the chemical sense because it **contains dissolved substances**.

Potable water

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

In the United Kingdom (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 by

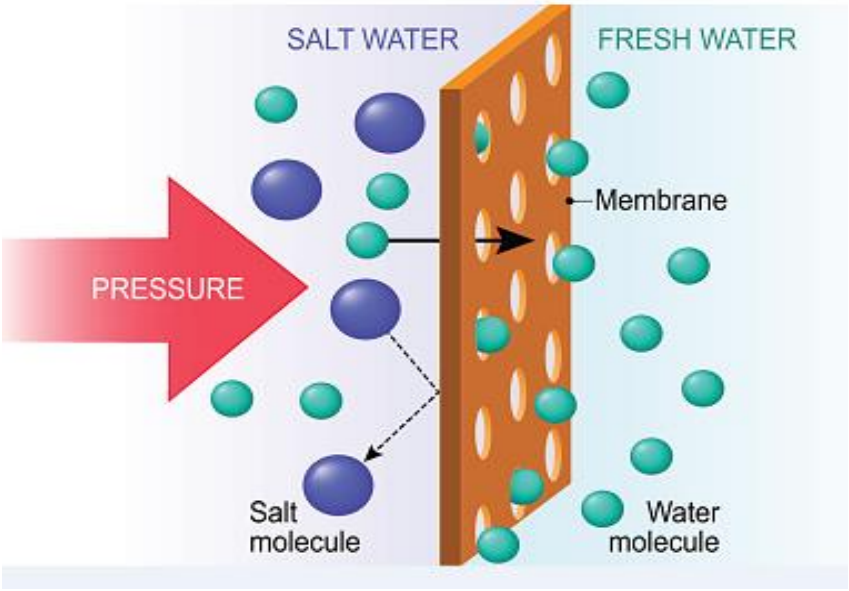
- choosing an appropriate source of fresh water
- passing the water through filter beds
- sterilising

Sterilising agents used for potable water include chlorine, ozone or ultraviolet light.

Potable 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 the processes that use membranes such as **reverse osmosis**.

Desalination by distillation in Hamburg Germany



Desalination by reverse osmosis using a **membrane**

Both types of desalination require **large amounts of energy**

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QuestionIT!

Using the Earth's resources and obtaining potable water (part 2)

- Potable water

1. Why is potable water not described as pure water by scientists?

2. What does the method used to produce potable water depend upon?

3. How is most potable water in the UK produced?

4. What two methods can be used for the desalination of salty water?

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AnswerIT!

Using the Earth's resources and obtaining potable wate (part 2)

- Potable water

1. What Why is potable water not described as pure water by scientists?

It contains dissolved substances.

2. What does the method used to produce potable water depend upon?

available supplies of water and local conditions.

3. How is most potable water in the UK produced?

choosing an appropriate source of fresh water

passing the water through filter beds

sterilising.

4. What two methods can be used for the desalination of salty water?

distillation

reverse osmosis.

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Using the Earth's resources and obtaining potable water (part 3)

- Waste water treatment

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**
- **harmful microbes**

Industrial waste water may require **removal** of

- **organic matter**
- **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

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QuestionIT!

Using the Earth's resources and obtaining potable water (part 3)

- Waste water treatment

Waste water treatment – AnswerIT

1. What needs to be removed from sewage and agricultural waste water?

2. What needs to be removed from industrial waste water?

3. What are the four stages in the treatment of sewage?

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AnswerIT!

Using the Earth's resources and obtaining potable wate (part 3)

- Waste water treatment

Waste water treatment – AnswerIT

1. What needs to be removed from sewage and agricultural waste water?

   Organic matter and harmful microbes.

2. What needs to be removed from industrial waste water?

   Organic matter and harmful chemicals.

3. What are the four stages in the treatment of sewage?

   screening and grit removal

   sedimentation to produce sewage sludge and effluent

   anaerobic digestion of sewage sludge

   aerobic biological treatment of effluent.

