National 5 Chemistry
Unit Three : Chemistry In Society

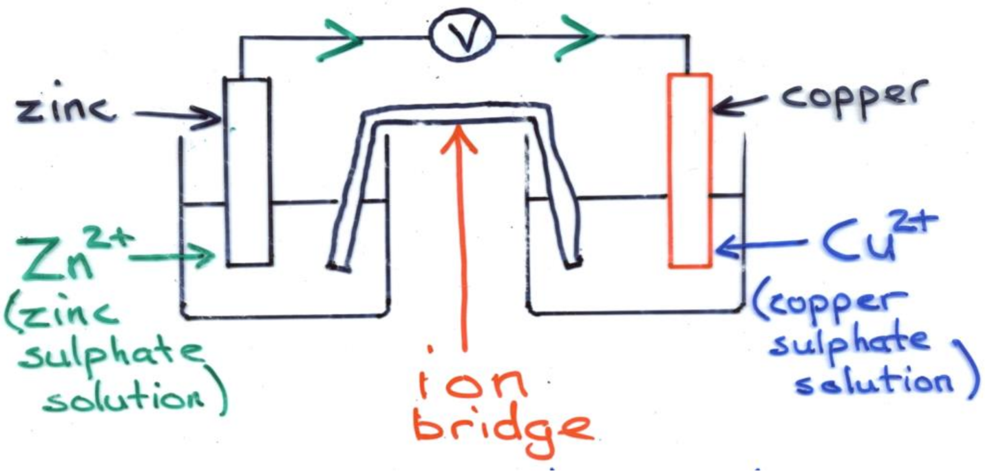
Metals

A **cell** is the simplest form of battery and consists of 2 different metals joined in a circuit, separated by an electrolyte.

An **electrolyte** is used to **complete the circuit** and is usually a solution of an **ionic** compound. This allows charge to flow.

The **further apart** the 2 metals are in the Electrochemical Series, the **higher** the voltage.

Electrons flow through the wires of the circuit from the metal **higher up** the Electrochemical Series to the one lower down, eg. Zn → Cu.



Displacement Reactions

These occur if the **solid metal is higher up** the Electrochemical Series than the metal in the salt solution. The metals will then swap places. The metal higher up would rather be in the ionic form so gives its electrons to the metal in solution.

Oxidation and Reduction

OILRIG

Oxidation Is Loss (of electrons)

Reduction Is Gain (of electrons)

A **Redox** reaction is one where reduction **and** oxidation occur at the same time, eg. **Displacements**, **electrolysis** and making electricity in a cell.

Redox Equations

The number of electrons in the 2 ion-electron equations must be the same, so that they cancel each other out.

1 $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

2 $Ag^+(aq) + e^- \rightarrow Ag(s)$

Equation 2 has only one electron moving so we must multiply this by 2 before we can add the 2 equations together to get the redox equation.

1 $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

2x2 $2Ag^+(aq) + 2e^- \rightarrow 2Ag(s)$

add $Zn(s) + 2Ag^+(aq) \rightarrow Zn^{2+}(aq) + 2Ag(s)$

Reactions of Metals

With Oxygen	**With Water**	**With Acid**
Magnesium	Potassium	Magnesium
Zinc	Sodium	Aluminium
Iron	Calcium	Zinc
Copper	Magnesium (when hot)	Iron
		Nickel
		Tin
		Lead

Extraction of Metals

Metals are extracted from their ores. This is a **reduction** process.

Metal	**Method of Extraction**
potassium ↓ aluminium	Electrolysis
zinc ↓ copper	Heating with carbon or carbon monoxide
silver ↓	Heat alone

Extraction of iron is done in a **blast furnace**. As well as the iron ore, carbon is added (turned into carbon monoxide gas for more efficient extraction) and limestone removes impurities.

Corrosion

This is a reaction where the surface of a metal is turned into a compound. This is an **oxidation** reaction of the metal.

