Whitley Academy

Chemistry Paper 2 (H) Knowledge Recall Booklet

Paper Chemistry 2H 8464/C/2H

For this paper, the following list shows the major focus of the content of the exam:

- 5.6.1 Rate of reaction
- 5.6.2 Reversible reactions and dynamic equilibrium
- 5.7.1 Carbon compounds as fuels and feedstock
- 5.8.1 Purity, formulations and chromatography
- 5.9.1 The composition and evolution of the Earth's atmosphere
- 5.10.1 Using the Earth's resources and obtaining potable water

Required practical activities that **will be assessed**:

- Required practical activity 11: investigate how changes in concentration affect the rates of reactions by a method involving measuring the volume of a gas produced and a method involving a change in colour or turbidity. This should be an investigation involving developing a hypothesis.
- Required practical activity 12: investigate how paper chromatography can be used to separate and tell the difference between coloured substances. Students should calculate R_f values.

Your teacher will tell you specific topic areas to focus on …

Topic	RAG			Revision technique					Date completed	Teacher Signed
	R	A	G	Flashcards	Mindmap	Notes	Video Watched (With notes)	Frog resource		

Recall it ...

Required Practical – Rates of Reaction

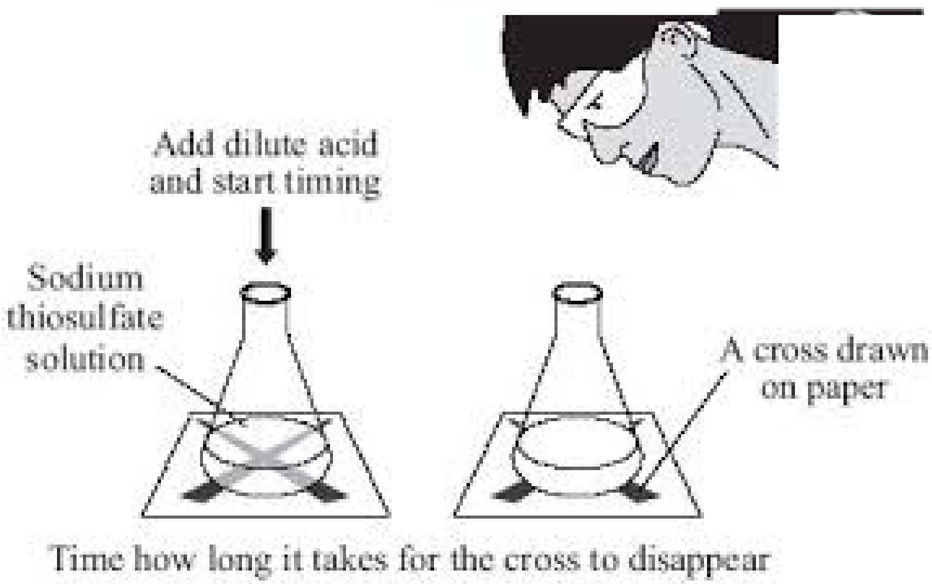
Use the information in the following page(s) to answer these questions ...

1. What at the reactants for this practical?
2. What are the independent, dependent and control variables for this investigation?
3. How do you know the reaction has reached its end point?
4. Write a detailed method for the experiment?
5. What safety needs to be considered for this experiment?

Required Practical – Rates of Reaction

<u>You will need to collect the following equipment:</u>

- 10 cm^3 measuring cylinder
- 100 cm^3 measuring cylinder
- 100 cm^3 conical flask
- A black cross drawn onto paper
- stop clock.



<u>Method:</u>

1. Measure out 10 cm^3 sodium thiosulfate solution in the 100 cm^3 measuring cylinder and pour into the conical flask.
2. Measure out and add 40 cm^3 water to the same conical flask.
3. Put the conical flask on the black cross.
4. Measure out 10 cm^3 of dilute hydrochloric acid in the 10 cm^3 measuring cylinder.
5. Put this acid into the flask. At the same time swirl the flask gently and start the stopclock.
6. Look down through the top of the flask. Stop the clock when you can no longer see the cross.
7. Repeat steps 1-6 using the volumes shown below.

Take care to avoid breathing in any sulfur dioxide fumes.

Recall it …

Required Practical – Measuring the volume of gas

Use the information in the following page(s) to answer these questions …

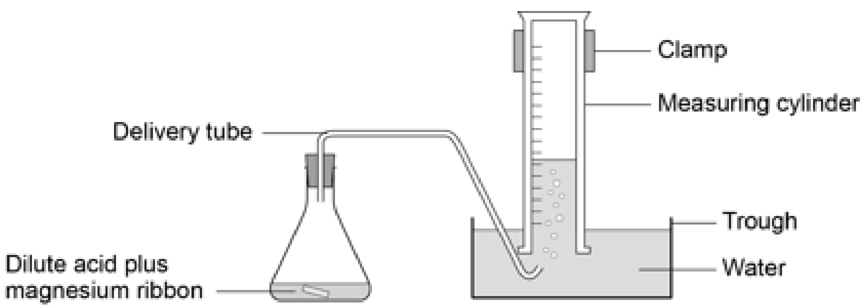
1. Sketch the apparatus and describe how the experiment is set up?
2. Name the reactants in the experiment?
3. What is produced and measured in the experiment?
4. Sketch a graph of the results?
5. Describe what they different parts of the graph tell you?

Required Practical - Measuring the volume of gas

1. Measure 50 cm^3 of 2.0 M hydrochloric acid using one of the measuring cylinders. Pour the acid into the 100 cm^3 conical flask.

2. Set up the apparatus as shown in the diagram.

   Half fill the trough or bowl with water.



3. Fill the other measuring cylinder with water. Make sure it stays filled with water when you turn it upside down.
4. When you are ready, add a 3 cm strip of magnesium ribbon to the flask, put the bung back into the flask as quickly as you can, and start the stopclock.