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Using the Earth's resources and obtaining potable water (part 4 HT only)

- Alternative methods of extracting metals

Alternative methods of extracting metals (HT only)

The Earth's resources of metal ores are limited.

The damage done by mining can be seen in the picture on the right. With a lot of waste produced the copper ore being mined recently contains less and less copper.

Copper ores are becoming **scarce** and new ways of extracting copper from low-grade ores including **phytomining**, and **bioleaching** are being developed. These methods avoid traditional mining methods of digging, moving and disposing of large amounts of rock.

Phytomining uses **plants** to **absorb metal compounds** (often from the waste from previous mining). The plants are harvested and then burned to produce ash that contains metal compounds.

Bioleaching uses **bacteria** to produce **leachate solutions** that contain (dissolved) **metal compounds**. The metal compounds 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.

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QuestionIT!

Using the Earth's resources and obtaining potable water (part 4 HT only)

- Alternative methods of extracting metals

Alternative methods of extracting metals (HT only)- **AnswerIT**

1. What type of ores can phytomining and bioleaching be used on?

2. Why are phytomining and bioleaching used?

3. How does phytomining extract metals?

4. Bioleaching uses bacteria to make leachate solutions that contain metal compounds, describe two ways the metals are extracted from these solutions.

AnswerIT!

Using the Earth's resources and obtaining potable wate (part 4 HT only)

- Alternative methods of extracting metals

Alternative methods of extracting metals (HT only)- **AnswerIT**

1. What type of ores can phytomining and bioleaching be used on?

   low-grade ores

2. Why are phytomining and bioleaching used?

   Avoids traditional mining methods of

   digging, moving and disposing of large amounts of rock.

3. How does phytomining extract metals?

   Uses plants to absorb metal compounds

   the plants are harvested and burned

   this produces ash that contains metal compounds.

4. Bioleaching uses bacteria to make leachate solutions that contain metal compounds, describe two ways the metals are extracted from these solutions.

displacement using scrap iron

electrolysis.

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Life cycle assessment and recycling (part 1)

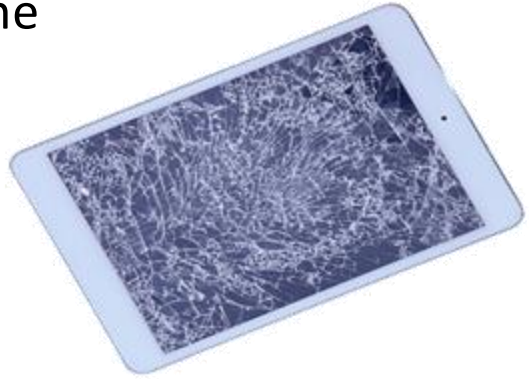
- Life cycle assessment

Life cycle assessments (LCA's) are carried out to assess the **environmental impact of products** in each of these stages:

Extracting and processing raw materials

Manufacturing and packaging

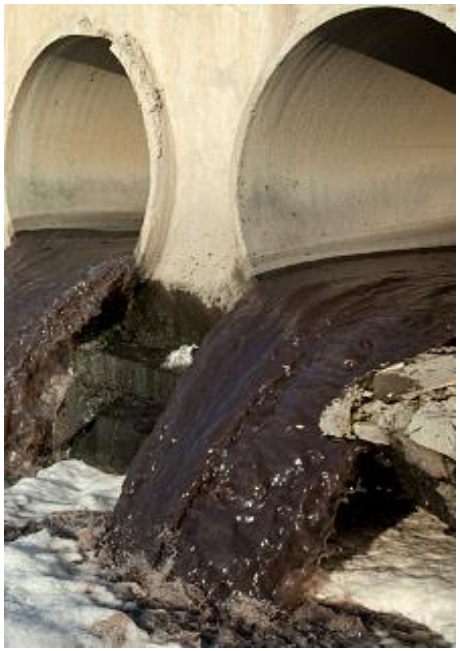
Uses and operation during it's Lifetime



Disposal at the end of it's useful life, including transport and distribution at each stage

Life cycle assessments

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 life cycle assessments is not a purely objective process.



