OCR (A) Physics GCSE

Topic P1: Matter

Summary Notes

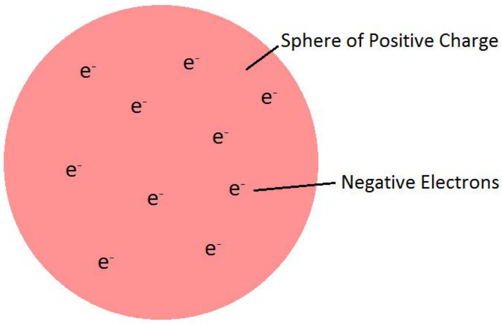
(Content in bold is for Higher Tier only)

P1.1 The Particle Model

How & Why the Atomic Model Has Changed Over Time

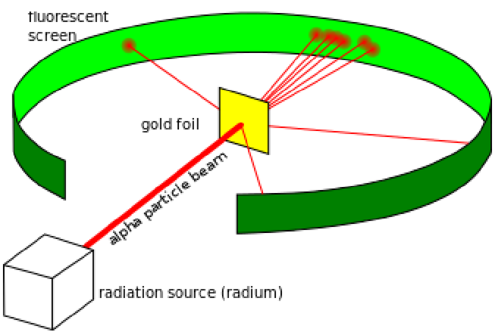
1800 - **Dalton** said everything was made of tiny spheres called **atoms**, that could not be divided

1897 - **JJ Thomson** discovered the **electron** and The Plum Pudding Model was hypothesised:



The overall charge of an **atom is neutral**, so the negative electrons were dispersed through the positive "pudding" to cancel out the charges.

1911 - **Rutherford** realised most of the atom was empty space and The **Gold Foil Experiment** was carried out by **Geiger and Marsden.**



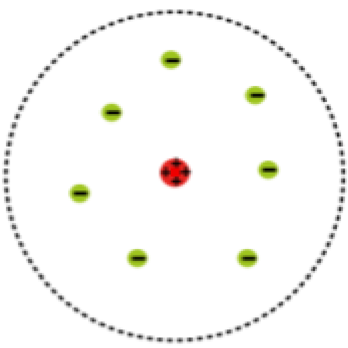
Kurzon, CC BY-SA 3.0

Most particles went straight through suggesting most of an atom is empty space.

Some particles were slightly deflected suggesting the nucleus must be positive, repelling other positive charges.

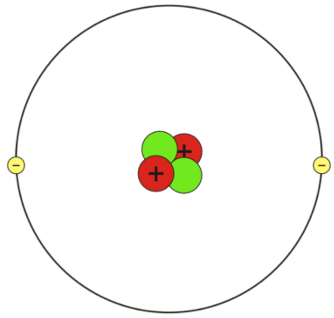
A few particles were deflected by >90° suggesting the nucleus contained most of the mass of the atom.

1913 - **Rutherford Model**



A positive nucleus at the centre of the atom, and negative electrons existing in a cloud around the nucleus

1913 – **Bohr** produced the final model of the atom



If Rutherford was right, the electrons in the cloud close to the nucleus would get attracted and cause the atom to collapse. So instead the electrons are said to exist in fixed 'orbitals'.

https://commons.wikimedia.org/wiki/Category:Bohr_model

The Structure & Size of the Atom

An atom consists of a positively charged **nucleus** containing **protons** and **neutrons**, surrounded by negatively charged **electrons**. Each of these sub-atomic particles has a relative mass and charge:

Subatomic Particle	Relative Mass	Relative Charge
Proton	1	+1
Nucleus	1	0
Electron	0 (0.0005)	-1

The typical size of an atom is 1×10^{-10} **metres** with the radius of the nucleus being 10,000 times smaller still. Nearly all of the mass of the atom is concentrated at the nucleus.

Electrons lie at different distances from the nucleus in different **energy levels**. The electron arrangements may change with the interaction with EM radiation.

Density

Mass per unit volume

$$density = \frac{mass}{volume} \qquad \rho = \frac{m}{v} \quad units\ are\ kgm^{-3}$$

Density depends on the **spacing** of the atoms in matter (the volume they take up).

Solids and liquids have similar, higher densities as the space between particles does not change significantly. Typically liquids have a lower density than solids with one main exception being ice, which is less dense than water.

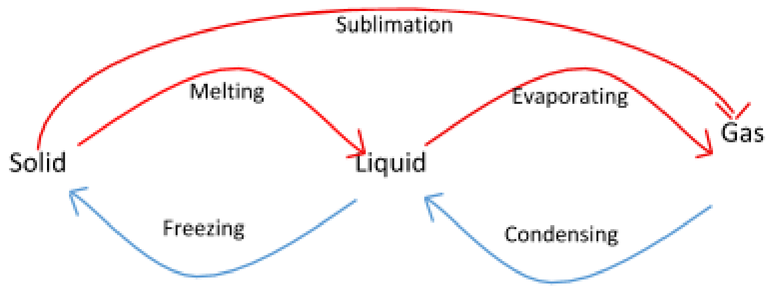
Gases have a much lower densities as the spacing between atoms is much greater. Gas particles have lots of energy to move, so they occupy a greater volume, decreasing their density compared to solids and liquids.

