

Edexcel Physics IGCSE

Topic 5: Solids, Liquids and Gases

Summary Notes

(Content in **bold** is for physics only)

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Density and pressure

The **density** of a substance is defined as the **mass per unit volume** and is measured in **kilograms per metre cubed (kg/m³)**.

$$\text{density} = \frac{\text{mass}}{\text{volume}} \quad \rho = \frac{m}{V}$$

To find the density of a liquid:

- Find the mass of the measuring cylinder by placing it on a balance, then fill it with the liquid and measure the new mass. The difference in masses is the mass of the liquid minus the cylinder (alternatively, we can press tare on the balance so it's zeroed). This avoids **zero error**.
- The volume can be read from the cylinder. It must be read straight-on to avoid **parallax error**.
- Find the density using the equation.

To find the density of solid:

- Measure the mass of the solid by placing it on a balance.
- If the solid is:
 - o regularly shaped, measure its dimensions using a ruler or other measuring tool and then use a mathematical formula to find the volume.
 - o irregularly shaped, immerse it in water and measure the volume of the water displaced. This is the volume of the solid.
- Find the density using the equation.

Pressure is defined as the force per unit area and is measured in **Pascals (Pa)**.

$$\text{pressure} = \frac{\text{force}}{\text{area}} \quad p = \frac{F}{A}$$

For example, lying down on a bed of nails compared to a single nail:

- The **force** applied is the weight of your body
- The total **area** is either a single pin point or many points spread out over a larger area
 - o Therefore, on a bed of nails, the pressure is lower as the area is greater.

The **pressure** at a point in a gas or liquid at rest acts **equally** in **all directions** and causes a force at right angles to any surface. Pressure in a fluid (gas or liquid) is created from the movement of particles (as they collide with a surface).

The pressure beneath a liquid surface increases with **depth**, the **density** of the liquid and the **gravitational field strength**.

- It is given by $p = \rho gh$
- Deeper in the fluid the more particles above the point, hence the greater their weight.
- Fluids with higher density have more particles per unit of volume, hence greater weight.
- Weight depends upon gravitational field strength.



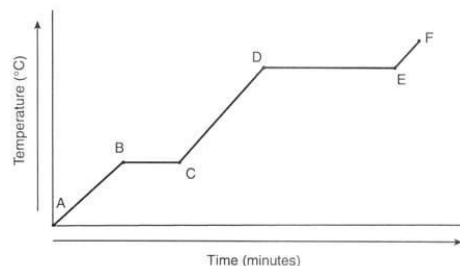
Change of state

Heating a system **increases** its **internal energy** and causes either an **increase** in **temperature** or a **change of state**.

- When the **temperature** of a body **rises**, the energy goes towards making the molecules **vibrate more** and **increases** their **kinetic energy**.
- When a body **changes state**, energy goes towards making the molecules **freer** from each other rather than increasing their kinetic energy – the temperature stays **constant**.
 - **Melting** occurs when molecules in a solid vibrate enough to move away from their fixed positions, turning into a liquid.
 - **Boiling** occurs when molecules in a liquid gain enough energy to break their bonds and become separate molecules, turning into a gas.

Graph showing the temperature of ice with time when energy is put in at a constant rate:

- From A to B the ice is rising in temperature
- From B to C it is melting into water
- From C to D the water is rising in temperature
- From D to E the water is boiling into steam
- From E to F the steam is rising in temperature



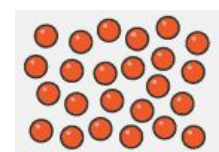
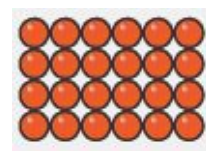
There is **no change in temperature while the substance is changing state** (the line is horizontal) because energy supplied is used to separate the particles (breaking the forces between the molecules).

Evaporation is the escape of molecules with **higher energy** from the **surfaces** of liquids. After they escape, the remaining molecules have a **lower average kinetic energy** which means the temperature is lower (i.e. evaporation **cools** the liquid). This is useful for cooling things down such as sweating from the body.

- To increase the rate of evaporation, increase temperature, increase surface area, or provide a draught.

Evaporation is different to boiling because it can happen at **any temperature** and only occurs at the **surface** of the liquid (boiling occurs throughout a liquid and only at the boiling point).

- Solids
 - Molecules **close** together in **regular** pattern
 - **Strong** intermolecular forces of attraction
 - Molecules **vibrate** but can't move about
- Liquids
 - Molecules **close** together in **random** arrangement
 - **Weaker** intermolecular forces of attraction than solids
 - Molecules **move around each other**
- Gases
 - Molecules **far** apart in **random** arrangement
 - Negligible/very weak intermolecular forces
 - Molecules move quickly in all directions



The **specific heat capacity** is the amount of energy required to raise the temperature of 1kg of a substance by 1°C and is measured in Joules per kilogram degree Celsius (J/kg°C).

change in thermal energy = mass × specific heat capacity × temperature change

$$\Delta Q = mc\Delta T$$

Ideal gas molecules

Gas molecules move **rapidly** and **randomly** due to **collisions** with other gas molecules.

Gases exert **pressure** on a container due to **collisions** between gas molecules and the wall. When the molecules rebound off the walls, they **change direction** so their velocity and therefore **momentum changes**. This means they exert a **force** because force is equal to the change in momentum over time.

- At a constant volume, if the **temperature increases**, the **pressure increases** because the molecules move faster so they collide **harder** and **more frequently** with the walls.
 - o The temperature at which the **pressure is zero** is called **absolute zero** (-273°C). The **Kelvin** scale of temperature defines absolute zero to be 0K with an increment of one Kelvin equal to an increment of one degree Celsius. This means that:
 - *temperature in kelvin = temperature in degrees celsius + 273*
 - o For a gas at fixed mass and volume, where the temperature is measured in Kelvin:

$$\frac{p_1}{T_1} = \frac{p_2}{T_2} \quad \text{or} \quad \frac{p}{T} = \text{constant}$$
- At a constant temperature, if the **volume increases**, the **pressure decreases** because the molecules collide **less frequently** with the walls and over a **greater area**.
 - o For a gas at fixed mass and temperature:

$$p_1V_1 = p_2V_2 \quad \text{or} \quad pV = \text{constant}$$

This is known as **Boyle's Law**

The **temperature in Kelvin** of a gas is proportional 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.