Selective or abbreviated life cycle assessments 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.

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QuestionIT!

Life cycle assessment and recycling (part 1)

- Life cycle assessment

1. Life cycle assessments are carried out to assess the environmental impact of what stages of a product?

2. What areas of life cycle assessments can be easily quantified?

3. Why are value judgements needed in the production of life cycle assessments?

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AnswerIT!

Life cycle assessment and recycling (part 1)

- Life cycle assessment

1. Life cycle assessments are carried out to assess the environmental impact of what stages of a product?

extracting and processing raw materials

manufacturing and packaging

use and operation during its lifetime

disposal at the end of its useful life.

2. What areas of life cycle assessments can be easily quantified?

water, resources, energy sources and production of some wastes.

3. Why are value judgements needed in the production of life cycle assessments?

numerical values need to be allocated.

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Life cycle assessment and recycling (part 2)

- Ways of reducing the use of resources

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, use of energy sources, waste and environmental impacts.

Metals, glass, building materials, clay ceramics and most plastics are produced from **limited raw materials**. Much of the energy for the processes comes from limited resources. **Obtaining raw materials** from the Earth by quarrying and mining causes **environmental impacts.**

Some products, such as **glass bottles**, can be **reused**. Glass bottles can be crushed and melted to make different glass products. Other products cannot be reused and so are recycled for a different use.

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 product e.g. scrap steel added to iron from a blast furnace reduces the need for iron ore.

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QuestionIT!

Life cycle assessment and recycling (part 2)

- Ways of reducing the use of resources

Ways of reducing the use of resources - **QuestionIT**

1. Name three things that reduce the use of limited resources.

2. Name three materials produced from limited resources.

3. Other than reusing how are glass bottles recycled

4. How are metals recycled?

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AnswerIT!

Life cycle assessment and recycling (part 2)

- Ways of reducing the use of resources

Ways of reducing the use of resources - **AnswerIT**

1. Name three things that reduce the use of limited resources.

   reuse, reduction in use and recycling.

2. Name three materials produced from limited resources.

   any three from metals/glass/building materials/ceramics/plastics/any reasonable.

3. Other than reusing how are glass bottles recycled

   crushed and melted.

4. How are metals recycled?

   melting and recasting.

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Using materials (Chemistry ONLY)

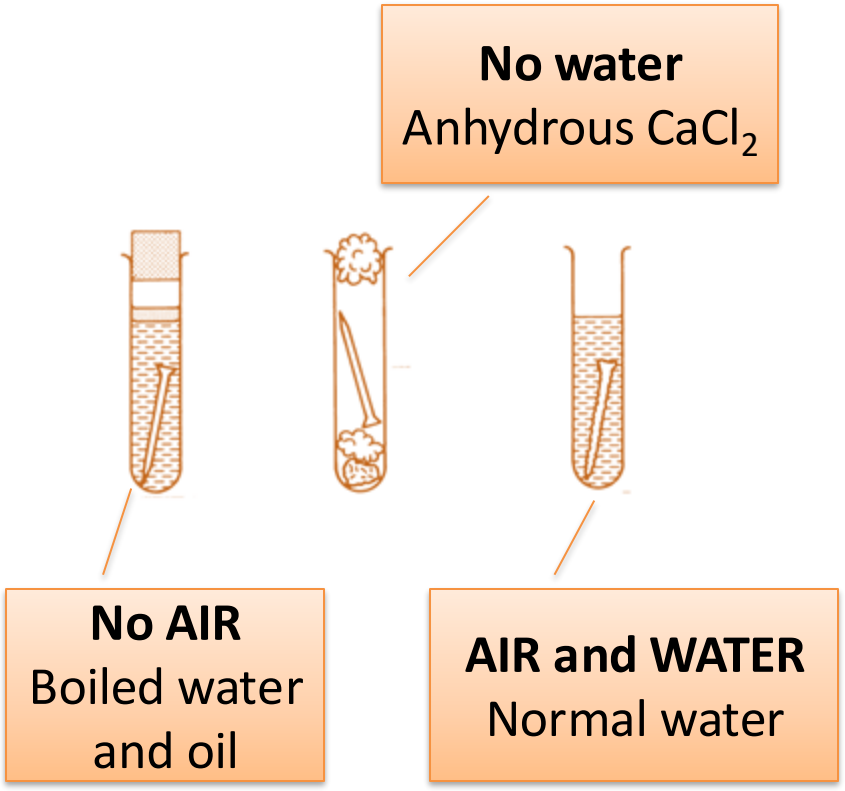
- Corrosion and its prevention
- Alloys as useful materials

