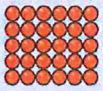
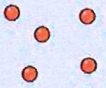
Foundations of chemistry

Threshold Concept

All matter is made of particles

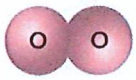
States of matter:

State	Solid	Liquid	Gas
Closeness of particles	Very close	Close	Far apart
Arrangement of particles	Regular pattern	Randomly arranged	Randomly arranged
Movement of particles	Vibrate around a fixed position	Move around each other	Move quickly in all directions
Energy of particles	Low energy	Greater energy	Highest energy
2D diagram			

Atoms and compounds:

Elements contain just **one type of atom.**

Oxygen (O_2)



Compounds contain **different types of atom** bonded together.

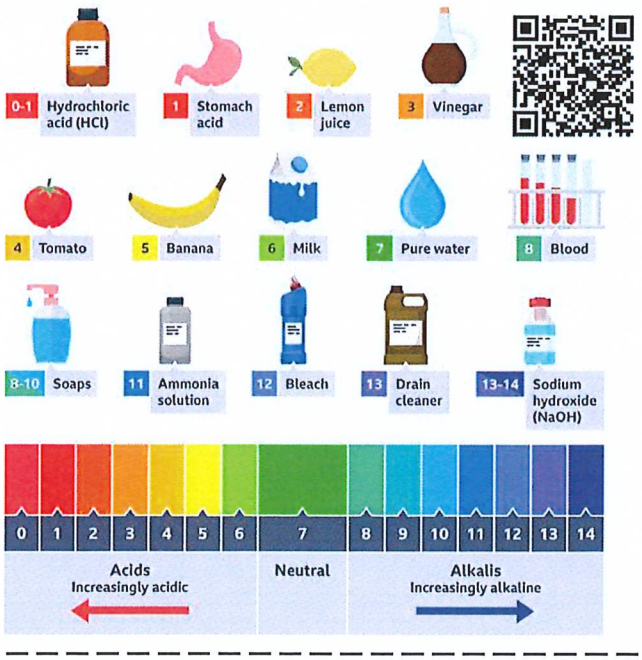
Carbon dioxide (CO_2)

Pure substances:

Pure substances are made from only one chemical element or one compound.

For example, salt is a pure substance made only of sodium chloride.

The pH scale:

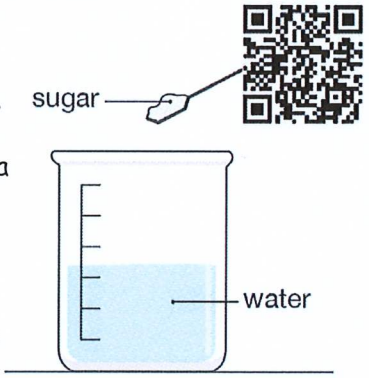


Keywords

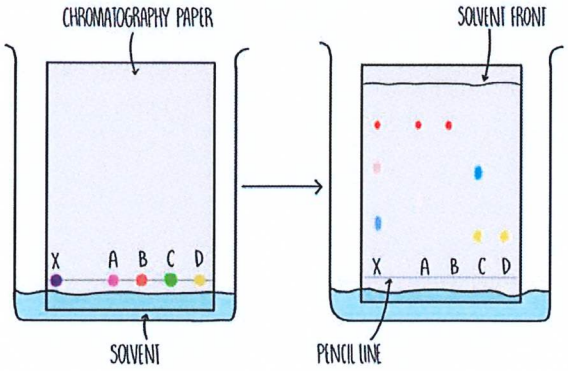
- **Particles:** The tiny things that all materials are made from. The smallest unit of matter.
- **Atom:** Atoms are the building blocks of all matter. Everything is made of atoms - even yourself. They are the smallest particle of an element, which are far too small to see.
- **Solid:** Have a fixed shape and cannot flow, because their particles cannot move from place to place, cannot be compressed (squashed), because their particles are close together and have no space to move into.
- **Liquid:** Flow and take the shape of their container, because their particles can move around each other, cannot be compressed, because their particles are close together and have no space to move into
- **Gas:** Flow and completely fill their container, because their particles can move quickly in all directions, can be compressed, because their particles are far apart and have space to move into

Solubility:

- Some solids dissolve in water to make a solution.
- These solids are soluble.
- A solution is made from a solute (usually a solid) and a solvent (liquid).
- Some gases, such as oxygen and carbon dioxide, can also dissolve in water.



