CHEMISTRY ONLY TOPICS FROM GCSE

This booklet is designed to support you to fill the gaps in your learning if you studied Combined Science GCSE and are now taking A Level Chemistry. These are the topics that you would have covered if you had taken Separate Science GCSE's instead of Combined Science.

You need to work through the different sections and complete the questions in as much detail as possible. There are links to useful clips and lessons to help you too. Make a summary of each, to accompany your answers to tasks. This document can be found on the website so you can follow the weblinks to the videos.

Return this work to Mrs Coyne or Mrs Parker at the start of the course in September.

TASK 1 - TRANSITION METALS

Transition Metals

THE TRANSITION METALS

1	2											3	4	5	6	7	0
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	?	?	?						

The general trend is the reactivity **decreases across the period**, but there are exceptions, for example Zinc is very reactive.

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn

Reactivity decreases →

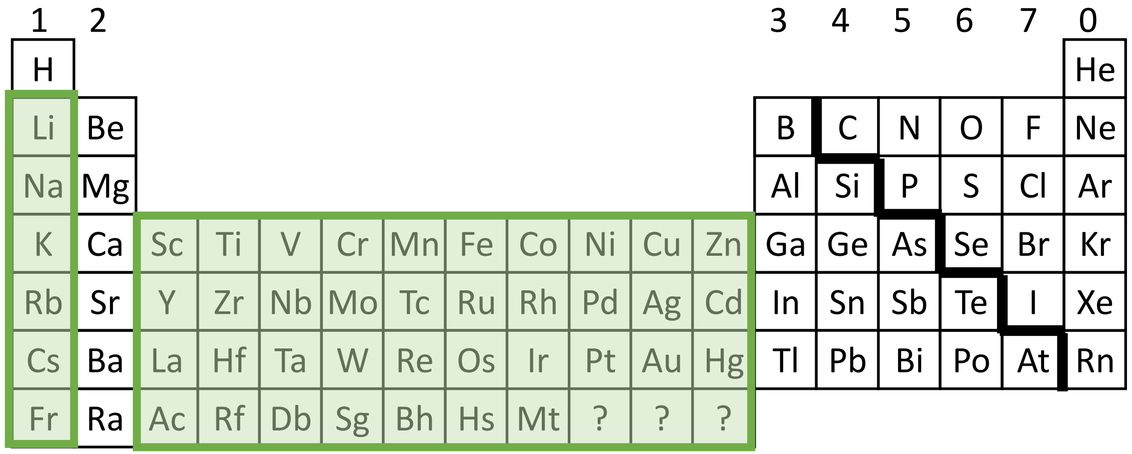
The transition metals are located **between group 2** and **group 3**.

The transition metals have:
High melting points
High boiling points
High densities

They are:
Shiny when polished
Malleable – can be hammered into a shape
Strong – don't break easily when a force is applied
Sonorous – makes a ringing sound when hit
Ductile – can be stretched into wires
Conductors of **electricity** and **heat**

Periodic table - PART 3
Chemistry only

Transition metals have **different properties** compared to the **alkali** metals (group 1).



	Alkali metals	**Transition metals**
Melting points	Low	High (except mercury, which is liquid at room temperature)
Reactivity	High (react vigorously with water or oxygen)	Low (do not react so vigorously with water or oxygen)
Strength	Soft or liquid so cannot withstand force	Strong and hard
Density	Low	High
Compounds formed	White or colourless	Coloured

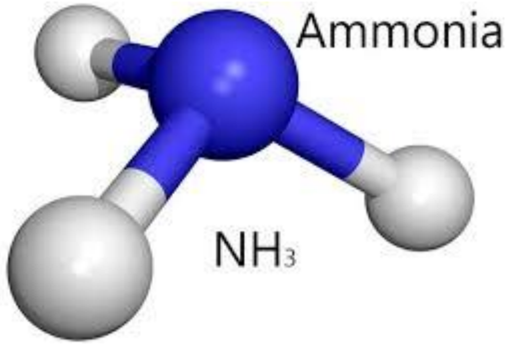
Periodic table - PART 3
Chemistry only

The transition metals have many different **uses** due to their **properties**. **Copper** has **properties** that make it useful for **electrical wiring** and **plumbing**. Not very reactive, **excellent conductor of electricity**, easily **bent** into shape for **water pipes** in plumbing.

They can also be useful as **catalysts**. A catalyst is a substance that **speeds up** a **chemical reaction** without being used up. Catalysts are hugely valuable in industry where they can **save time** and **energy**.

Nickel is the catalyst used in the hydrogenation of oil to produce **margarine**

Iron is the catalyst used in the Haber process to produce **ammonia**



1. Where are transition metals found on the periodic table?
2. How do the melting points of transition metals compare to Group 1 metals?
3. How do the densities of transition metals compare to Group 1 metals?
4. How does the strength of transition metals compare to Group 1 metals?
5. Describe the differences between the reactions of the alkali metals and the reactions of transition metals.
6. State two typical properties of transition metals.
7. State one use of transition metals.
8. Explain why copper is used for plumbing

TASK 2 - NANOPARTICLES

- Nanoparticles

- Nanoparticles

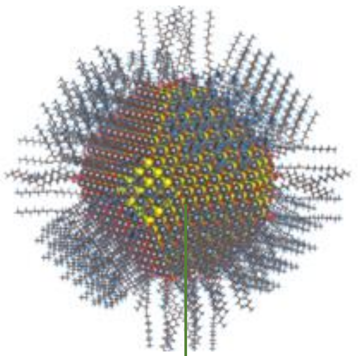
Covalent bonding - PART 3
CHEMISTRY ONLY

Nanoscience is the study of **small** particles that are between **1 and 100 nanometres** in size. Particles consisting of **fewer than 100 atoms** are often called **nanoclusters**.

1 nanometre (1 nm) = **1×10^{-9} metres** (0.000 000 001m or a billionth of a metre).

Nanoparticles are smaller than **fine particles** ($PM_{2.5}$) which have diameters between 1×10^{-7} metres and 2.5×10^{-6} .

To comprehend how small this is, **coarse particles**, like dust, have diameters between 1×10^{-5} and 2.5×10^{-6} .



The size of a typical nanoparticle is …

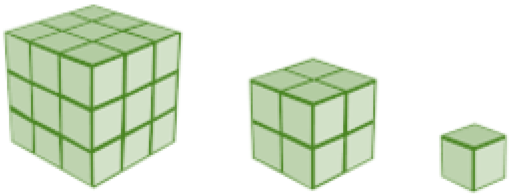
… to a football as a football is …

…to the Earth

Covalent bonding - PART 3
CHEMISTRY ONLY

Nanoparticles show different properties to the same materials in bulk as they have a **high surface area to volume ratio**.

The diagram shows this idea:



Surface area (height x width x number of sides)	3x3x6 **=54**	2x2x6 **=24**	1x1x6 **=6**
Volume (height x width x length)	3x3x3 **=27**	2x2x2 **=8**	1x1x1 **=1**
Surface to volume ratio (surface area / volume)	54/27 **=2**	24/8 **=3**	6/1 **=6**

As particle size gets smaller, the surface area to volume ratio gets larger.

As the side of cube decreases by a factor of 10 the surface area to volume ratio increases by a factor of 10.

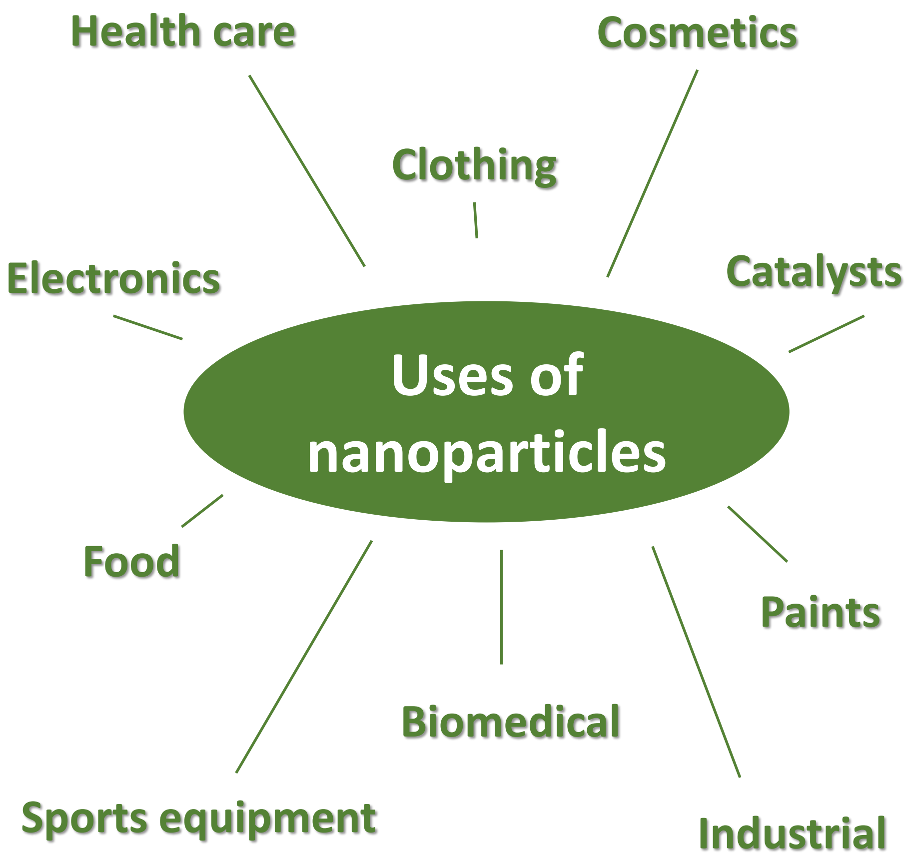
Nanoparticles show different properties to the same materials in bulk and have a high surface area to volume ratio. It also means that smaller quantities are needed to be effective than the materials with normal particle sizes.