Corrosion and its prevention

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.

iron + water + oxygen → hydrated iron (III) oxide



Corrosion and its prevention

Corrosion can be prevented by applying a **coating that acts as a barrier**, such as **greasing**, **painting** or **electroplating**.

Galvanising: Some of these coatings are reactive and contain a more reactive metals to provide **sacrificial protection**, e.g. **zinc** is used to **galvanise iron**.

In this factory the metal is being coated in zinc to provide **sacrificial protection**.

The **zinc is more reactive than the iron**, so **zinc oxide** will be produced in preference to iron oxide, thus **protecting the iron from corrosion**.

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

Oxygen and water are unable to penetrate this layer to react with the aluminium atoms below

Alloys as useful materials

Most metals in everyday use are alloys.

Bronze	Brass	Gold for jewellery
• Alloy of copper and tin	• Alloys of copper and zinc	• Alloy with silver, copper and zinc • Proportion of gold in alloy is measured in carats • 24 carat = 100% gold; 18 carat = 75% gold

Alloys as useful materials

Most metals in everyday use are alloys.

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**.
Stainless steels containing **chromium** and **nickel** are **hard** and **resistant to corrosion**.

Aluminium alloys are low density

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QuestionIT!

Using materials (Chemistry ONLY)

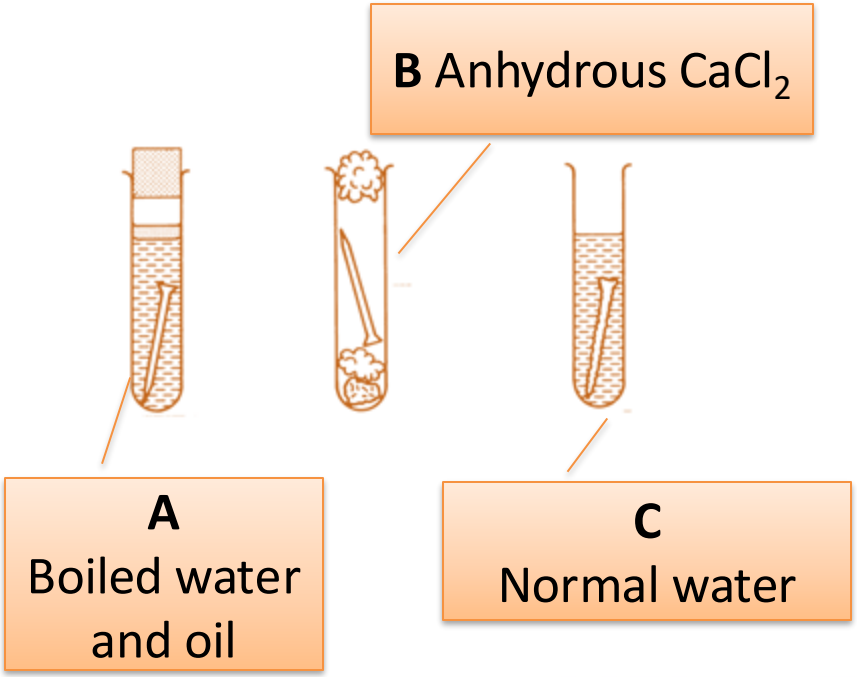
- Corrosion and its prevention
- Alloys as useful materials

