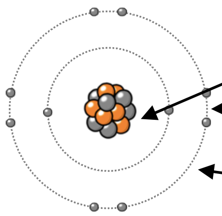
# Trilogy Chemistry F Topic 1 Atomic structure and periodic table part 1

## Atoms, elements and compounds

| | | |
|---|---|---|
| **Atom** | *The smallest part of an element that can exist* | Have a radius of around 0.1 nanometres and have no charge (0). |
| **Element** | *Contains only one type of atom* | Around 100 different elements each one is represented by a symbol e.g. O, Na, Br. |
| **Compound** | *Two or more elements chemically combined* | Compounds can only be separated into elements by chemical reactions. |



| | |
|---|---|
| **Central nucleus** | Contains protons and neutrons |
| **Electron shells** | Contains electrons |

## Electronic structures

| Electronic shell | Max number of electrons |
|---|---|
| 1 | 2 |
| 2 | 8 |
| 3 | 8 |
| 4 | 2 |

## Relative electrical charges of subatomic particles

| Name of Particle | Relative Charge | Relative Mass |
|---|---|---|
| Proton | +1 | 1 |
| Neutron | 0 | 1 |
| Electron | -1 | Very small |

$^{7}_{3}Li$

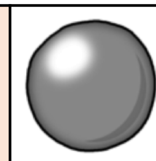
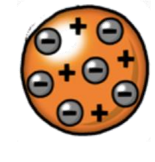
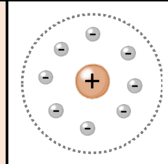
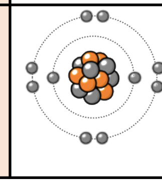
| | | |
|---|---|---|
| **Mass number** (7) | *The sum of the protons and neutrons in the nucleus* | |
| **Atomic number** (3) | *The number of protons in the atom* | Number of electrons = number of protons |

## Mixtures

| | | |
|---|---|---|
| **Mixtures** | *Two or more elements or compounds not chemically combined together* | Can be separated by physical processes. |

| Method | Description | Example |
|---|---|---|
| **Filtration** | *Separating an insoluble solid from a liquid* | To get sand from a mixture of sand, salt and water. |
| **Crystallisation** | *To separate a solid from a solution* | To obtain pure crystals of sodium chloride from salt water. |
| **Simple distillation** | *To separate a solvent from a solution* | To get pure water from salt water. |
| **Fractional distillation** | *Separating a mixture of liquids each with different boiling points* | To separate the different compounds in crude oil. |
| **Chromatography** | *Separating substances that move at different rates through a medium* | To separate out the dyes in food colouring. |

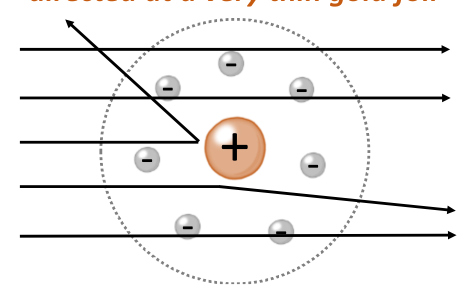
## The development of the model of the atom

| | | | |
|---|---|---|---|
| **Pre 1900** |  | *Tiny solid spheres that could not be divided* | Before the discovery of the electron, John Dalton said the solid sphere made up the different elements. |
| **1897 'plum pudding'** |  | *A ball of positive charge with negative electrons embedded in it* | JJ Thompson 's experiments showed that showed that an atom must contain small negative charges (discovery of electrons). |
| **1909 nuclear model** |  | *Positively charge nucleus at the centre surrounded negative electrons* | Ernest Rutherford's alpha particle scattering experiment showed that the mass was concentrated at the centre of the atom. |
| **1913 Bohr model** |  | *Electrons orbit the nucleus at specific distances* | Niels Bohr proposed that electrons orbited in fixed shells; this was supported by experimental observations. |

| | |
|---|---|
| **James Chadwick** | *Provided the evidence to show the existence of neutrons within the nucleus* |

## Rutherford's scattering experiment

*A beam of alpha particles are directed at a very thin gold foil*



Most of the alpha particles passed right through.
A few (+) alpha particles were deflected by the positive nucleus.
A tiny number of particles reflected back from the nucleus.

## Chemical equations

| | | |
|---|---|---|
| **Chemical equations** | *Show chemical reactions - need reactant(s) and product(s) energy always involves and energy change* | Law of conservation of mass states the total mass of products = the total mass of reactants. |
| **Word equations** | *Uses words to show reaction*<br>**reactants → products**<br>magnesium + oxygen → magnesium oxide | Does not show what is happening to the atoms or the number of atoms. |
| **Symbol equations** | *Uses symbols to show reaction*<br>**reactants → products**<br>$2Mg + O_2 \rightarrow 2MgO$ | Shows the number of atoms and molecules in the reaction, these need to be balanced. |

## Relative atomic mass

| | | |
|---|---|---|
| **Isotopes** | *Atoms of the same element with the same number of protons and different numbers of neutrons* | **$^{35}Cl$ (75%) and $^{37}Cl$ (25%)**<br>Relative abundance = (% isotope 1 x mass isotope 1) + (% isotope 2 x mass isotope 2) ÷ 100<br>**e.g. (25 x 37) + (75x 35) ÷ 100 = 35.5** |

# Trilogy Chemistry F Topic 1 Atomic structure and periodic table part 2

## The Periodic table

Alkali metals

Halogens

Noble gases

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 | ? | ? | ? | | | | | | |

Metals to the left of this line, non metals to the right

| | | |
|---|---|---|
| Elements arranged in order of atomic number | *Elements with similar properties are in columns called groups* | Elements in the same group have the same number of outer shell electrons and elements in the same period (row) have the same number of electron shells. |

## Development of the Periodic table

| | | |
|---|---|---|
| Before discovery of protons, neutrons and electrons | *Elements arranged in order of atomic weight* | Early periodic tables were incomplete, some elements were placed in inappropriate groups if the strict order atomic weights was followed. |
| Mendeleev | *Left gaps for elements that hadn't been discovered yet* | Elements with properties predicted by Mendeleev were discovered and filled in the gaps. Knowledge of isotopes explained why order based on atomic weights was not always correct. |