Rusting is the corrosion of iron.
This process can be investigated using **ferroxyl** indicator. This turns blue in the presence of Fe^{2+} ions (the first stage of rusting)

2 things are needed for rusting to occur:
1. Oxygen (from air)
2. Water

Rusting is **speeded up** by:
1. Salt
2. Acid
3. Attaching a metal lower in the Electrochemical Series

Preventing Corrosion:

1. Physical protection (paint, plastic, metal stops air and water getting to the metal)
2. Sacrificial protection (a metal higher in the Electrochemical Series is attached)
3. Direct Electrical Protection (attached to a negative terminal supplying electrons)

In **sacrificial** protection, the metal higher up gives its electrons up to the iron. It is corroded to save the iron.

Iron can be covered by another metal by **electroplating**. It is attached to the negative terminal and dipped into a solution containing ions of the other metal.

Galvanising is the covering of iron by **zinc** (can be done by electroplating or just dipping in liquid zinc). This offers BOTH **physical** and **sacrificial** protection as zinc is higher in the Electrochemical Series.

On the other hand, **tin-plating** offers only physical protection and if cracked would then speed up rusting as tin is below iron.

Polymers

Most plastics and synthetic fibres are made from chemicals from **crude oil. Fibres**, both natural and synthetic, are examples of **polymers**.
Synthetic as used in the term "synthetic fibre" means "**man-made**".
The properties of plastics are related to their uses:
eg. **Lightweight and strong** – polystyrene bags, **durability** – plastic bottles, **electrical insulation** – coating for electrical cables and **thermal insulation** – pot handles.

Natural versus Synthetic Polymers

Natural polymers

Advantages	Disadvantages
Biodegradable	Expensive
Made from renewable resources	Don't last long

Synthetic Polymers

Advantages	Disadvantages
Long-lasting	Non-biodegradable
Cheap	Made from oil – a finite resource
Lots of properties	Burn to give off toxic fumes

Biodegradable means something which is broken down naturally by bacteria.
Most plastics are **not biodegradable** and their durability can cause environmental problems with litter.

Some plastics burn or smoulder to give off toxic fumes

Polymer	Gas given off when burned
All plastics	Carbon monoxide
Polyurethane	Hydrogen cyanide (HCN)
PVC	Hydrogen chloride

A **thermoplastic** polymer is one which can be **melted** or **reshaped**.
A **thermosetting** polymer is one which **cannot** be shaped in this way.
Bakelite is a thermosetting plastic used in plugs and electrical sockets because it is an insulator and will not melt.

Monomer – a small molecule which join together to form a plastic.

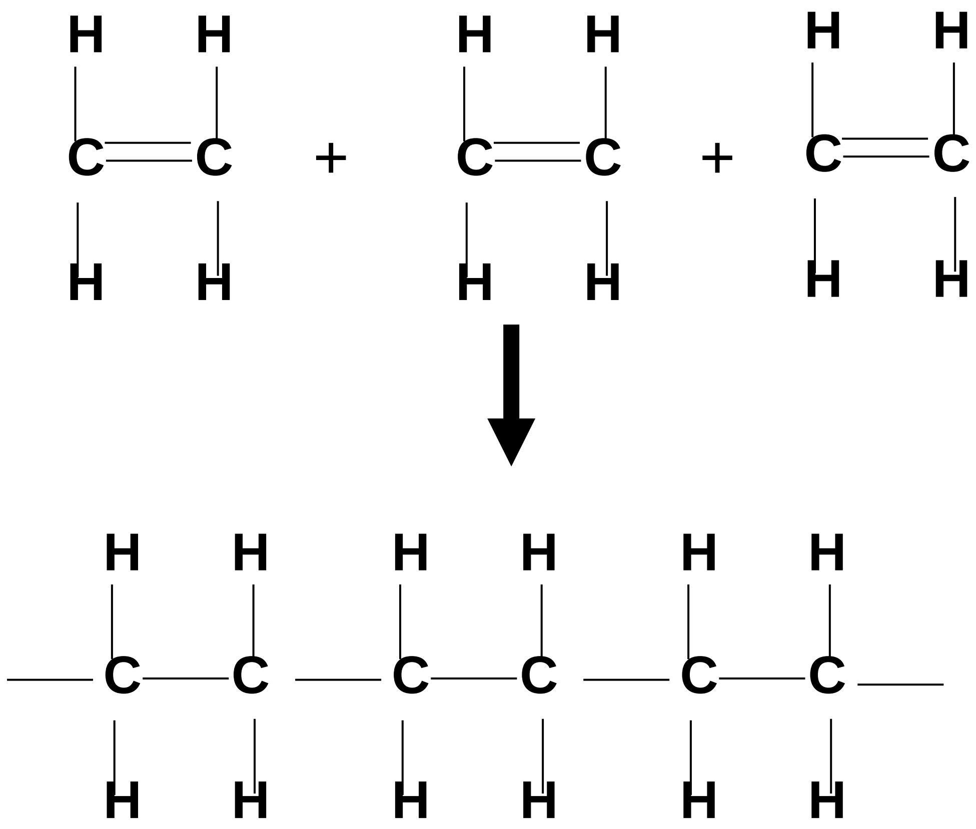
Polymer – the large molecule made up from many monomers.

