Paper 2

Chemistry

Review

C6 – Rate and extent of chemical change

Rate of reaction.

Measuring the rate of anything always involves a **measurement of time**

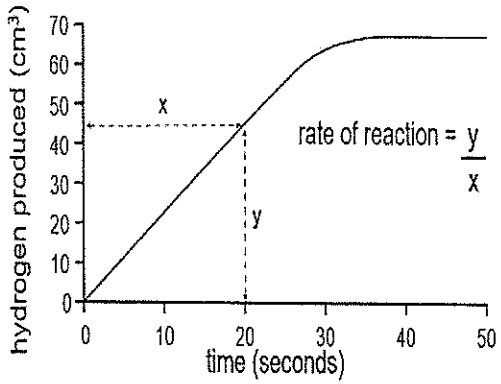
The rate of a chemical reaction can be found using:

$$\text{rate} = \frac{\text{quantity of reactant used}}{\text{time}}$$

$$\text{rate} = \frac{\text{quantity of product formed}}{\text{time}}$$

Quantities for reactants or products are measured in **mass in g** or by **volume in cm^3**

Rate calculations can be done from tables of data or graphs:



Volume of hydrogen produced = 45cm
Time taken = 20 seconds
Rate = $\frac{45}{20\ s}$ cm^3
rate = 2.25 cm^3/s

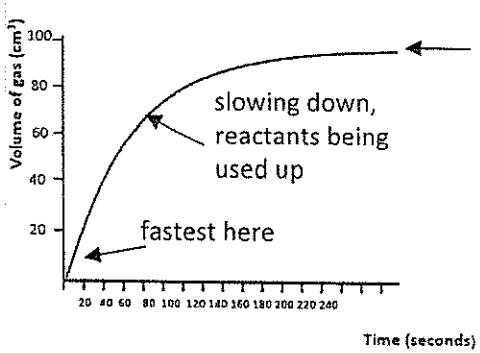
The progression of a chemical reaction

For a reaction to take place, reactant particles have to collide.

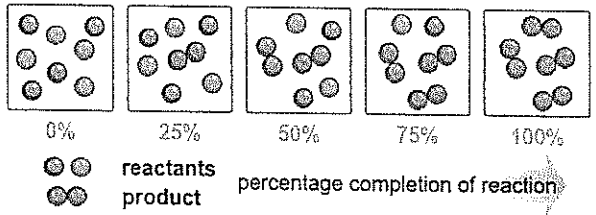
The rate of a reaction depends on the **frequency of collisions** and **the energy with which the particles collide.**

The minimum amount of energy needed to start a reaction is called the **activation energy.**

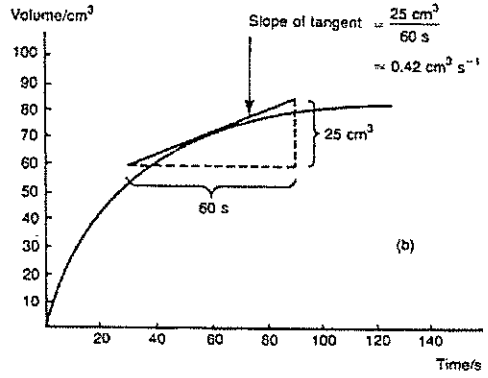
A reaction is always **fastest at the beginning** and slows down over time as the reactants get used up and the frequency of collisions decreases.



stopped, all reactants used up



Using a tangent to calculate rate (HT)



- Draw a line along the point you're interested in. The line should touch the curve at the point given.
- Make a triangle. Try to make the angles either side of the line equal.
- Measure the change in volume and change in time
- Calculate the gradient
- Use units from the axes to determine the units for rate

C6 – Rate and extent of chemical change

1. Give two ways of calculating the rate of a reaction

2. What does a rate calculation always have to include?

3. What are solid reactants or products measured in?

4. What are liquid or gaseous products measured in?

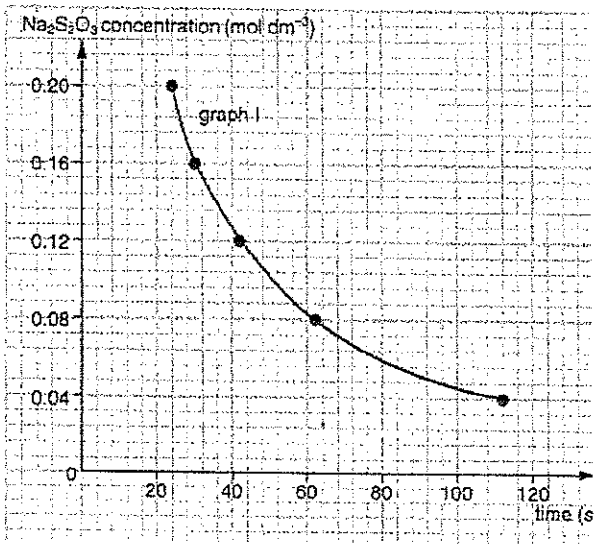
5. How is the rate calculated from a graph?

1. What point in a reaction is the fastest?

2. Why does a reaction slow down as it progresses?

3. Why do reactions stop?

4. What two factors affect the rate of a reaction?



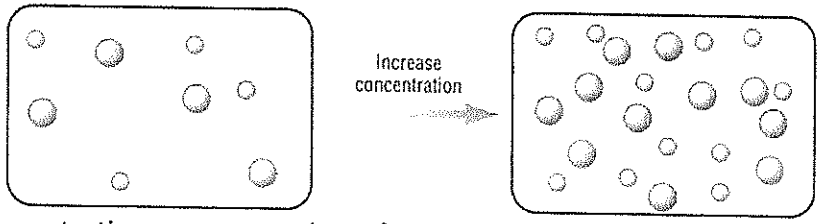
1. Describe how to draw a tangent at 50s.

2. Draw the tangent at 50s

3. What will the units for the rate of this reaction be?

C6 – Rate and extent of chemical change

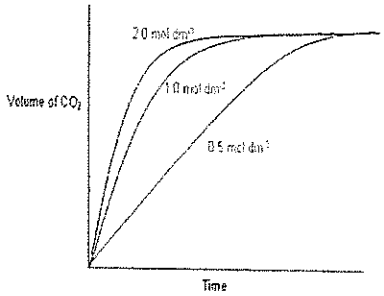
The effect of concentration



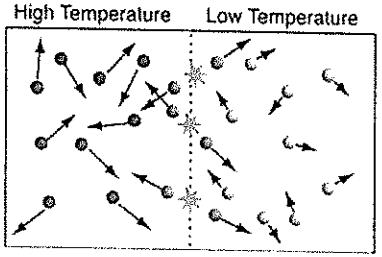
Concentration means number of particles per cm^3

Increasing the concentration of any of the reactants increases the rate of the reaction

This is because there are more particles per cm^3 so there are **more frequent collisions**, increasing the rate.

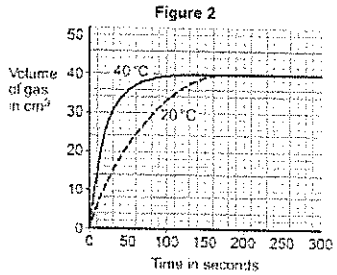


The effect of temperature

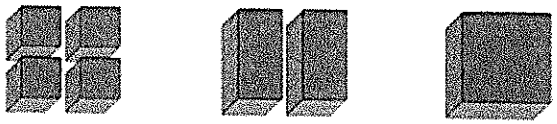


Increasing the temperature of the reactants increases the rate of the reaction.

This is because the particle have more kinetic energy and therefore move faster, so there are **more frequent collisions**, increasing the rate.



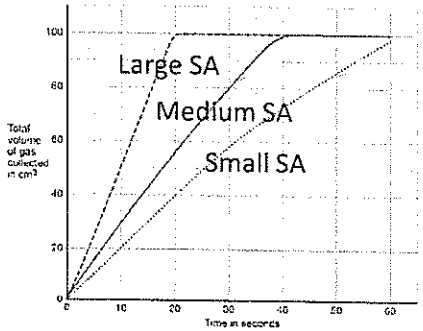
The effect of surface area



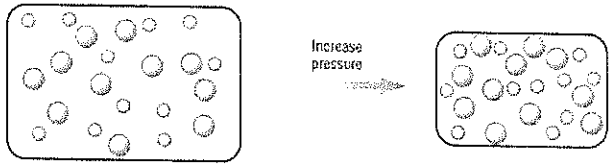
The smaller the pieces of a solid, the higher the surface area

Increasing the surface area of solid reactants increases the rate of reaction.

This is because there is a greater area available for collisions to occur so there are **more frequent collisions**, increasing the rate.

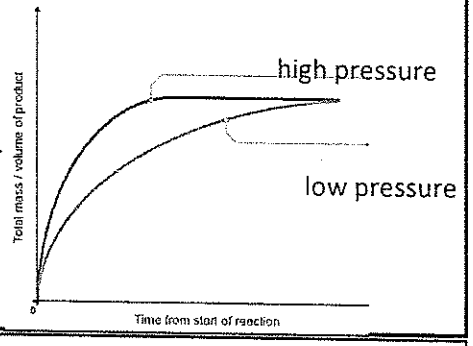


The effect of pressure



Increasing the pressure of gaseous reactions increases the rate of the reaction.

This is because the same number of particles are now in a smaller volume, so there are **more frequent collisions**, increasing the rate.