## Metals and non metals

| | | |
|---|---|---|
| Metals | *To the left of the Periodic table* | Form positive ions. Conductors, high melting and boiling points, ductile, malleable. |
| Non metals | *To the right of the Periodic table* | Form negative ions. Insulators, low melting and boiling points. |

## Group 7

| | | |
|---|---|---|
| Halogens | *Consist of molecules made of a pair of atoms* | Have seven electrons in their outer shell. Form -1 ions. |
| | *Melting and boiling points increase down the group (gas → liquid → solid)* | Increasing atomic mass number. |
| | *Reactivity decreases down the group* | Increasing proton number means an electron is more easily gained |

| | | | |
|---|---|---|---|
| With metals | Forms a metal halide | Metal + halogen → metal halide e.g. Sodium + chlorine → sodium chloride | e.g. NaCl metal atom loses outer shell electrons and halogen gains an outer shell electron |
| With hydrogen | Forms a hydrogen halide | Hydrogen + halogen → hydrogen halide e.g. Hydrogen + bromine → hydrogen bromide | e.g. $Cl_2 + H_2 \rightarrow 2HCl$ |
| With aqueous solution of a halide salt | A more reactive halogen will displace the less reactive halogen from the salt | Chlorine + potassium bromide → potassium chloride + bromine | e.g. $Cl_2 + 2KBr \rightarrow 2KCl + Br_2$ |

## Group 1

| | | |
|---|---|---|
| Alkali metals | *Very reactive with oxygen, water and chlorine* | Only have one electron in their outer shell. Form +1 ions. |
| | *Reactivity increases down the group* | Negative outer electron is further away from the positive nucleus so is more easily lost. |

| | | | |
|---|---|---|---|
| With oxygen | Forms a metal oxide | Metal + oxygen → metal oxide | e.g. $4Na + O_2 \rightarrow 2Na_2O$ |
| With water | Forms a metal hydroxide and hydrogen | Metal + water → metal hydroxide + hydrogen | e.g. $2Na + 2H_2O \rightarrow 2NaOH + H_2$ |
| With chlorine | Forms a metal chloride | Metal + chlorine → metal chloride | e.g. $2Na + Cl_2 \rightarrow 2NaCl$ |

## Group 0

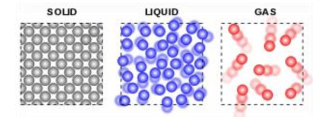
| | | |
|---|---|---|
| Noble gases | *Unreactive, do not form molecules* | This is due to having full outer shells of electrons. |
| | *Boiling points increase down the group* | Increasing atomic number. |

# Trilogy Chemistry Topic 2: Structure and Bonding Foundation

## Chemical bonds

| | | |
|---|---|---|
| Ionic | *Particles are oppositely charged ions* | Occurs in compounds formed from metals combined with non metals. |
| Covalent | *Particles are atoms that share pairs of electrons* | Occurs in most non metallic elements and in compounds of non metals. |
| Metallic | *Particles are atoms which share delocalised electrons* | Occurs in metallic elements and alloys. |

## The three states of matter

| | | | |
|---|---|---|---|
| Solid, liquid, gas | *Melting and freezing happen at melting point, boiling and condensing happen at boiling point.* | The amount of energy needed for a state change depends on the strength of forces between particles in the substance. | (HT only) Limitations of simple model:<br>• There are no forces in the model<br>• All particles are shown as spheres<br>• Spheres are solid |

| | |
|---|---|
| *s* | solid |
| *l* | liquid |
| *g* | gas |

## Properties of ionic compounds

| | |
|---|---|
| *High melting and boiling points* | Large amounts of energy needed to break the bonds. |
| *Do not conduct electricity when solid* | Ions are held in a fixed position in the lattice and cannot move. |
| *Do conduct electricity when molten or dissolved* | Lattice breaks apart and the ions are free to move. |

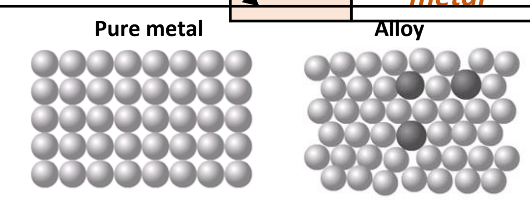
## Metals as conductors

| | |
|---|---|
| *Good conductors of electricity* | Delocalised electrons carry electrical charge through the metal. |
| *Good conductors of thermal energy* | Energy is transferred by the delocalised electrons. |

## Properties of metals and alloys

| | |
|---|---|
| *High melting and boiling points* | This is due to the strong metallic bonds. |
| *Pure metals can be bent and shaped* | Atoms are arranged in layers that can slide over each other. |

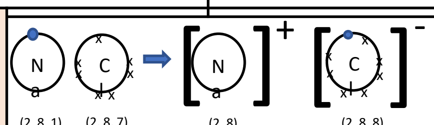
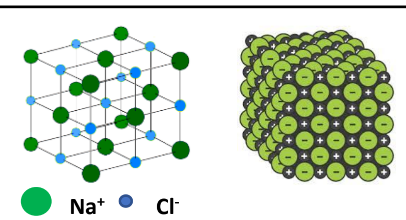
| | | |
|---|---|---|
| Alloys | *Mixture of two or more elements at least one of which is a metal* | Harder than pure metals because atoms of different sizes disrupt the layers so they cannot slide over each other. |




## Ionic bonding

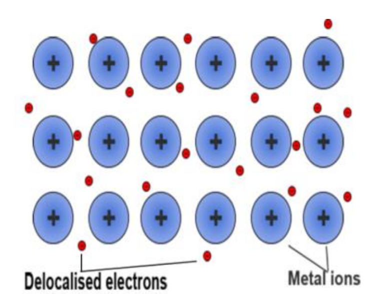
| | | |
|---|---|---|
| Electrons are transferred so that all atoms have a noble gas configuration (full outer shells). | *Metal atoms lose electrons and become positively charged ions* | Group 1 metals form +1 ions<br>Group 2 metals form +2 ions |
| | *Non metals atoms gain electrons to become negatively charged ions* | Group 6 non metals form -2 ions<br>Group 7 non metals form -1 ions |

