Edexcel GCSE Physics

Topic 14: Particle model

Notes

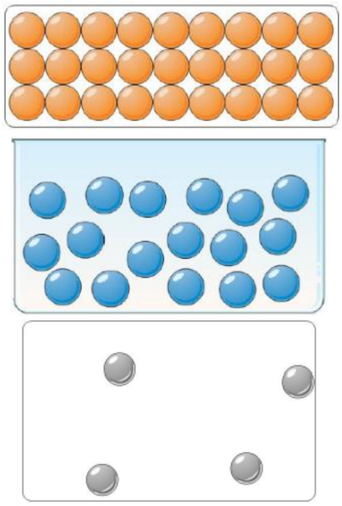
(Content in bold is for Higher Tier only)

Density

Mass per unit volume

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$$\rho = \frac{m}{V} \quad \text{units are (usually) kgm}^{-3}$$



Density depends on the spacing of the atoms in matter

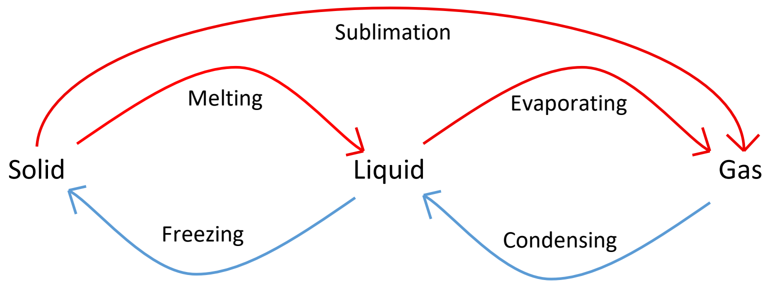
- Solids and liquids have similar densities. This is because the space between particles does not change significantly
    - Usually liquids have a lower density than solids (main exception is ice and water)
- Gases have a far lower density
    - The spacing between atoms increase x10, as the particles 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

Heating a System

- The amount of energy the particles have increases
- Particles vibrate more
- The temperature of the system increases
    - OR the system changes state
- The "system" could be an ice cube, a gas, etc.

Specific Heat Capacity

- The energy required to raise the temperature of 1kg of a substance by 1°C
    - (the difference of 1°C is the same as 1 Kelvin)

$$\text{energy} = \text{mass} \times \text{specific heat capacity} \times \text{temperature change}$$
$$E = mc\Delta T$$
$$\text{units are } Jkg^{-1}{}^{\circ}C^{-1}$$

Specific Latent Heat

- The energy 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

Energy is absorbed when melting and evaporating
Energy is released when freezing and condensing

$$\text{energy} = \text{mass} \times \text{specific latent heat}$$
$$E = ml$$
$$\text{units are } Jkg^{-1}$$

Insulation

- Thermal energy transfers out of any system
    - This means some energy is wasted, as it is lost to the surroundings
- Using thermal insulators, e.g. foam, reduces the amount of energy lost (as it is a poor thermal conductor)
- Use reflective coatings to reflect IR radiation (heat) back into the system
- Think about the given situation to see how the system can be insulated

Pressure of a Gas

Particles in a gas move randomly in every direction
A Fluid can be a liquid or a gas

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

- Remember, pressure produces a net force at right angles to any surface
- Particles collide with a wall, changing velocity
- This means they change momentum during their collision
- So they exert a force on the wall (as force $= \frac{\Delta \text{momentum}}{\text{time}}$)
- Press is the force across the area of the wall.

Temperature and Pressure (in a constant volume)

- Increased temperature means more energy given to the particles
- The thermal energy is transferred to kinetic
    - Particles move at faster speed
    - Collisions with walls occur more often
    - The particles also hit the wall with greater impact
    - So pressure increases

Absolute Zero

- This temperature is 0 Kelvin, or -273°C
- Nothing can exist at a colder temperature than this, this is the coldest possible temperature
- Particles at this temperature have no energy, so they do not vibrate at all, they remain perfectly still.

Converting Kelvin to Centigrade:

$$\text{T kelvin} = (\text{T} - 273)\ \text{centigrade}$$
$$\text{so } 4\text{K} = -269°\text{C}$$
$$\text{and } 0°\text{C} = 273\text{K}$$

Pressure changes (Physics Only)

Gases want to remain at a constant temperature

- Increasing the pressure of the gas causes it to compress (have a smaller volume)
  - Pressure increases, so greater force per area
  - Same force is exerted on walls, as temperature and energy of particles is constant
  - Force needs to be exerted on a smaller area and volume decreases
    - Other way round?
  - Volume increases, so a greater area that particles collide with
  - Same force is exerted on the walls as velocity is constant (as velocity is only affected by temperature) and pressure decreases
- So this means pressure $\propto \frac{1}{\text{volume}}$ (inversely proportional)

For a gas at fixed mass and temperature:

$$P_1V_1 = P_2V_2$$

Where *P* is pressure and *V* is volume in states *1* and *2.*

Doing Work on a Gas (Physics Only)

- **Doing work on a gas increases its temperature**

$$\mathbf{WD = Force \times distance = \frac{Force}{Area} \times (area \times distance) = Pressure \times Volume}$$
$$\mathbf{work\ done = pressure \times volume}$$

Adding More Particles to A Fixed Volume (Physics Only)

- **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 with A Decreasing Volume (Physics only)

- **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**