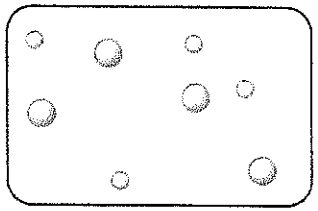


In all cases, the overall amount of product is the SAME, the end point of the reaction is just reached faster

C6 – Rate and extent of chemical change

The effect of concentration

1. In the box below, draw a reaction involving a higher concentration of the green reactant molecules.



2. What happens to the rate of a reaction if you increase the concentration?

The effect of temperature

1. Describe how increasing the temperature affects the rate of a reaction.

2. Explain why this happens in terms of particles.

The effect of surface area

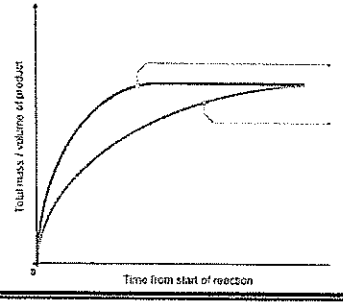
1. Reactions involving what sort of reactant are affected by surface area?

2. What type of piece has a large surface area?

The effect of pressure

1. Reactions involving what type of reactants are affected by pressure?

2. Label the diagram with 'low pressure' and 'high pressure'



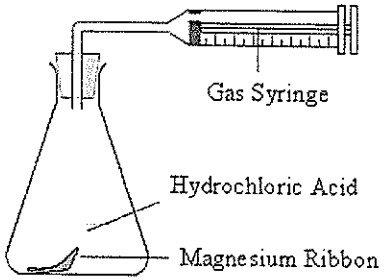
What happens to the overall amount of product if you change the rate of a reaction?

C6 – Required practical – the effect of concentration on rate of reaction

Experiment 1

Using volume of gas collected over time as a measure of the rate

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

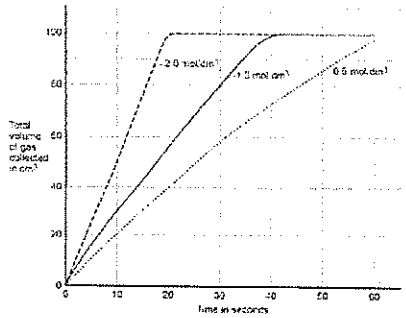


Independent variable: concentration of HCl
Dependent variable : Volume of gas produced / min
Control variables : volume of HCl, mass of Mg, temperature of acid

Method

1. Measure 20cm^3 0.5M HCl into a conical flask.
2. Insert 2 x 2cm pieces of Mg and attach a gas syringe
3. Start a stopwatch and measure the volume of gas collected every 20 seconds until the reaction is over.
4. Repeat using different concentrations of HCl.

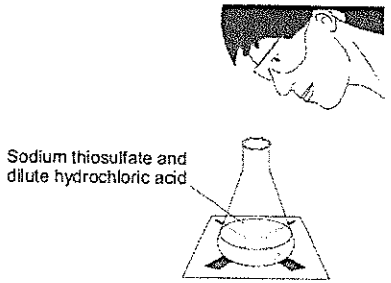
An increase in the concentration leads to an increase in the rate of the reaction, but the same volume of product overall



Experiment 2

Investigating the effect of changing the concentration of HCl on the rate of reaction

$$HCl_{(aq)} + Na_2S_2O_{3\ (aq)} \rightarrow NaCl_{(aq)} + SO_{2(g)} + S_{(s)} + H_2O_{(l)}$$



The sulphur being made is insoluble and is what makes the liquid go cloudy

Independent variable: concentration of HCl
Dependent variable : Time taken for the cross to disappear
Control variables : volume of HCl, volume of sodium thiosulphate, temperature of both solutions, concentration of sodium thiosulphate

Method

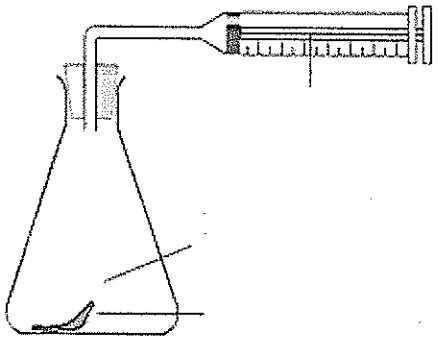
1. Use a measuring cylinder to put 10 cm^3 sodium thiosulfate solution into the conical flask.
2. Put the conical flask on the black cross.
3. Put 10 cm^3 of 0.5M hydrochloric acid into the 10 cm^3 measuring cylinder.
4. Put this acid into the flask. At the same time swirl the flask gently and start the stopwatch.
5. Look down through the top of the flask. Stop the stopwatch when you can no longer see the cross. Record the time.
6. Repeat steps 1-5 using different concentrations of HCl – 1M, 1.5M, 2M and 2.5M

C6 – Required practical – the effect of concentration on rate of reaction

Experiment 1

Using volume of gas collected over time as a measure of the rate

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

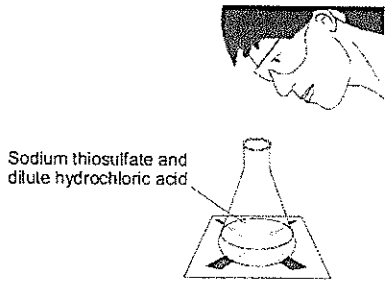


1. Label the diagram to show the equipment and chemicals used in this investigation
2. What is the independent variable?
3. Name two control variables.
4. What is a sensible volume of HCl to use?
5. Which piece of equipment, essential for a rate calculation, is not shown?

Experiment 2

Investigating the effect of changing the concentration of HCl on the rate of reaction

$$HCl_{(aq)} + Na_2S_2O_{3\ (aq)} \rightarrow NaCl_{(aq)} + SO_{2(g)} + S_{(s)} + H_2O_{(l)}$$

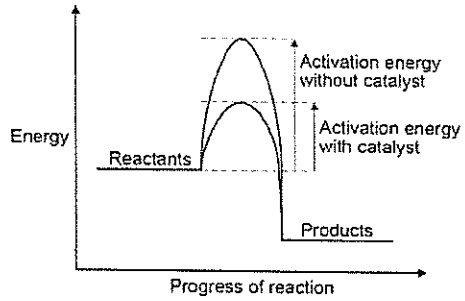


1. What is the dependent variable in this reaction?
2. Why does the solution go cloudy?
3. Name two control variables.

C6 – Rate and extent of chemical change

Catalysts

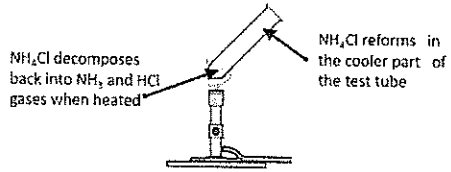
- Catalysts are substances that speed up chemical reactions without themselves being used up.
- They provide a different pathway for the reaction with a lower activation energy.
- Different reactions require different catalysts.



Reversible reactions

These are reactions in which the products can react to produce the original reactants
They are represented by the symbol ⇌
The direction of the reaction can be changed by changing the conditions
For example:

ammonium chloride $\underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}}$ ammonia + hydrogen chloride



If a reaction is exothermic in one direction, it is endothermic in the opposite direction.
The same amount of energy is transferred in each case.

hydrated copper sulfate (blue) $\underset{\text{exothermic}}{\overset{\text{endothermic}}{\rightleftharpoons}}$ anhydrous copper sulfate (white) + water

When a reversible reaction takes place in sealed apparatus, then a point occurs when the forward and backward reactions occur at the same rate. This is **equilibrium**

The effect of changing conditions on equilibrium (HT)

If a system is at equilibrium and a change is made to the conditions, then the system responds to counteract the change.
E.g. – if the temperature is increased, then the system will respond by increasing the rate of the endothermic reaction, to bring the temperature back down

If the concentration of the reactants is increased, then equilibrium will shift right and more products will be made.

In gaseous reactions, a change in pressure will result in equilibrium shifting to the side that restores the pressure.
E.g. :

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

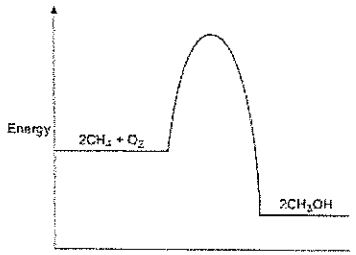
In this reaction, there are 4 moles of gas on the reactants side and only 2 on the product side
If the pressure is increased, equilibrium will shift right as there are fewer moles on the products side, and this will decrease the pressure.

C6 – Rate and extent of chemical change

1. What is a catalyst?

2. How do they speed up reactions?

3. Draw on the energy level diagram below to show how it would change in the presence of a catalyst.



1. What is a reversible reaction?

2. What symbol is used in an equation to represent a reversible reaction?

3. If a reaction is endothermic in the forward direction, what does this tell us about the backward reaction?

4. If 300J of energy is absorbed during an endothermic reaction, how much will be released in the opposite direction?

5. What is equilibrium?

1. When a change is introduced into a closed system, what does the system respond in order to do?

2. If the temperature of a reaction mixture at equilibrium is increased, what would the change aim to do?

3. What sort of reaction would achieve a drop in temperature?

4. If the pressure is increased in a gaseous reaction, which way would equilibrium shift?

Side with fewest moles/side with most moles

Exam Exposure

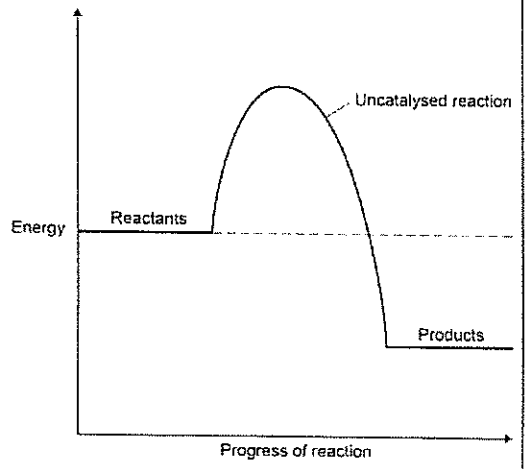
Temperature also affects the rate of the reaction.