Polymerisation – the reaction where many monomers join to form a polymer.

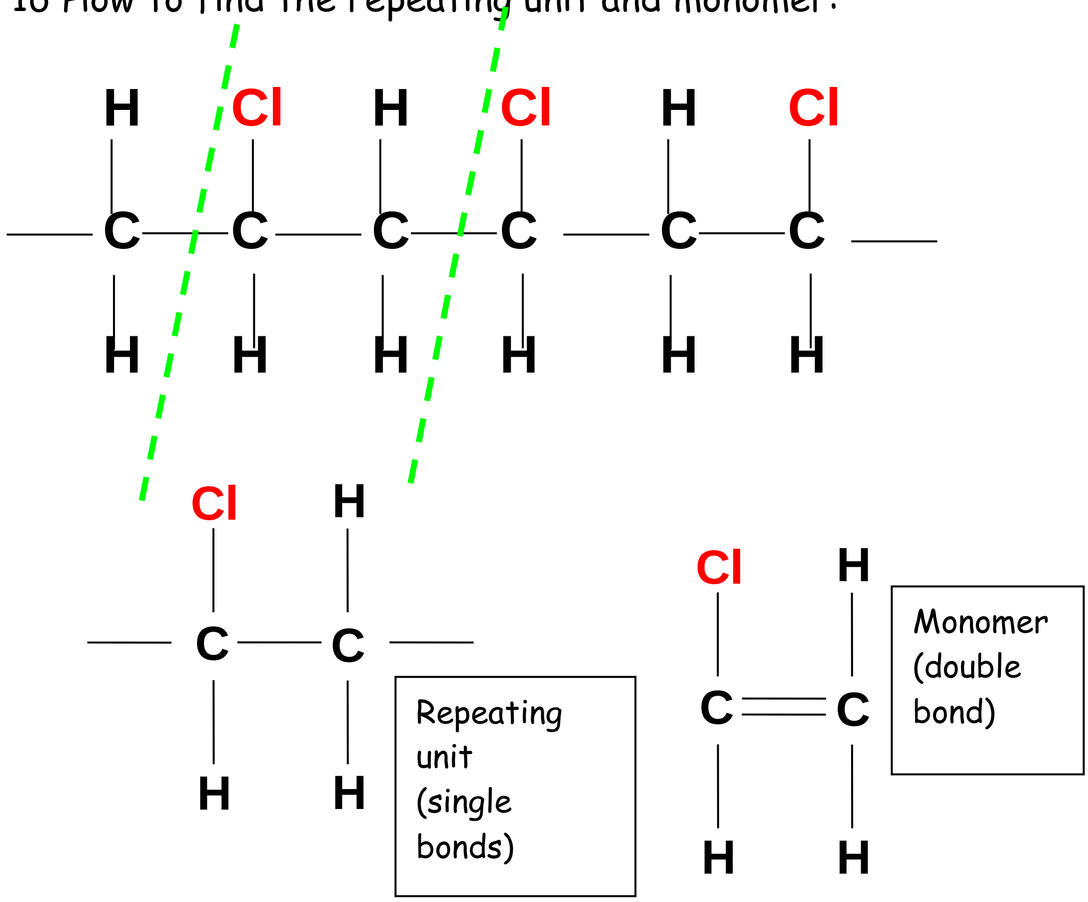
Many plastics are made from small, unsaturated molecules produced by **cracking** of naphtha from crude oil.
Addition polymerisation is when **unsaturated** molecules add together by opening up the carbon-carbon-double-bond and adding onto each other.