## Ionic compounds

| | |
|---|---|
| Dot and cross diagram |  |
| Giant structure |  |

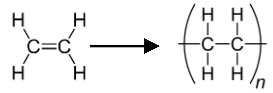
| | |
|---|---|
| Structure | • *Held together by strong electrostatic forces of attraction between oppositely charged ions*<br>• *Forces act in all directions in the lattice* |

## Metallic bonding

| | | |
|---|---|---|
| *Giant structure of atoms arranged in a regular pattern* |  | Electrons in the outer shell of metal atoms are delocalised and free to move through the whole structure. This sharing of electrons leads to strong metallic bonds. |

# Trilogy Chemistry Topic 2: Structure and Bonding Foundation

## Polymers

| | | | |
|---|---|---|---|
| Very large molecules | *Solids at room temperature* | Atoms are linked by strong covalent bonds. |  |

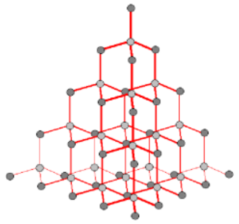
## Properties of small molecules

Usually gases or liquids

*Covalent bonds in the molecule are strong but forces between molecules (intermolecular) are weak*

| | |
|---|---|
| Low melting and boiling points. | Due to having weak intermolecular forces that easily broken. |
| Do not conduct electricity. | Due to them molecules not having an overall electrical charge. |
| Larger molecules have higher melting and boiling point | Intermolecular forces increase with the size of the molecules. |

## Diamond

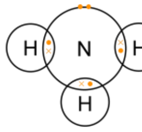
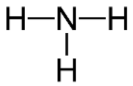
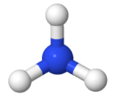
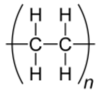
| | | | |
|---|---|---|---|
| *Each carbon atom is bonded to four others* |  | Very hard. | Rigid structure. |
| | | Very high melting point. | Strong covalent bonds. |
| | | Does not conduct electricity. | No delocalised electrons. |

## Giant covalent structures

| | | |
|---|---|---|
| Diamond, graphite, silicon dioxide | *Very high melting points* | Lots of energy needed to break strong, covalent bonds. |

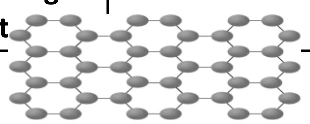
## Covalent bonding

Atoms share pairs of electrons

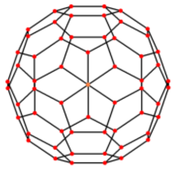
| | | |
|---|---|---|
| *Can be small molecules e.g. ammonia* |  | Dot and cross :<br>+ Show which atom the electrons in the bonds come from<br>- All electrons are identical |
| |  | 2D with bonds:<br>+ Show which atoms are bonded together<br>- It shows the H-C-H bond incorrectly at 90° |
| |  | 3D ball and stick model:<br>+ Attempts to show the H-C-H bond angle is 109.5° |
| *Can be giant covalent structures e.g. polymers* |  | |

## Graphene and fullerenes

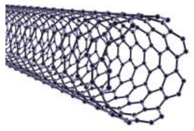
### Graphene

| | | |
|---|---|---|
| <br>*Single layer of graphite one atom thick* | Excellent conductor. | Contains delocalised electrons. |
| | Very strong. | Contains strong covalent bonds. |

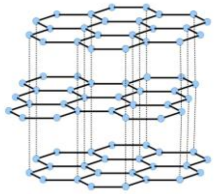
### Fullerenes

| | | |
|---|---|---|
|  | Buckminsterfullerene, $C_{60}$<br>First fullerene to be discovered. | Hexagonal rings of carbon atoms with hollow shapes. Can also have rings of five (pentagonal) or seven (heptagonal) carbon atoms. |

### Carbon nanotubes

| | | | |
|---|---|---|---|
|  | *Very thin and long cylindrical fullerenes* | Very conductive. | Used in electronics industry. |
| | | High tensile strength. | Reinforcing composite materials. |
| | | Large surface area to volume ratio. | Catalysts and lubricants. |

## Graphite

| | | | |
|---|---|---|---|
| *Each carbon atom is bonded to three others forming layers of hexagonal rings with no covalent bonds between the layers* |  | Slippery. | Layers can slide over each other. |
| | | Very high melting point. | Strong covalent bonds. |
| | | Does conduct electricity. | Delocalised electrons between layers. |

# Trilogy Chemistry –Topic 3 F QUANTITATIVE CHEMISTRY

## Relative formula mass ($M_r$)

| | | | |
|---|---|---|---|
| $M_r$ | *The sum of the relative atomic masses of the atoms in the numbers shown in the formula. The Mr is the mass of 1 mole of the formula in grams.* | The sum of the $M_r$ of the reactants in the quantities shown equals the sum of the $M_r$ of the products in the quantities shown. | $2Mg + O_2 \rightarrow 2MgO$<br>48g + 32g = 80g<br>80g = 80g |

## Conservation of mass and balanced symbol equations

| | | |
|---|---|---|
| Balanced symbol equations | *Represent chemical reactions and have the same number of atoms of each element on both sides of the equation* | $H_2 + Cl_2 \rightarrow 2HCl$<br>Subscript; Normal script<br>Subscript (small number at the bottom, after the element) numbers show the number of atoms of the element to its left.<br>Normal script (in front of the formula) numbers show the number of molecules. |

| | | |
|---|---|---|
| Conservation of mass | *No atoms are lost or made during a chemical reaction* | Mass of the products equals the mass of the reactants. |