1. What is corrosion?

2. What is rusting?

3. What is needs to be present for iron to rust?

4. Look at the following diagram and explain the purpose of A, B and C.



5. Name four methods of preventing corrosion.

6. Why would coating iron with zinc prevent corrosion?

7. Why does aluminium not corrode?

8. Name the metals in the alloy bronze.

9. Name the metals in the alloy brass.

10. Gold jewellery is usually an alloy with which metals?

11. What does the term 24 carat gold mean?

12. What are steels?

13. What are the properties of high carbon steel?

14. What are the properties of low carbon steel?

15. What metals are added to iron to make stainless steel?

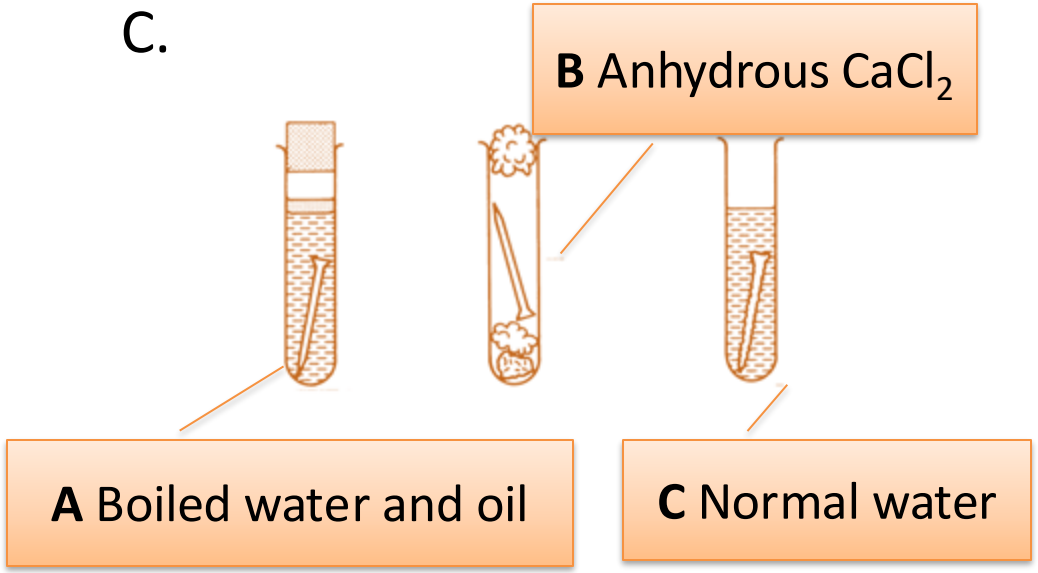
16. What are the properties of stainless steel?

AnswerIT!

Using materials (Chemistry ONLY)

- Corrosion and its prevention
- Alloys as useful materials

1. What is corrosion?
   Destruction of materials by chemical reactions with substances in the environment.
2. What is rusting?
   Corrosion of iron.
3. What is needs to be present for iron to rust?
   Water and air.
4. Look at the following diagram and explain the purpose of A, B and C.



A = no air
B = No water
C = air and water

5. Name four methods of preventing corrosion.
   Greasing, painting, electroplating, galvanising.
6. Why would coating iron with zinc prevent corrosion?
   Zinc more reactive than iron, sacrificial protection, oxygen react with zinc rather than iron.
7. Why does aluminium not corrode?
   Layer of aluminium oxide.
8. Name the metals in the alloy bronze.
   Copper and tin.
9. Name the metals in the alloy brass.
   Copper and zinc.
10. Gold jewellery is usually an alloy with which metals?
    Silver, copper, zinc.

11. What does the term 24 carat gold mean?
    100% pure gold.
12. What are steels?
    Alloys of iron.
13. What are the properties of high carbon steel?
    Strong, brittle.
14. What are the properties of low carbon steel?
    Softer, more easily shaped.
15. What metals are added to iron to make stainless steel?
    Chromium, nickel.
16. What are the properties of stainless steel?
    Hard, resistant to corrosion.