Monomer name	**Polymer name**
Ethene	Poly(ethene)
Propene	Poly(propene)
Vinyl chloride	Poly(vinyl chloride) - PVC
Tetrafluoroethene	Poly(tetrafluoroethene) – Teflon non-stick coating

Ethene monomers add together to form poly(ethene) as follows:



16 How to find the repeating unit and monomer:



Thermosetting Polymers

Formed by cross-linking between chains (covalent bonds NOT hydrogen bonding).

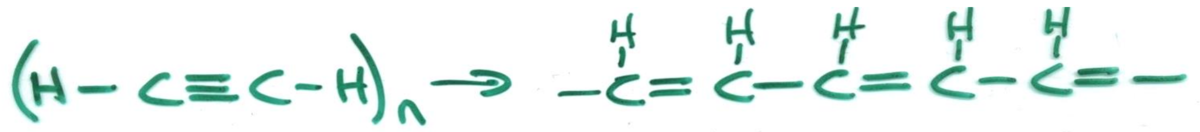
Examples:

Bakelite

Urea-methanal

Interesting Polymers with Special Properties

1. **Poly(ethyne)** – conducts electricity



Electrons can move due to alternating double-single bonds.

2. **Poly(ethenol)** – water soluble due to lots of polar OH groups. Used for hospital laundry bags, surgical stitches, car coatings.

3. **BIOPOL** – biodegradable.

Fertilisers

The increasing population of Earth has led to a need for more efficient food production to grow enough food to feed the increasing number of people on Earth.

Growing plants require nutrients including compounds of:

nitrogen (N)	phosphorus (P)	potassium (K)

- Different types of crops need fertilisers containing different proportions of N, P and K.

Decomposition of protein in plants and animal remains recycles nitrogen in the nitrogen cycle.

Fertilisers are substances that restore the essential element for plant growth.

- Fertilisers need to be soluble to be absorbed through plant roots.

Soluble compounds of	Ammonium salts	Potassium salts	Nitrates	Phospha tes

- Overuse of fertilisers can result in unused fertiliser being washed into rivers and lochs causing damage to wildlife.

Nitrifying bacteria in plant rood nodules can convert (fix) nitrogen from the air into compounds containing nitrogen.

- Plants with such root nodules include clover, peas and beans.
- The nitrogen compounds formed are nitrates (NO_3).
- These bacterial methods for fixing nitrogen are cheaper than chemical methods.

Synthetic methods can be made from nitrogen compounds such as ammonia (NH_3) and nitric acid (HNO_3).

Ammonia (NH_3) is made by the **Haber Process**.

$$\text{Nitrogen} + \text{Hydrogen} \rightleftharpoons \text{Ammonia}$$

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

- The Haber Process is carried out at a moderately high temperature (450°C) as higher temperatures lead to the breakdown of ammonia into nitrogen and hydrogen.

- Not all the reactants turn into ammonia as eventually the ammonia breaks down as quickly as it is formed.
- The catalyst used in the Haber Process is **iron**.

** The ⇌ sign means that the reaction is reversible.**

Nitric acid is made by the **Ostwald Process**.

- The Ostwald Process involves the catalytic oxidation of ammonia to form nitric acid.

  Stage 1: Ammonia + Oxygen → Nitrogen monoxide + Water

  Stage 2: Nitrogen monoxide + Oxygen → Nitrogen dioxide

  Stage 3: Nitrogen dioxide + Oxygen + Water → Nitric Acid

- The Ostwald Process is carried out at moderate temperature (900°C).
- The reaction is exothermic so once started, the reaction does not require further heating.
- A **platinum** catalyst is used in this process.
- When nitrogen dioxide is dissolved in water, nitric acid is formed.

The percentage mass of elements in fertilisers can be calculated.