Covalent bonding - PART 3
CHEMISTRY ONLY

Nanoparticles have many applications in **medicine**, in **electronics**, in **cosmetics** and sun creams, as deodorants, and as **catalysts**.

New developments in nanoscience are very exciting but will need more research into possible issues that might arise from their increased use.

There are some concerns that nanoparticles may be **toxic** to people. They may be able to enter the brain from the bloodstream and cause harm. Some people think more tests should take place before nanoparticles of a material are used on a wider scale.



Learn three examples for your exam

1. What does nanoscience refer to?

2. What are nanoparticles?

3. What are coarse particles?

4. Why do nanoparticles have different properties from those for the same materials in bulk?

5. Name 5 uses of nanoparticles.

TASK 3 – IDENTIFICATION OF IONS

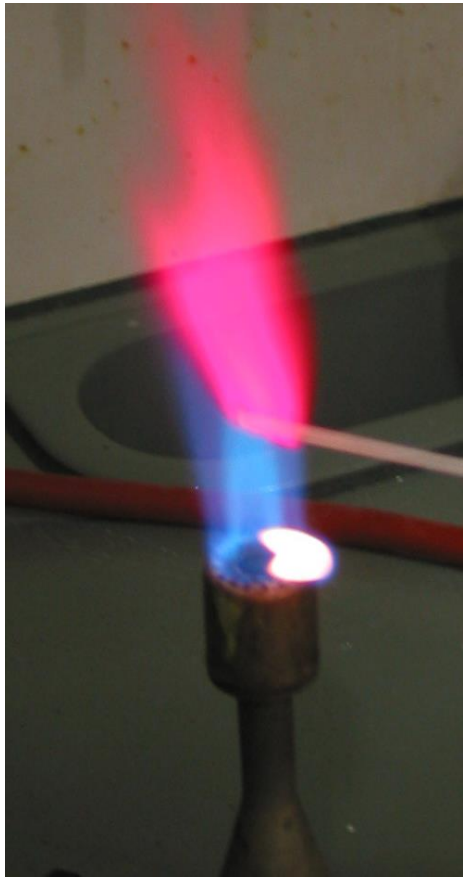
- FLAME TESTS
- METAL HYDROXIDES
- IDENTIFYING NON METAL IONS
- REQUIRED PRACTICAL 7 IDENTIFYING METAL IONS

Flame Tests

Flame tests can be used to identify some metal ions (cations).

- **Lithium** compounds results in a **crimson** flame.
- **Sodium** compounds result in a **yellow** flame.
- **Potassium** compounds result in a **lilac** flame.
- **Calcium** compounds result in **orange-red** flame.
- **Copper** compounds result in a **green** flame.

All of these colours are distinctive and can be used to identify these metal ions.



If a sample containing a mixture of ions is tested then some of flame colours can be masked and so will not be seen.

Identification of ions by chemical means Part 1(Chemistry only)

Metal Hydroxides

Sodium hydroxide solution can be used to identify some **metal ions** (**cations**).

Sodium hydroxide is added to a solution of the metal ion to be tested, a **solid precipitate** (often coloured) is formed and can be used to identify the metal ion.

Aluminium, calcium and **magnesium** ions form **white precipitates** when **sodium hydroxide solution** is added, but **only** the **aluminium hydroxide** precipitate **dissolves** in ***excess*** sodium hydroxide solution.

Coloured precipitates

Copper (II) ions form a **blue precipitate**.
Iron (II) ions form a **green precipitate**.
Iron (III) ions form a **brown precipitate**
when sodium hydroxide solution is added.

Identification of ions by chemical means Part 1 (Chemistry only)

You will be expected to write word and balanced symbol equations for all the precipitation reactions.

Aluminium chloride + sodium hydroxide → aluminium hydroxide + sodium chloride

$AlCl_3$ (aq) + $3NaOH$ (aq) → $Al(OH)_3$ (s) + $3NaCl$ (aq)

Calcium chloride + sodium hydroxide → calcium hydroxide + sodium chloride

$CaCl_2$ (aq) + $2NaOH$ (aq) → $Ca(OH)_2$ (s) + $2NaCl$ (aq)

Magnesium chloride + sodium hydroxide → magnesium hydroxide + sodium chloride

$MgCl_2$ (aq) + $2NaOH$ (aq) → $Mg(OH)_2$ (s) + $2NaCl$ (aq)

Copper(II) chloride + sodium hydroxide → copper (II) hydroxide + sodium chloride

$CuCl_2$ (aq) + $2NaOH$ (aq) → $Cu(OH)_2$ (aq) + $2NaCl$ (aq)

Iron (II) chloride + sodium hydroxide → iron (II) hydroxide + sodium chloride

$FeCl_2$ (aq) + $2NaOH$ (aq) → $Fe(OH)_2$ (s) + $2NaCl$ (aq)

Iron (III) chloride + sodium hydroxide → iron (III) hydroxide + sodium chloride

$FeCl_3$ (aq) + $3NaOH$ (aq) → $Fe(OH)_3$ (s) + $3NaCl$ (aq)

1. What is a flame test?

2. What colour flame would the following metal ions have in a flame test?
   a) Lithium b) Sodium c) Potassium d) Calcium e) Copper

3. What might cause some flame colours to be masked?

4. What is a precipitate?

5. Sodium hydroxide is used to identify some metal ions. What colour precipitate do aluminium, calcium and magnesium ions form?

6. How is are aluminium ions distinguished from calcium and magnesium ions in the reaction with sodium hydroxide?

7. What colour precipitate do the following ions make with sodium hydroxide?
   a) Copper (II) b) Iron (II) c) Iron (III)

8. Write the word equation for the reaction between calcium chloride and sodium hydroxide.

9. Write the balanced symbol equation for the reaction between aluminium chloride and sodium hydroxide.

10. What colour would be the precipitates be in the above reactions?

11. How could you distinguish between them?

Identification of ions by chemical means Part 2 (Chemistry only)

Identifying Carbonates

Carbonates react with **dilute acids** to form **carbon dioxide gas**. Carbon dioxide can be identified with limewater.

Identifying Halide Ions

Halide ions in solution produce **precipitates** with silver nitrate solution in the presence of dilute nitric acid.

Silver **chloride** is **white.**

Silver **bromide** is **cream.**

Silver **iodide** is **yellow.**

Identifying Sulfate Ions

Sulfate ions in solution produce a **white precipitate** with **barium chloride** in the presence of **dilute hydrochloric acid**.

Again you need to remember these colours and be able to write out the word and symbol equations shown on the next slide in the exam. Do not forget the state symbols.

Identification of ions by chemical means Part 2 (Chemistry only)

Halide Ions

Sodium chloride + silver nitrate → sliver chloride + sodium chloride

$NaCl\ (aq) + AgNO_3\ (aq) \rightarrow AgCl\ (s) + NaCl\ (aq)$

Sodium bromide + silver nitrate → silver bromide + sodium chloride

$NaBr\ (aq) + AgNO_3\ (aq) \rightarrow AgBr\ (s) + NaCl\ (aq)$

Sodium iodide + silver nitrate → silver iodide + sodium chloride

$NaI\ (aq) + AgNO_3\ (aq) \rightarrow AgI\ (s) + NaCl\ (aq)$

Sulfate Ions

Barium chloride + sodium sulfate → barium sulfate + sodium chloride

$BaCl_2\ (aq) + Na_2SO_4\ (aq) \rightarrow BaSO_4\ (s) + 2NaCl\ (aq)$

1. How would you test for a carbonate?
2. How would you test the gas produced by the above reaction?
3. How would you test for halide ions?
4. How could you use the above test to distinguish between halide ions?
5. Silver nitrate is added to an unknown chemical in solution. A cream precipitate is produced. What is the halide ion present?
6. (HT) Write the balanced ionic equation for the reaction above.
7. How would you test for sulfate ions?
8. Write the word and balanced symbol equation for the reaction between sodium sulfate and barium chloride.