Explain how increasing the temperature affects the **rate** of the reaction.

You should refer to particles and collisions. **(3)**

Figure 1 shows the reaction profile for a reaction without a catalyst.

Figure 1



(a) Label the activation energy (E_A) for the reaction on **Figure 1**.

(b) Label the energy change for the reaction on **Figure 1**.

(c) Draw the reaction profile for the reaction **with a catalyst** on **Figure 1**.

Outline a plan to investigate how the rate of this reaction changed when the concentration of the hydrochloric acid was changed.

- Describe how you would do the investigation and the measurements you would make.
- Describe how you would make it a fair test.

You do **not** need to write about safety precautions (6)

Exam Exposure

rate increases

allow reaction happens faster

1

(because) particles have more energy

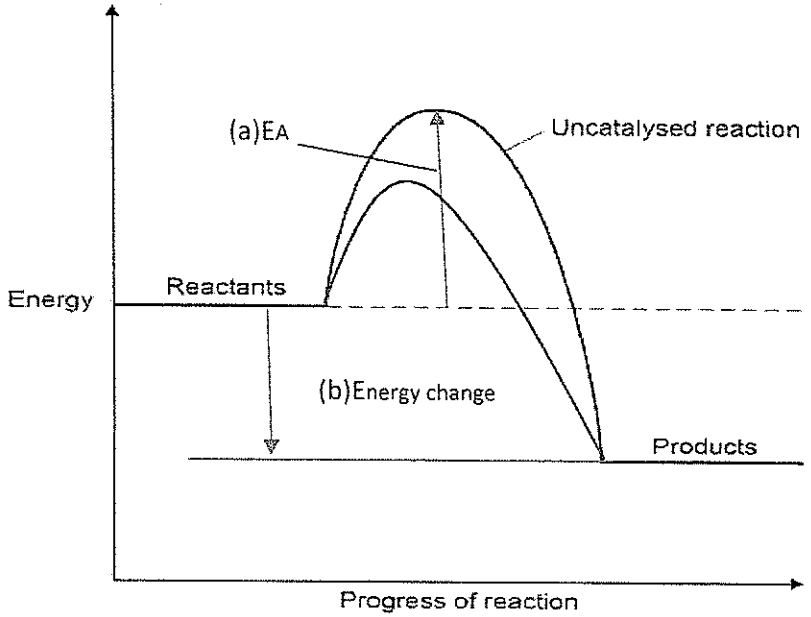
allow (because) particles move faster

allow (because) more particles have energy greater than the activation energy

1

(so) more frequent collisions

1



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Level 3 (5–6 marks):
A coherent method is described with relevant detail, which demonstrates a broad understanding of the relevant scientific techniques and procedures. The steps in the method are logically ordered with the dependent and control variables correctly identified. The method would lead to the production of valid results.

Level 2 (3–4 marks):
The bulk of a method is described with mostly relevant detail, which demonstrates a reasonable understanding of the relevant scientific techniques and procedures. The method may not be in a completely logical sequence and may be missing some detail.

Level 1 (1–2 marks):
Simple statements are made which demonstrate some understanding of some of the relevant scientific techniques and procedures. The response may lack a logical structure and would not lead to the production of valid results.

Indicative content

- remove bung and add magnesium
- start stopclock / timer
- measure volume of gas at fixed time intervals
- repeat with different concentrations of acid
- control volume of acid
- control initial temperature of acid
- control amount / mass / length / particle size of magnesium

6

C7 – Organic Chemistry

Crude oil

Crude oil = a mixture of **hydrocarbons.**

- It is a **non-renewable resource (fossil fuel)**
- Made from remains of dead sea creatures **compressed** over millions of years

Hydrocarbons - molecules containing **hydrogen** and **carbon only.**

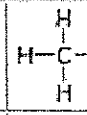
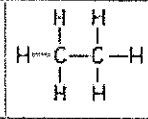
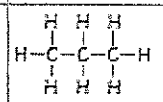
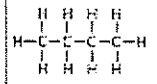
Two types of hydrocarbons are **alkanes** and **alkenes.**

The hydrocarbons in crude oil are mostly alkanes.

Alkanes

- Alkanes = **saturated** hydrocarbons.
- Held together by **single covalent bonds.**
- General formula = C_nH_{2n+2}
- Have different boiling points – longer the chain, higher the boiling point

You need to remember the names, and formulas of the first 4 alkanes.

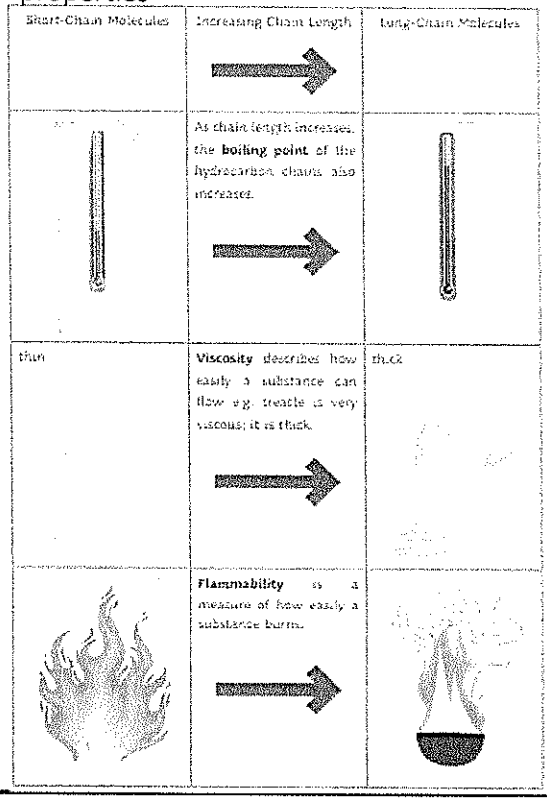
Name of Alkane	Structural Formula	Molecular Formula
methane		CH_4
ethane		C_2H_6
propane		C_3H_8
butane		C_4H_{10}

Fractional Distillation

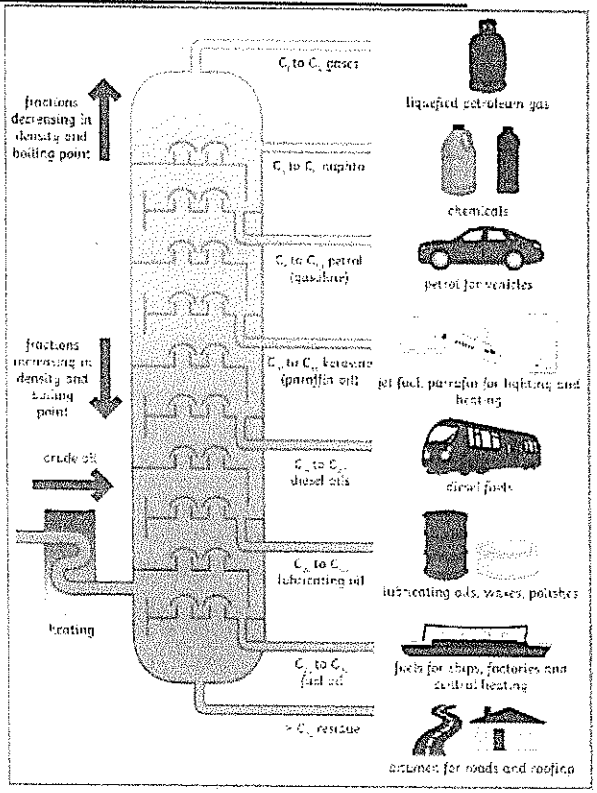
- Used to **separate** the mixtures of hydrocarbons in **crude oil.**

Steps in Fractional Distillation

1. Crude oil enters **fractioning column** and is heated to boiling point so the hydrocarbons evaporate.
2. It is **cooler** at the **top** of the fractionating column and **hotter** at the **bottom.**
3. Vapours rise up the column and, as they rise, they cool
4. The different hydrocarbons condense at different **boiling points**
5. The different 'fractions' have different properties



Uses of the different fractions



Supply and demand

Product	Supply in tonnes	Demand in tonnes
petrol	100	300
diesel	200	100
heating oil	250	50

After fractional distillation, we find:

- we have more of the long chain hydrocarbons than we need
- There are not enough short chain hydrocarbons.
- Short chain are more useful as they are more flammable so can be used as fuels.

C7 – Organic Chemistry

1. What is crude oil?
2. What is a hydrocarbon?
3. What type of hydrocarbons are alkanes?
4. State the general formula for alkanes.
5. Name the first four alkanes.
6. What sort of bonding is found in hydrocarbons?

1. What is the name for the process that results in the separation of the fractions of crude oil?
2. What happens to the boiling point of hydrocarbons as the chain length **increases**?
3. What happens to the viscosity of hydrocarbons as the chain length **increases**?
4. What does flammable mean?
5. What are the two changes of state that occur during fractional distillation?
6. Which physical property is used to separate the fractions?

1. What is one use for the hydrocarbons that are between 14 and 20 carbons long?
2. What is the range of lengths of hydrocarbons in fuel oil?
3. What are the smallest hydrocarbons used for?
4. What happens to the flammability of hydrocarbons as the chain length **increases**
5. What is the range of hydrocarbon lengths found in petrol?
6. What is the problem with supply and demand of the different hydrocarbon chains?