Required practical: Chromatography



Equations for this topic:

$$R_f \text{ value} = \frac{\text{distance travelled by substance } (B)}{\text{distance travelled by solvent } (A)}$$

Periodic Table

Threshold Concept

All elements fit within the Periodic Table

Link to information on most of the topic, consisting of slides, videos, and quizzes

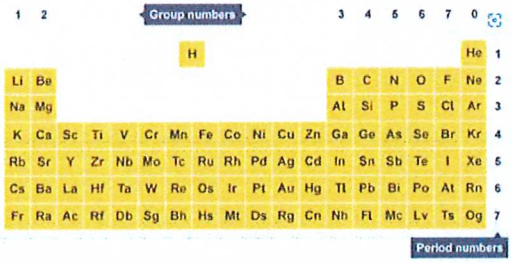
Keywords

Elements - a substance that cannot be broken down into any other substance.
Periodic Table - a table showing every element that is known to exist.
Symbol - a sign/letter/character that is used to represent something

Periodic Table & Developing the Periodic Table

Task 1 & 2

Mendeleev redesigned Newlands periodic table by organising the periodic table by atomic weights and the properties of the elements. Some gaps were left based on his predictions of other elements that hadn't been discovered yet.
As more elements were found, the modern periodic table took from organised by atomic number.



RAM & Isotopes

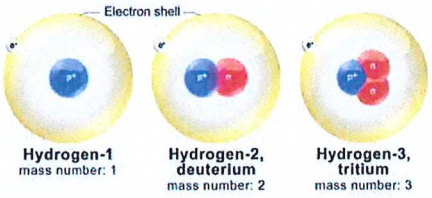
Task 10

RAM

Isotopes

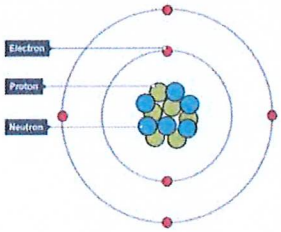
Atoms of the same element must have the same number of protons, but they can have different numbers of neutrons. Atoms of the same element with different numbers of neutrons are called isotopes. Isotopes of an element have:

- the same atomic number
- different mass numbers



Atomic Structure

Task 8



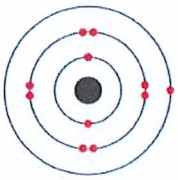
Subatomic particle	Relative mass	Relative charge
Proton	1	+1
Neutron	1	0
Electron	Very small	-1

Electronic Configuration

Task 9

Example, using an atom of sodium

No. of electrons per shell
1st shell: up to 2
2nd shell: up to 8
3rd shell: up to 8
etc



Group 1 - Alkali Metals

Task 4

1

Li
Na
K
Rb
Cs
Fr

All share similar properties:
- Are soft (can be cut)
- Have relatively low MP
- Have low densities

The further down the group you go, the more reactive the elements become.
- They will react will air and tarnish quite quickly.
- They will react with water to produce an alkaline solution (hence the name) and turn universal indicator blue/purple

Group 7 - Halogens

Task 5

7

F
Cl
Br
I
At
Ts

All have 7 electrons in outer shell.
All diatomic (made up of two atoms bonded together.

The further down the group you go, the less reactive the elements become.
The further down the group you go, the higher its MP and BP, because:
- Molecules become larger
- Intermolecular forces become stronger
- More energy is needed to overcome these forces

Group 0 - Noble Gases

Task 3

0

He
Ne
Ar
Kr
Xe
Rn
Og

All have full outer shells.
All unreactive (inert).

All have low boiling points. Lower down the group, the higher it gets.
This is because, going down the group:
- Atoms become larger
- Intermolecular forces between atoms become stronger
- More energy is needed to overcome these forces

Metals

Threshold Concept

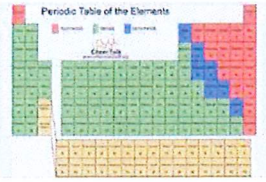
Identify most metals have similar properties

Keywords

Metal..... DEFINITION
Non metal ..... DEFINITION
Property ..... a characteristic of a particular substance
Reaction ..... a process that leads to the change of one set of chemical substances into another
Alloy ..... a mixture of two or more metals, or a metal and a non-metal
Displacement ..... A more reactive metal will displace a less reactive metal from its compound.

Metals and non metals

Most elements on the periodic table are metals. They are grouped together in the middle to the left-hand side of the periodic table.
Non metals are on the right-hand side.