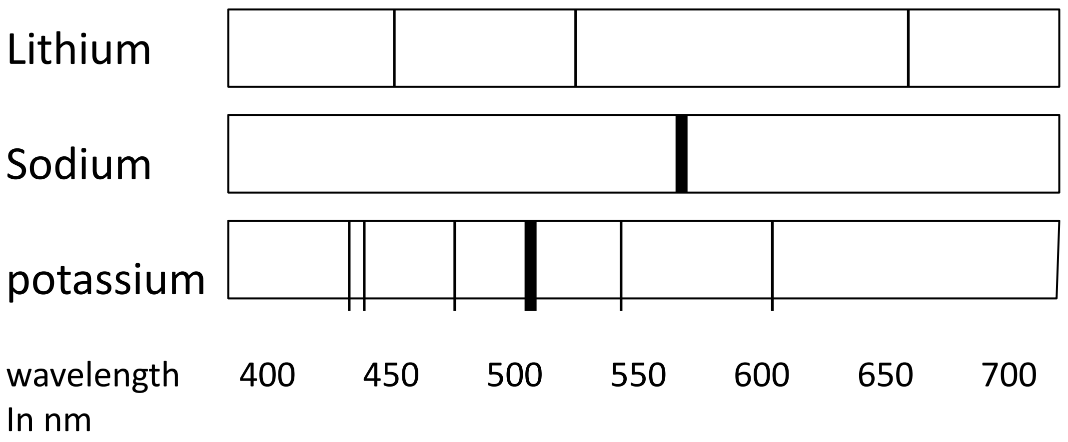
Identification of ions by instrumental methods (Chemistry only)

Elements and compounds can be detected and identified using **instrumental methods**. Instrumental methods are:

- **Accurate**
- **Sensitive**
- **Rapid**

These are the **advantages** of using instrumental methods compared with the earlier chemical tests, you need to know these for the exam.

- **Flame emission spectroscopy** is used to analyse metal ions in solution.
- The sample is **put into a flame** and the **light given out is passed through a spectroscope**.
- The output is a **line spectrum** that can be analysed to **identify the metal ions** in the solution and **measure their concentrations.**



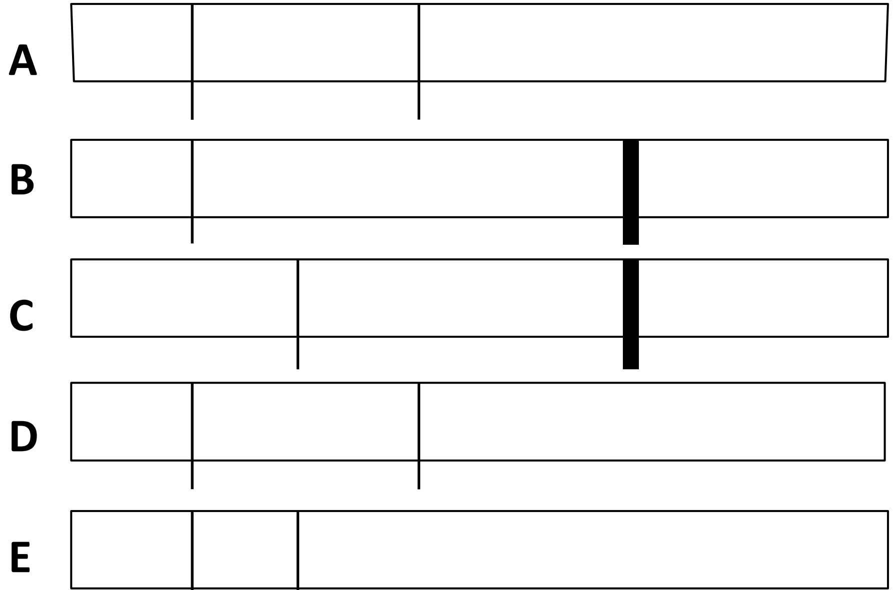
Each metal has their own patterns of bands which allows them to be identified as being present in the solution.

1. Give three advantages of instrumental methods for detecting ions compared with chemical methods.

2. What is flame emission spectroscopy used for?

3. How is flame emission spectroscopy carried out?

4. Five different samples were analysed using flame emission spectroscopy, the results are shown below. Which two of the results show the same metal?

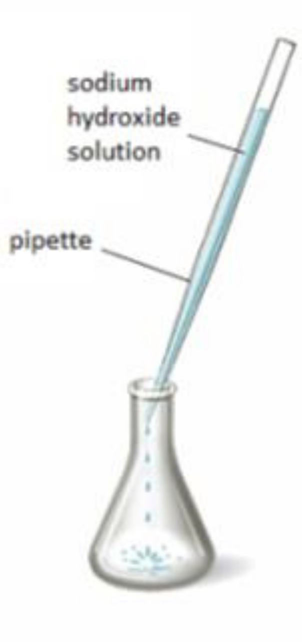


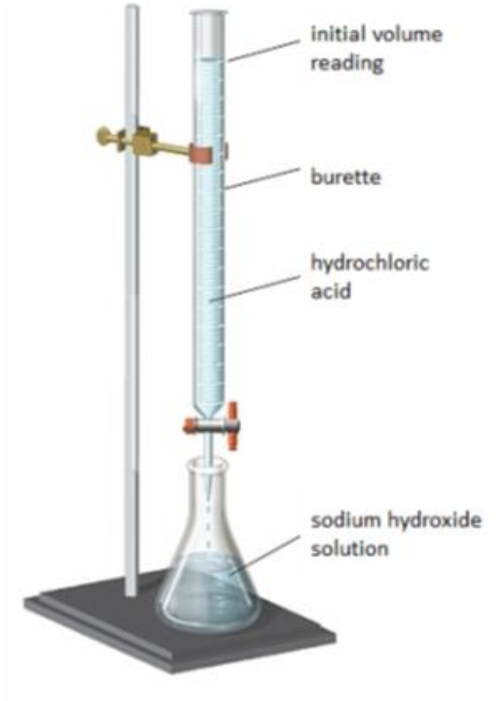
TASK 4 - TITRATION

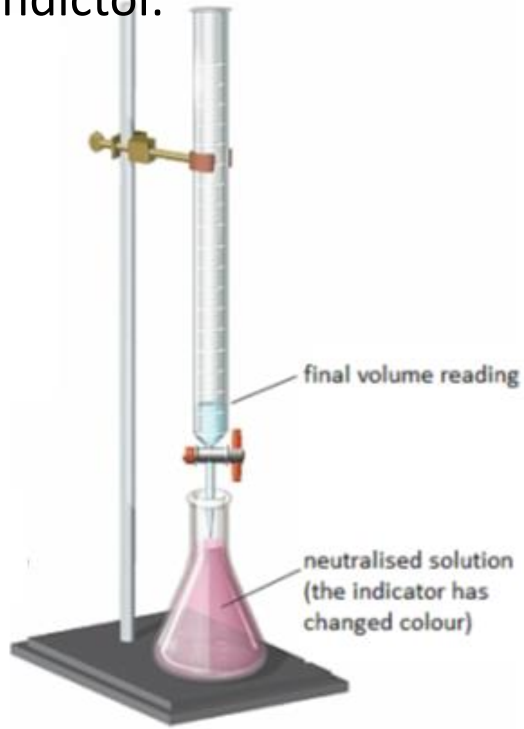
- TITRATIONS
- TITRATION CALCULATIONS 1
- TITRATION CALCULATIONS 2

Reactions of acids - PART 2 - CHEMISTRY ONLY

The **volumes** of acid and alkali solutions that react with each other can be measured by **titration** using a suitable indictor.







1. Use the pipette to add 25 cm^3 of alkali to a conical flask and add a few drops of indicator.

2. Fill the burette with acid and note the starting volume. Slowly add the acid from the burette to the alkali in the conical flask, swirling to mix.

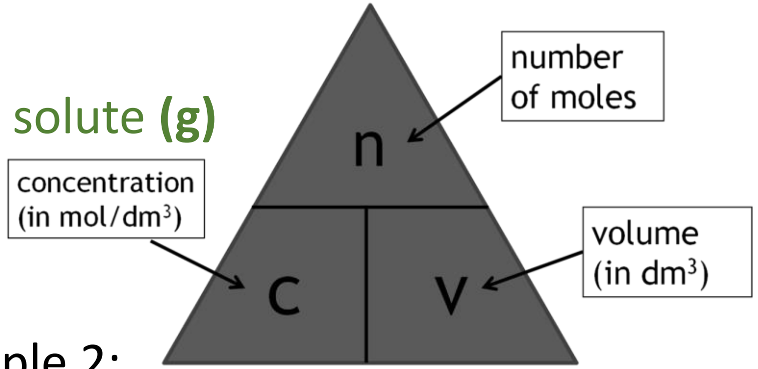
3. Stop adding the acid when the end-point is reached (the appropriate colour change in the indicator happens). Note the final volume reading. Repeat steps 1 to 3 until you get consistent readings.

Reactions of acids – PART 2 – CHEMISTRY ONLY
Higher

The **concentration** of a **solution** is the amount of **solute per volume of solution**.
Chemists measure concentration in moles per cubic decimetre **(mol/dm³)**.

n = v c

Where:
n is the number of moles **(mol)** or the mass of the solute **(g)**
c is the concentration **(mol/dm³** or **g/dm³)**
v is the volume **(dm³)**



Example 1:

What is the concentration of a solution that has 35.0g of solute in 0.5dm³ of solution?