C7 – Organic Chemistry

Cracking

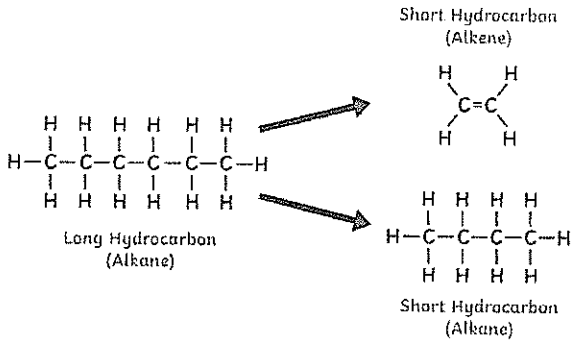
- This is done to solve the problem of having too many long chain hydrocarbons and not enough short ones
- Long hydrocarbons are **broken down** into smaller, more useful hydrocarbons.
- Short chain hydrocarbons are more useful as they are more flammable

Two types of cracking: catalytic and steam cracking.

Catalytic cracking – needs a **high temperature** and a **catalyst.**

Steam cracking – **high temperature and steam**

- Cracking produces a **short-chain alkane** and an **alkene.**



Cracking equations

Same number of carbon and hydrogen atoms on both sides of the equation:

$C_{20}H_{42} \rightarrow C_{14}H_{30} + C_6H_{12}$

long chain hydrocarbon | shorter, more useful alkane | alkene

Alkenes

- Alkenes are **unsaturated** hydrocarbons.
- Contain carbon-carbon **double bonds.**

Test for Alkenes

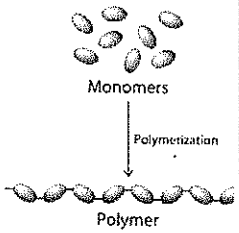
Use bromine water to test for alkenes.
If an alkene is present, the bromine water turns from orange/brown to colourless.
Alkanes do not react with bromine water.

Uses for alkenes:

- Can be used as fuels
- Can be used as a starting material for other chemicals
- Can be used to make polymers (e.g. plastic)

Polymers

- Polymers are large molecules made of many repeating units (monomers)
- Alkenes (small molecules) are joined together to make polymers



Poly(ethene) – plastic bags/drinks bottles

Poly(propene) – strong tough plastics

Drawing and naming polymers

1. Redraw the **monomer given**, but without the double bond. Make sure to copy all other elements exactly.
2. Put brackets around the monomer and extend joining bonds out through the brackets on both sides
3. Add an 'n' at the bottom right of the bracket
4. To name the polymer, you put **poly** in front of the monomer name

E.g.:
Draw and name the polymer made from the monomer ethene:

Ethene | Poly ethene

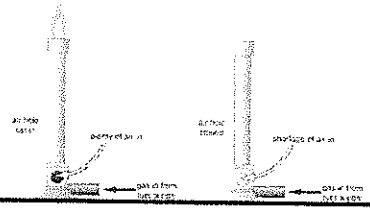
Combustion of Hydrocarbons

Combustion means burning.

Complete combustion - when there is a good supply of **oxygen** for a fuel to burn.

Fuel + oxygen → carbon dioxide + water

Incomplete combustion - **not enough oxygen**
Products are **carbon monoxide** and water.
Carbon monoxide = poisonous gas



C7 – Organic Chemistry

1. What is cracking?

2. Why is cracking done?

3. What are the two types of cracking?

4. What conditions are needed for catalytic cracking?

5. Complete this cracking equation by putting numbers in the boxes:

$$C_{30}H_{62} \rightarrow C_{22}H_{\square} + C_{\square}H_{\square}$$

6. What two types of hydrocarbons are formed during cracking?

1. Why are alkanes called 'unsaturated'?

2. Which chemical is used to test for alkenes?

3. What is the colour change for a positive alkene test?

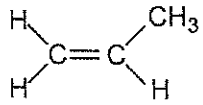
4. Give two uses for alkenes

5. What are polymers?

6. What is the name for the small molecules that make up polymers?

1. What is the name of the polymer formed from the monomer butene?

2. Draw the polymer made from the monomer propene given below:



3. Name the polymer made in question 2

4. What is combustion?

5. When does incomplete combustion happen?

6. What are the waste products of complete combustion?

7. Which toxic gas is formed during incomplete combustion?

Exam Exposure

Describe how crude oil is formed (3)

Describe how crude oil is separated into fractions by fractional distillation. (3)

Large alkane molecules can be cracked to produce more useful molecules. The equation shows the cracking of dodecane.

$$\underset{\text{dodecane}}{C_{12}H_{26}} \longrightarrow \underset{\text{butane}}{C_4H_{10}} + \underset{\text{hexene}}{C_6H_{12}} + \underset{\text{ethene}}{C_2H_4}$$

Give **two** conditions used to crack large alkane molecules. (2)

1 _____

2 _____

Almost all of the crops that we eat can be converted into fuel for cars. Vegetable oils can be used as biodiesel. Diesel from crude oil is called fossil diesel. When either biodiesel or fossil diesel burn they both produce similar amounts of carbon dioxide. Both types of diesel produce carbon monoxide. However, biodiesel produces fewer carbon particles and less sulfur dioxide.

Use the information at the start of this question and your knowledge and understanding to evaluate the use of biodiesel compared with fossil diesel as a fuel for cars. Remember to give a conclusion to your evaluation. (6)

Exam Exposure

Plankton - *allow biomass allow (marine) animals organisms/ ignore plants*

1

buried in mud- *allow compressed under mud allow compressed in sedimentary rock ignore fossilised*
1

over a long period of time or over millions of years 1

crude oil heated

1

(hydrocarbons / liquids) evaporate -*allow (hydrocarbons / liquids) vaporise / boil*

1

vapours / gases condense

1

fractions have different boiling points **or** fractions collect at different levels depending upon boiling point

1

high temperature
allow heating / hot / 250-900 °C

1

catalyst or steam

allow named catalyst eg zeolite, Al_2O_3, silica, ceramic

allow in the absence of air / oxygen

1

any **five** from:

accept converse statements for fossil diesel.

ignore cost / ease of manufacture / usage issues

for biodiesel:

- less global dimming (because fewer carbon particles)
- less acid rain (because less sulfur dioxide)

  *if neither point awarded, fewer carbon particles and less sulfur dioxide = **1** mark*
- renewable resource / sustainable

  accept fossil fuel / diesel supplies are limited
- use <u>waste</u> vegetable oils / fats
- vegetables / plants absorbed carbon dioxide / carbon neutral

  accept fossil fuel / diesel releases locked up carbon / is not carbon neutral
- uses land which could be used to produce food
- third world countries can produce bio diesel
- biodegrades easily
- more NOx released

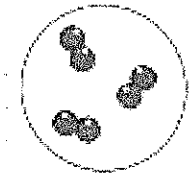
5

justified conclusion

1

C8 – Chemical Analysis

Pure substances



Pure = single element or compound – not mixed with any other substance.

Testing to see if a substance is pure:
- Pure substances have specific melting and boiling points

- Compare your data to a library of known values.

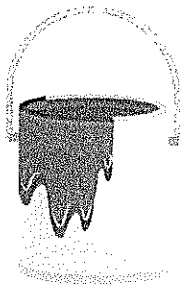
E.g. Water has a boiling point of 100°C, if it is above or below this, it is not pure.

Formulations

Formulation = a mixture that is designed as a useful product.

- Components mixed carefully to get the required **properties**.

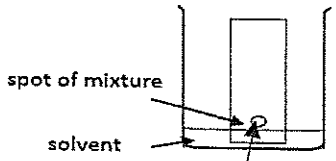
Examples of formulations:
- Fuels
- Cleaning agents
- Paints
- Medicines
- Alloys
- Fertilisers
- Food



Chromatography

- Technique used to separate mixtures of **soluble substances**.
- How soluble a substance is determines how far it travels across paper.

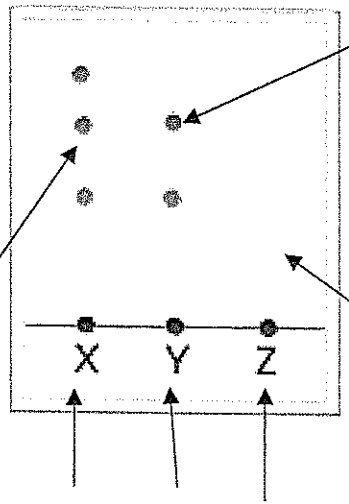
More soluble = travels further (higher up paper)



Mobile phase
- **Solvent** is the mobile phase
- The substances dissolve in the solvent
- The solvent then moves through the stationary phase.

Stationary phase
- Does not move. The paper is the stationary phase.

Important – start line on paper must be drawn in **pencil** as pencil is **insoluble** and **will not run**
The spot and start line must be **above the solvent line** so the colours won't just wash into the solvent in the beaker.



Y is a mixture as it contains 2 substances (2 spots)

X is a mixture as it contains 3 substances (3 spots)

Z is pure as it only contains one substance (1 spot)

Three samples (x, y and z)

Rf Values

This is the ratio of the distance moved by a substance to the distance moved by the compound

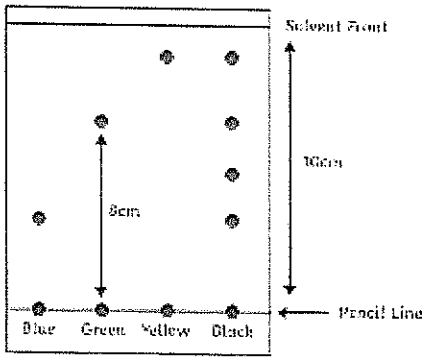
$$R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$$

- Should always be between 0 and 1.

- Each substance has a unique Rf value.

- Can compare Rf values to a library of known substances

- Can identify unknown substances.



Rf value of green:

8cm / 10cm = 0.8

C8 – Chemical Analysis

1. What is a pure substance?

2. How can you test that a substance is pure?

1. What is a formulation?

2. Give 3 examples of formulations.

1. What is chromatography used for?

2. What determines how far the substance travels?

3. What is the mobile phase in paper chromatography?

4. What is the stationary phase in paper chromatography?

5. How would you be able to identify a pure substance on a chromatogram?

6. Draw and label a diagram of the experiment to Investigate how many different colours there are in food colouring using paper chromatography.