5. Record the volume of hydrogen gas given off at suitable intervals (eg 10 seconds) in a table such as the one on the next page

6. Repeat steps **1-5** using 1.0 M hydrochloric acid.

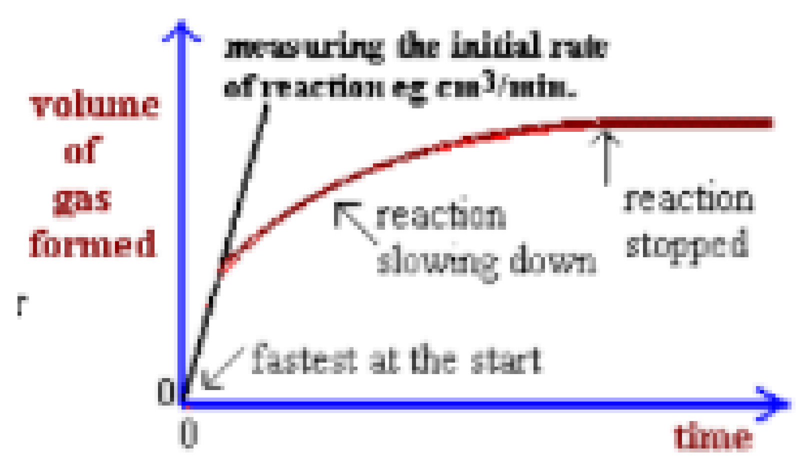
7. Plot a graph with:

   - 'Volume of gas produced in cm^3 (for 2.0 M hydrochloric acid)' on the y-axis
   - 'Time in seconds' on the x-axis.

8. Draw a smooth, curved line of best fit.

9. Plot a curve for 1.0 M hydrochloric acid on the same graph.

10. Use this graph to compare the rates of reaction of 1.0 M and 2.0 M hydrochloric acid with magnesium.



Recall it ...

Required Practical – Chromatography

Use the information in the following page(s) to answer these questions ...

1. In detail describe the method for the investigation?
2. What are the common mistakes for chromatography, and what is done to prevent them?
3. Describe how to calculate Rf value?
4. What is the stationary and mobile phase of chromatography?
5. Describe how to find which dyes a mixture contains on a chromatogram?

Required Practical - Chromatography

1. Use a ruler to draw a horizontal pencil line 2 cm from a short edge of the chromatography paper.

   Mark five pencil spots at equal intervals across the line. Keep at least 1 cm away from each end.

2. Use a glass capillary tube to put a small spot of each of the known colourings on four of the pencil spots. Then use the glass capillary tube to put a small spot of the unknown mixture on the 5th pencil spot.

   Try to make sure each spot is no more than 5 mm in diameter.

   Label each spot **in pencil**.

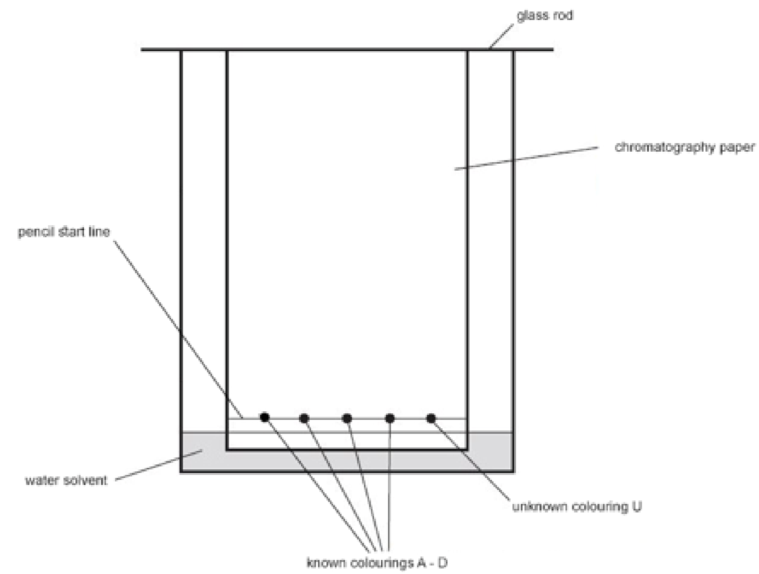
3. Pour water into the beaker to a depth of **no more than 1 cm**.

4. Tape the edge of the chromatography paper to the glass rod. The paper needs to be taped at the end furthest from the spots.

   Rest the rod on the top edge of the beaker. The bottom edge of the paper should dip into the water.

   Ensure that the:

   - **pencil line is above the water surface**
   - **sides of the paper do not touch the beaker wall**



5. Wait for the water solvent to travel at least three quarters of the way up the paper. Do **not** disturb the beaker during this time.

   Carefully remove the paper. Draw another pencil line on the dry part of the paper as close to the wet edge as possible.

6. Hang the paper up to dry thoroughly.

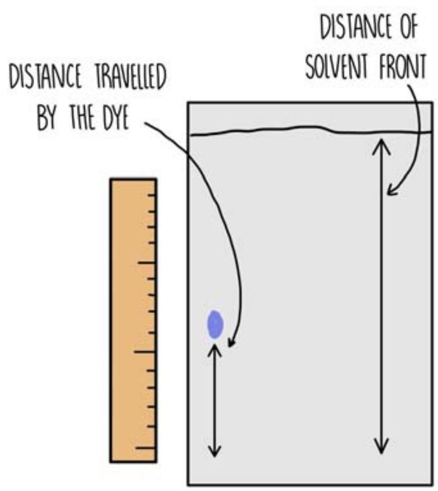
7. Measure the distance in mm between the two pencil lines. This is the distance travelled by the water solvent.

Required Practical - Chromatography

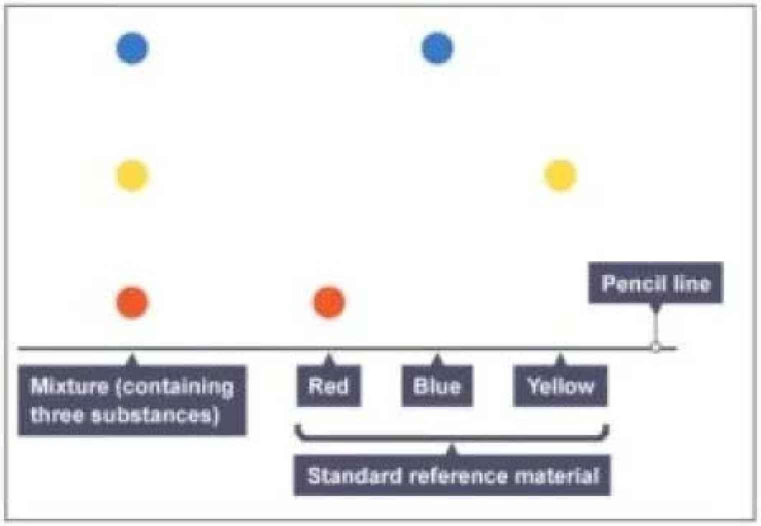
7. For each of the four known colours, measure the distance in mm from the bottom line to the centre of each spot. Write each measurement in the table.

