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GCSE Physics AQA: Topic 3

Changes of State and the Particle Model:

Density of Materials

- **Density Formula:** Density (ρ\rhoρ) is calculated as:
- $Density = \frac{Mass}{Volume}$
  where:
  - **Density** (ρ) is in kilograms per cubic metre (kg/m^3).
  - **Mass** is in kilograms (kg).
  - **Volume** is in cubic metres (m^3).
- **Density and Particle Spacing:**
  - **Solids:** Particles are arranged in a fixed, closely packed structure, resulting in high density.
  - **Liquids:** Particles are less tightly packed than in solids, so liquids generally have lower density than solids but higher than gases.
  - **Gases:** Particles are widely spaced with high kinetic energy, resulting in very low density compared to solids and liquids.
- **Applications and Examples:**
  - **Example:** Water has a density of approximately 1000 kg/m^3, while air has a density of about 1.2 kg/m^3. This difference explains why objects float in water but sink in air.

Changes of State

- **Physical vs. Chemical Changes:**
  - **Physical Changes:** State changes (e.g., melting, boiling) are physical changes because they do not alter the substance's chemical composition.
  - **Chemical Changes:** Result in a new substance with different properties and cannot easily be reversed.
- **Energy and State Changes:**
  - **Melting and Boiling:** Energy is absorbed to overcome intermolecular forces. During melting, energy is used to break bonds between particles in a solid, while boiling requires energy to overcome the forces between particles in a liquid.

- **Freezing and Condensation:** Energy is released as particles lose kinetic energy and form bonds (freezing) or come closer together (condensation).

Internal Energy and Energy Transfers:

Definition

- Internal energy = total energy stored in a system's particles:
  - **Kinetic energy** (movement/vibration)
  - **Potential energy** (due to forces between particles)

When you **heat a system**, energy is transferred to its particles:

- Temperature rise = increase in **kinetic energy**.
- Change of state = increase in **potential energy** (bonds broken/formed).

3.2.2 Temperature Changes and Specific Heat Capacity

- **Specific Heat Capacity Formula:** The specific heat capacity
- is calculated using: $\Delta E = m \times c \times \Delta\theta$
- **ΔE** is the change in thermal energy (Joules, J).
  - **m** is the mass (kg).
  - **c** is the specific heat capacity (J/kg°C).
  - **Δθ** is the temperature change (°C).

Changes of State and Specific Latent Heat

- **Latent Heat:** Latent heat is the energy required to change the state of a substance at constant temperature.
- **Specific Latent Heat Formulas:**

Two Types

1. **Latent heat of fusion** – energy needed to **melt** a solid into a liquid (or freeze).

2. **Latent heat of vaporisation** – energy needed to **boil** a liquid into a gas (or condense).

Particle Model and Pressure:

Particle Motion in Gases

Gas Particle Behaviour

- Gas particles move **randomly and quickly** in all directions.
- Collisions between particles and container walls create **pressure**.

Temperature and Kinetic Energy

- Heating a gas increases the **kinetic energy** of particles.
- Faster motion → **more frequent and forceful collisions** → **higher pressure**.

Pressure in Gases

Definition

Pressure is the **force per unit area** exerted by gas particles colliding with the container walls.

  - `Pressure = Force / Area`

- Measured in **Pascals (Pa)** or **N/m²**.

Changing the Volume

- If temperature is constant:
  - **Decreasing the volume** increases pressure (particles hit walls more often).
  - **Increasing the volume** decreases pressure.
  - This relationship is:

$$P_1 \times V_1 = P_2 \times V_2$$

- (Pressure × Volume = constant)

Temperature and Pressure

- Increasing temperature → particles move faster → pressure increases (if volume is fixed).

Example

- A sealed balloon left in the sun expands because gas particles inside gain kinetic energy and collide more forcefully with the walls.

Doing Work on a Gas

When a gas is **compressed** (e.g., in a pump):

- Work is done **on the gas**.
- Energy is transferred to the particles → they **move faster**, **temperature increases**.

If compressed **too quickly**, gas can get **very hot** (e.g., bicycle pump becomes warm)