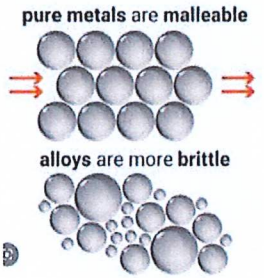


Physical properties of metals

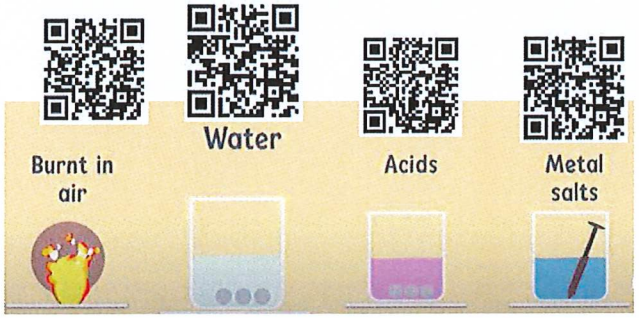
Properties	Metals	Non-metals
Appearance	Shiny	Dull
Hardness	Very hard or hard	Brittle
Malleability	Malleable	Non-malleable
Ductility	Ductile	Non-ductile
Heat conduction	Good conductor	Bad conductor
Conduction of electricity	Good conductor	Bad conductor
State	Solid	Solids, liquid, gases
Density	Higher	Lower

Metals and alloys

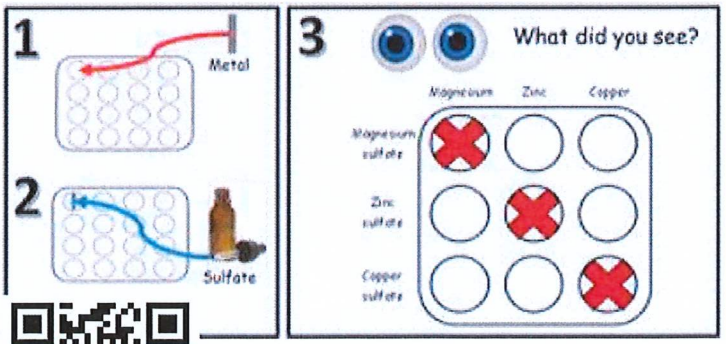
Making alloys changes the metals properties by changing its structure. Alloying is done for many reasons, typically to increase strength, increase corrosion resistance, or reduce costs



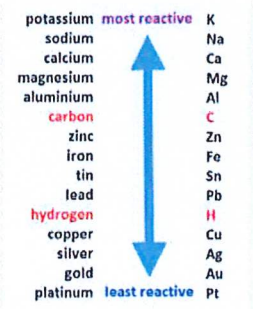
Chemical properties of metals



Practical - Displacement reactions



The reactivity series



The Reactivity Series lists metals in order how easily they react with other substances

Equations for this topic

Metal + acid → salt + hydrogen
Metal + oxygen → Metal oxide
Metal + water → Metal hydroxide + hydrogen

Rock Cycle

Threshold Concept

Understand that rocks change within 3 types over time.

Keywords

- **Rock:** The solid mineral material forming part of the surface of the earth and other similar planets, exposed on the surface or underlying the soil.

- **Earth:** The planet on which we live; the world.

- **Cycle:** Move in or follow a regularly repeated sequence of events.

- **Temperature:** The degree or intensity of heat present in a substance or object.

- **Pressure:** Continuous physical force exerted on or against an object by something in contact with it.

Types of rocks

Sedimentary rocks

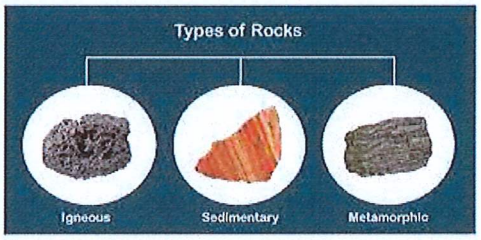
Sedimentary rocks are formed from sediments that have settled at the bottom of a lake, sea or ocean, and have been compressed over millions of years.

Metamorphic rocks

Metamorphic rocks are formed from other rocks which change due to **heat** or **pressure**.

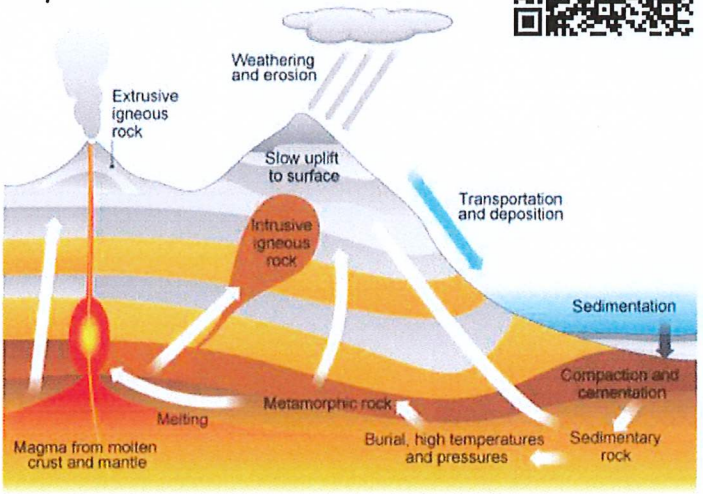
Igneous rocks

Igneous rocks are formed from molten (liquid) rock that has cooled and solidified.