## Mass changes when a reactant or product is a gas

| | | |
|---|---|---|
| Mass appears to increase during a reaction | *One of the reactants is a gas* | Magnesium + oxygen → magnesium oxide |
| Mass appears to decrease during a reaction | *One of the products is a gas and has escaped* | Calcium carbonate → carbon dioxide + calcium oxide |

## Chemical measurements

| | | |
|---|---|---|
| Whenever a measurement is taken, there is always some uncertainty about the result obtained | *Can determine whether the mean value falls within the range of uncertainty of the result* | 1. Calculate the mean<br>2. Calculate the range of the results<br>3. Estimate of uncertainty in mean would be half the range |

Example:
1. Mean value is 46.5s
2. Range of results is 44s to 49s = 5s
3. Time taken was 46.5s 2.5s

## Concentration of solutions

| | |
|---|---|
| Measured in mass per given volume of solution ($g/dm^3$) | *Conc. = mass (g) / volume ($dm^3$)* |

# Trilogy Chemistry Foundation Topic 4 Chemical Changes 1

Oxidation Is Loss (of electrons) Reduction Is Gain (of electrons)

## Reactions of acids

### Reactions of acids and metals

Acids react with some metals to produce salts and hydrogen.

| | | |
|---|---|---|
| **Reactions with acids** | *metal + acid → salt + hydrogen* | magnesium + hydrochloric acid → magnesium chloride + hydrogen<br><br>zinc + sulfuric acid → zinc sulfate + hydrogen |

### Neutralisation of acids and salt production

| Acid name | Salt name |
|---|---|
| *Hydrochloric acid* | Chloride |
| *Sulfuric acid* | Sulfate |
| *Nitric acid* | Nitrate |

sodium hydroxide + hydrochloric acid → sodium chloride + water

calcium carbonate + sulfuric acid → calcium sulfate, + carbon dioxide + water

| | | |
|---|---|---|
| **Neutralisation** | *Acids can be neutralised by alkalis and bases* | An **alkali** is a soluble base e.g. metal hydroxide.<br>A **base** is a substance that neutralises an acid e.g. a soluble metal hydroxide or a metal oxide. |

## Extraction of metals and reduction

| Extraction using carbon | |
|---|---|
| *Metals less reactive than carbon can be extracted from their oxides by reduction.* | For example:<br>zinc oxide + carbon → zinc + carbon dioxide |

Unreactive metals, such as gold, are found in the Earth as the metal itself. They can be mined from the ground.

## Reactivity of metals

| | Reactions with water | Reactions with acid |
|---|---|---|
| **Group 1 metals** | *Reactions get more vigorous as you go down the group* | *Reactions get more vigorous as you go down the group* |
| **Group 2 metals** | *Do not react with water* | *Observable reactions include fizzing and temperature increases* |
| **Zinc, iron and copper** | *Do not react with water* | *Zinc and iron react slowly with acid. Copper does not react with acid.* |

### Metal oxides

| | | |
|---|---|---|
| **Metals and oxygen** | *Metals react with oxygen to form metal oxides* | magnesium + oxygen → magnesium oxide<br>$2Mg + O_2 \rightarrow 2MgO$ |
| **Reduction** | *This is when oxygen is removed from a compound during a reaction* | e.g. metal oxides reacting with hydrogen, extracting low reactivity metals |
| **Oxidation** | *This is when oxygen is gained by a compound during a reaction* | e.g. metals reacting with oxygen, rusting of iron |

### The reactivity series

| | | |
|---|---|---|
| **Metals form positive ions when they react** | *The reactivity of a metal is related to its tendency to form positive ions* | The reactivity series arranges metals in order of their reactivity (their tendency to form positive ions). |
| **Carbon and hydrogen** | *Carbon and hydrogen are non-metals but are included in the reactivity series* | These two non-metals are included in the reactivity series as they can be used to extract some metals from their ores, depending on their reactivity. |
| **Displacement** | *A more reactive metal can displace a less reactive metal from a compound.* | Silver nitrate + Sodium chloride →<br><br>Sodium nitrate + Silver chloride |

most reactive

| | |
|---|---|
| potassium | K |
| sodium | Na |
| calcium | Ca |
| magnesium | Mg |
| aluminium | Al |
| carbon | C |
| zinc | Zn |
| iron | Fe |
| tin | Sn |
| lead | Pb |
| hydrogen | H |
| copper | Cu |
| silver | Ag |
| gold | Au |
| platinum | Pt |

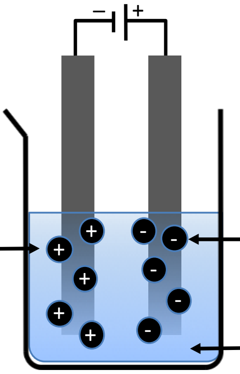
least reactive

PiXL
Partners in excellence

# Trilogy Chemistry Foundation Topic 4 Chemical Changes 2

## Electrolysis

| Process of electrolysis | *Splitting up using electricity* | When an ionic compound is melted or dissolved in water, the ions are free to move. These are then able to conduct electricity and are called electrolytes. Passing an electric current though electrolytes causes the ions to move to the electrodes. |
|---|---|---|
| Electrode | *Anode* *Cathode* | The positive electrode is called the anode. The negative electrode is called the cathode. |
| Where do the ions go? | *Cations* *Anions* | Cations are positive ions and they move to the negative cathode. Anions are negative ions and they move to the positive anode. |




### Electrolysis of aqueous solutions

The ions discharged when an aqueous solution is electrolysed using inert electrodes depend on the relative reactivity of the elements involved.

| At the negative electrode | Metal will be produced on the electrode if it is less reactive than hydrogen. Hydrogen will be produced if the metal is more reactive than hydrogen. |
|---|---|
| At the positive electrode | Oxygen is formed at positive electrode. If you have a halide ion ($Cl^-$, $I^-$, $Br^-$) then you will get chlorine, bromine or iodine formed at that electrode. |