35/0.5 = 70 g/dm³

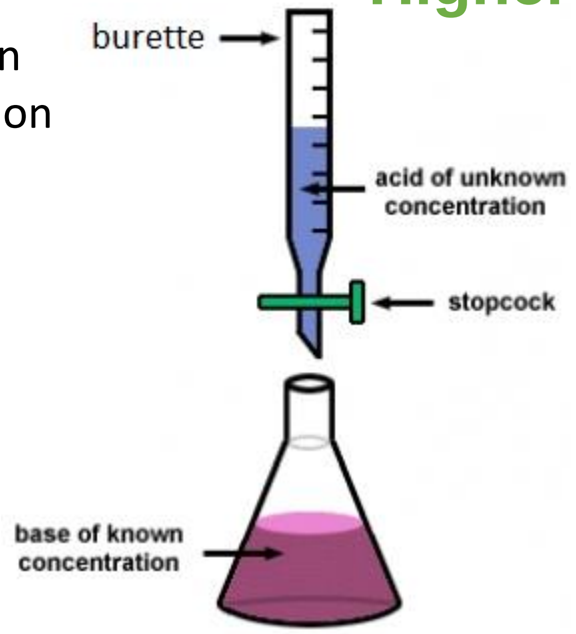
Example 2:

How many moles of magnesium nitrate are there in 0.50 dm³ of a 2 mol/dm³ solution?

2 x 0.50 = 1 mol

Reactions of acids – PART 2 - CHEMISTRY ONLY Higher

If the volumes of two solutions that react completely are known and the concentrations of one solution is known, the concentration of the other solution can be calculated.



Example:

2NaOH(aq) + H_2SO_4(aq)→ Na_2S0_4(aq) + 2H_2O(l)

It takes 12.20cm^3 of sulfuric acid to neutralise 24.00cm^3 of sodium hydroxide solution, which has a concentration of 0.50mol/dm^3.

Calculate the concentration of the sulfuric acid in g/dm^3

0.5 mol/dm^3 x (24/1000) dm^3 = 0.012 mol of NaOH

The equation shows that 2 mol of NaOH reacts with 1 mol of H_2SO_4, so the number of moles in 12.20cm^3 of sulfuric acid is **(0.012/2) = 0.006 mol of sulfuric acid**

Calculate the concentration of sulfuric acid in mol/ dm^3

0.006 mol x (1000/12.2) dm^3 =0.49mol/dm^3

Calculate the concentration of sulfuric acid in g/ dm^3

H_2SO_4 = (2x1) + 32 + (4x16) = 98g

0.49 x 98g = 48.2g/dm^3

TASK 5 - ACIDS

- STRONG AND WEAK ACIDS

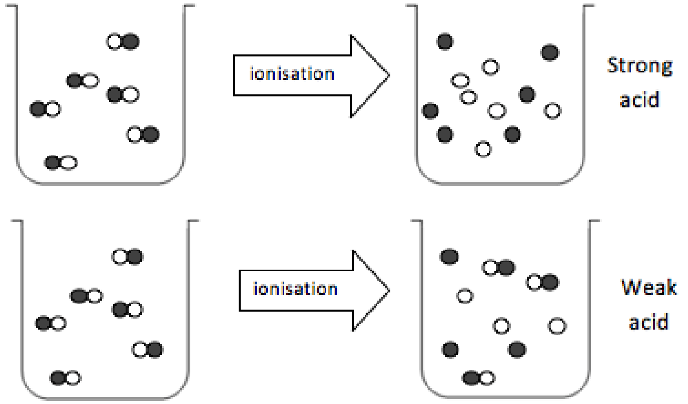
Reactions of acids - PART 2 - HIGHER

Acids must **dissolve** in water to show their acidic properties.
A **concentrated acid** has a relatively **large amount of solute** dissolved in the solvent.
A **dilute acid** has a relatively **smaller amount of solute** dissolved in the solvent

The molecules split up to form **hydrogen** ions.

A **strong** acid is **completely ionised** in aqueous solution. E.g. Hydrochloric, nitric and sulfuric acid.

A **weak** acid is only **partially ionised** in aqueous solution. E.g. Ethanoic, citric and carbonic.



A **weak acid** (aq) has a **lower pH** than a **strong acid** (aq) of the same concentration.

This is because a **weak acid** has a **lower concentration of hydrogen ions.**

As the pH decrease by one unit, the hydrogen ion concentration of the solution increase by a factor of 10.

Concentration of hydrogen ions in mol/dm^3	pH
0.10	1.0
0.010	2.0
0.0010	3.0
0.00010	4.0

1. What ions do aqueous acids contain?
2. What ions do aqueous alkalis contain?
3. What is the pH scale?
4. How can pH be measured?
5. What pH is a neutral solution?
6. What pH do aqueous acid solutions have?
7. What pH do aqueous alkali solutions have?
8. Write a balanced symbol equation for the reaction between hydrogen ions and hydroxide ions.
9. What are the units for the concentration of a solution?
10. What is the concentration of a solution that has 40g of solute in $2dm^3$ of solution?

TASK 6 – CELLS, BATTERIES AND FUEL CELLS

- CELLS AND BATTERIES

- FUEL CELLS

Cells and batteries (Chemistry only)

Cells contain chemicals which react to produce electricity.

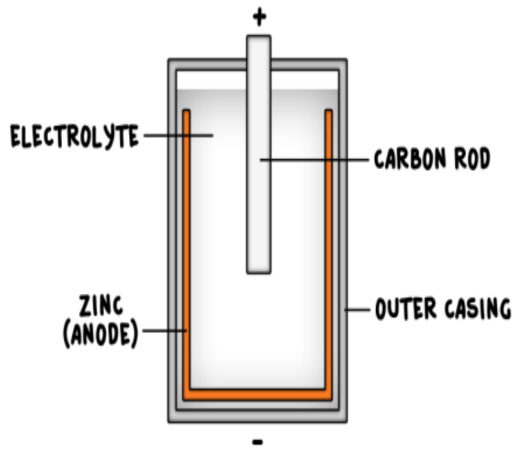
The voltage produced by a cell is dependent upon a number of factors including the type of electrode and electrolyte.

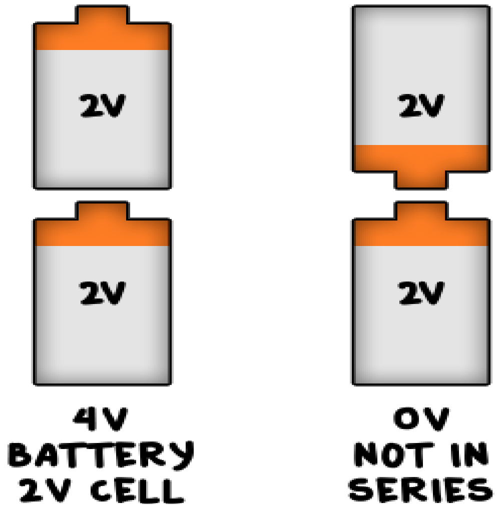
A simple cell can be made by connecting two different metals in contact with an electrolyte.

Batteries consist of two or more cells connected together in series to provide a greater voltage.

In non-rechargeable cells and batteries the chemical reactions stop when one of the reactants has been used up. Alkaline batteries are non-rechargeable.

Rechargeable cells and batteries can be recharged because the chemical reactions are reversed when an external electrical current is supplied.





Fuel Cells (Chemistry only)

Fuel cells are supplied by an external source of fuel (e.g. hydrogen) and oxygen or air. The fuel is oxidised electrochemically within the fuel cell to produce a potential difference (a voltage).

The overall reaction in a hydrogen fuel cell involves the oxidation of hydrogen to produce water.

hydrogen + oxygen → water

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

(Higher Tier only)

There are two electrodes in the hydrogen fuel cell.

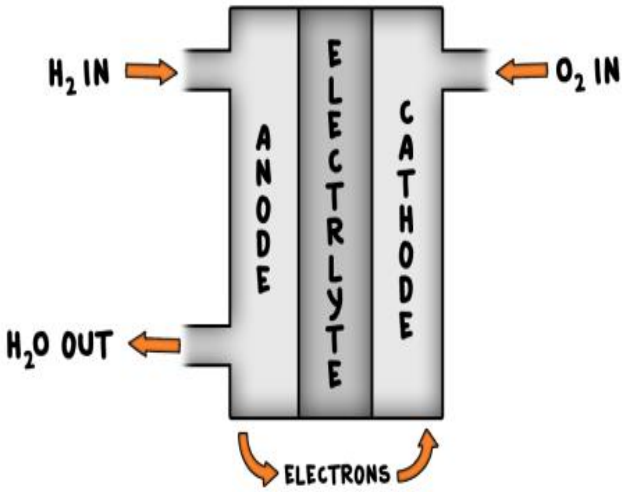
At the cathode (+ charged)

$2H_2(g) \rightarrow 4H^+(aq) + 4e^-$

At the anode (- charged)

$4H^+(aq) + O_2(g) + 4e^- \rightarrow 2H_2O(g)$

Hydrogen fuel cells offer a potential alternative to rechargeable cells and batteries.