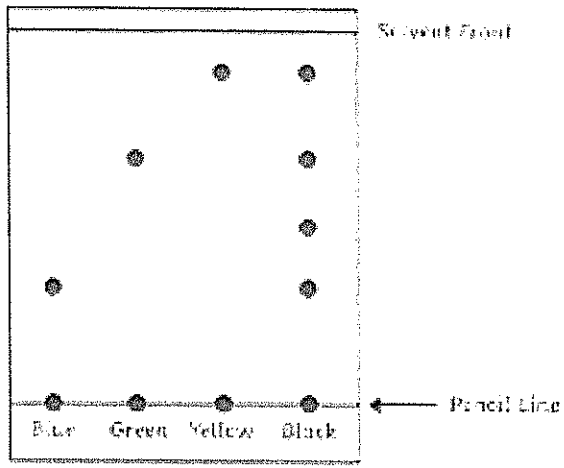
1. How do you calculate the Rf value?

2. Rf values should always be between...

3. Use a ruler to measure the distance the solvent moved in the diagram below.

4. Use a ruler to measure how far the yellow spot moved

5. Calculate the Rf value for yellow



C8 – Chemical Analysis

Required Practical – Paper Chromatography

Aim: Investigate how paper chromatography can be used to separate and distinguish between coloured substances.

Method

1) Using a ruler, measure 1cm from bottom of chromatography paper and draw a line across the paper with a **pencil**.

2) Using a pipette, drop small spots of each ink onto pencil line (leave a gap so do not merge).

3) Pour solvent into a beaker, do not fill solvent above the pencil line on the paper.

4) Place chromatograph paper into beaker and allow solvent to move up the paper.

5) Remove paper just before solvent reaches top of the paper and leave to dry.

6) Calculate R_f values of all the spots using the equation below:

$$R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$$

Common questions

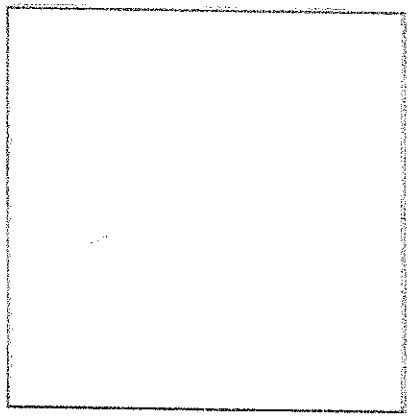
Q1) Why is a pencil used instead of a pen?
A1) Ink in the pen would move up the paper with the substances.

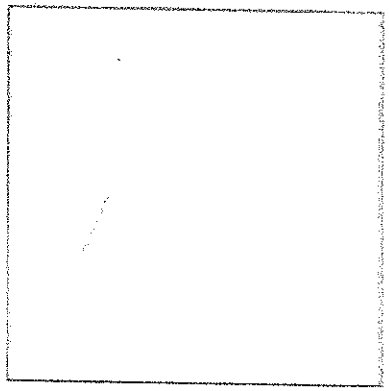
Q2) Why do you not fill the solvent above the line?
A2) Substances would wash off into the solvent instead of rising up the paper

Q3) Why might water not work as a solvent?
A3) Some substances are **insoluble** in water.

Identification of the Common Gases

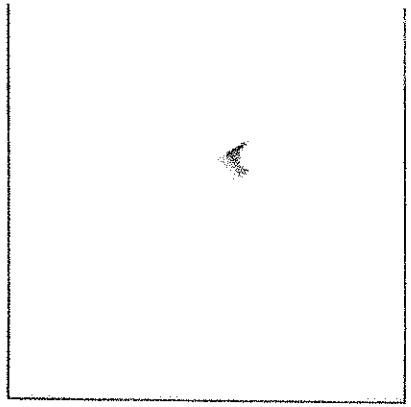
Test for hydrogen – Place a **burning** splint at the opening of a test tube. If hydrogen gas is present, it will burn with a **squeaky-pop sound.**

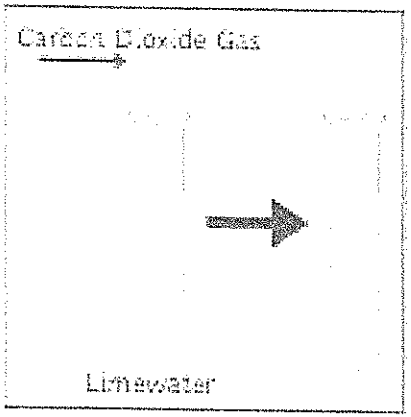




Test for Oxygen – Place a **glowing** splint inside a test tube. The splint will **relight** in the presence of oxygen.

Test for Carbon Dioxide –Bubble the gas through the lime water – if the gas is carbon dioxide, the limewater turns **cloudy**.





Test for Chlorine – Damp litmus paper is held over the of gas. If the tube contains chlorine, the litmus paper becomes **bleached** and **turns white.**

C8 – Chemical Analysis

1. Describe how you would carry out paper chromatography to separate and identify the different colours in food dye.

2. Why is a pencil used instead of a pen?

3. Why do you not fill the solvent above the pencil line?

4. Why might water not work as a solvent?

1. Describe the tests and the positive results for:

a) Hydrogen

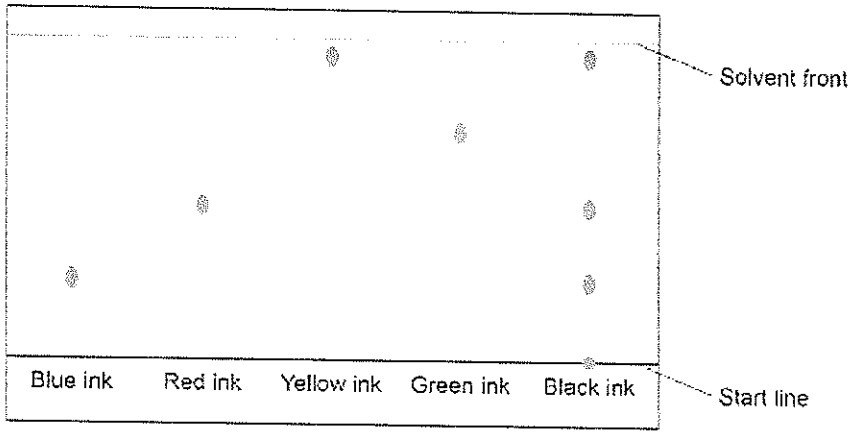
b) Carbon dioxide

c) Oxygen

d) Chlorine

Exam Exposure

The figure below shows a paper chromatogram of five different inks.



(a) Explain how paper chromatography separates substances. (3)

(b) Use the figure above to calculate the R_f value of the blue ink. (3)

R_f value = _____

(a) Which substance is a mixture? **(1)**

Tick (✓) **one** box.

Air ☐ Gold ☐ Methane ☐ Nitrogen ☐

(b) Chromatography involves a stationary phase and a mobile phase.

Phase	What is used
	Beaker
Mobile phase	Chromatography paper
	Food colouring
Stationary phase	Pencil line
	Solvent

(2)

(c) Food colourings are often mixtures of dyes.

What name is given to mixtures that are designed as useful products?

(1)

_____

Exam Exposure

(a) mobile phase / solvent moves through paper

1

and carries substances different distances

1

which depend on their attraction for paper and solvent

allow which depend on solubility in solvent and attraction to paper

1

(b) both measurements from artwork for **1** mark (1.3 ± 0.1 cm and 5.3 ± 0.1 cm)

1

correct equation used for **1** mark

1

0.25 ± 0.02

1

*accept 0.25 ± 0.02 without working shown for **3** marks*

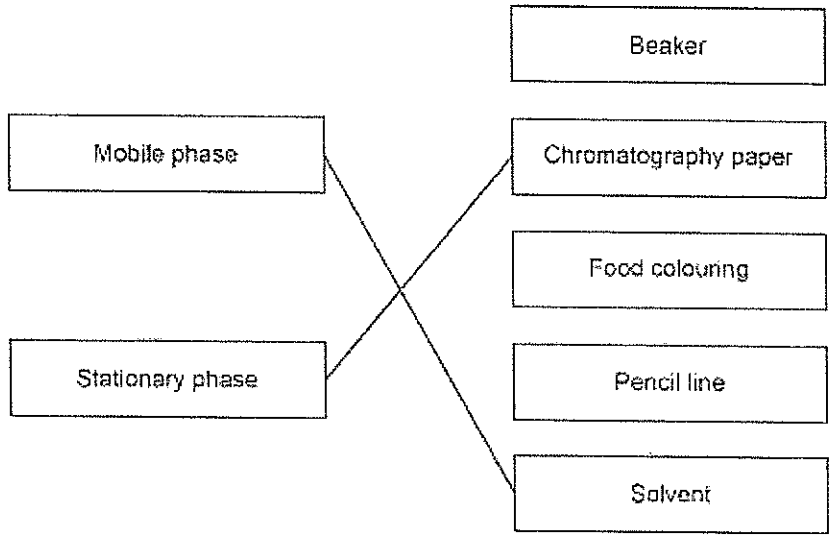
*allow ecf from incorrect measurement to final answer for **2** marks*

(a) Which substance is a mixture? **(1)**

Tick (✓) **one** box.