8. Use the following equation to calculate the R_f value for each of the known colours.

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



$$R_f \text{ VALUE} = \frac{\text{DISTANCE TRAVELLED BY THE DYE}}{\text{DISTANCE TRAVELLED BY THE SOLVENT}}$$



- Stationary phase is paper.
- Mobile phase is a liquid, commonly water, but could be ethanol or a non-polar solvent.

Recall it …

Rates of reaction

Use the information in the following page(s) to answer these questions …

1. Describe the two ways of how to calculate the rate of a chemical reaction?
2. How can you use a volume of gas vs time graph to find out the rate of a chemical reaction?
3. What does the slope of a graph tell you about the rate of a chemical reaction?
4. What is collision theory? What is activation energy?
5. Name 5 factors that affect the rate of a chemical reaction?
6. Explain how the following factors affect the rate of a chemical reaction – concentration, pressure, surface area and temperature?
7. Describe what is a catalyst? What do catalysts do to activation energy?
8. Sketch a labelled reaction profile for a chemical reaction with a catalyst?
9. Describe what is a reversible reaction? Give an example of a reversible reaction?
10. If the forward reaction is exothermic, what does this tell us about the backwards reaction?
11. Describe exactly how equilibrium is achieved?

Rate of reactions part 1 – Calculating rates of reactions

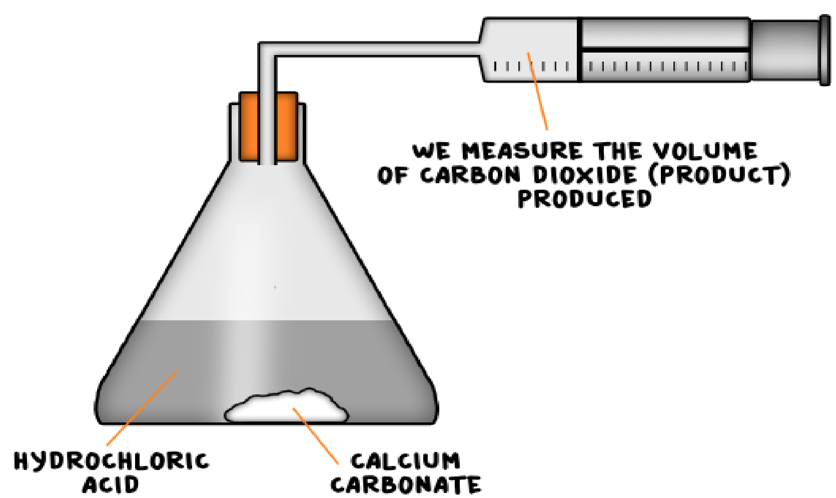
The rate of a chemical reaction can be found by measuring the quantity of a reactant used or the quantity of product formed over time.

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

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

The quantity of reactant or product can be measured by the mass in grams or by a volume in cm^3.

The units of rate of reaction may be given as g/s or cm^3/s.



Rate of reactions part 1 – Calculating rates of reactions

Worked example 1

25cm^3 of carbon dioxide was given off in the first 2 seconds of a reaction. Calculate the mean rate of reaction and give the units.

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

Mean rate of reaction = $\frac{25cm^3}{2\ s}$

Mean rate of reaction = 12.5 cm^3/s

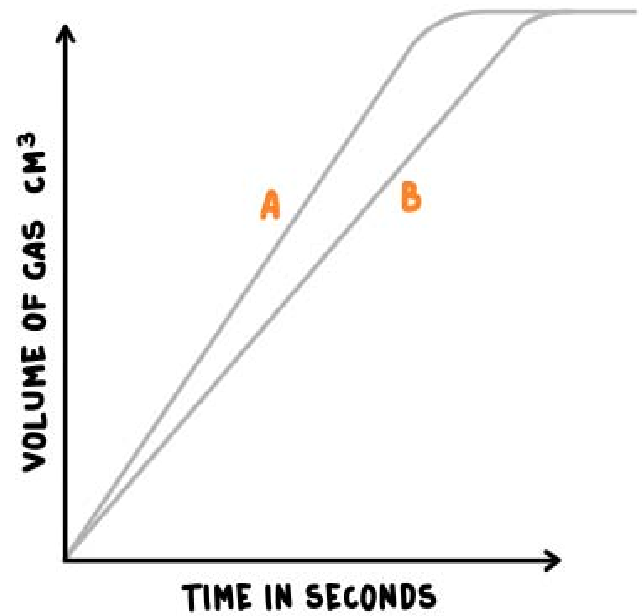
Worked example 2 (Higher Tier)

The above reaction was carried out again. The new results showed that 2 dm^3 of carbon dioxide was released in 200 seconds. Calculate the mean rate of reaction in mol/dm^3

(1 mole of any gas occupies 24 dm^3 at STP)

Moles of carbon dioxide = $\frac{2\ dm^3}{24\ dm^3}$ = 0.83 moles

Mean rate of reaction = $\frac{0.83\ moles}{200\ s}$ = 0.0042 mol/s

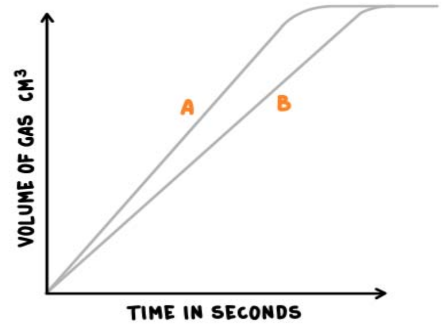


Slope A will have a greater rate of reaction as it is steeper.

Rates of reactions part 2 – Factors which affect rates of reactions

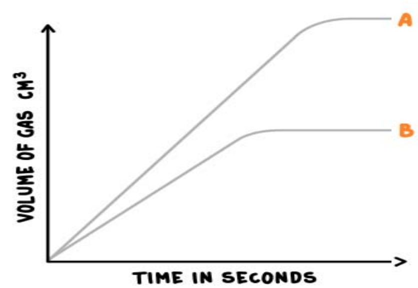
Factors which affect the rates of chemical reactions include:

- The concentrations of reactants in solution
- The pressure of reacting gases
- The surface area of solid reactants
- The temperature
- The presence of a catalyst



Collision theory explains how these factors affect rates of reactions. According to this theory, chemical reactions can occur only when reacting particles collide with each other and with sufficient energy. The minimum amount of energy that particles must have to react is called the activation energy.