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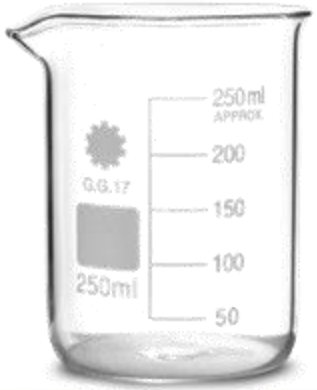
Using materials (Chemistry ONLY)

- Ceramics, polymers and composites

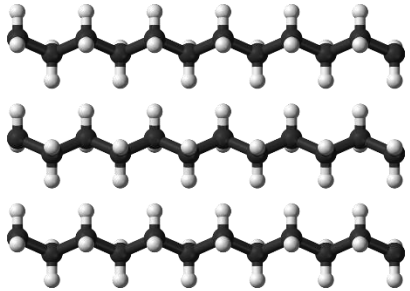
Ceramics

Most of the glass we use is **soda-lime glass**, made by **heating** a mixture of **sand, sodium carbonate and limestone**.

Soda-lime glass	Borosilicate glass	Clay ceramics
Heat sand, sodium carbonate and limestone	Heat sand and boron trioxide Melts at a higher temperature than soda-lime glass	Shape wet clay Heat in a furnace e.g. pottery and bricks



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**.

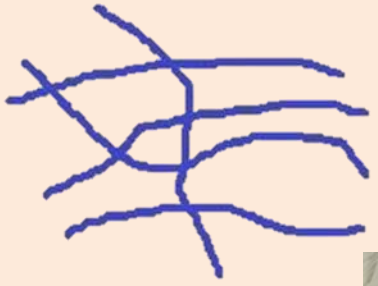


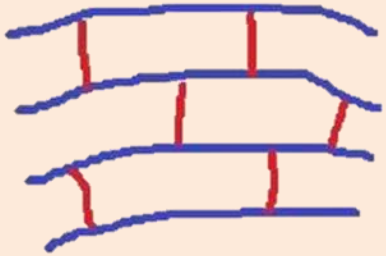
- **LDPE**s are made at **high pressure** and **moderate temperatures** whereas **HDPE**s are made at **lower temperatures and pressures** with a **catalyst**
- **LDPE** have **side chains**; **HDPE** have **no side chains** and have **stronger attractions** between molecules **and higher melting points.**

Thermosoftening and thermosetting

Polymers can be categorised according to their overall structure and properties.

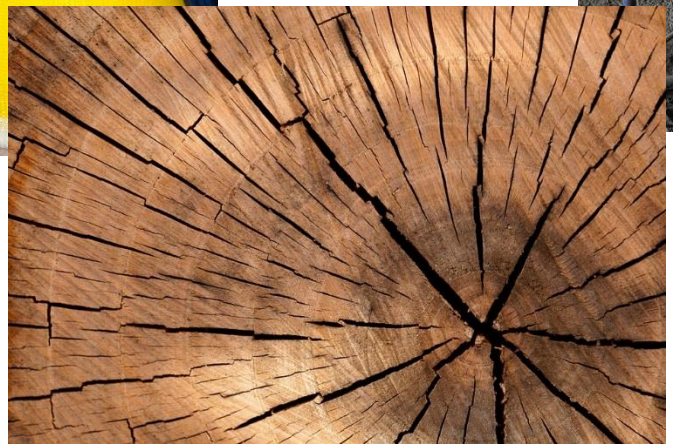
Thermosoftening	Thermosetting
• **No crosslinks** • **Low** melting points • **Melt** when heated • **Can** be shaped when hot	• **Have crosslinks** • **High** melting points • **Do not melt** when heated • **Cannot** reshape





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 **reinforcement**.



Examples of composites include: **fibreglass**, **concrete**, **reinforced concrete** (a composite of a composite) and **wood** (a natural composite).

QuestionIT!