### Extracting metals using electrolysis

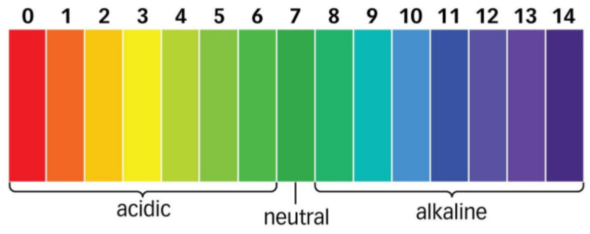
| |
|---|
| *Metals can be extracted from molten compounds using electrolysis.* |
| *This process is used when the metal is too reactive to be extracted by reduction with carbon.* |
| *The process is expensive due to large amounts of energy needed to produce the electrical current. Example: aluminium is extracted in this way.* |
| *Aluminium extraction uses CRYOLITE to lower the melting point of aluminium oxide. Electrodes have to be replaced regularly as they are made of GRAPHITE (CARBON) which react with the oxygen produced.* |

## Reactions of acids

### Soluble salts

| Soluble salts | *Soluble salts can be made from reacting acids with solid insoluble substances (e.g. metals, metal oxides, hydroxides and carbonates).* |
|---|---|
| Production of soluble salts | *Add the solid to the acid until no more dissolves. Filter off excess solid and then crystallise to produce solid salts.* |

### The pH scale and neutralisation




You can use universal indicator or a pH probe to measure the acidity or alkalinity of a solution against the pH scale.

In neutralisation reactions, hydrogen ions react with hydroxide ions to produce water:

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

| Acids | *Acids contain hydrogen ions ($H^+$) in aqueous solutions.* |
|---|---|
| Alkalis | *Aqueous solutions of alkalis contain hydroxide ions ($OH^-$).* |

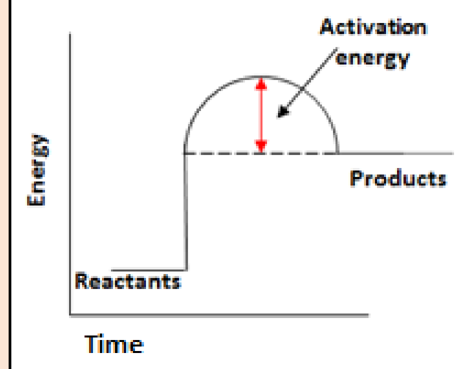
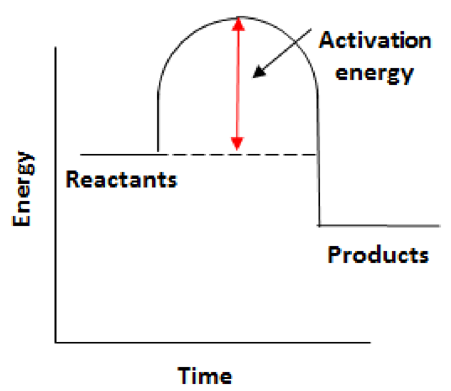
| | | | |
|---|---|---|---|
| Endothermic | *Energy is taken in from the surroundings so the temperature of the surroundings decreases* | • Thermal decomposition<br>• The reaction of citric acid and sodium hydrogencarbonate | • Sports injury packs |
| Exothermic | *Energy is transferred to the surroundings so the temperature of the surroundings increases* | • Combustion<br>• Many oxidation reactions<br>• Neutralisation | • Hand warmers<br>• Self-heating cans |

Types of reaction

## Trilogy Chemistry F Topic 5 Energy changes

Reaction profiles

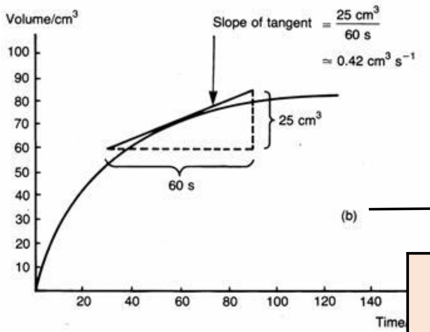
| | | |
|---|---|---|
| Activation energy | *Chemical reactions only happen when particles collide with sufficient energy* | The minimum amount of energy that colliding particles must have in order to react is called the activation energy. |

| | | |
|---|---|---|
| Endothermic |  | Products are at a higher energy level than the reactants. As the reactants form products, energy is transferred from the surroundings to the reaction mixture. The temperature of the surroundings decreases because energy is taken in during the reaction. |
| Exothermic |  | Products are at a lower energy level than the reactants. When the reactants form products, energy is transferred to the surroundings. The temperature of the surroundings increases because energy is released during the reaction. |

# Trilogy Chemistry Topic 6 :The rate and extent of chemical change Foundation

## Rate of reaction

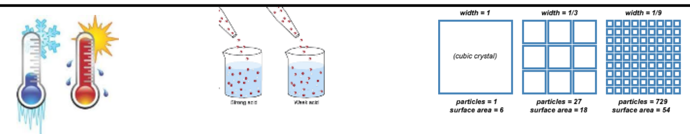
### Calculating rates of reactions




| | | |
|---|---|---|
| Rate of chemical reaction | *This can be calculated by measuring the quantity of reactant used or product formed in a given time.* | Rate = quantity of reactant used / time taken<br>Rate = quantity of product formed / time taken |

### Factors affecting rates

| Factors affecting the rate of reaction | |
|---|---|
| Temperature | *The higher the temperature, the quicker the rate of reaction.* |
| Concentration | *The higher the concentration, the quicker the rate of reaction.* |
| Surface area | *The larger the surface area of a reactant solid, the quicker the rate of reaction.* |
| Pressure (of gases) | *When gases react, the higher the pressure upon them, the quicker the rate of reaction.* |

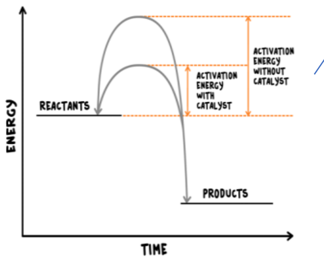


### Collision theory and activation energy

| | | |
|---|---|---|
| Collision theory | *Chemical reactions can only occur when reacting particles collide with each other with sufficient energy.* | Increasing the temperature increases the frequency of collisions and makes the collisions more energetic, therefore increasing the rate of reaction.<br><br>Increasing the concentration, pressure (gases) and surface area (solids) of reactions increases the frequency of collisions, therefore increasing the rate of reaction. |
| Activation energy | *This is the minimum amount of energy colliding particles in a reaction need in order to react.* | |

## Catalysts

| | |
|---|---|
| *Catalyst* | A catalyst changes the rate of a chemical reaction but is not used in the reaction. |
| *Enzymes* | These are biological catalysts. |
| *How do they work?* | Catalysts provide a different reaction pathway WITH A LOWER ACTIVATION ENERGY. |




If a catalyst is used in a reaction, it is not shown in the word equation.