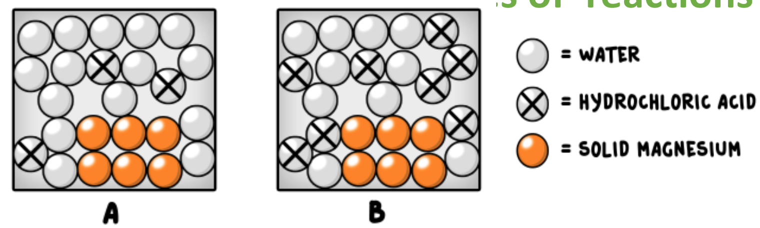
Increasing the surface area, temperature or using a catalyst will increase the rate of reaction so the gradient of the line increases from B to A. The difference is that increasing the concentration provides more reacting particles therefore more product, therefore the graph below is produced.



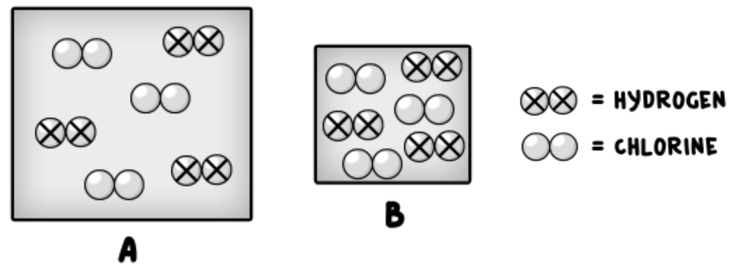
The explanations on the next slide are very important and you will need to use them accurately in the exams to gain credit.

Rates of reactions part 2 – Factors which affect rates of reactions

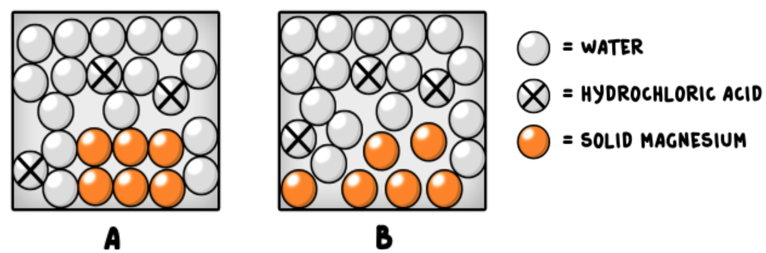
Increasing the concentration of reactants in solution increases the frequency of collisions, and so increases the rate of reaction.



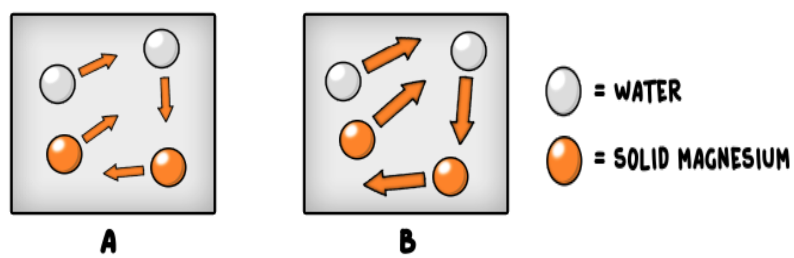
Increasing the pressure of reacting gases increases the frequency of collisions, and so increases the rate of reaction.



Increasing the surface area of solid reactants increases the frequency of collisions, and so increases the rate of reaction.



Increasing the temperature increases the frequency of collisions and makes the collisions more energetic, and so increases the rate of reaction.



Rates of reactions part 3 – Factors which affect rates of reactions - catalysts

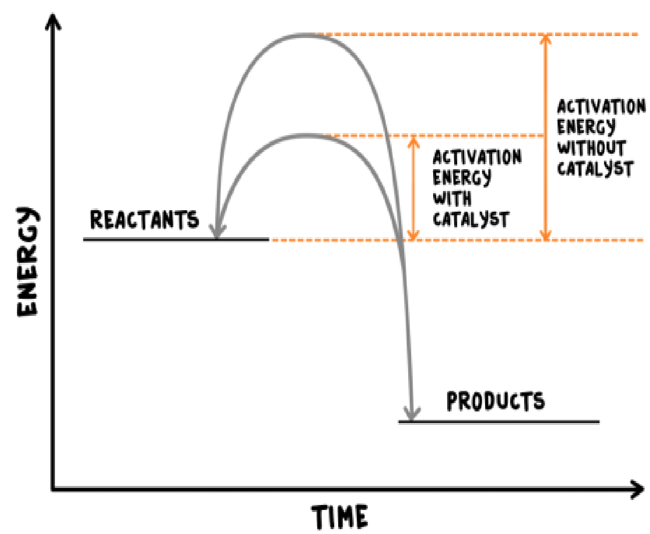
Catalysts change the rate of chemical reactions but are not used up during the reaction.

This means that the catalyst is still there, unchanged, at the end of the reaction.

Different reactions need different catalysts. Enzymes act as catalysts in biological systems.

Carbohydrase is an enzyme/catalyst that only breaks down carbohydrate.
Chlorophyll is the catalyst that enables carbon dioxide and water to react together to make glucose during photosynthesis.

Catalysts increase the rate of reaction by providing a different pathway for the reaction that has a lower activation energy.
A reaction profile for a catalysed reaction can be drawn as shown on the right.



You should be able to explain catalytic action in terms of activation energy. For example, "from the reaction profile I can see that the catalyst **lowers** the activation energy".

Reversible reactions

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 conditions e.g.

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

The reaction above shows that if we heat up the reaction mixture, more ammonium chloride will break down to give ammonia and hydrogen chloride. This is very useful if we are trying to make either of these chemicals.
Conversely if we cool the reaction mixture down we will get more ammonia and hydrogen chloride combining together to make ammonium chloride.

Reversible reactions

If a reversible reaction is **exothermic** in one direction, it is **endothermic** in the opposite direction (they are reversible/opposites). The same amount of energy is transferred in each case e.g.

$$\text{Hydrated copper sulfate} \underset{\text{exothermic}}{\overset{\text{endothermic}}{\rightleftharpoons}} \text{anhydrous copper sulfate} + \text{water}$$

Blue | **White**

What will happen then in the above reaction if we heat it up?