The rock cycle

Rocks on earth do not always stay the same.



Rocks are continually changing due to processes such as, weathering, erosion and large earth movements. The rocks are gradually recycled over millions of years, changing between the different rock types.

Types of weathering

1. Biological weathering

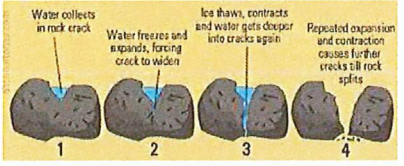
This describes rocks being broken up by the roots of plants, or animals burrowing into them.

2. Chemical weathering

This describes rocks being broken up because substances in rainwater, rivers and seawater or the air, react with the in the rocks.

3. Physical weathering

This describes rocks being broken up by changes in temperature, freezing and thawing of trapped water or the action of waves and rivers.



Required practical

Equations for this topic

Chemistry of the atmosphere

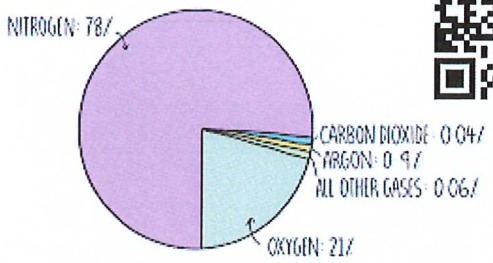
Threshold Concept

The Earth's atmosphere is made of different gases.

Keywords

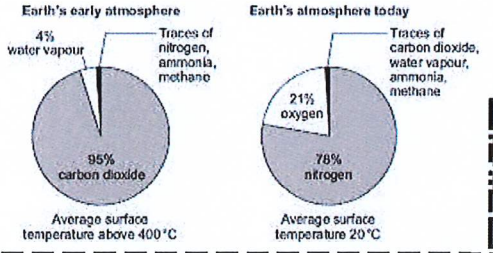
- **Atmosphere**: An atmosphere is the layers of gases surrounding a planet.
- **Pollutants**: A pollutant is a chemical. or biological substance which harms water, air, or land quality.
- **Climate change**: Climate change refers to long-term shifts in temperatures and weather patterns.
- **Combustion**: Combustion is another name for burning. In a combustion reaction, fuel is burned and reacts with oxygen to release energy.
- **Global Warming**: Global warming is the long-term warming of the planet's overall temperature.

The Proportion of gases in the earths atmosphere



History of the earths atmosphere

- The proportion of oxygen increased because of **photosynthesis** by plants and algae.
- The proportion of ammonia decreased as it reacted with the newly formed oxygen in the atmosphere to form nitrogen and water vapour.
- The proportion of methane decreased as it reacted with the newly formed oxygen to form carbon dioxide and water.

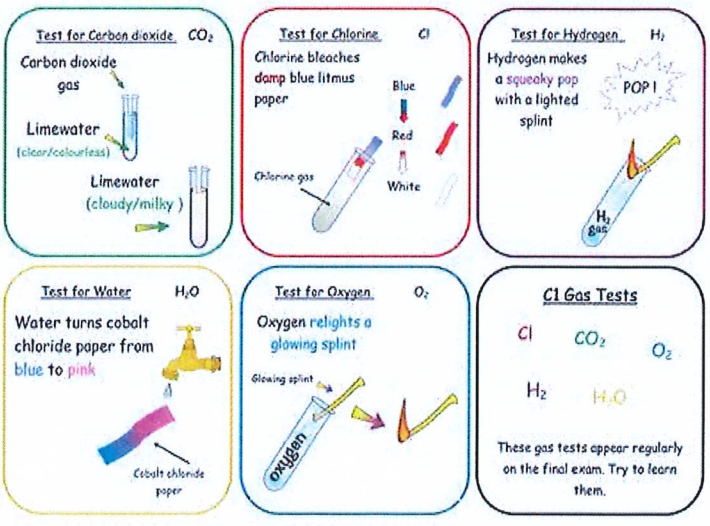


Greenhouse gases

Greenhouse gases present in the atmosphere include:

- water vapour
- carbon dioxide
- methane

Required practical — Testing for gases



Combustion

Complete combustion:

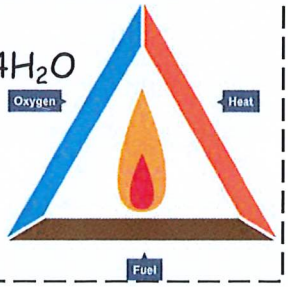
Propane + oxygen → carbon dioxide + water

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

Incomplete combustion:

Propane + oxygen → carbon monoxide + carbon + water

$C_3H_8 + 3O_2 \rightarrow 2CO + C + 4H_2O$



Equations for this topic

Bonding Part 1

Threshold Concept

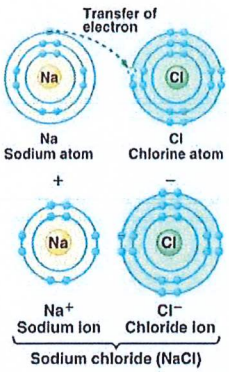
How do 100 elements make up everything in the universe?

Keywords

Electron - a subatomic particle with a negative charge
Electrostatic attraction - strong attraction between oppositely charged ions
Weak intermolecular forces - force of attraction between atoms, elements and molecules
Delocalised electron - free moving electron that isn't a part of any atom
Ion – a charged particle

Forming ions

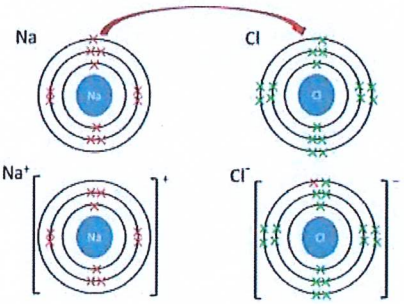
An ion is an charged particle.
Atoms will lose or gain electrons to get a full outer shell.
The **metal** atom **loses electrons** to become a **positive** ion
The **non-metal** atom **gains electrons** to become a **negative** ion.



Use task 3-5

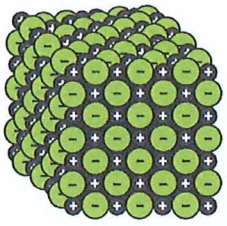
Ionic bonds

Ionic bonds are formed between metals and non-metals. Metals **lose** electrons and **non-metals** gain electrons. The oppositely charged ions attract one another forming an ionic bond.



Ionic compounds and properties

Positive and negative ions join together to form a giant ionic lattice



electrostatic attraction is strong

↓

Ionic compounds have a high M.P

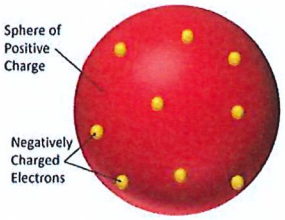
↓

Lots of energy needed to overcome attraction

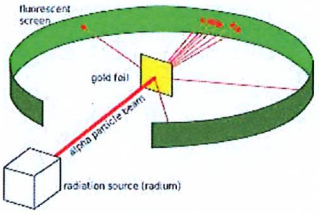
Ionic compounds <u>don't</u> conduct when <u>solid</u> because the ions are locked in position. When molten or dissolved the ions are free to move and can conduct

History of the atom

JJ Thomson – Suggested the <u>plum pudding model</u>. Atoms were a ball of positive charge with negative particles scattered within.



Ernest Rutherford – Alpha scattering experiment. Found that atoms has a very small, positive nucleus and the majority of atoms are empty space.



Bonding Part 2

Threshold Concept

How do 100 elements make up everything in the universe?

Keywords

Electron - a subatomic particle with a negative charge

Electrostatic attraction - strong attraction between oppositely charged ions

Weak intermolecular forces - force of attraction between atoms, elements and molecules

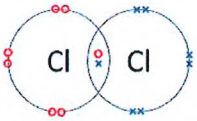
Delocalised electron - free moving electron that isn't a part of any atom

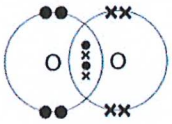
Ion – a charged particle

Covalent bonds

Two non-metals will form a covalent bond. The atoms share electrons to make themselves stable.

Cl — Cl





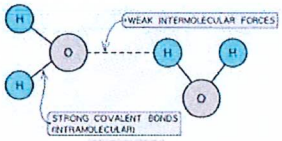
O═O

- 1 shared pair = a single bond
- 2 shared pairs = a double bond
- 3 shared pairs = a triple bond

Simple Covalent compounds

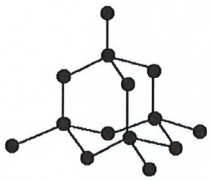
Simple covalent compounds have strong covalent bonds between atoms and weak intermolecular forces between molecules.