Using materials (Chemistry ONLY)

- Ceramics, polymers and composites

1. How is soda-lime glass made?
2. How is borosilicate glass made?
3. How do soda-lime and borosilicate glass differ?
4. How are clay ceramics made?
5. Give 2 examples of clay ceramics.
6. What are low density and high density poly(ethene) made from?

7. What is a thermosetting polymer?

8. What is a thermosoftening polymer?

9. What is a composite made of?

10. Give 3 examples of composites.

AnswerIT!

Using materials (Chemistry ONLY)

- Ceramics, polymers and composites

1. How is soda-lime glass made?
   Heating a mixture of sand, sodium carbonate and limestone.
2. How is borosilicate glass made?
   Heating a mixture of sand and boron trioxide.
3. How do soda-lime and borosilicate glass differ?
   Borosilicate glass melts at a higher temperature.
4. How are clay ceramics made?
   Shaping wet clay, heating in a furnace.
5. Give 2 examples of clay ceramics.
   Brick and pottery.
6. What are low density and high density poly(ethene) made from?
   Ethene.

7. What is a thermosetting polymer?
   Do not melt when heated, have cross links.
8. What is a thermosoftening polymer?
   Melt when heated, no cross links.
9. What is a composite made of?
   A matrix or binder and fibres or fragments.
10. Give 3 examples of composites.
    Fibre glass, wood, concrete, reinforced concrete.

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The Haber process and NPK
(Chemistry ONLY)

- The Haber process
- Production and uses of NPK fertilisers

The Haber process

The production of **ammonia** is a **reversible reaction** that can reach a **dynamic equilibrium**:

nitrogen + hydrogen ⇌ ammonia

The purified gases are **passed over a catalyst of iron** at a **high temperature** and **high pressure**. On **cooling** the **ammonia liquefies** (turns into a liquid) and is removed. The remaining hydrogen and nitrogen are **recycled.** The ammonia can be used to make **nitrogen-based fertilisers**.

The reactants for the reaction come from the following:

- **Nitrogen** is extracted from the **air**
- **Hydrogen** is obtained from **natural gas**.

The conditions for the Haber process are:

- A temperature of **450°C**
- A pressure of **200 atmospheres**
- An **iron catalyst**

Reversible reactions and dynamic equilibrium

In some chemical reactions, the products of the reaction can react to produce the original reactants. Such reactions are called **reversible reactions** and are represented by:

$$A + B \rightleftharpoons C + D$$

This is different to the usual → or = sign. With these all the reactants change to products in the reaction, but in **reversible reactions** there are always **some reactants** and **some products.**

The direction of reversible reactions can be changed by changing the reaction conditions.

When a reversible reaction occurs in apparatus which prevents the escape of reactants and products (a **closed system**), **dynamic equilibrium** is reached as the rate of the forward and reverse reactions occur at **exactly the same rate**.

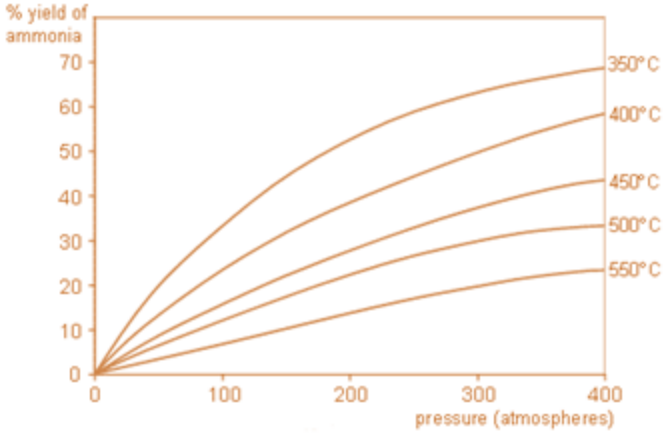
The Haber process, a compromise in conditions (HT)

The reaction is **reversible** so some of ammonia breaks down into nitrogen and hydrogen. The reaction is **exothermic** and there are **more moles of gas** on the left hand side of the reaction:

$$3H_2 + N_2 \rightleftharpoons 2NH_3$$

This means the forward reaction is favoured if there is a **high pressure** and **lower temperature.** Both of these will push the **position of equilibrium** to the **right** to maximise the **yield**.