The half equations are only needed for the higher tier, however they are very important and worth revising carefully

1. Give two factors which may affect the voltage given out by a battery.

2. Here is a reactivity series of metals. The most reactive is first, the least reactive is last:

Magnesium Zinc Tin Copper

Which two metals would you use to make a battery which had the highest voltage? Explain why.

3. Why do non-renewable batteries stop producing a voltage after a certain time?

4. How are rechargeable batteries recharged?

1. What chemical is the fuel in a fuel cell ?

2. What happens to this fuel inside the fuel cell to produce a potential difference?

3. Write the overall balanced symbol equation for the reaction in a fuel cell.

4. Write the half equation for the reaction that happens at the cathode in a fuel cell.

5. Write the half equation for the reaction that happens at the anode in a fuel cell

TASK 7 – ORGANIC CHEMISTRY (ALKENES)

- ALKENES
- REACTIONS OF ALKENES 1
- REACTIONS OF ALKENES 2

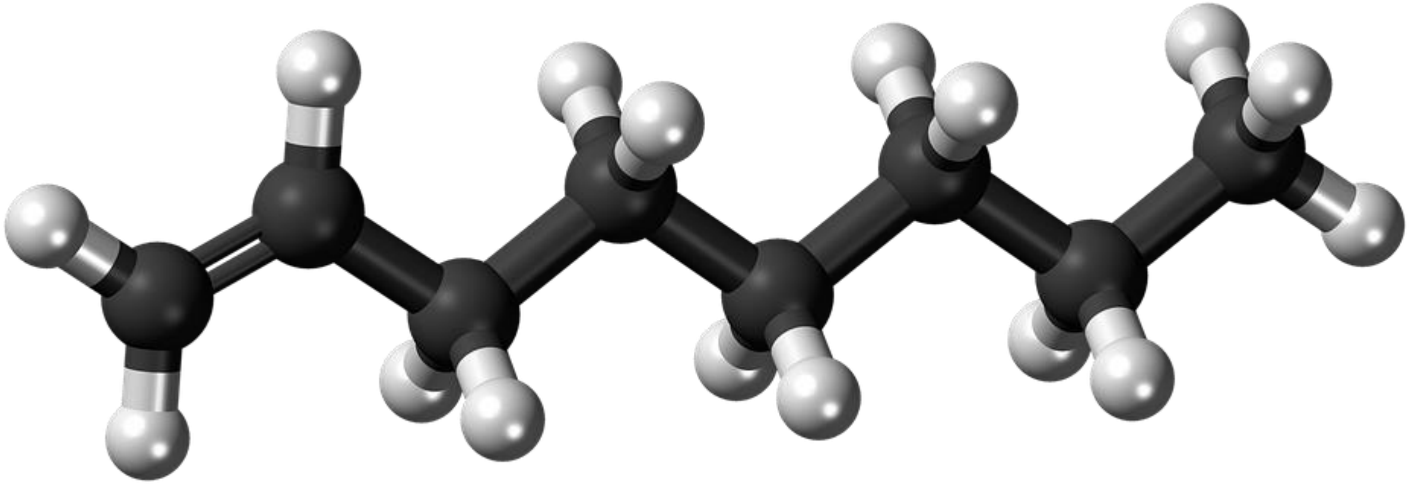
Structure and formulae of alkenes (Chemistry only)

We already know that alk**anes** have the general formulae C_nH_{2n+2}

Alk**enes** are hydrocarbons with a **double carbon-carbon bond**. The general formula for the homologous series of alkenes is C_nH_{2n}

The first four members of the alkanes are ethene, propene, butene and pentene.

There is no chemical called methene, as the double bond must be between two carbons. Any hydrocarbon starting with meth- can only have one carbon.



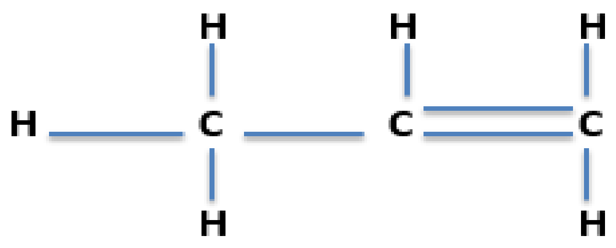
Structure and formulae of alkenes (Chemistry only)

Worked examples

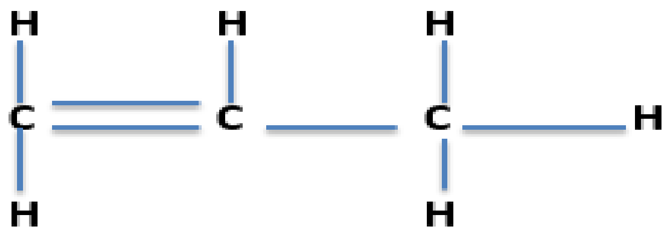
Ethene has two carbon atoms so it's formula will be $\mathbf{C_2H_{(2x2)}}$ this gives $\mathbf{C_2H_4}$
Propene has three carbon atoms so it's formula will be $\mathbf{C_3H_{(2x3)}}$ this gives $\mathbf{C_3H_6}$
Butene has four carbon atoms so it's formula will be $\mathbf{C_4H_{(2x4)}}$ this gives $\mathbf{C_4H_8}$
Propene has five carbon atoms so it's formula will be $\mathbf{C_5H_{(2x5)}}$ this gives $\mathbf{C_5H_{10}}$

You will be expected to know the names and formulae of these first four alkenes, you will be expected to calculate the formulae of alkenes with more than five carbons

Where the double bond is placed is not important at this stage so for propene we can draw it in one of two ways e.g.



Or



Both are $\mathbf{C_3H_6}$

Reaction of alkenes (Chemistry only)

Alkenes are hydrocarbons with the functional group C ═ C . This is the **carbon-carbon double bond**.

Alkenes react with oxygen in combustion reactions in the same way as other hydrocarbons, but they tend to burn in air with **smoky flames** because of **incomplete combustion**.

Alkenes can therefore react as alkanes do e.g.

butene + oxygen → carbon dioxide + water

$$C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$$

Incomplete combustion however produces either carbon monoxide CO or carbon C i.e.

$$C_4H_8 + 4O_2 \rightarrow 4CO + 4H_2O$$

Or

$$C_4H_8 + 2O_2 \rightarrow 4C + 4H_2O$$

Alkenes react with hydrogen, water and the halogens (chlorine, bromine and iodine) by the addition of atoms across the carbon-carbon double bond so that the double bond becomes a single carbon-carbon bond.

Propene + hydrogen → propane

Propene + water → propanol

Propene + chlorine → chloropropane

1. What type of bond do all alkenes contain?

2. What is the general formula for the homologous series of alkenes?

3. Why are alkenes unsaturated?

4. What are the first four members of the homologous series of alkenes?

5. What would be the formula of an alkene that contained 18 hydrogen atoms?
6. Draw the structural formula of butane C_4H_8

7. Write the balanced symbol equation for the incomplete combustion of octane C_8H_{16} to produce carbon monoxide and water.

8. What alcohol will be produced when water reacts with butane?

9. What chemical is produced when bromine reacts with pentene?

TASK 8 – ORGANIC CHEMISTRY (ALCOHOLS & CARBOXYLIC ACIDS)

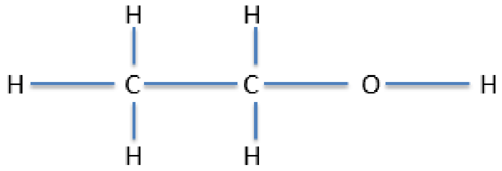
- ALCOHOLS
- REACTIONS OF ALCOHOLS
- CARBOXYLIC ACIDS

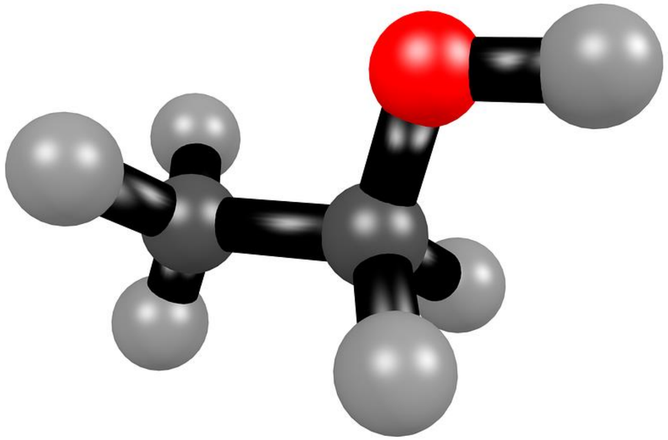
Reactions of alcohols (Chemistry only)

Alcohols contain the functional group **-OH**

Methanol has the formula CH_3OH
Ethanol has the formula CH_3CH_2OH or C_2H_5OH
Propanol has the formula $CH_3CH_2CH_2OH$ or C_3H_7OH
Butanol has the formula $CH_3CH_2CH_2CH_2OH$ or C_4H_9OH

An alternative way to show the alcohol structure is:





Reactions of alcohols (Chemistry only)

Alcohols have a number of important reactions:

- When **ethanol reacts with sodium,** bubbles of **hydrogen gas** are given off and colourless **sodium ethoxide** solution is left

Sodium + ethanol → sodium ethoxide + hydrogen

- All the alcohols **dissolve in water** to give **colourless solutions** with a **pH of 7**.
- Alcohols can react with an **oxidising reagent** to make the **carboxylic acid** e.g. **ethanol** will oxidise to make **ethanoic acid**.
- Alcohols also undergo **combustion** reactions with oxygen e.g.