Properties – low m.p and b.p
- cannot conduct electricity

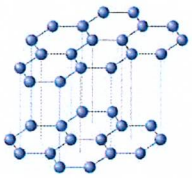


Giant Covalent Structures

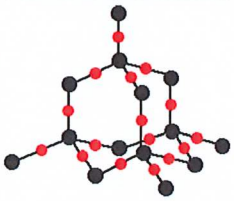
Diamond



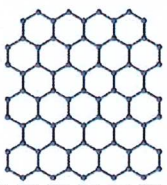
Graphite



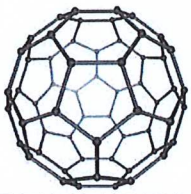
Silicon dioxide



Graphene

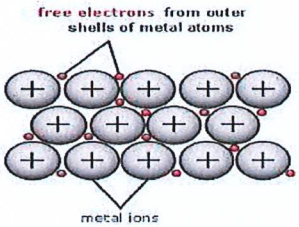


Fullerenes



Metallic bonding

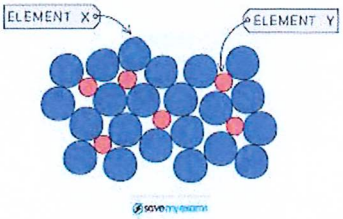
Metals consist of a giant metallic structure. They are positive metal ions surrounded by a sea of delocalised electrons



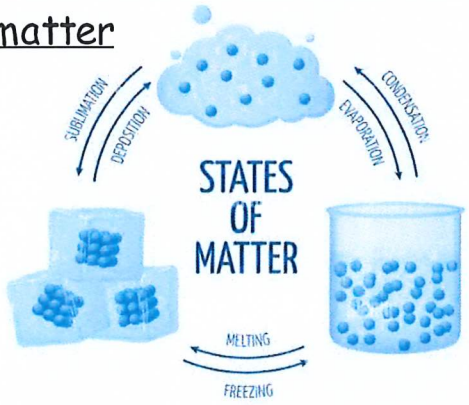
Alloys

Alloys are a mixture of metals and another element.

Alloys are stronger than metals as the different sized atoms distort the layers



States of matter



Quantitative chemistry

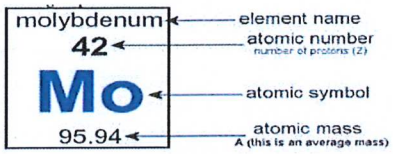
Threshold Concept

To understand that total mass of reactants equals total mass of products

Keywords

Conservation - the mass of the reactants must equal the mass of the products in a chemical reaction
Formula mass - the combined mass numbers of an element or compound
Concentration - the amount of substance dissolved in a solution
Equation - symbol representation of a chemical reaction
Loss - the process of losing something
Gain - the process of gaining something

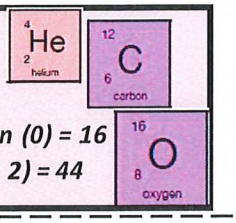
RFM



RAM is atomic mass of an element

RFM is the combination of all elements **Ar** in a compound or Molecule

Work example
Helium (He) Ar = 4
Carbon dioxide = CO_2
Carbon (C) = 12 Oxygen (0) = 16
Mr of CO_2 = 12 + (16 x 2) = 44



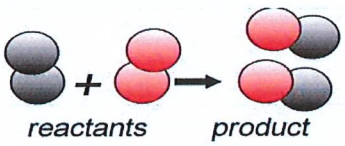
Balancing Equations

As the same number of elements are at the start and the end of reactions. The Equation needs to be balanced.

$Mg + O_2 \rightarrow MgO$ **(Unbalanced)**

2$Mg + O_2 \rightarrow$ **2**MgO **(Balanced)**

Conservation of Mass



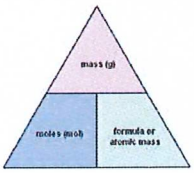
The reactants mass must always equal the mass of the products

2g + 2g —> 4g

We can not destroy atoms.