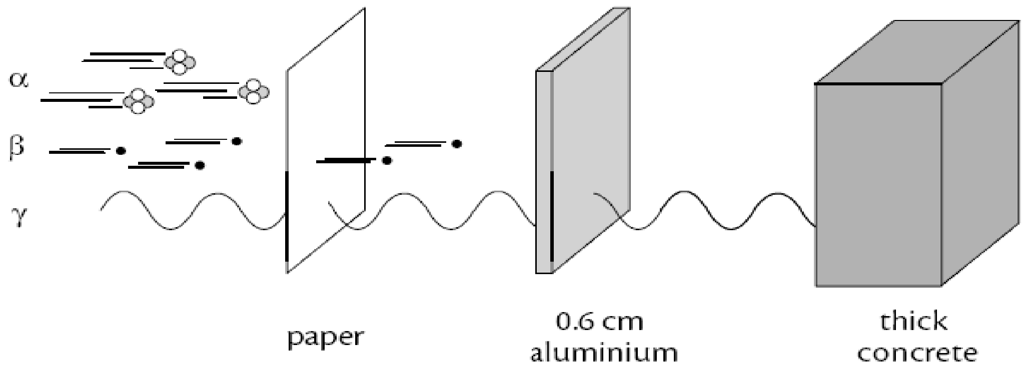
e.g. Calculate the percentage mass of nitrogen in ammonium nitrate, NH_4NO_3.

❶Find the GFM	**❷Find the mass of N in the formula**	**❸Divide: ❷mass in formula by ❶GFM**
NH_4NO_3. 2 X N = 2 X 14 = 28 4 X H = 4 X 1 = 4 3 X O = 3 X 16 = 48 **Total = 80 g**	2 X N = 2 X 14 = 28 g	% Mass = 28/80 x 100% **%Mass = 35%**

Nuclear Chemistry

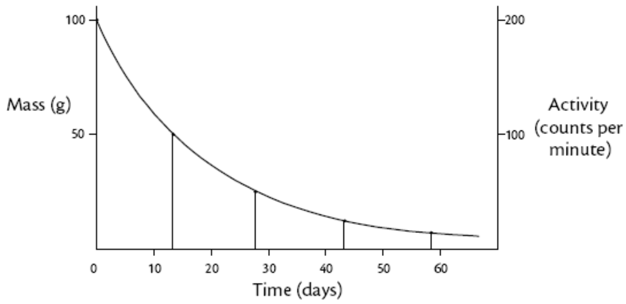
Radioactive decay involves changes in the nuclei of atoms.
Unstable nuclei (radioisotopes) are transformed into more stable nuclei by releasing energy.
The stability of nuclei depends on the proton:neutron ratio.

Name	α (alpha)	β (beta)	γ (gamma)
Penetration	Few cm in air	Thin metal foil	Great thickness of concrete
Nature	He nucleus	Electron	Electromagnetic radiation
Symbol	$^{4}_{2}He$	$^{0}_{-1}e$	None
Charge	2+	1-	None
Mass (amu)	4	1/2000	None



In decay equations, mass numbers and atomic numbers (nuclear charge) are balanced.

Half life ($t_{½}$) - the time taken for the activity or mass of a radioisotope to halve.
This is not affected by temperature or concentration as collisions are not relevant. It is nuclear decay.



The quantity of radioisotope, half-life or time elapsed can be calculated given the value of the other two variables.

Elements are created in the stars from simple elements by nuclear fusion.
All naturally occurring elements, including those found in our bodies, originated in stars.

Nuclear Reactions:

- Fusion (2 light radioisotopes combine)
- Fission (heavy radioisotope splits)
- Emission of α, β or γ.

<u>Uses of Radioisotopes</u>

Consider:

- type of radiation (can it travel far enough?)
- half-life (will it last long enough to be detected or short enough not to cause damage?).

Medical – treatment of cancer
^{60}Co (Cobalt-60) γ-emitter so penetrates body tissue.
^{32}P β-emitter so can only treat skin cancer.
Ingested radioisotopes have to be γ-emitters.
Isotopic labelling, carbon dating and nuclear power generation by uranium fission and nuclear fusion are other uses.

Chemical Analysis

There are two types of chemical analysis:

- Qualitative analysis
- Quantitative analysis.

