AQA GCSE Physics

Topic 3: Particle Model of Matter

Notes

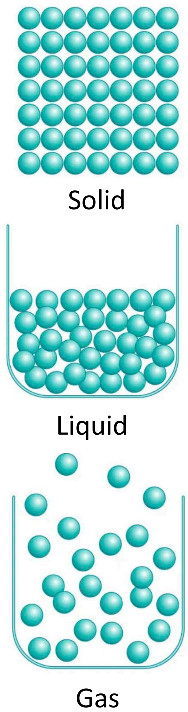
(Content in bold is for Higher Tier only)

Density

- The density is defined as the mass per unit volume $\text{density} = \frac{\text{mass}}{\text{volume}}$

$$\rho = \frac{m}{V}$$

Where the density ρ, in kilograms per metre cubed, kg/m^3, mass, m, in kilograms, kg and volume, V, in metres cubed, m^3



Density depends on the spacing of the atoms in matter

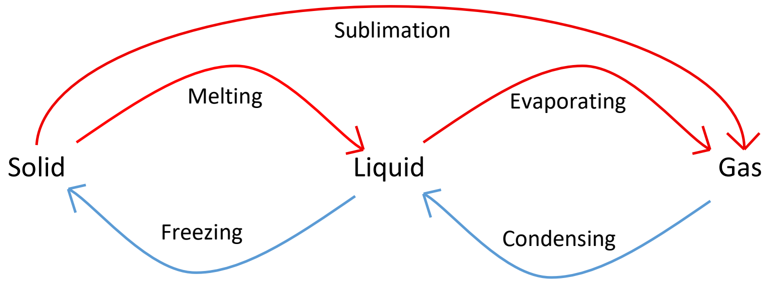
- Solids and liquids have similar densities as the space between particles does not change significantly
  - Usually liquids have a lower density than solids (main exception is ice and water)

- Gases have a far lower density
  - The spacing between atoms increase x10, as the particles have lots of energy to move, so volume increases greatly and therefore the density decreases greatly compared to solids/liquids

Remember if questions involve change in state and ask for new volume/pressure, the mass is the same!

Changes of State

- Mass is conserved during a change of state.
- If 20g of liquid evaporates, the gas produced will also weigh 20g



These *physical* changes are reversible, and **not** *chemical* changes

- They are not chemical because the material retains its original properties when reversed

Internal Energy

- Energy which is stored by particles (atoms and molecules) within a system
  - the energy takes the forms of:
    - Kinetic Energy (vibration of atoms etc.)
    - Potential Energy (between the particles)

Heating a System

- Heating increases the energy the particles have
- This increases the internal energy
  - This either raises the temperature of the system
  - Or produces a change of state

Temperature Changes

Specific Heat Capacity

- The amount of energy required to raise the temperature of 1kg of a substance by 1°C.

$$\text{change in thermal energy} = \text{mass} \times \text{specific heat capacity} \times \text{temperature change}$$

$$\Delta E = mc\Delta T$$

Where ΔE is the change in thermal energy, in joules J, specific heat capacity, c in joules per kilogram per degree Celcius $\text{Jkg}^{-1}\text{°C}^{-1}$, mass m in kilograms kg and temperature change ΔT in degrees Celcius °C .

Specific Latent Heat

- The amount of energy needed to change the state of 1kg of a substance without a change in temperature
  - The substance needs to be at the right temperature to change state first
- Specific Latent Heat of fusion is energy to melt/freeze
- Specific Latent Heat of vaporisation is energy to boil/condense

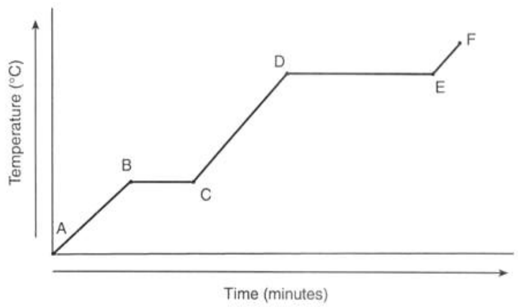
$$\text{energy for a change of state} = \text{mass} \times \text{specific latent heat}$$
$$E = mL$$

Where E, is the Energy in joules J, m is the mass in kilograms kg and specific latent heat L in joules per kilogram J/kg.

- Energy is absorbed when melting and evaporating and energy is released when freezing and condensing.
- Sublimation is when solid goes straight to gas – “dry ice” (solid CO_2 does this)

Graph here shows the temperature of ice:

- At A it is Solid.
- At B, reaches 0°C .
- From B to C there is no temperature change because the energy is used through melting.
- From C to D it is in liquid state.
- From D to E the water is boiling. This takes longer, because evaporation takes more energy
- From E to F the gas is heating.



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Pressure

- The molecules of a gas are in constant random motion. The temperature of the gas is related to the average kinetic energy of the molecules.
- The higher the temperature, the greater the average kinetic energy and so the faster the average speed of the molecules.
- When the molecules collide with the wall of their container they exert a force on the wall. The total force exerted by all of the molecules inside the container on a unit area of the walls is the gas pressure.
- Changing the temperature of a gas, held at constant volume, changes the pressure exerted by the gas (known as the Pressure law).

Pressure in Gases (Physics only)

- Changing the volume of a gas affects the pressure
    - A gas can be compressed or expanded by pressure changes. The pressure produces a net force at right angles to the wall of the gas container (or any surface).
    - Increasing the volume in which a gas is contained, at constant temperature, can lead to a decrease in pressure (known as Boyle's law), this is due to the reduced number of collisions per unit area.
- For a gas at fixed mass and temperature:

$$P_1V_1 = constant$$

Where the pressure P is in pascals, Pa and the volume, V, in metres cubed, m^3.

- Therefore, increasing the volume of a container will lead to a decrease in pressure.

Increasing the pressure of a gas (Physics only)

Doing work on a gas increases its temperature

$$\textbf{Work Done} = \textbf{Force} \times \textbf{distance} = \frac{\textbf{Force}}{\textbf{area}} \times (\textbf{area} \times \textbf{distance}) = \textbf{Pressure} \times \textbf{Volume}$$

$$\textbf{work done} = \textbf{pressure} \times \textbf{volume}$$

- **Adding more particles to a fixed volume**
    - **Doing work on a gas means compressing or expanding the gas, so changing the volume**
    - **Pumping more gas into the same volume means more particles are present, so more collisions occur per unit time with the walls, so pressure increases.**
    - **Energy is transferred to the particles when more gas is added into the fixed volume, so this heats the gas**
- **A fixed number of particles for a smaller volume**
    - **The particles collide with the wall which is moving inward**
    - **So the particles gain momentum, as the rebound velocity is greater than the approaching velocity**
    - **So as the particle has a greater velocity, the pressure increases as the particles collide with the walls more frequently (time between collisions decreases)**

- **And the temperature also increases, as the kinetic energy of each particle increases.**