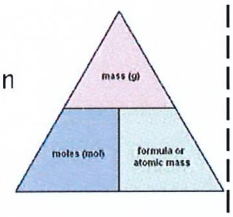
Moles

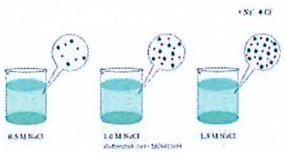
Chemical amounts are measured in moles. One mole of a substance contains **6.02×10^{23} particles (Avagadro's number)**



Concentration

Concentration is the amount of substance in a certain volume of solution (g/dm3)





Percentage by mass

The amount of an element in a compound is called its percentage composition. It can be calculated using the mass of the given element in the compound and the **RFM** of the Compound.

$$\text{Mass \%} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100\%$$

Limiting reactions

The reactant that gets used up first in a reaction is called the limiting reactant. This reactant is not in EXCESS

Reacting masses

The mass of a product or reactant can be determined from having a balanced symbol equation. Once balanced, the equation tells you how many moles of each substance react with each other : Mg + **2**HCl —> **$MgCl_2$ + H_2** **(Balanced)**

This equation states that: 1 : Mg 2 : HCl to form 1 : $MgCl_2$ 1 : H_2

Using the formula and moles you can use this information to work out how much product you will make

Chemical analysis

Threshold Concept

How do we identify a substance?

Keywords

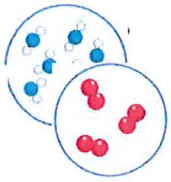
Pure – a substance made from just one element of compound

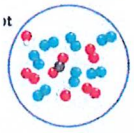
Impure – a substance made from more than one element or compound

Analyse – to find the chemical composition of a substance

Sample – a portion of a substance taken from a larger amount

Pure and impure



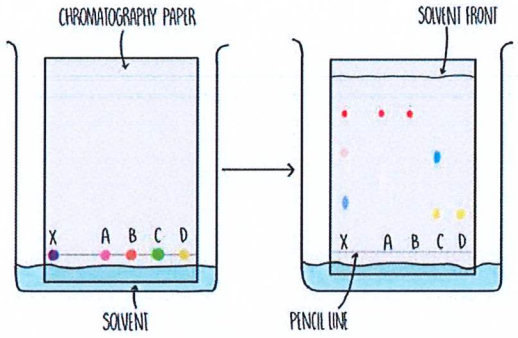


Pure substances are made up of just one type of element or compound. They will have one set melting or boiling point.

Impure substances are a mixture of elements or compounds and have a range of melting/boiling points.

Chromatography required practical

Chromatography is a method used to separate the substances in a mixtures.



Stationary phase – where the molecules can't move (chromatography paper)

Mobile phase – where the molecules can move (the solvent)