Propanol + oxygen → carbon dioxide + water

$$C_3H_7OH + 5O_2 \rightarrow 3CO_2 + 4H_20$$

Aqueous solutions of ethanol are produced when sugar solutions are fermented using yeast.

The conditions needed for **fermentation** to happen are:

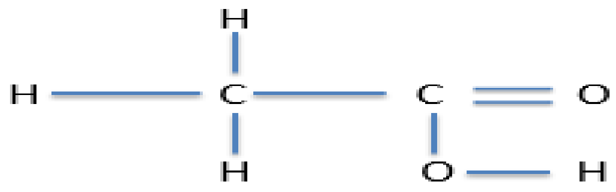
- A **temperature** between **25^{O}C and 45^{O}C**
- **Water** but **no oxygen**

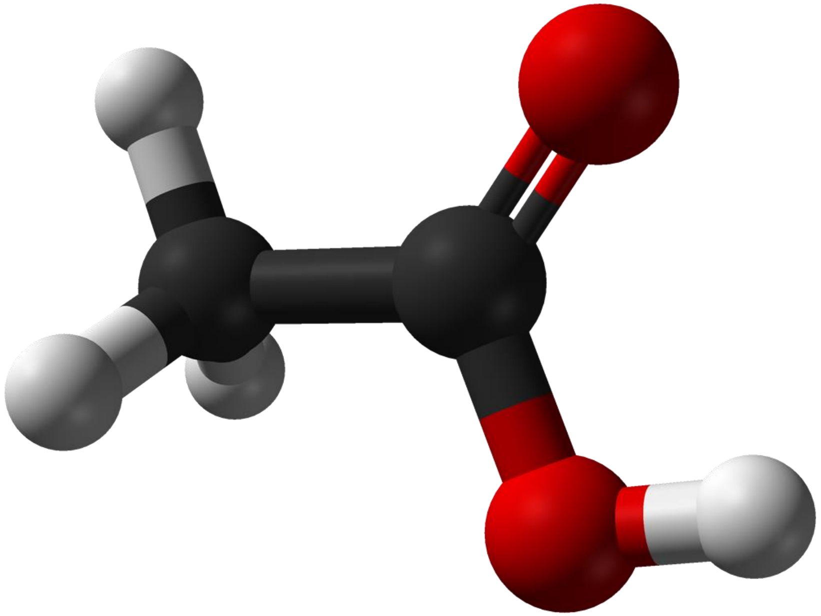
Reactions of carboxylic acids (Chemistry only)

Carboxylic acids have the functional group **-COOH**

Methanoic acid has the formula CHOOH
Ethanoic acid has the formula CH_3COOH
Propanoic acid has the formula C_2H_5COOH
Butanoic acid has the formula C_3H_7COOH

An alternative way to show the carboxylic acid structure is:





Reactions of carboxylic acids (Chemistry only)

Carboxylic acids have a number of important reactions:

- When we react carboxylic acids with a **metal carbonate** a **salt, carbon dioxide** and **water** are produced e.g.

  Sodium carbonate + propanoic acid → sodium propanoate + carbon dioxide + water

- Carboxylic acids with **five or less carbons dissolve in water.** Carboxylic acids with **more than five carbons in them are less soluble**.
- Carboxylic acids will **react with alcohols** to make an **ester and water**, an **acid catalyst** is needed (ethyl ethanoate is the ester below)

  Ethanoic acid + ethanol → ethyl ethanoate + water

(HT only)

Carboxylic acids are described as **weak acids** as they are only **partially ionised**, therefore they give off relatively **few hydrogen ions** in comparison to strong acids and have a **higher pH** than strong acids.

1. Name and give the formulae of the first three alcohols.

2. What is the functional group that all alcohols contain?

3. What are the conditions needed for sugar to ferment into alcohol?

4. Write a word equation for the reaction between ethanol and oxygen.

5. Write a word equation for the reaction between ethanol and sodium.
6. What is the functional group that all carboxylic acids contain?

7. Name the first four members of the homologous series of carboxylic acids.

8. Name and give the formula of the carboxylic acid that contains four carbon atoms.

9. Draw the structural formula of propanoic acid.

10. Which two chemicals are made when an alcohol and a carboxylic acid are reacted together?

TASK 9 - POLYMERS

- ADDITION POLYMERS
- CONDENSATION POLYMERS

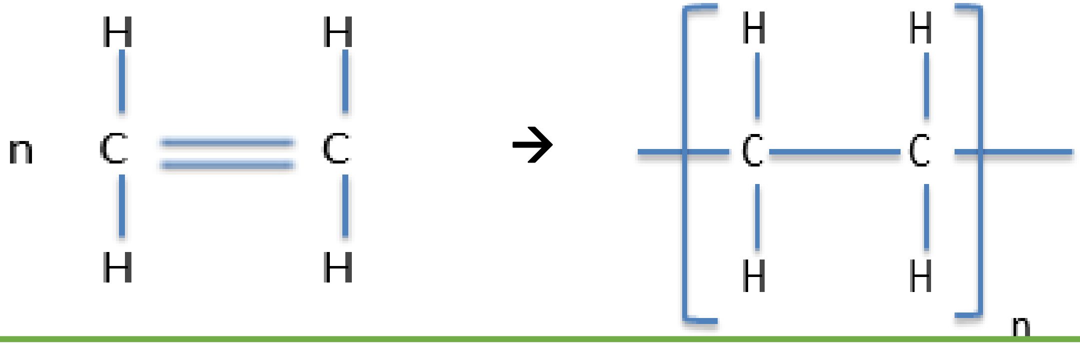
Addition polymerisation (Chemistry only)

Alkenes can be used to make **polymers** such as poly(ethane) and poly(propene) by **addition polymerisation.**

In addition polymerisation reactions, **many small molecules** (monomers) **join together** to form **very large molecules** (polymers).

Polythene has many uses.

An example of this is



One of the double bonds in the monomer breaks to form a single bond with other monomers. This leads to a very long polymer.

In **addition polymers** the repeating unit, **n,** has the **same atoms as the monomer** because no other molecule is formed in the reaction.

You must be able to move from the monomer to the polymer or polymer to the monomer

Condensation, polymerisation and amino acids (Chemistry HT only)

Condensation polymerisation involves **monomers with two functional groups**. When these types of monomers react they join together, usually **losing small molecules** such as **water**, and so the reactions are called **condensation reactions.**

The simplest polymers are produced from **two different monomers** with two of **the same functional groups** on each monomer.

An example of this is:

Ethane diol (this is ethane with two –di – alcohol – ol groups at either end)

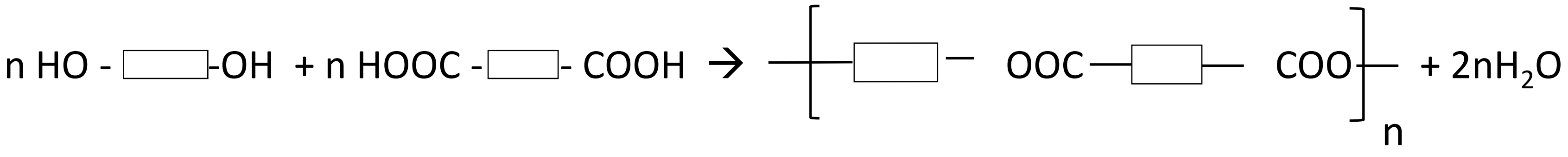
$HO - CH_2 - CH_2 - OH$ **or** HO - - OH

And

Hexanedioic acid (this is hexane with two carboxylic acid groups at the end)

$HOOC - CH_2 - CH_2 - CH_2 - CH_2 - COOH$ **or** HOOC - - COOH

Polymerise to produce a polyester

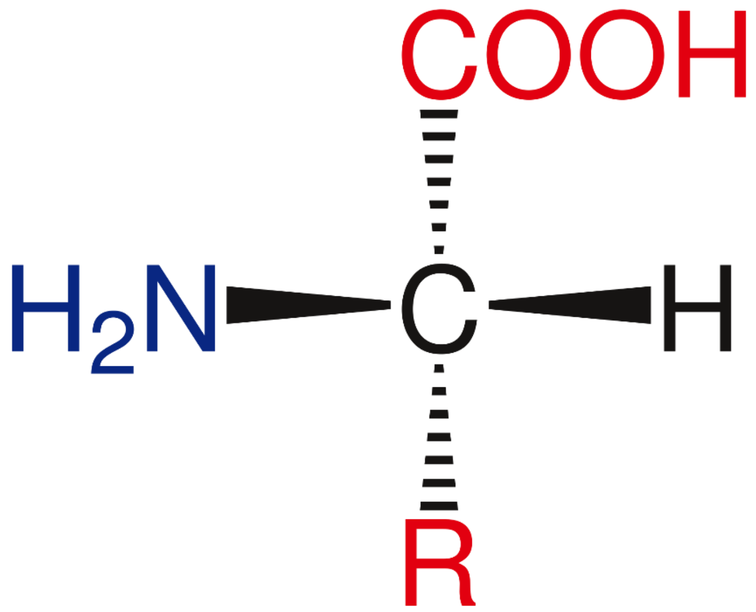


Condensation, polymerisation and amino acids (Chemistry HT only)

Amino acids have **two different functional groups** in a molecule. Amino acids react by condensation polymerisation to produce **polypeptides**.

e.g. glycerine is H_2NCH_2COOH and polymerises to produce the polypeptide $(-HNCH_2COO-)n$ and n H_2O

Different amino acids can be combined in the same chain to produce **proteins.**



1. What is polymerisation?

2. What type of polymerisation joins alkenes together to make polymers?

3. What is the monomer called which forms the polymer poly(ethene)?

4. What type of polymer would butene make and what would it be called?
5. HT ONLY - What happens during condensation polymerisation?