We will get more anhydrous copper sulfate and water, because the **endothermic direction** from left to right will **absorb the heat** we add.

What will happen if we cool it down?

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

If we enclose in this box nitrogen N_2 , hydrogen H_2 and ammonia NH_3 the following reactions take place

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

When the **forward reaction** is happening at the **same rate** as the **backwards reaction**, there will be no overall change in the amount of any of the three chemicals- **equilibrium** has been reached.

Recall it ...

Dynamic Equilibrium

Use the information in the following page(s) to answer these questions ...

1. What to the amount of product formed, or reactant used depend upon?
2. What is Le Chatelier's Principle?
3. Name three conditions that could be changed?
4. Describe the effect of changing concentration giving an example?
5. Describe the effect of changing temperature giving an example?
6. Describe the effect of changing pressure giving an example?

The Effect of changing conditions on equilibrium (HT only)

The relative amounts of all the reactants and products at equilibrium depend on the conditions of the reaction.

Using Le Chatelier's Principle we can predict what might happen when we change the conditions of a system. A system is simply the reversible reaction that is taking place in an apparatus which prevents any escape of chemicals.

Le Chatelier's Principle

If a system is at equilibrium and a change is made to any of the conditions, then the system responds to counteract the change

The three conditions which could be changed and are:

- Concentration
- Temperature
- Pressure

You must use Le Chatelier's principle in your explanation.

The two equations we are going to use to explain these changes are:

$$I_2\,(g) + H_2\,(g) \rightleftharpoons 2HI\,(g)$$

and

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$$

How could you change the concentration, temperature or pressure in either of these reactions?

The Effect of changing conditions on equilibrium (HT only)

The Effect of Changing Concentration

If the **concentration** of one of the reactants or products is changed, the system is **no longer at equilibrium** and the concentrations of all the substances will change until **equilibrium** is reached again.

e.g. the hydrogen iodine and hydrogen iodide equilibrium:

$$I_2\,(g) + H_2\,(g) \rightleftharpoons 2HI\,(g)$$

Increasing the concentration of HI by putting more HI gas into the system makes it react to break down the HI gas to H_2 and I_2 so that we have the same proportions of HI, H_2 and I_2

If the concentration of a **reactant** is **increased, more products** will be formed until equilibrium is reached again.
If the concentration of a **product** is **decreased, more reactants** will react until equilibrium is reached again.

So if we increase the amount of hydrogen and iodine, more hydrogen iodide gas will be made.
If we decrease the amount of hydrogen iodide, more hydrogen and iodine will react to make hydrogen iodide.

The Effect of changing conditions on equilibrium (HT only)

The Effect of Changing Temperature

If the temperature of a system at equilibrium is **increased**:
The relative amount of products at equilibrium **increases** for an **endothermic** reaction.
The relative amount of products at equilibrium **decreases** for an **exothermic** reaction.

If the temperature of a system at equilibrium is **decreased**:
The relative amount of products at equilibrium **decreases** for an **endothermic** reaction.
The relative amount of products at equilibrium **increases** for an **exothermic** reaction.

If we apply these to the equation below:

$$N_2\,(g) + 3H_2\,(g) \underset{\text{endothermic}}{\overset{\text{exothermic}}{\rightleftharpoons}} 2NH_3\,(g)$$

Increasing the temperature will give more nitrogen N_2 and hydrogen H_2 and less ammonia NH_3.
Decreasing the temperature the opposite result occurs- we would get more ammonia NH_3 and less nitrogen N_2 and hydrogen H_2.

The Effect of changing conditions on equilibrium (HT only)

The Effect of Changing Pressure

For gaseous reactions at equilibrium:

An **increase** in pressure causes the equilibrium position to shift towards the side with the **smaller** number of molecules, as shown by the symbol equation for that reaction.

A **decrease** in pressure causes the equilibrium position to shift towards the side with **larger** number of molecules, as shown by the symbol equation for that reaction.

As 1 mole of gas at STP occupies 24 $dm^{3,}$ we can apply this knowledge to the equation.

$$N_2\ (g) + 3H_2\ (g) \rightleftharpoons 2NH_3\ (g)$$

There are 4 moles of reactants: 1 mole of nitrogen N_2 and 3 moles of H_2
There are only 2 moles of the ammonia NH_3 product.

The reactants will have 96 dm^3 at STP and the products will only occupy 48 dm^3 .

So if we **increase** the pressure, the equilibrium position will shift towards the right hand side simply because the two moles of ammonia take up a **smaller** volume so, from **Le Chatelier's principal,** making more of the product that has less volume reduces the pressure that we have just increased.

Recall it ...

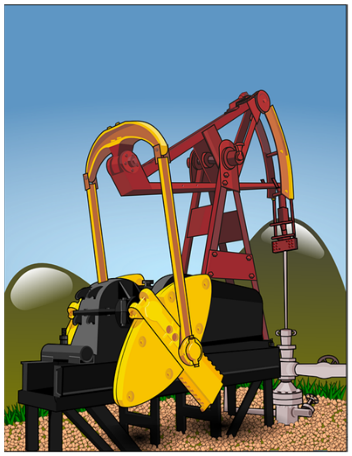
Crude Oil

Use the information in the following page(s) to answer these questions …

1. Describe what is crude oil? What is a hydrocarbon? Where does crude oil come from?
2. What is the generic formula for alkanes? Name, give the chemical and structural formula to the first five alkanes?
3. Name the technique used to separate crude oil? What are the broken parts of oil called? Based on what properties are the fractions of oil separated?
4. What are the boiling points, flammability and viscosity of the fractions released at the top of the fractionating column?
5. Describe 4 fractions released by oil?
6. Give the word and symbol equation for the combustion of methane? Describe what is oxidised and reduced in the reaction? What is meant by oxidation and reduction?
7. Describe how to balance a symbol equation showing the combustion of an alkane?
8. Describe what is cracking? What is catalytic cracking and steam cracking?
9. Describe the test for alkenes?

Crude oil, hydrocarbons and alkanes

Crude oil is a **finite resource** found in rocks. Crude oil is the remains of an **ancient biomass** consisting mainly of **plankton** that was **buried in mud**.



The two definitions below are very important you must learn both of them

Crude oil is a mixture of a very large number of compounds.