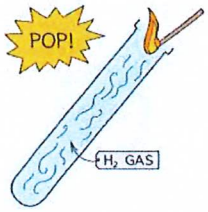
Formulations

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

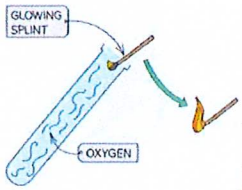
- Fuels
- Cleaning products
- Paints

Test for gases

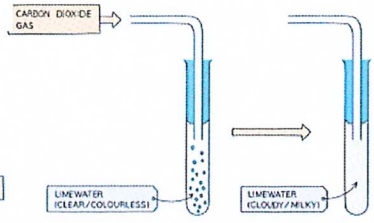
Test for Hydrogen



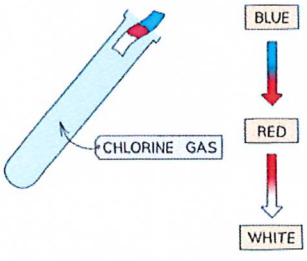
Test for Oxygen



Test for Carbon Dioxide

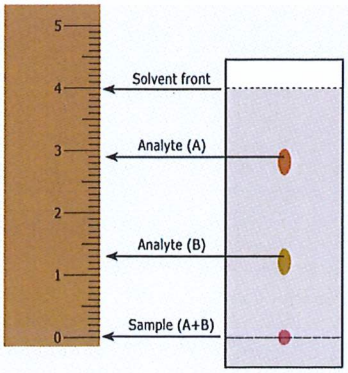


Test for Chlorine



Rf Value

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



Chemical analysis Triple

Threshold Concept

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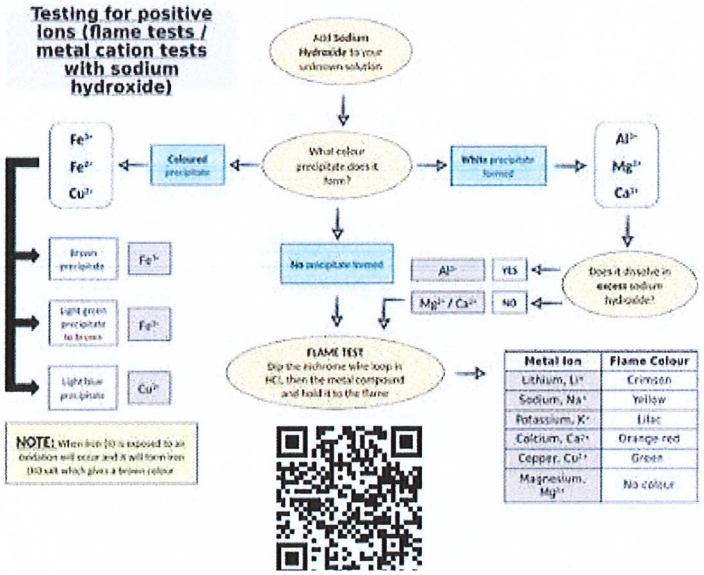
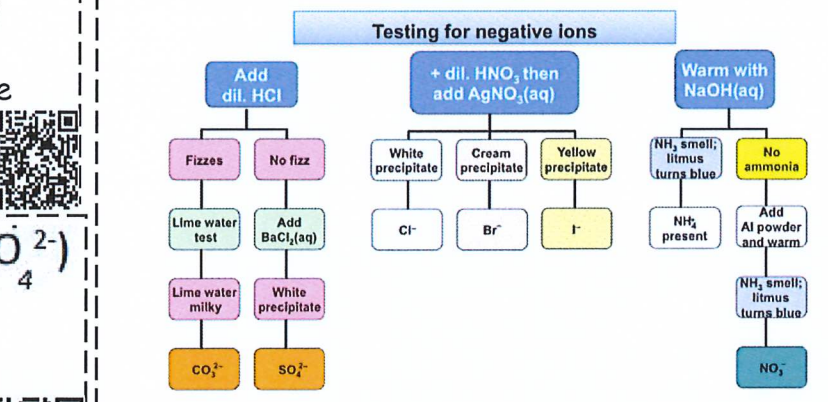
Testing for metal ions

Metal ions will form coloured precipitates when they react with sodium hydroxide.

Metal Cation	Effect of adding NaOH
Aluminium (Al^{3+})	White precipitate, dissolves in excess NaOH to form a colourless solution
Magnesium (Mg^{2+})	White precipitate, incoluble so remains in excess NaOH
Calcium (Ca^{2+})	White precipitate, insoluble so remains in excess NaOH
Copper (II) (Cu^{2+})	Light blue precipitate, insoluble in excess
Iron (II) (Fe^{2+})	Green precipitate, insoluble in excess
Iron (III) (Fe^{3+})	Red–brown precipitate, insoluble in excess

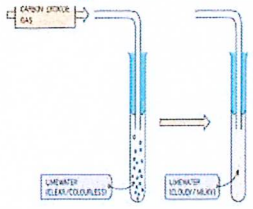
Identifying ions required practical





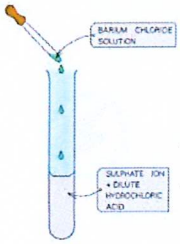
Testing for carbonate ions CO_3^{2-}

$K_2CO_3 + 2HCl \rightarrow 2KCl + CO_2 + H_2O$



- Metal carbonate and hydrochloric acid
- Forms Carbon dioxide
- Turns lime water cloudy

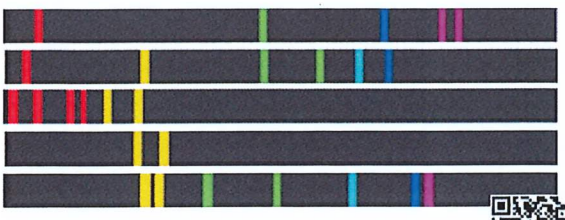
Testing for Sulphate ions (SO_4^{2-})



$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$

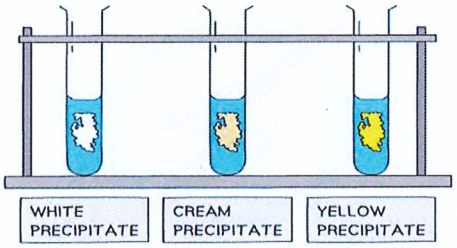
- Add barium chloride
- White precipitate formed

Flame emission spectroscopy



An instrumental technique used to identify metal ions.

Testing for Halide ions (Cl^-, Br^-, I^-)



$Ag^+ + Cl^- \rightarrow AgCl$

- Add nitric acid
- Add a few drops of silver nitrate
- Chloride forms a white precipitate
- Bromide forms a cream precipitate
- Iodide forms a yellow precipitate