6. HT ONLY - Explain how amino acids polymerise to form a polypeptide.

7. HT ONLY - Name and give the formula of one amino acid that polymerises in this way.

TASK 10 – AMINO ACIDS & DNA

- AMINO ACIDS

- DNA

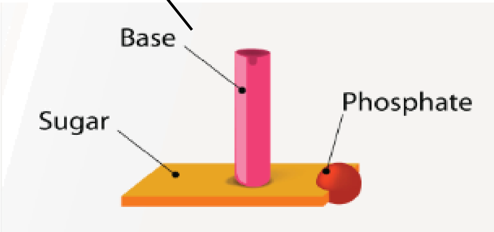
DNA and other naturally occurring polymers

DNA (deoxyribonucleic acid) is a large molecule essential for life. DNA encodes genetic instructions for the development and functioning of living organisms and viruses.

Most DNA molecules are **two polymer chains**, made from **four different monomers** called **nucleotides**, in the form of a **double helix**.

We can show the double helix structure in the following way

Each nucleotide contains a **base**, a **phosphate** and a **deoxyribose sugar**.
There are four different bases: **guanine, cytosine, thymine** or **adenine**. The nucleotide depends upon the base it contains.



There are other naturally occurring polymers:

- **Starch** and **cellulose** are both made from the **monomer glucose**
- **Proteins** are made from the **monomer amino acids**

1. What is DNA?
2. What does DNA do?
3. Describe the structure of DNA.
4. What are the monomers that make up DNA?
5. What three substances make up these monomers?
6. Name three other naturally occurring polymers important for life.
7. Name the monomer for protein, starch and cellulose.

TASK 11 – YIELD AND ATOM ECONOMY

- YIELD 1
- YIELD 2
- ATOM ECONOMY

Yield and atom economy - CHEMISTRY ONLY

Even though **no atoms** are **gained** or **lost** in a chemical reaction, it is not always possible to obtain the calculated **amount** of **product** because:

- The **reaction may not go to completion** because it is **reversible**
- Some of the **product may be lost** when it is separated from the reaction mixture
- Some of the **reactants may react in ways different to the expected** reactions

The amount of **product** obtained is known as the **yield**.

The **theoretical yield** is the **maximum** calculated amount of a **product** that could be formed from a **given amount** of **reactants**.

The **actual yield** is the **actual** amount of **product** obtained from a **chemical** reaction.

Yield and atom economy - CHEMISTRY ONLY

When **compared** with the **maximum theoretical** amount as a **percentage**, it is called the **percentage yield** and is calculated as:

$$\text{Percentage yield} = \frac{\text{mass of product actually made}}{\text{maximum theoretical mass of product}} \times 100$$

A piece of sodium metal is heated in chlorine gas. A maximum theoretical mass of 10g for sodium chloride was calculated, but the actual yield was only 8g.

Calculate the percentage yield.

Percentage yield = 8/10 x 100

= 80%

This means the percentage yield is 80%

HIGHER:

200g of calcium carbonate is heated. It decomposes to make calcium oxide and carbon dioxide. *Calculate the theoretical mass of calcium oxide made.*

$CaCO_3 \rightarrow CaO + CO_2$

M_r of $CaCO_3$ = 40 + 12 + (16x3) = 100

M_r of CaO = 40 + 16 = 56

100g of $CaCO_3$ would make 56 g of CaO

So 200g would make 112g

Yield and atom economy - CHEMISTRY ONLY

The **atom economy (atom utilisation)** is a measure of the **amount** of **starting materials** that end up as **useful products**. It is important for **sustainable development** and for **economic reasons** to use reactions with **high atom economy**. The percentage atom economy is calculated using a **balanced equation** for the reaction as follows:

Example:

$$\frac{\text{Relative formula mass of desired product from equation}}{\text{Sum of relative formula mass of all reactants from equation}} \times 100$$

Calculate the atom economy for making hydrogen by reacting zinc with hydrochloric acid:

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

M_r of H_2 = 1 + 1 = 2

M_r of $ZnCl_2$ = 65 + 35.5 + 35.5 = 136

Atom economy = $\frac{2}{136 + 2} \times 100$

= $\frac{2}{138} \times 100$ = 1.45%

This method is unlikely to be chosen as it has a low atom economy.

The less waste there is, the higher the atom economy, the less materials are wasted, less energy used, so making the process more economic, 'greener' and sustainable.

1. What is meant by the term ‘yield’?

2. What is the equation for calculating percentage yield?

3. Give 2 reasons why it is not always possible to obtain the expected amount of product from a reaction.

4. What is meant by the term ‘atom economy’?

5. Why is it important to use reactions with high atom economy?

6. What is the equation for calculating the percentage atom economy from a balanced chemical equation?

7. Magnesium is heated in air to make magnesium oxide. Suggest why the actual yield might be less than the maximum theoretical yield.

8. In the neutralisation of sulfuric acid with sodium hydroxide, the theoretical yield from 13.8g of sulfuric acid is 20g. In a synthesis, the actual yield is 17.4g. What is the percentage yield for this synthesis?

9. Calculate the atom economy for making hydrogen from methane and steam.

$$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$$

TASK 12 – CONCENTRATIONS OF SOLUTIONS & VOLUMES OF GASES

- CONCENTRATIONS 1
- CONCENTRATIONS 2
- GAS VOLUMES 1
- GAS VOLUMES 2

The **concentration** of a **solution** is the amount of **solute per volume of solution**.

Chemists measure concentration in moles per cubic decimetre **(mol/dm^3)**.

$$\text{Concentration } (mol/dm^3) = \frac{\text{amount (mol)}}{\text{volume } (dm^3)}$$

Example 1:

What is the concentration of a solution that has 35.0g of solute in $0.5dm^3$ of solution?

$35/0.5 = 70\ g/dm^3$

Example 2:

Calculate the mass of magnesium chloride ($MgCl_2$) if there is 1 dm^3 of a 1mol/ dm^3 solution.

Mass of 1 mole of magnesium chloride = $24 + (35.5 \times 2) = 95$ g
So there are 95 g of magnesium chloride in 1 dm^3 of a 1 mol/dm^3 solution.

Quantities - CHEMISTRY ONLY
Higher

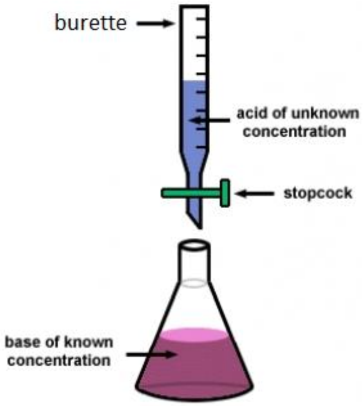
If the volumes of two solutions that react completely are known and the concentrations of one solution is known, the concentration of the other solution can be calculated.

2NaOH(aq) + H_2SO_4(aq)→ Na_2S0_4(aq) + 2H_2O(l)

It takes 12.20cm^3 of sulfuric acid to neutralise 24.00cm^3 of sodium hydroxide solution, which has a concentration of 0.50mol/dm^3.

Calculate the concentration of the sulfuric acid in g/dm^3

0.5 mol/dm^3 x (24/1000) dm^3 = 0.012 mol of NaOH



The equation shows that 2 mol of NaOH reacts with 1 mol of H_2SO_4, so the number of moles in 12.20cm^3 of sulfuric acid is **(0.012/2) = 0.006 mol of sulfuric acid**

Calculate the concentration of sulfuric acid in mol/ dm^3

0.006 mol x (1000/12.2) dm^3 =0.49mol/dm^3

Calculate the concentration of sulfuric acid in g/ dm^3

H_2SO_4 = (2x1) + 32 + (4x16) = 98g

0.49 x 98g = 48.2g/dm^3

Quantities - CHEMISTRY ONLY
Higher

Equal amounts of moles or gases occupy the same volume under the same conditions of temperature and pressure. The **volume** of **one mole** of any **gas** at **room temperature and pressure (rtp)** (**20°C and 1 atmospheric pressure**) is **24 dm^3**.