## Reversible reactions and dynamic equilibrium

| | |
|---|---|
| *Reversible reactions* | In some chemical reactions, the products can react again to re-form the reactants. |
| *Representing reversible reactions* | A + B $\rightleftharpoons$ C + D |
| *The direction* | The direction of reversible reactions can be changed by changing conditions:<br>heat<br>A + B $\rightleftharpoons$ C + D<br>cool |

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

$\rightleftharpoons$

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

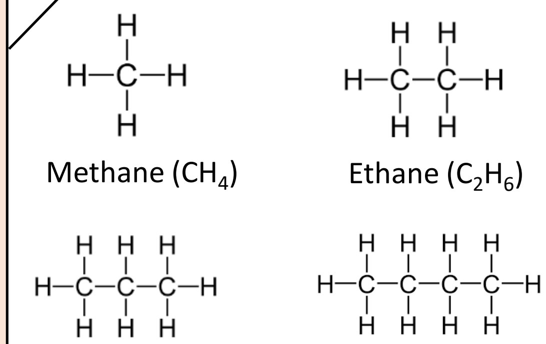
For example:
Hydrated copper sulfate (blue) $\underset{\text{exothermic}}{\overset{\text{endothermic}}{\rightleftharpoons}}$ Anhydrous copper sulfate (white) + Water

# Trilogy Chemistry Organic Chemistry Topic 7

## Crude oil, hydrocarbons and alkanes

| | | |
|---|---|---|
| **Crude oil** | *A finite resource* | Consisting mainly of plankton that was buried in the mud, crude oil is the remains of ancient biomass. |
| **Hydrocarbons** | *These make up the majority of the compounds in crude oil* | Compounds containing hydrogen and carbon atoms only. Most of these hydrocarbons are called alkanes. |
| **General formula for alkanes** | *$C_nH_{2n+2}$* | For example: $C_2H_6$ $C_6H_{14}$ |

Display formula for first four alkanes



Methane ($CH_4$) Ethane ($C_2H_6$) Propane ($C_3H_8$) Butane ($C_4H_{10}$)

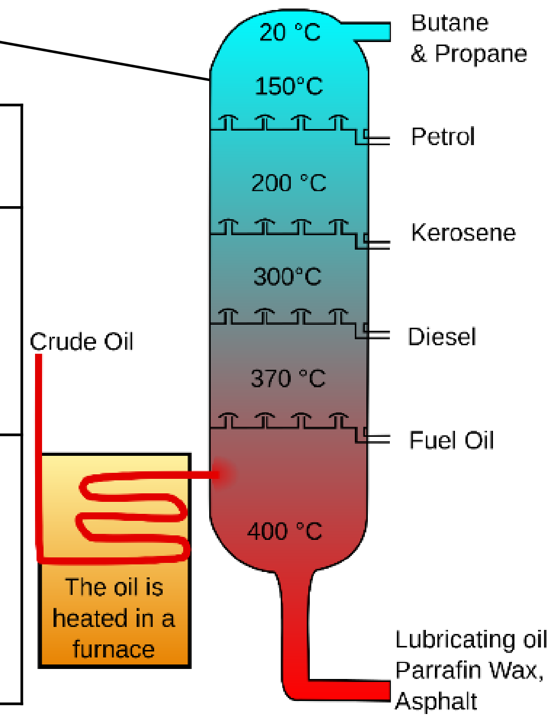
## Carbon compounds as fuels and feedstock

## Fractional distillation and petrochemicals

| | | |
|---|---|---|
| **Fractions** | *The hydrocarbons in crude oil can be split into fractions* | Each fraction contains molecules with a similar number of carbon atoms in them. The process used to do this is called fractional distillation. |
| **Using fractions** | *Fractions can be processed to produce fuels and feedstock for petrochemical industry* | We depend on many of these fuels; petrol, diesel and kerosene. Many useful materials are made by the petrochemical industry; solvents, lubricants and polymers. |

| Hydrocarbon chains | | |
|---|---|---|
| | *In oil* | Hydrocarbon chains in crude oil come in lots of different lengths. |
| | *Boiling points* | The boiling point of the chain depends on its length. During fractional distillation, they boil and separate at different temperatures due to this. |

During fractional distillation, the crude oil is heated until it *evaporates*. The vapours rise up the tower, where fractions *condense* at their different boiling points. The long chains condense at the bottom of the column, the shorter chains condense near the top.