P1.2 Changes of State

Conservation of Mass

Mass is **conserved** during a change in state of a substance. The volume the substance takes up will change, resulting in a different density, but mass remains constant.

e.g. If 20g of liquid evaporates, the gas produced will also weigh 20g.



These **physical** changes are reversible, and are **not chemical** changes because the material retains its original properties when the change is reversed.

Heating a System

Heat and temperature are not the same. **Temperature** is a measure of the average **kinetic energy** of particles in a system, measured on a relative scale. **Heat** is a form of **energy**, and is measured on an absolute scale.

When a substance gains heat energy there are two possible outcomes:

- It could raise in temperature, but remain in the same state
- It could remain the same temperature, but change state

Specific Heat Capacity & Latent Heat

Specific heat capacity (c) is the energy required to raise the temperature of 1kg of a substance by 1°C (or 1ºKelvin) and describes the energy to melt or freeze.

$$energy = mass \times specific\ heat\ capacity \times temperature\ change$$

$$E = mc\Delta T$$

$$units\ are\ J/kg°C$$

Specific latent heat (l) is the energy required to change the state of 1kg of a substance without a change in temperature and describes the energy to boil or condense.

$$energy = mass \times specific\ latent\ heat$$

$$E = ml$$

$$units\ are\ Jkg^{-1}$$

P1.3 Pressure (Physics Only)

Molecule Motion

Particles in a fluid move **randomly** in every direction. A fluid can be a liquid or a gas.

$$pressure = \frac{force}{area}$$

Pressure produces a net force at **right angles** to any surface.

Temperature & Pressure

Temperature and pressure are proportional when volume is constant. Increasing the temperature means **more energy** is given to the particles in a fluid. This thermal energy is transferred to kinetic energy, so the particles move faster. Therefore collisions of the particles with the container walls become more frequent and forceful. As a result, pressure of the fluid increases (and volume will too unless it is fixed).

$$pressure \propto temperature \qquad p = kT$$

Volume & Pressure

Volume and Pressure are inversely proportional at a constant temperature. As pressure increases, greater force is applied per unit area via collisions so the particles occupy a smaller volume. If volume increases, the area over which particles collide with is larger, so pressure decreases.

$$pressure \propto \frac{1}{volume} \qquad p = \frac{k}{V}$$

Temperature, Volume & Work

Temperature and volume of a fluid are proportional at a constant pressure. As the temperature increases, a **greater force** is exerted on walls as particles have more kinetic energy. For pressure to stay constant the area of the container must increase as the particles exert more force, therefore volume increases.

$$volume \propto temperature \qquad V = kT$$

When work is done (a force is applied) to a fluid, its temperature increases

$$WD = Force \times distance = \frac{Force}{area} \times (area \times distance) = Pressure \times Volume$$

This can be done by:

- **Introducing more gas into the same volume, so more particles are present, more collisions occur and pressure increases. This transfers energy to the particles so the fluid heats up.**

- **Reducing the volume of the fluid so the particles collide with the wall more frequently, increasing the pressure and the kinetic energy of each particle. This increased energy means the fluid heats up.**

The Earth's Atmosphere

Earth's atmosphere is assumed to be **isothermal**, meaning it is all the same temperature. It is also transparent to solar radiation but opaque to terrestrial radiation.

The atmosphere is also assumed to have **uniform density** for simplification.

Atmospheric Pressure

Atmospheric pressure is measured as the **total weight of the air above** a unit area at a certain altitude and decreases as height above Earth's surface increases. With higher elevation, there are fewer air molecules in a given area meaning there is a smaller weight of air, therefore less pressure.

This phenomenon can be observed with helium space balloons. At Earth's surface, the balloon is under greater atmospheric pressure than in space. Therefore, as the balloon rises into space, the helium gas exerts a greater force from the inside of the balloon than the thinner air from the outside, causing the balloon to expand.
Expansion will stop when the pressure from the helium inside the balloon is equal to the pressure outside, and they are in **equilibrium**. Typically, the balloon bursts before these equilibrium conditions are achieved.

Floating & Sinking

In a fluid, an object will float if its weight is less than the weight of the fluid it displaces

e.g. So a 1000kg boat will sink into the water until it has displaced 1000kg of water. Providing the boat doesn't completely submerge before it displaces this amount, then it will float.

An object will sink if its weight is greater than the weight of the fluid it displaces.

Liquid Pressure

Pressure in a liquid varies with depth and density, and this leads to the liquid exerting an upwards force on a partially submerged object. This upwards force is known as buoyancy force and it counteracts the weight of the floating object.

e.g. A ping pong ball floats on water as its density is less than the density of the water. The weight of the displaced water is greater than the weight of the ping pong ball, so there is a resultant buoyancy force and the ball floats.

Pressure & Depth

As water depth increases, the weight of the water in the above water column is greater. Therefore a greater force is experienced as greater pressure.

$$pressure\ due\ to\ a\ column\ of\ liquid = height\ of\ column \times density\ of\ liquid \times g$$

g (gravitational acceleration) = 10