You can calculate the **volume** of a gas at room temperature and pressure from its **mass** and **relative formula mass** using the equation:

$$\textbf{Number of moles} = \frac{\textbf{mass}}{\textbf{relative formula mass}}$$

Volume of gas at rtp = moles x 24

You can calculate the **volumes** of gaseous **reactants** and **products** from a **balanced equation** and a given **volume** of a gaseous **reactant or product** using the following equation:

$$\textbf{Volume of gas at rtp} = \frac{\textbf{number of moles} \times \textbf{molar mass}}{\textbf{volume (24 dm}^3\textbf{)}}$$

Quantities - CHEMISTRY ONLY
Higher

What is the volume of 3.5g of hydrogen?

A_r : H (1)

M_r : H_2 = 2

1 mole in g = 2g

3.5/2 = 1.75 mol

volume H_2 = 1.75 x 24 = 42 dm^3

6g of a hydrocarbon gas had a volume of 4.8 dm^3. Calculate its molecular mass.

1 mole = 24 dm^3, so 4.8/24 = 0.2 mol

M_r = 6 / 0.2 = 30

if 6g = 0.2 mol, 1 mol equals 30 g

What is the volume of 11.6 g of butane (C_4H_{10}) gas at RTP?

M_r : (4 x 12) + (10 x 1) = 58

11.6/58 = 0.20 mol

volume = 0.20 x 24 = 4.8 dm^3

What mass of magnesium carbonate is needed to make 6 dm^3 of carbon dioxide?

$$MgCO_{3(s)} + H_2SO_{4(aq)} \rightarrow MgSO_{4(aq)} + H_2O_{(l)} + CO_{2(g)}$$

1 mole = 24 dm^3, 6 dm^3 is equal to 6/24 = 0.25 mol of gas

From the equation, 1 mole of $MgCO_3$ produces 1 mole of CO_2, which occupies a volume of 24 dm^3.

so 0.25 moles of $MgCO_3$ is needed to make 0.25 mol of CO_2

M_r : $MgCO_3$ = 24 + 12 + (3 x 16) = 84,

Mass of $MgCO_3$ = 0.25 x 84 = 21g

1. What are the units for concentration?

2. What is the equation for the calculation of concentration from the moles and volume of solution?

3. What can be said about equal amounts of moles of gases and the volume they occupy?

4. What is meant by RTP?

5. What is the concentration, in g/ dm^3, of a solution that has 40g of solute in $2dm^3$ of solution

6. Calculate the concentration in mol/dm^3 of a solution that has 0.75 mol of an acid in $3dm^3$ of solution.

7. It takes 28.0cm^3 of potassium hydroxide to neutralise 25.00cm^3 of nitric acid at a concentration of 0.50 mol/dm^3.

$$HNO_3 + KOH \rightarrow KNO_3 + H_2O$$

Calculate the concentration of the potassium hydroxide.

8. What is the volume of 4.5g of oxygen?

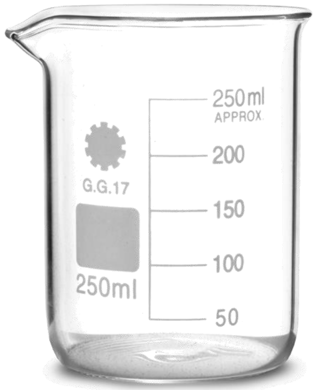
9. Calculate the number of moles of hydrogen that occupy 6dm^3 at RTP.

TASK 13 - MATERIALS

- CERAMICS AND COMPOSITES
- ALLOYS
- TYPES OF POLYMERS

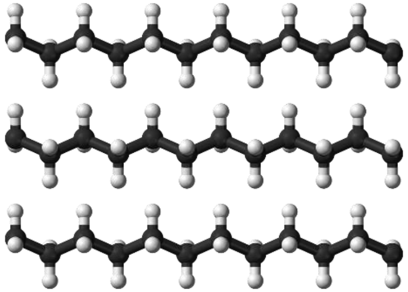
Most of the glass we use is **soda-lime glass**, made by **heating** a mixture of **sand, sodium carbonate and limestone**.

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

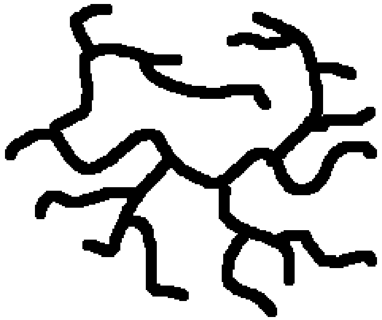


Polymers

The properties of **polymers** depend on what **monomers** they are made from and the **conditions** under which they are made. For example, **low density** (LD) and **high density** (HD) **poly(ethene)** are produced from **ethene**.



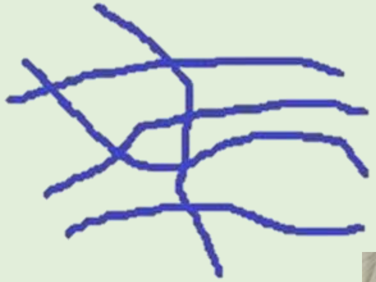
- **LDPE**s are made at **high pressure** and **moderate temperatures** whereas **HDPE**s are made at **lower temperatures and pressures** with a **catalyst**
- **LDPE** have **side chains**; **HDPE** have **no side chains** and have **stronger attractions** between molecules **and higher melting points.**

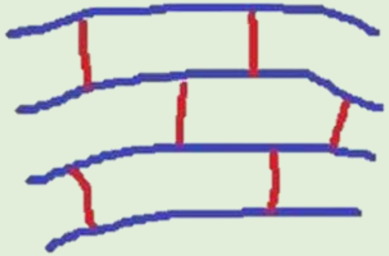


Thermosoftening and thermosetting

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

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





Most **composites** are made of **two materials**, a **matrix or binder** surrounding and binding together **fibres or fragments** of the other material, which is called **reinforcement**.

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

1. How is soda-lime glass made?

2. How is borosilicate glass made?

3. How do soda-lime and borosilicate glass differ?

4. How are clay ceramics made?

5. Give 2 examples of clay ceramics.

6. What are low density and high density poly(ethene) made from?
7. What is a thermosetting polymer?

8. What is a thermosoftening polymer?

9. What is a composite made of?

10. Give 3 examples of composites.

TASK 14 – HABER PROCESS & FERTILIZERS

- HABER PROCESS
- FERTLILZERS

The Haber process

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

$$\textbf{nitrogen + hydrogen} \rightleftharpoons \textbf{ammonia}$$

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

The reactants for the reaction come from the following:

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

The conditions for the Haber process are:

- A temperature of **450^{o}C**
- A pressure of **200 atmospheres**
- An **iron catalyst**

Reversible reactions and dynamic equilibrium

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

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

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

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

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

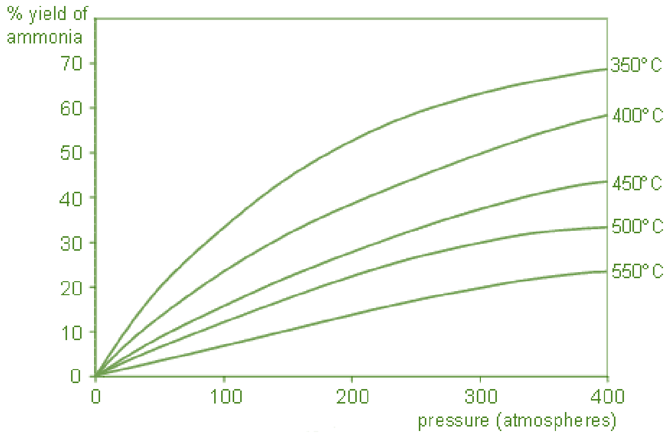
The Haber process, a compromise in conditions (HT)

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

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

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

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



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

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

$$NH_3 + HNO_3 \rightarrow NH_4NO_3$$

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

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

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

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

Phosphate rock treated with nitric acid produces:

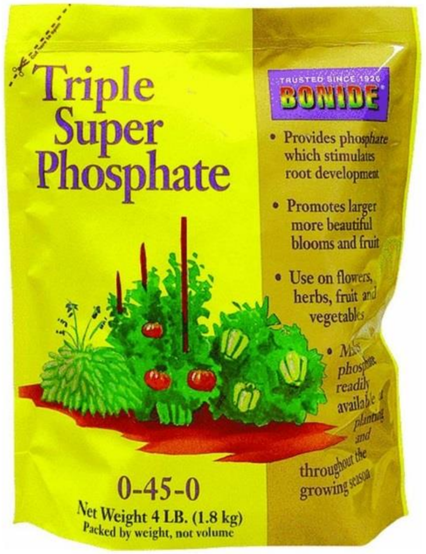
Calcium nitrate

Phosphate rock treated with sulfuric acid produces:

Single superphosphate (SSP)

Phosphate rock treated with phosphoric acid produces:

Triple superphosphate (TSP)



1. What is a reversible reaction?

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

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

4. What three elements do most fertilisers contain?

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

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

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

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

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

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