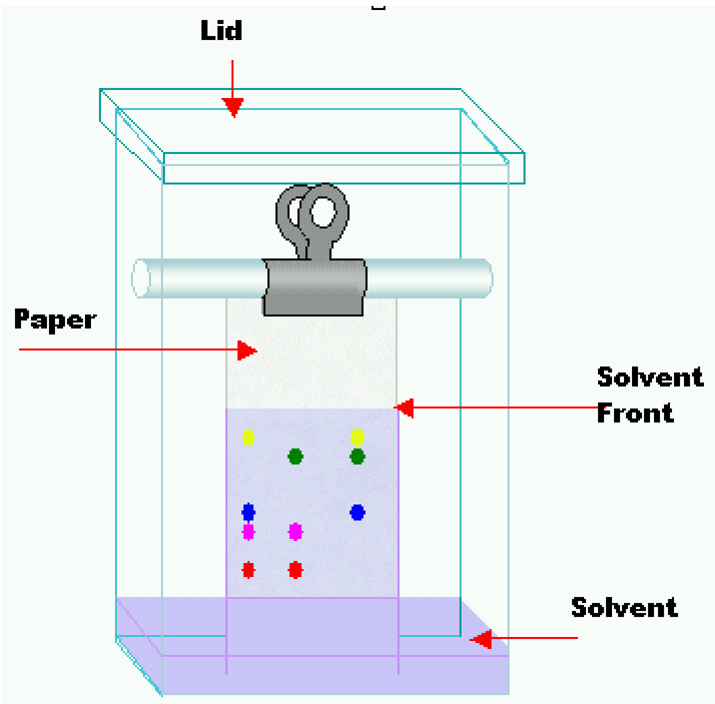
Qualitative analysis allows the presence of a substance to be detected.

Quantitative analysis allows the presence of a substance to be detected and allows us to work how much of the substance there is.

Qualitative Analytical Methods

1. **Flame Testing**
   - When metal compounds are placed in a flame, characteristic colours are produced.
   - Different metals give different colours, therefore the presence of a metal in a compound can be detected using flame colour.
   - Flame colours can be found in the data booklet on page 6.

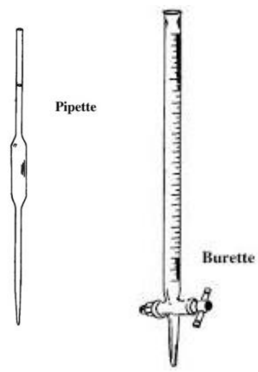
2. **Chromatography**
   - Chromatography can be used to separate mixtures of substances.
   - Chromatography involves spotting small quantities of a substance on a piece of chromatography paper, then placing this chromatography paper vertically in a solvent. The solvent flows up the paper and separates the single spot for the substance into a spot for each component of the mixture.
   - Advanced forms of chromatography are available that allow better separation of mixtures. High Performance Liquid Chromatography (HPLC) and Gas Phase Chromatography (GPC) and Liquid Chromatography Mass Spectrometry (LCMS) are all example of such techniques.



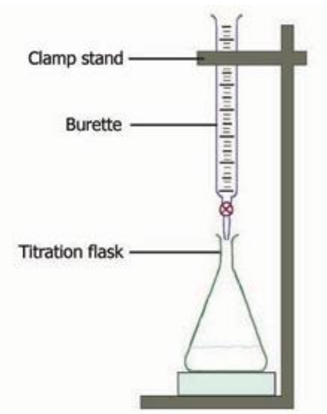
Quantitative Analysis

1. Titration

A titration can be used to determine the concentration of acid or base used in a neutralisation reaction.



In a titration a pipette is used to transfer a known volume of acid or base into a conical flask. An indicator is then added to the conical flask. The indicator allows the end point of the titration to be easily observed.



A burette is filled with acid or base of a known concentration.

The burette is then used to accurately add known volumes of acid or base into the conical flask. When a colour change is observed, the reaction has reached its end point.

The measurements in a titration are often recorded in a table such as the following:

	1st (Rough)	2nd	3rd
Initial Volume (cm^3)			
End Volume (cm^3)			
Titre (cm^3)			

The average titre can be worked out using concordant values. Concordant values are values that are with 0.2 cm^3 of each other.

The concentration of the unknown solution (in the flask) can then be calculated by:

1. n = CV for the chemical added from the burette.
2. Use this to calculate N for the unknown from the molar ratio in the balanced equation.
3. C = n÷V for the unknown solution.