Most of the compounds in crude oil are **hydrocarbons**, which are **molecules** made up of **hydrogen and carbon only.**

Crude oil, hydrocarbons and alkanes

Most of the hydrocarbons in crude oil are hydrocarbons called **alkanes**. The general formula for the homologous series of alkanes is $\mathbf{C_nH_{2n+2}}$

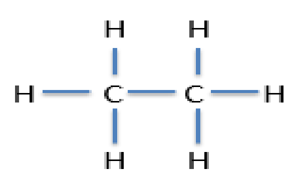
The first four members of the alkanes are methane, ethane, propane and butane.

Worked examples

Methane has one carbon atom so it's formula will be $\mathbf{C_1H_{(2x1)+2}}$ this gives $\mathbf{CH_4}$
Ethane has two carbon atoms so it's formula will be $\mathbf{C_2H_{(2x2)+2}}$ this gives $\mathbf{C_2H_6}$
Propane has three carbon atoms so it's formula will be $\mathbf{C_3H_{(2x3)+2}}$ this gives $\mathbf{C_3H_8}$
Butane has four carbon atoms so it's formula will be $\mathbf{C_4H_{(2x4)+2}}$ this gives $\mathbf{C_4H_{10}}$

You will be expected to know the names and formulae of these first four alkanes. You will be expected to calculate the formulae of alkanes with more than four carbons.

These can also be shown as:



Fractional distillation and petrochemicals and properties of hydrocarbons

The many hydrocarbons in crude oil may be separated into **fractions**, each of which contains molecules with a **similar number of carbon atoms** by fractional distillation

Below is a diagram of a fractional distillation column, learn the order of the fractions on the right hand side

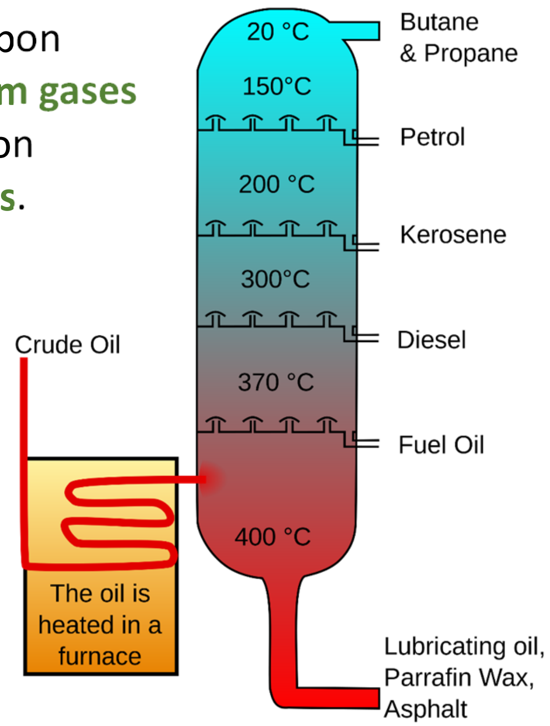
If we look at the diagram on the right all the hydrocarbon molecules in the highest fraction – **liquefied petroleum gases** will have between **1 and 4 carbons**. All the hydrocarbon molecules in **petrol** will have between **5 and 9 carbons**.

Some properties of hydrocarbons depend on the **size of their molecules**, including:

- **Boiling point**
- **Viscosity**
- **Flammability**

These change with increasing molecular size.

We know that as we go **up** the fractional distillation column the boiling point and viscosity **decrease**, the flammability **increases**.



Fractional distillation and petrochemicals and properties of hydrocarbons

The fractions produced in fractional distillation can be processed to produce fuels e.g. petrol, and feedstock (reactants for further chemical reactions) for the petrochemical industry.

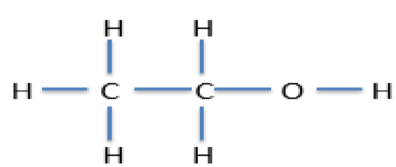
Examples of these useful materials are:

- **Solvents** – nail varnish remover
- **Lubricants** – oil for car engines
- **Polymers** – polythene and **p**oly**v**inyl **c**hloride PVC
- **Detergents** – washing up liquid

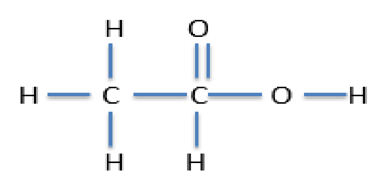
It would be helpful to know all of these useful materials and the examples for the exam.

The vast array of natural and synthetic carbon compounds occur due to the ability of carbon atoms to form families of similar compounds.

Examples of this are ethanol C_2H_5OH and ethanoic acid CH_3COOH. Both contain two carbon atoms, but they make very different compounds with very different properties. This would also be the case for molecules with three or four etc. carbon molecules.



Ethanol

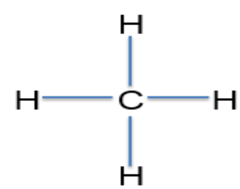


Ethanoic acid

The **combustion** of hydrocarbon fuels releases energy. During combustion, the carbon and hydrogen in the fuels are **oxidised**. The **complete combustion** of a hydrocarbon produces **carbon dioxide** and **water** e.g.

Methane + oxygen → carbon dioxide + water

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + H_2O(l)$$



If we look at methane we can see that to make carbon dioxide and water all of the carbon and hydrogen bonds must break, these will then make carbon and oxygen bonds for carbon dioxide i.e. the **carbon is oxidised** and hydrogen and oxygen bonds for the water i.e. the **hydrogen is oxidised**.

The examination boards states that students should be able to write **balanced equations** for the complete combustion of hydrocarbons with a given formula.

Worked Example

What is the balanced symbol equation for the combustion of C_9H_{20}

$$C_{11}H_{24} + 17O_2 \rightarrow 11CO_2 + 12H_2O$$

The number in front of **CO_2 is always the subscript from the alkane for carbon** e.g. 11

The number in front of **H_20 is always half the subscript from the alkane for hydrogen** e.g. 12

We then **add up the number of oxygen atoms** we now have as products e.g. 22 from CO_2 and 12 from H_2O which gives 34, we then **put half this number in front of O_2** e.g. $17O_2$

Cracking and alkenes

Hydrocarbons can be broken down (cracked) to produce smaller **more useful** molecules.

This is a very important definition.

$$C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$$

The two products made are both more useful than the starting hydrocarbon, but notice that there are always the **same number** of carbons and hydrogens on the left hand side of the equation and on the right hand side.