## Carbon compounds as fuels and feedstock

## Cracking and alkenes

| | |
|---|---|
| **Alkanes to alkenes** | *Long chain alkanes are cracked into short chain alkenes.* |
| **Alkenes** | *Alkenes are hydrocarbons with a double bond (some are formed during the cracking process).* |
| **Properties of alkenes** | *Alkenes are more reactive that alkanes and react with bromine water. Bromine water changes from orange to colourless in the presence of alkenes.* |

| | | |
|---|---|---|
| **Cracking** | *The breaking down of long chain hydrocarbons into smaller chains* | The smaller chains are more useful. Cracking can be done by various methods including catalytic cracking and steam cracking. |
| **Catalytic cracking** | *The heavy fraction is heated until vaporised* | After vaporisation, the vapour is passed over a hot catalyst forming smaller, more useful hydrocarbons. |
| **Steam cracking** | *The heavy fraction is heated until vaporised* | After vaporisation, the vapour is mixed with steam and heated to a very high temperature forming smaller, more useful hydrocarbons. |

**Cracking general equation:**

Long chain alkane → shorter chain alkane + alkene

E.g. Decane → hexane + butene

$C_{10}H_{22}$ → $C_6H_{14}$ + $C_4H_8$

| | |
|---|---|
| **Alkenes and uses as polymers** | *Used to produce polymers. They are also used as the starting materials of many other chemicals, such as alcohol, plastics and detergents.* |
| **Why do we crack long chains?** | *Without cracking, many of the long hydrocarbons would be wasted as there is not much demand for these as for the shorter chains.* |

## Properties of hydrocarbons

| | |
|---|---|
| **Combustion** | During the complete combustion of hydrocarbons, the carbon and hydrogen in the fuels are oxidised, releasing carbon dioxide, water and energy. |

**Example: complete combustion of methane:**

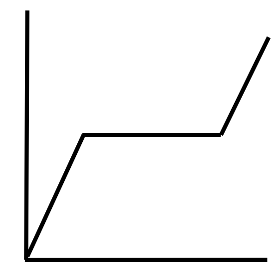
Methane + oxygen → carbon dioxide + water

$CH_4$ (g) + $2O_2$ (g) → $CO_2$ (g) + 2 $H_2O$ (l)

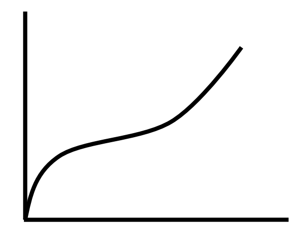
| | |
|---|---|
| **Boiling point (temperature at which liquid boils)** | *As the hydrocarbon chain length increases, boiling point increases.* |
| **Viscosity (how easily it flows)** | *As the hydrocarbon chain length increases, viscosity increases.* |
| **Flammability (how easily it burns)** | *As the hydrocarbon chain length increases, flammability decreases.* |

PiXL
Partners in

| | | |
|---|---|---|
| **Pure substances** | *A pure substance is a single element or compound, not mixed with any other substance.* | Pure substances melt and boil at specific temperatures. Heating graphs can be used to distinguish pure substances from impure. |



***Melting point of a pure substance – melt and boil at fixed temperatures***



***Melting point of an impure substance – do not have a fixed melting or boiling point***

# Pure substances

# Topic 8 Chemical Analysis

## Formulations

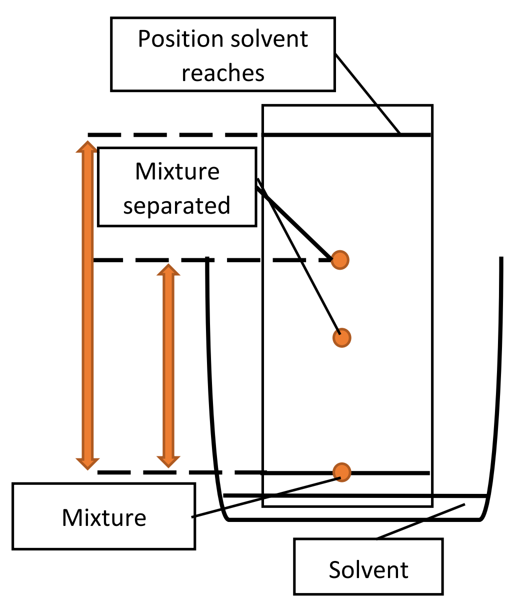
| | |
|---|---|
| **Formulation** | *A formulation is a mixture that has been designed as a useful product.* |
| **How are formulations made?** | *By mixing chemicals that have a particular purpose in careful quantities.* |
| **Examples of formulations.** | *Fuels, cleaning agents, paints, medicines and fertilisers.* |

## Identification of common gases

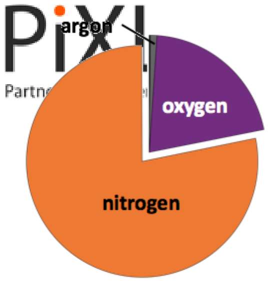
| Gas | Test | Positive result |
|---|---|---|
| **Hydrogen** | *Burning splint* | 'Pop' sound. |
| **Oxygen** | *Glowing splint* | Re-lights the splint. |
| **Chlorine** | *Litmus paper (damp)* | Bleaches the paper white. |
| **Carbon dioxide** | *Limewater* | Goes cloudy (as a solid calcium carbonate forms). |

## Chromatography

| | | |
|---|---|---|
| **Chromatography** | *Can be used to separate mixtures and help identify substances.* | Involves a mobile phase (e.g. water or ethanol) and a stationary phase (e.g. chromatography paper). |
| **$R_f$ Values** | *The ratio of the distance moved by a compound to the distance moved by solvent.* | $R_f = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}$ |
| **Pure substances** | *The compounds in a mixture separate into different spots.* | This depends on the solvent used. A pure substance will produce a single spot in all solvents whereas an impure substance will produce multiple spots. |



# AQA GCSE Chemistry of the atmosphere Topic 9




## Composition and evolution of the atmosphere

### Proportions of gases in the atmosphere

| Gas | *Percentage* |
|---|---|
| Nitrogen | *~80%* |
| Oxygen | *~20%* |
| Argon | *0.93%* |
| Carbon dioxide | *0.04%* |

### How oxygen increased

| | | |
|---|---|---|
| **Algae and plants** | *These produced the oxygen that is now in the atmosphere, through photosynthesis.* | carbon dioxide + water → glucose + oxygen<br>$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ |
| **Oxygen in the atmosphere** | *First produced by algae 2.7 billion years ago.* | Over the next billion years plants evolved to gradually produce more oxygen. This gradually increased to a level that enabled animals to evolve. |