However, a **low temperature** would give a **slow rate of reaction**, so a **compromise temperature** of 450°C is used.
High pressures can be **dangerous**, lowering the pressure increases **safety**.



Very high pressure and temperatures will also have a **cost implication**. A **compromise** on temperature and pressure leads to **reduced costs** and a more **economically viable product**.

Fertilisers

Many fertilisers contain **nitrogen**, **phosphorus** and **potassium** to **improve agricultural productivity**. They are therefore known as NPK fertilisers. **Ammonium nitrate** is a salt used as a fertiliser, produced from the reaction between **ammonia** and **nitric acid**.

$$NH_3 + HNO_3 \rightarrow NH_4NO_3$$

Preparation of ammonium sulfate from ammonia solution and dilute sulfuric acid.

- Add known volume of dilute sulfuric acid to an evaporating basin.
- Add known volume and concentration of ammonia to the sulfuric acid.
- Test with universal indicator paper to ensure neutral.
- Evaporate the solution slowly using Bunsen burner to concentrate the solution.
- Cool until crystals form; dry the sample.

Fertilisers

Potassium chloride, **potassium sulfate** and **phosphate rock** are obtained by mining, but phosphate rock (calcium phosphate) **cannot** be used directly as a fertiliser as it is **insoluble**.

Phosphate rock is treated with **acid** to produce **soluble salts** that can be used as fertilisers.

Phosphate rock treated with nitric acid produces:

Calcium nitrate

Phosphate rock treated with sulfuric acid produces:

Single superphosphate (SSP)

Phosphate rock treated with phosphoric acid produces:

Triple superphosphate (TSP)

QuestionIT!

Using materials (Chemistry ONLY)

- Ceramics, polymers and composites

1. What is a reversible reaction?

2. (HT) Give the balanced symbol equation for the reaction between nitrogen and hydrogen to produce ammonia.

3. (HT) What compromises are made in the reaction conditions for the production of ammonia in the Haber process?

4. What three elements do most fertilisers contain?

5. What is produced when ammonia reacts with nitric acid?

6. Write a balanced symbol equation for the reaction between ammonia and nitric acid.

7. Name two salts which are mined and can be used as fertilisers.

8. State why phosphate rock cannot be used directly as a fertiliser.

9. What can phosphate rock be treated with to produce soluble salts?

10. Name the salt produced when phosphate rock reacts with:
    a. Nitric acid
    b. Sulfuric acid
    c. Phosphoric acid.

AnswerIT!

Using materials (Chemistry ONLY)

- Ceramics, polymers and composites

1. What is a reversible reaction?
   The products of the reaction can react to produce the original reactants.
2. (HT) Give the balanced symbol equation for the reaction between nitrogen and hydrogen to produce ammonia.
   $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$
3. (HT) What compromises are made in the reaction conditions for the production of ammonia in the Haber process?
   Slightly higher temperature – to increase rate of reaction; slightly lower pressure – to reduce cost and increase safety.
4. What three elements do most fertilisers contain?
   Nitrogen, phosphorus and potassium.
5. What is produced when ammonia reacts with nitric acid?
   Salt, ammonium nitrate.

6. Write a balanced symbol equation for the reaction between ammonia and nitric acid.

$$NH_3 + HNO_3 \rightarrow NH_4NO_3$$

7. Name two salts which are mined and can be used as fertilisers.
   Potassium chloride, potassium sulfate.
8. State why phosphate rock cannot be used directly as a fertiliser.
   Insoluble.
9. What can phosphate rock be treated with to produce soluble salts?
   Acid.
10. Name the salt produced when phosphate rock reacts with:
    a. Nitric acid *Calcium nitrate*
    b. Sulfuric acid *Single superphosphate*
    c. Phosphoric acid. *Triple superphosphate.*