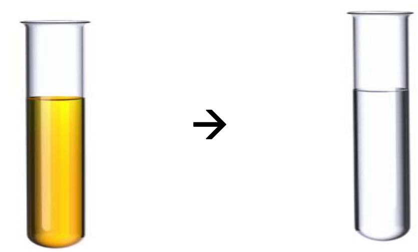
Cracking can be done by various methods including:
Catalytic cracking – the hydrocarbon is heated to a high temperature and a catalyst used
Steam cracking – the hydrocarbon is heated and mixed with steam

Cracking and alkenes

The products of cracking include alkanes and another type of hydrocarbon called **alkenes**.

Alkenes are **more reactive** than alkanes and react with **orange-brown bromine water** to turn it **colourless**. There is a high demand for fuels with small molecules and so some of the products of cracking are useful as fuels.

The test for an alkene



Orange/brown bromine water → **Turns colourless when alkene is added**

Alkenes are used to produce **polymers** and as starting materials for the production of many other chemicals.

Recall it ...

Pure Substances and Formulations

Use the information in the following page(s) to answer these questions ...

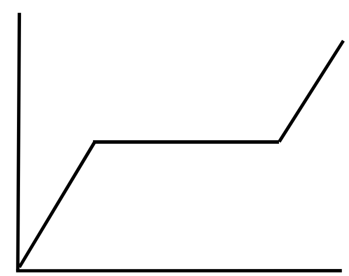
1. What is a pure substance?
2. How do we distinguish pure substances from mixtures?
3. What is a formulation? Give examples of formulations?
4. Why is chromatography used?
5. What is Rf value? How is it calculated?

Pure substances and Formulations

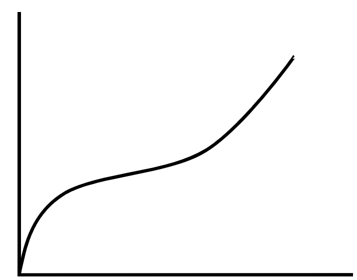
In chemistry, a **pure substance** is a **single element or compound not mixed** with any other substance.

Learn this definition for the exam

Pure substances have **specific** melting and boiling temperatures.
These can be used to distinguish pure substances from mixtures.



Melting point of a pure substance



Melting point of an impure substance

In Science we would not refer a substance such as milk as being pure as it is a mixture of a number of different substances.

A **formulation** is a **mixture** that has been designed as a useful product.

Formulations are made by mixing the components in carefully measured quantities to ensures that the product has the required properties. Formulations include fuels, cleaning agents, paints, medicines, alloys, fertilisers and foods

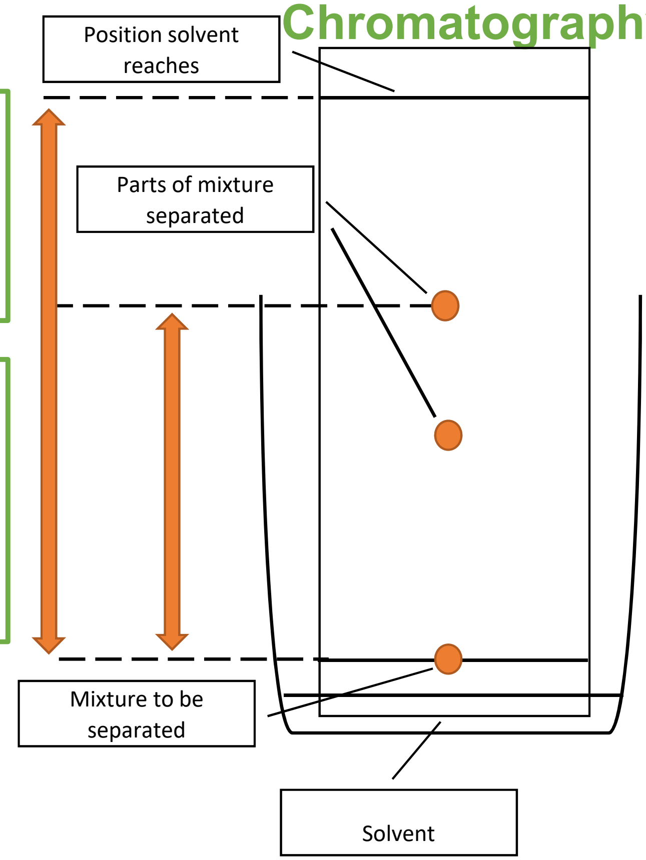
Chromatography

Chromatography can be used to **separate mixtures.**
Chromatography involves a **stationary phase** and a **mobile phase**.

The ratio of the distance moved by a compound (centre of spot from origin) can be expressed as it's R_f value:

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

When calculating the R_f value remember the **solvent will always travel further than the substance** so the **R_f value can never be greater than 1**.



Different compounds have different Rf values in different solvents, which can be used to help identify the compounds. A pure compound will produce a single spot in all solvents.

Recall it ...

The Atmosphere

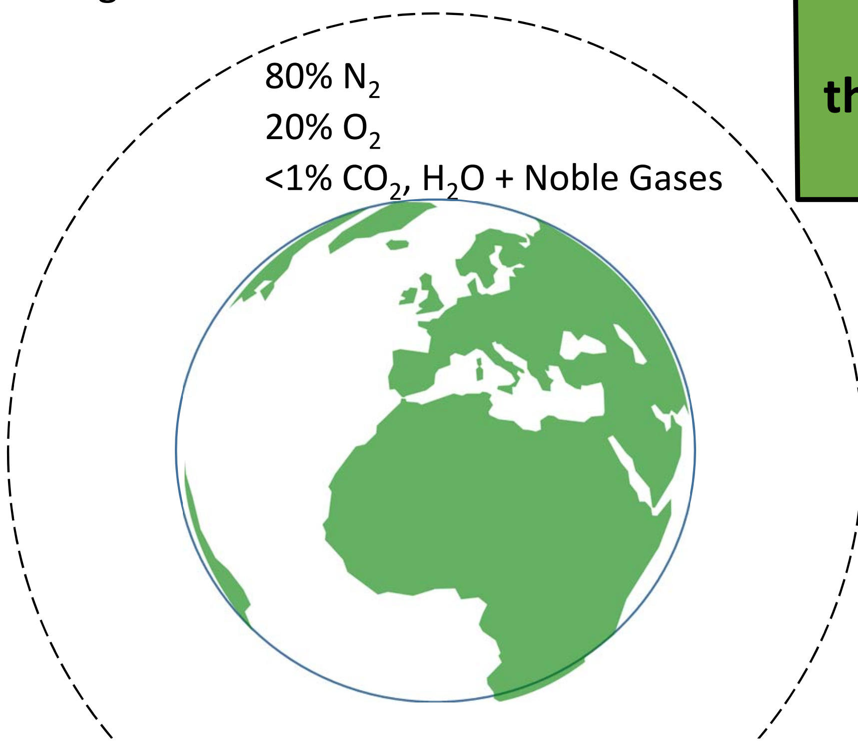
Use the information in the following page(s) to answer these questions …