### The Earth's early atmosphere

| | | |
|---|---|---|
| **Volcano activity 1st Billion years** | *Billions of years ago there was intense volcanic activity* | This released gases (mainly $CO_2$) that formed to early atmosphere and water vapour that condensed to form the oceans. |
| **Other gases** | *Released from volcanic eruptions* | Nitrogen was also released, gradually building up in the atmosphere. Small proportions of ammonia and methane also produced. |
| **Reducing carbon dioxide in atm[illegible]** | *When the oceans formed, carbon [illegible] it* | This formed carbonate precipitates, forming sediments. This reduced the levels [illegible] in [illegible] atmosphere. |

### How carbon dioxide decreased

| | | |
|---|---|---|
| **Reducing carbon dioxide in the atmosphere** | *Algae and plants* | These gradually reduced the carbon dioxide levels in the atmosphere by absorbing it for photosynthesis. |
| **Formation of sedimentary rocks and fossil fuels** | *These are made out of the remains of biological matter, formed over millions of years* | Remains of biomass which fell to the bottom of oceans. Over millions of years layers of sediment settled on top of them and the huge pressures turned them into coal, oil, natural gas and sedimentary rocks. The sedimentary rocks contains "locked up" carbon dioxide from the biological matter. |

## $CO_2$ and methane as greenhouse gases

### Greenhouse gases

| | |
|---|---|
| **Carbon dioxide, water vapour and methane** | *Examples of greenhouse gases that maintain temperatures on Earth in order to support life* |
| **The greenhouse effect** | *Radiation from the Sun enters the Earth's atmosphere and reflects off of the Earth. Some of this radiation is re-radiated back by the atmosphere to the Earth, warming up the global temperature* |

### Human activities and greenhouse gases

| | |
|---|---|
| **Carbon dioxide** | *Human activities that increase carbon dioxide levels include burning fossil fuels and deforestation.* |
| **Methane** | *Human activities that increase methane levels include raising livestock (for food) and using landfills (the decay of organic matter released methane).* |
| **Climate change** | *There is evidence to suggest that human activities will cause the Earth's atmospheric temperature to increase and cause climate change.* |

### Global climate change

#### Carbon footprints

The total amount of greenhouse gases emitted over the full life cycle of a product/event. This can be reduced by reducing emissions of carbon dioxide and methane.

| Effects of climate change |
|---|
| Rising sea levels |
| Extreme weather events such as severe storms |
| Change in amount and distribution of rainfall |
| Changes to distribution of wildlife species with some becoming extinct |

## Common atmospheric pollutants

### Atmospheric pollutants from fuels / Properties and effects of atmospheric pollutants

| | | |
|---|---|---|
| **carbon monoxide** | incomplete combustion | *Toxic, colourless and odourless gas. Not easily detected, can kill.* |
| **sulfur dioxide** | sulfur impurities in fuel | *Cause respiratory problems in humans and acid rain which affects the environment.* |
| **oxides of nitrogen** | nitrogen and oxygen in the air react at high temperatures in the engine | *Cause respiratory problems in humans and acid rain which affects the environment.* |
| **carbon dioxide** | complete combustion | *Global warming* |
| **particulates (of carbon)** | incomplete combustion | *Cause global dimming and health problems in humans.* |

# Trilogy Chemistry F Topic 10Using resources

## Using the Earth's resources and obtaining potable water

### Using the Earth's resources and sustainable development

| | | |
|---|---|---|
| Earth's resources | *Used to provide warmth, shelter, food and transport for humans* | Natural resources and resources from agriculture provide: timber, food, clothing and fuels. |
| | | Finite resources from the Earth, oceans and atmosphere are processed to provide energy and materials. |
| Chemistry and resources | *Research and techniques improve agricultural and industrial processes* | These improvements provide new products and improve sustainability. |
| Plastics | *Normally made using ethene from crude oil* | However, the raw material ethene can also be obtained from ethanol, which can be produced during fermentation. Industries are now starting to use a renewable crop for this process. |

### Potable water

Sterilising agents include chlorine, ozone and UV light.

| | | |
|---|---|---|
| Potable water | *Water of an appropriate quality is essential for life and contains low levels of dissolved compounds so it is safe to drink.* | Human drinking water should have low levels of dissolved salts and microbes. This is called potable water. |
| UK water | *Rain provides water with low levels of dissolved substances* | This water collects in the ground/lakes/rivers. To make potable water an appropriate source is chosen, which is then passed through filter beds and then sterilised. |
| Desalination | *Needs to occur is fresh water is limited and salty/sea water is needed for drinking* | This can be achieved by distillation or by using large membranes e.g. reverse osmosis. These processes require large amounts of energy. |

### Waste water treatment

| | | |
|---|---|---|
| Waste water | *Produced from urban lifestyles and industrial processes* | These require treatment before used in the environment. Sewage needs the organic matter and harmful microbes removed. |
| Sewage treatment | *Includes many stages* | - Screening and grit removal<br>- Sedimentation to produce sludge and effluent (liquid waste or sewage).<br>- Anaerobic digestion of sludge<br>- Aerobic biological treatment of effluent. |

## Life cycle assessment and recycling

### Life cycle assessment

| | | |
|---|---|---|
| LCAS | *Life cycle assessments are carried out to assess the environmental impact of products* | They are assessed at these stages:<br>- Extraction and processing raw materials<br>- Manufacturing and packaging<br>- Use and operation during lifetime<br>- Disposal |
| Values | *Allocating numerical values to pollutant effects is difficult* | Value judgments are allocated to the effects of pollutants so LCA is not a purely objective process. |

### Ways of reducing the use of resources

| | | |
|---|---|---|
| Reduce, reuse and recycle | *This strategy reduces the use of limited resources* | This, therefore, reduces energy sources being used, reduces waste (landfill) and reduces environmental impacts. |
| Limited raw materials | *Used for metals, glass, building materials, plastics and clay ceramics* | Most of the energy required for these processes comes from limited resources. Obtaining raw materials from the Earth by quarrying and mining causes environmental impacts. |
| Reusing and recycling | *Metals can be recycled by melting and recasting/reforming* | Glass bottles can be reused. They are crushed and melted to make different glass products. Products that cannot be reused are recycled. |