Air ☐

(b)

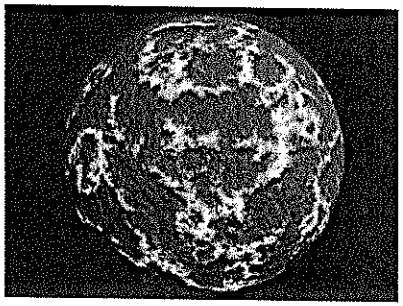


(c) Formulation

C9 – Earth & Atmosphere

Early Atmosphere vs modern atmosphere:

Gas	Levels in earth's early atmosphere	Percentage in air today
Nitrogen	None	78
Oxygen	None	21
Others – CO_2 and argon	Very High	1
Water vapour	Very high	Varies – but usually only around 1%
Ammonia	High	None



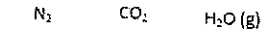
4.6 billion years →

We think that the atmosphere on Earth was once like that of Mars or Venus is today

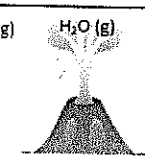
When Earth was formed it was so hot it was molten on the surface, and the atmosphere was full of toxic gases like methane and ammonia.

We cannot be sure about exactly what the Earth's early atmosphere as we have no evidence from so long ago

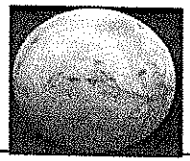
How did the atmosphere change?



1. Volcanoes released nitrogen, carbon dioxide and water vapour

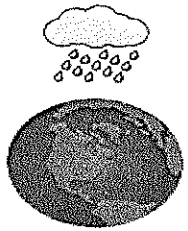


2. The earth cooled and solidified



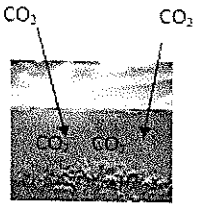
3. Water vapour in the atmosphere condensed and feel as rain

4. Oceans, lakes and rivers formed



5. Carbon dioxide from the air dissolved in the oceans

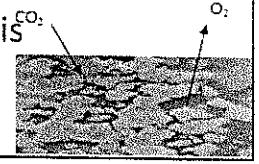
6. Some of this reacted to form sedimentary rocks like limestone



7. Algae and then plants evolved, removing carbon dioxide from the air and produced oxygen by photosynthesis

Carbon dioxide + water → glucose + oxygen

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$



8. Many early plants and marine organisms were buried and decayed underground, locking up carbon in fossil fuels like coal (plants) and oil (animals)

C9 – Earth & Atmosphere

1. Name two gases that were present in large quantities in Earth's early atmosphere

2. What is the most abundant gas in today's atmosphere?

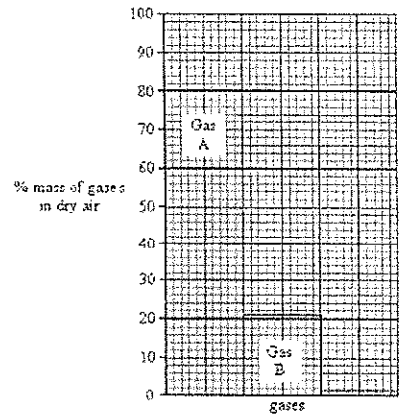
3. Which two planets do we think Earth's early atmosphere was similar to?

4. Why can we not be sure about the Earth's early atmosphere?

5. Give two differences between the early atmosphere and today's atmosphere.

6. The data for today's atmosphere is shown on the chart below:

Use the table on page 1 to name:
Gas A
Gas B



1. How did nitrogen form in the atmosphere?

2. How did water vapour levels decrease?

3. Name 2 ways carbon dioxide was removed from the early atmosphere before plants evolved.

4. Which organisms were the first to photosynthesise?

5. Why did oxygen levels rise?

6. Write the equation for photosynthesis

7. What is 'locked up carbon'?

8. Describe how carbon dioxide in the air ended up in rocks like limestone

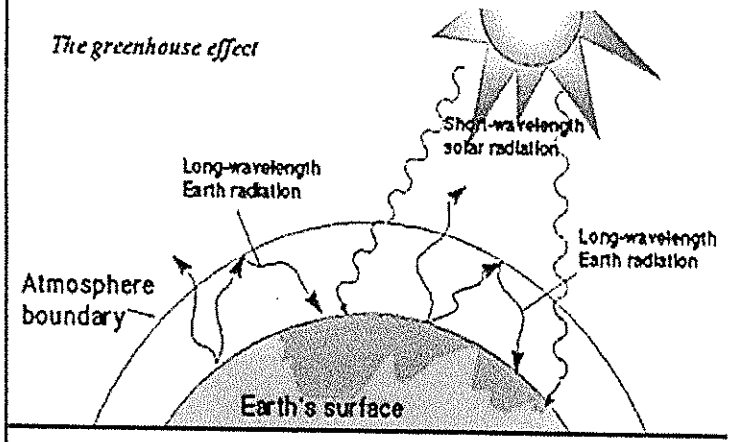
9. How was coal formed?

C9 – Earth & Atmosphere

The greenhouse effect

The greenhouse layer is a layer of gases in the atmosphere made of:

- carbon dioxide
- methane
- water vapour



1. Short wavelength infrared radiation from the sun reaches Earth
2. Some energy is absorbed by the Earth
3. Longer wavelength IR is reflected by the Earth
4. Longer wavelength IR cannot get through the greenhouse layer as easily so some is trapped, warming the Earth

The thicker the layer of gases, the more heat is trapped

Global warming

The greenhouse layer is getting thicker, because:

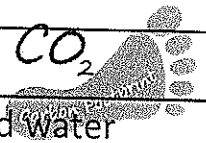
- CO_2 released from fossil fuels to generate electricity
- CO_2 released from fossil fuels in vehicles
- Methane released from cattle
- Methane released from rotting landfill sites

Many scientists believe that human activities are causing the warming of the Earth.

Potential consequences:

- Melting ice caps
- Loss of habitats for animals and plants
- Damage to coral reefs caused by warmer oceans
- Changes to animal migration patterns
- Extreme weather patterns – more hurricanes, heat waves, droughts, snow and ice
- Difficulty growing crops so reduced food supply

Carbon footprint



The total amount of CO_2, CH_4 and water vapour released by of a product or service.
E.g for a concert:

- electricity in performance
- Fossil fuels used by people travelling there
- Plastics used and disposed of in refreshments etc

Carbon footprints can be reduced by recycling, reducing energy use or eating vegetarian diets but this is hard to get people to do.

Pollutants :

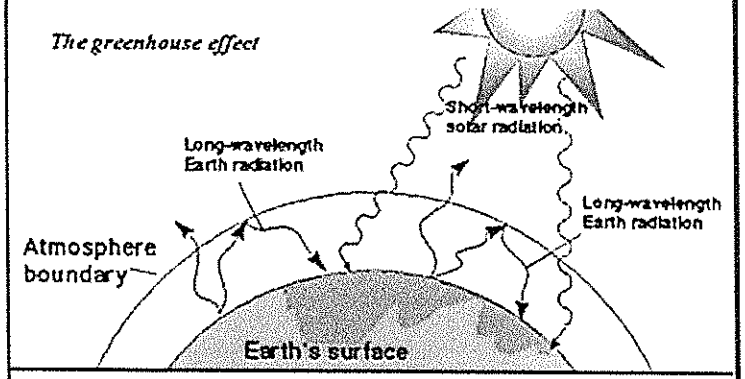
Pollutant	Source	Effects
Carbon dioxide	Combustion	Global warming
Carbon monoxide	Incomplete combustion of fuels	Toxic gas, can be fatal
Sulfur dioxide	Traces of sulfur in coal react with oxygen when burned	Acid rain
Nitrogen oxides	Hot engines provide the energy for N_2 to react with O_2	Acid rain
particulates	Incomplete combustion	Global dimming, breathing problems

C9 – Earth & Atmosphere

The greenhouse effect

1. What is the 'greenhouse' layer?

2. Name the 3 greenhouse gases



1. What sort of radiation is emitted from the sun?

2. How is the wavelength of the radiation reflected from Earth different than that from the sun?

3. Why is some heat trapped?

4. What is the relationship between the thickness of the layer and the amount of heat trapped?

Global warming

1. Name two human activities that release CO_2

2. Name two sources of methane

1. Name two impacts of global warming on animals

2. Why might coral reefs be damaged by global warming?

3. Why might our food supply be under threat?

Carbon footprint

1. What is the 'carbon footprint'?

2. Name two ways a person can reduce their carbon footprint.

3. Why is it difficult to get people to reduce their carbon footprint?

Pollutants :

Pollutant	Source	Effects
Carbon dioxide		Global warming
	Incomplete combustion of fuels	Toxic gas, can be fatal
Sulfur dioxide		
Nitrogen oxides		Acid rain
particulates		

Exam Exposure

(a) Carbon dioxide is a greenhouse gas. What is another greenhouse gas? Tick **one** box (1)

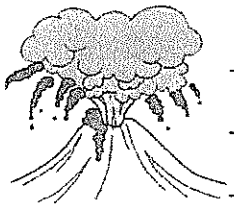
Argon ☐ Methane ☐ Nitrogen ☐ Oxygen ☐

(b) Greenhouse gases cause global climate change. Give **two** effects of global climate change. **(2)**

(c) 4.1 kg of a plastic, used to make plastic bottles, has a carbon footprint of 6.0 kg of carbon dioxide. Calculate the carbon footprint of **one** plastic bottle of mass 23.5 g **(2)**

Answer

Describe how volcanoes caused the oceans to be formed. **(2)**



Explain how the percentages of nitrogen, oxygen and carbon dioxide in the Earth's atmosphere today have changed from the Earth's early atmosphere. (6)

Exam Exposure

(a) methane

1

(b) any **two** examples from:

allow effects from the same bullet point

- rising sea levels
- melting ice
- agricultural problems
- extremes of weather
- loss of habitats

ignore global warming
ignore acid rain
ignore global dimming
*do **not** accept reference to ozone*

2

(c) $\frac{6.0}{4.1} \times 0.0235$

1

= 0.0344(kg)

water <u>vapour</u> given out from volcano

accept steam

1

condensed

accept rain / clouds formed just 'cools' is insufficient

1

Explain how the percentages of nitrogen, oxygen and carbon dioxide in the Earth's atmosphere today have changed from the Earth's early atmosphere. (6)

Level 3: Relevant points (reasons / causes) are identified, given in detail and logically linked to give a clear account.