1. What are the proportion of different gases in the atmosphere?
2. What is the approximate age of the earth? What was the earth like then?
3. Which gases where released from volcanoes?
4. How did our oceans form?
5. What did green plants and algae do to the levels of oxygen and carbon dioxide in our atmosphere? Why?
6. What did the formation of sedimentary rocks and fossil fuels do to the levels of carbon dioxide in our atmosphere?
7. What does complete combustion produce?
8. What does incomplete combustion produce?
9. What other gases are produced by the combustion of fuels? Why?
10. Describe the effects of carbon monoxide, sulphur oxides / nitrogen oxides and particulates?

The proportions of different gases in the atmosphere

For **200 million years**, the proportions of different gases in the atmosphere have been much the same as they are today:

- about four-fifths (approximately **80%**) **nitrogen**
- about one-fifth (approximately **20%**) **oxygen**
- small proportions of various other gases, including carbon dioxide, water vapour and noble gases.



You must learn these percentages for the exam

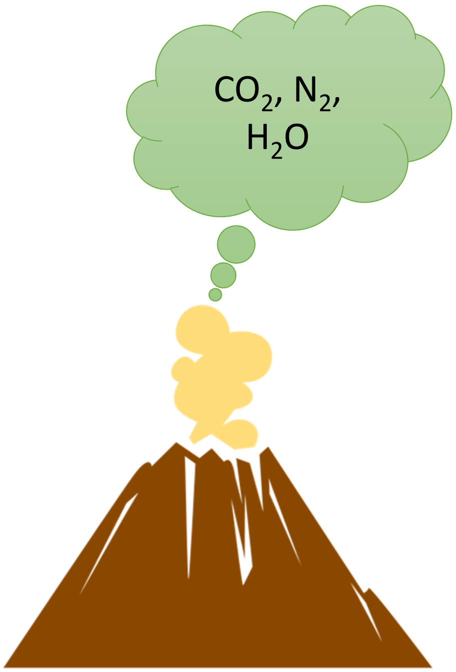
The Earth's early atmosphere

Theories about what was in the Earth's early atmosphere and how the atmosphere was formed have changed and developed over time. Evidence for the early atmosphere is limited because of the time scale of 4.6 billion years.

There are a number of different theories as to how the atmosphere evolved.

One theory suggests:

- During the first billion years there was **intense volcanic activity** that **released gases** that formed the early atmosphere consisting of mainly **carbon dioxide** with **little or no oxygen gas**.
- **Water vapour condensed** to form the oceans.
- **Volcanoes** also produced **nitrogen** which gradually built up in the atmosphere and there may have been small proportions of **methane** and **ammonia**.
- When the oceans formed, **carbon dioxide dissolved in the water** and **carbonates** were **precipitated** producing sediments, reducing the amount of carbon dioxide in the atmosphere.



How oxygen increased and carbon dioxide decreased

Organisms evolved that changed the atmosphere in a significant way.

Algae and plants produced the **oxygen** that is now in the atmosphere by **photosynthesis**, which can be represented by the equation:

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

$$\text{Carbon dioxide} + \text{water} \xrightarrow{\text{light}} \text{glucose} + \text{oxygen}$$

Algae first produced oxygen about 2.7 billion years ago and soon after this oxygen appeared in the atmosphere. Over the next billion years plants evolved and the percentage of oxygen gradually increased to a level that enabled animals to evolve.

Algae and plants **decreased** the percentage of **carbon dioxide** in the atmosphere by **photosynthesis**. Carbon dioxide was also decreased by the formation of **sedimentary rocks** and **fossil fuels** that contain carbon.

Oxygen increases due to photosynthesis.
Carbon dioxide decreases due to photosynthesis, formation of sedimentary rocks and fossil fuels.

Earths resources and sustainable development

Recall it ...

Use the information in the following page(s) to answer these questions …

1. Why and how do humans used the earth resources?
2. The Earth’s resources are finite, What does this mean?
3. What is 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.

Potable Water

Recall it …

Use the information in the following page(s) to answer these questions …

1. What is potable water? How is potable water different to pure water?
2. Where does our drinking water come from?
3. What is done to water from lakes and rivers to make it potable?
4. Name three sterilising agents?
5. What is used if our sources of fresh water are limited?
6. Name two ways in which desalination is done? What is the disadvantage of desalination?
7. Name and describe two types of waste water?
8. Describe the 4 steps involved in sewage treatment?

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

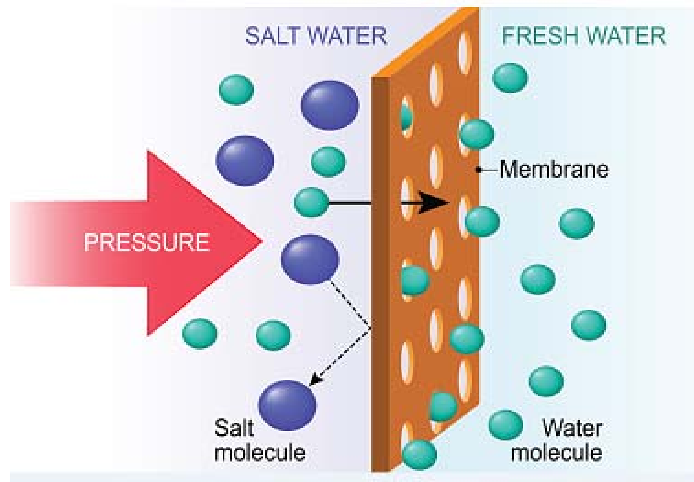
- choosing an appropriate source of fresh water
- passing the water through filter beds
- sterilising

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**

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

Metal Extraction

Recall it ...

Use the information in the following page(s) to answer these questions …

1. What is the situation with the earth's copper reserves?
2. Name two techniques used to extract low grade copper ores?
3. Describe phytomining ?
4. Describe bioleaching?

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.