5–6

Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.

3–4

Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

1–2

Indicative content

nitrogen increased
- because volcanoes produced nitrogen
- because (denitrifying) bacteria produced nitrogen
- because ammonia was converted to nitrogen

oxygen increased
- because algae and plants produced oxygen
- by photosynthesis

carbon dioxide decreased
- because algae and plants used carbon dioxide
- by photosynthesis
- because oceans formed and carbon dioxide dissolved in the water
- because carbon dioxide formed carbonates, which precipitate as sediments or formed sedimentary limestone rocks
- because algae / plants and animals formed fossil fuels / coal / crude oil / natural gas

C10 – Using Resources

Earth's Resources

We use Earth's resources to provide **warmth, shelter, food and transport.**
E.g.:

- metals from the Earth's crust to build buildings and cars
- Timber and oil to burn for warmth
- Crop plants for food
- Products from crude oil to serve as fuels in cars, trains and planes

Finite resources – ones that will run out as they are being used much faster than they can be replaced, e.g. oil
Renewable resources – resources that will not run out, e.g. wood, wind etc.

Chemistry plays an important part in finding improvements or alternatives to current resources.

Natural	Improved or replaced by....
Wood for furniture	Plastic/polymers
Food crops	Fertilisers/artificially grown foods such as Quorn
Oil for fuel	Ethanol/hydrogen fuel cells
Rubber for tyres	Polymers

Life-Cycle Assessments (LCA)

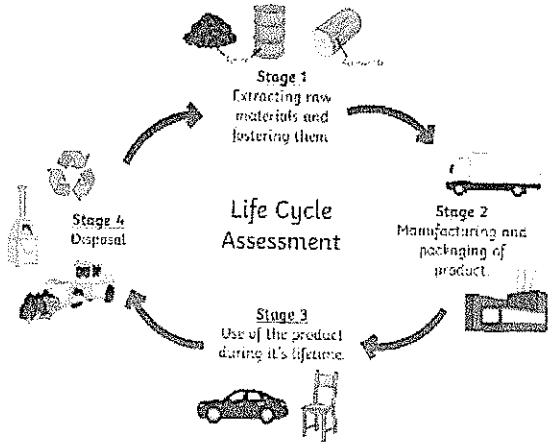
- These assess the environmental impact of a product in these stages:

Stage 1 – extracting raw materials needed to make products.
- Energy cost and effect on habitats of extraction
- Are the raw materials finite/renewable?

Stage 2 – Manufacturing and packaging product
- How much energy and resources are needed?
- What waste products/pollution are released?
- Transportation of goods from factors to user need considering.

Stage 3 – Use of product during its lifetime
- E.g. a car has a significant impact as needs filled up with petrol which is a finite resource.

Stage 4 – Disposal at end of product's life.
1) Landfill – high environmental impact
2) Incineration – burning of product
3) Recycling – e.g. batteries contain metals that are harmful to environment – recycling means no new compounds need to be taken out of the ground.



Example LCA for plastic vs paper bags:

Stage of Life Cycle Assessment	Plastic Bag	Paper Bag
Stage 1 – raw material	Uses finite resource. Process of fractional distillation, cracking and polymerisation all require energy.	Made from trees/recycled paper. Making paper from trees required more energy than recycled paper. Less energy than plastic bags.
Stage 2 – Manufacture	Cheap to make	More expensive to make
Stage 3 – Use	Low environmental impact as can be re-used many times. Much stronger product.	Only be reused a limited number of times – short lifetime.
Stage 4 - disposal	Do not biodegrade easily in landfill.	Paper bags degrade easily in landfill sites.

- Different people have different opinions and so depends on who completes the LCA. Bias may be added.
- Some companies may only discuss some of environmental impacts of their product.
- Accurate numerical values should be used where possible – for example to show how much energy has been used.

C10 – Using Resources

1. What are the 4 main uses of the Earth's materials?

2. What is a renewable resource?

3. What is a finite resource?

4. Give an example of a finite resource

5. Give an example of a renewable resource

6. Give an example of a natural product that has been replaced by modern chemistry or farming.

1. What does LCA stand for?

2. What does an LCA assess?

3. What are the 4 stages that are assessed in an LCA?

4. Suggest one environmental impact of extraction of raw materials such as metals or oil.

5. Name two ways products are disposed of at the end of their 'life'

1. Why might an LCA be inaccurate?

2. What are the raw materials for a
a) paper bag
b) plastic bag

3. Why might the disposal of a plastic bag have a greater environmental impact than the disposal of a paper one?

C10 – Using Resources

Reducing the use of resources

Metals, glass, ceramics, building materials and most plastics are produced from limited resources.

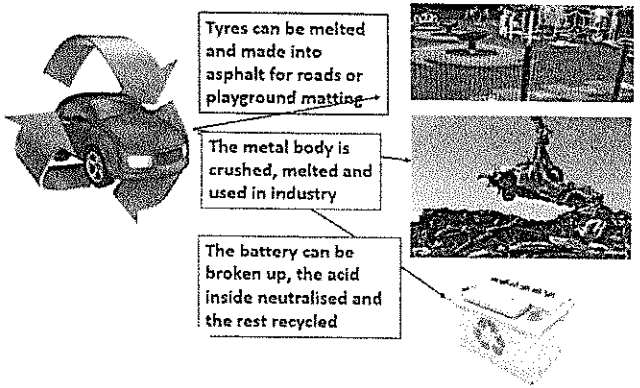
The energy for the processes involved in making/extracting raw materials also comes from limited resources – e.g. oil.

We can reduce the use of limited resources by reducing use, reusing materials and recycling materials at the end of their life.

Reduce, reuse, recycle.

E.g.

- Glass bottles can be reused.
- Metals can be melted down and recast and so recycled.
- Scrap steel can be added to extracted iron to reduce the amount of iron that has to be extracted in the blast furnace.



Evaluating methods to reduce, reuse, recycle

Advantages	Disadvantages
Fewer resources such as mines and quarries are needed to extract finite materials	Requires collection and transport of items – involving staff, vehicles and use of fuel
Crude oil does not need to be extracted – avoids high energy costs for fractional distillation etc.	Materials, such as metals, very often have to be separated from other materials first
Less greenhouse gases produced.	Some metals need melting before being reused – energy costs.
Less items in landfill	

Biological extraction techniques (HT only)

- Earth's supply of metal ores is limited.
- There are fewer sites that give lots of copper (high grade ore sites)
- New ways of extracting from low grade ore sites are:

- Phytomining
- Bioleaching

Disadvantage = **slow processes**

Advantage = reduce need for the traditional mining methods of digging, moving and disposing of large amounts of rock.

Phytomining (HT only)

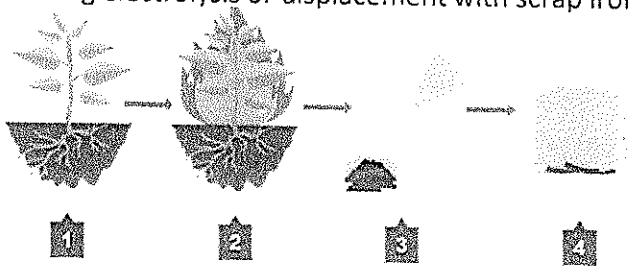
1) Plants are grown on a low-grade ore

2) The plants absorb metal ions through their roots

3) The plants are harvested and burnt

4) Ash left behind contains metal compounds

5) Ash is dissolved in acid and copper is extracted using electrolysis or displacement with scrap iron.



Bioleaching (HT only)

- Uses **bacteria** to produce a solution called **leachate** – contains copper ions.
- The copper can be extracted by using iron to **displace** the copper from the leachate.

- Does not need high temperatures
- Produces **toxic substances** which can damage the environment.

- Iron is cheaper than copper – use of scrap iron is a cost-effective way to produce copper from leachate.

- Can also undergo **electrolysis** to produce copper.

C10 – Using Resources

1. Give three ways we can reduce our use of limited resources.

2. Give an example of a product that can be reused

3. What has to be done to metals before they can be recast?

4. How is scrap iron used to reduce the amount of iron needing to be extracted?

1. State two advantages of recycling.

2. State two disadvantages of recycling.

1. What is a 'high grade ore' site?

2. Name the two biological extraction techniques

3. State a disadvantage of biological extraction techniques.

1. What organisms are used in phytomining?

2. What happens to the plants once they've grown?

3. What is used to displace the copper ions from solution?

4. What organisms are used in bioleaching?

C10 – Using Resources Water

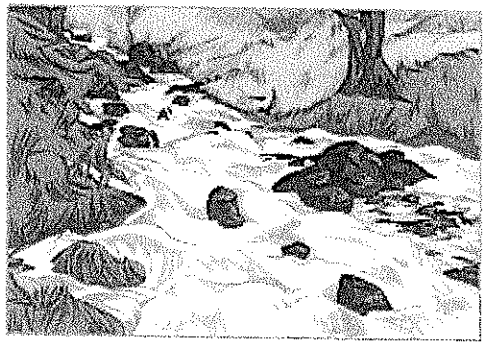
Potable Water

- Water is **essential** for life.
- **Potable water is** water that is safe to drink.
- Potable water is not pure as it contains some dissolved substances.

In the UK – rain water provides water with low levels of dissolved substances that collects in the ground and in lakes and rivers. This is fresh water.

Most potable water is produced by:
1) Choosing an appropriate source of fresh water
2) Passing the water through filter beds
3) Sterilising to kill bacteria

Sterilising agents used for potable water include:
- Chlorine
- Ozone
- Ultraviolet light



Desalination of Sea Water

- **Potable** water can be made from sea water through desalination.
- Required a lot of **energy** to **remove salt** in sea water.

Can be done by:

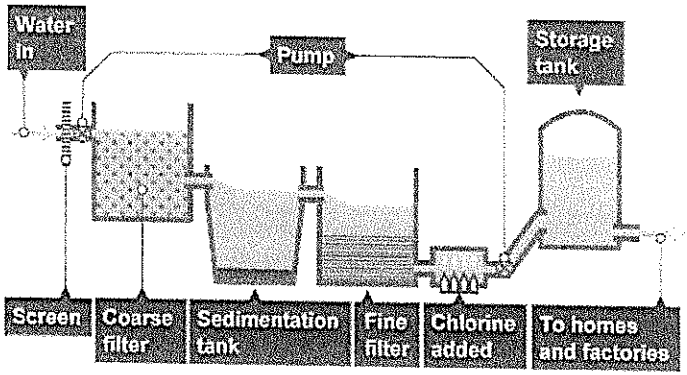
Distillation
- Sea water heated until it boils
- Steam is **condensed** to make potable water
- Requires a lot of **energy**

Reverse Osmosis
- Water put under **high pressure** and passed through **membrane** with tiny holes in.
- Holes allow water through but not salt/ions
- Very **expensive**
- Produces **large volumes** of waste water.

Waste Water Treatment

- Waste water needs to be treated before being released back into environment

Pollutants can be present in waste water including:
- Human waste contains harmful **bacteria** and nitrogen – can harm aquatic ecosystems.
- Industrial waste can contain **toxic** substances
- Agricultural waste water can contain **fertilisers** or **pesticides** – disrupt ecosystems.



Sewage treatment involves:
1) Screening and grit removal to remove large particles

2) Sedimentation – allows tiny particles to settle – produces sewage sludge and effluent (liquid that remains on the top)

3) Sewage sludge is digested anaerobically by specific bacteria

4) Effluent is treated with aerobic bacteria to reduce volume of solid waste.

C10 – Using Resources

1. What is potable water?

2. What is fresh water?

3. Where does fresh water collect in the UK?

4. After finding an appropriate source of water, what two stages are needed to make it potable?

5. What are the 3 methods of sterilising water?

6. Why is water treated with chlorine?

1. How can potable water be made from sea water?

2. Give a disadvantage of this technique.

3. Describe the process of distillation.

4. Describe the process of reverse osmosis.

1. State three pollutants that may be present in waste water.

2. Complete the table to explain the steps in treating waste water.

Step	**Explanation**
Screening	
Sedimentation	
Anaerobic digestion	
Aerobic digestion	

C10 – Using Resources – Required Practical – Analysis and purification of water

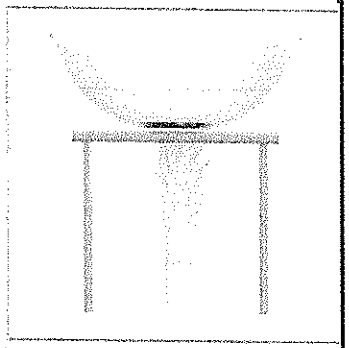
Analysing the pH of Water Samples

- Test pH of each water sample using pH probe or universal indicator.
- Compare to pH chart if using universal indicator

Analysis the Mass of Dissolved Solids

1) Measure out 50 cm^3 of water sample using measuring cylinder.

2) Take the mass of evaporating basin using top pan balance.



3) Heat the sample in the evaporating basin gently until all liquid evaporates.

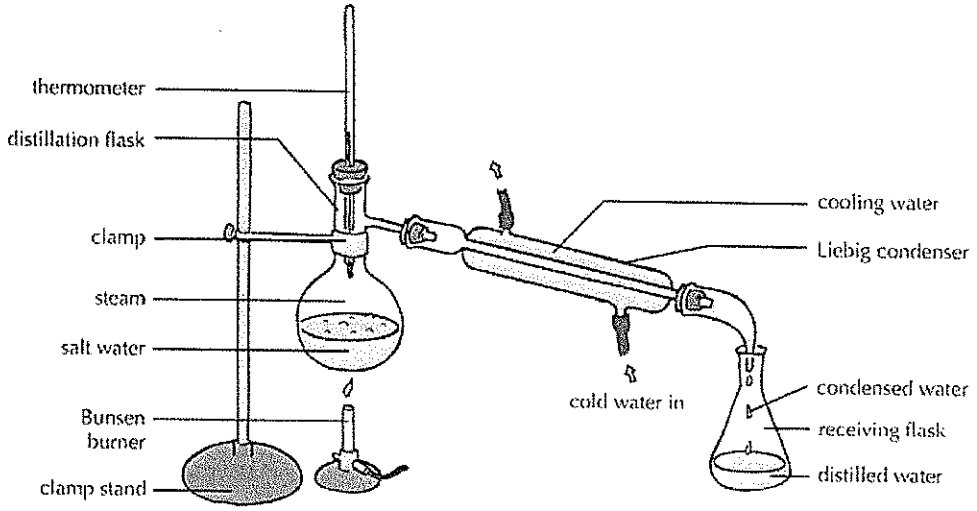
4) Let the evaporating basin cool

5) Re-take the mass of the evaporating basin.

6) Calculate the mass of the solid left behind by doing: final mass – initial mass.

7) Repeat with different water samples (e.g. rainwater, salt water, spring water)

Distillation of water Sample



1) Set up apparatus as shown in picture with the sample of water in the round bottom flask.

2) Heat water sample until it boils gently.

3) Water vapour enters the tube at the side (condenser)

4) There is cold water surrounding the tube

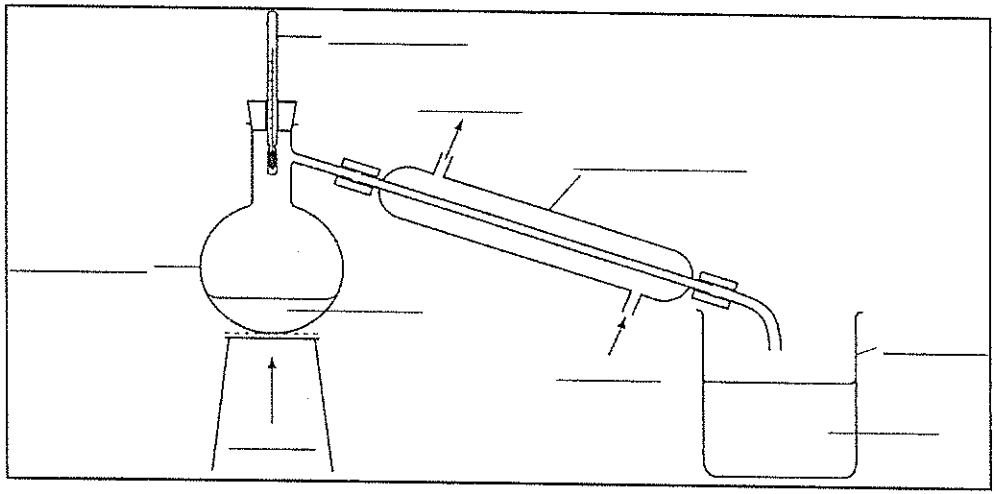
5) The water vapour cools and condenses and collects in the flask.

6) The water collected should be **pure**.

C10 – Using Resources – Required Practical – Analysis and purification of water

1. Write a method of how to investigate the mass of solids in different samples of water.

1. Label the diagram below to show how to purify salt water.



Bunsen, water sample, water, beaker, condenser, water in, water out, thermometer, round bottom flask

2. What is the name of this technique?

3. What two changes of state happen during this?

4. Describe the water that is collected in the beaker

Exam Exposure

Give **one** way that carbon dioxide emissions can be reduced when a plastic bottle is manufactured.**(1)**

Emissions from cars contain carbon dioxide. Explain why carbon dioxide emissions during use and operation are **not** the total carbon footprint for a car. Refer to the stages of the life cycle assessment of a car in your answer. **(3)**

(a) Which process can be used to produce potable water from salty water?

Distillation ☐ Electrolysis ☐ Filtration ☐ Sterilisation ☐

(b) What is removed when the water is filtered?

Gases ☐ Solids ☐ Liquids ☐

(c) What is used to sterilise the water?

Carbon ☐ Chlorine ☐ Sodium chloride ☐

Water that is safe to drink is called potable water. Compare how easily potable water can be obtained from:

- waste water (sewage)
- ground water (fresh water). (6)

Exam Exposure

use less plastic

or

use recycled plastic

allow carbon capture
ignore any reference
to energy / fuels

at high temperatures (in the engine)

1

nitrogen

1

reacts with oxygen (to produce nitrogen dioxide)

1

(a) Distillation

(b) Solids

(c) Chlorine

Level 2: Scientifically relevant features are identified, the way(s) in which they are similar / different is made clear and (where appropriate) the magnitude of the similarity / difference is noted.

4–6

Level 1: Relevant features are identified and differences noted.

1–3

Indicative content

ground water	**waste water**
easier to obtain	more difficult to obtain
fewer processes	more processes
takes less time	takes more time
filtered through filter beds to remove insoluble particles	screening and grit removal to remove large particles
	sedimentation to produce sewage sludge and effluent
	aerobic biological treatment of effluent to reduce solid waste
sterilised using chlorine, ozone or uv light to kill bacteria	and then sterilised using chlorine, ozone or uv light to kill bacteria
	sludge is anaerobically digested by specific bacteria to remove organic matter