Physics Knowledge Organiser
Particle Model of Matter (Triple Science)

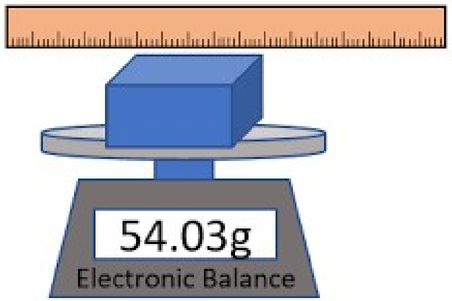
Density
Density is the measure of how much mass there is in a given volume. A denser material have more particles in the same volume compared to a less dense material.

Density Equation (Need to learn this)

$\rho = \frac{m}{V}$ Density = $\frac{Mass}{Volume}$

Density in kilograms per metre cubed (kg/m^3)
Mass in kilograms (kg)
$Volume$ in metres cubed (m^3)

Density practical (regular objects, irregular objects and liquids



Method for a regular solid

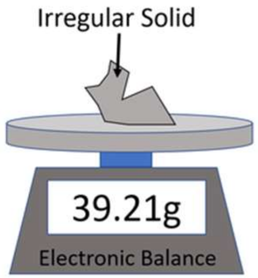
1) Measure and record the mass of the object using a balance.

2) Measure and record the length, width and height of the object using a 30cm ruler.

3) Calculate and record the volume (length x width x height).

4) Calculate the density of the object by doing its mass divided by its volume,

$\rho = \frac{m}{v}$ $Density = \frac{mass}{volume}$



Method for an irregular solid

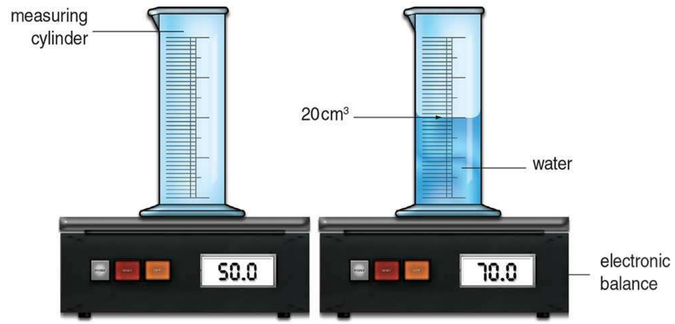
1) Measure the mass of the object using a balance.

2) Fill a Eureka can with water. Tie the object to a piece of cotton and lower it into the eureka can till it is completely submerged.

3) Measure and record the volume of water as this equals the volume of the object.

4) Calculate the density of the object by doing its mass divided by its volume,

$\rho = \frac{m}{v}$ $Density = \frac{mass}{volume}$



Method for a liquid

1) Measure the mass of the beaker using a balance.

2) Measure and record a set volume of water. Measure the mass of the water and the beaker using a balance.

3) Subtract the mass of the beaker from this value to get the mass of the water.

4) Calculate the density of the object by doing its mass divided by its volume,

$\rho = \frac{m}{v}$ $Density = \frac{mass}{volume}$

Specific Heat Capacity

The specific heat capacity of a substance is the amount of energy needed to change the temperature of 1 kg of the substance by 1°C.

This equation you don't need to learn but you do need to apply.

ΔE = m x c x Δθ
ΔE = change in thermal energy (J)
m = mass (normally kg)
c = Specific heat capacity (J/kg °C)
Δθ = temperature change (°C)

Example 1: Applying the ΔE = m x c x Δθ

A mass of 3kg of lead with a specific heat capacity of 130 J/kg°C increased in temperature by 10 °C. Calculate the energy change in the lead.

$$\Delta E = m \times c \times \Delta\theta$$
$$\Delta E = 3 \times 130 \times 10$$
$$\Delta E = 3900J$$

Example 2: Rearranging the ΔE = m x c x Δθ
Calculate the specific heat capacity of magnesium block of mass 1.5kg as the temperature is increased from 15 °C to 35 °C. The energy that is transferred to the iron block is 30,600J.

ΔE = m x c x Δθ
Δθ = 35°C - 15°C = 20°C
30600 = 1.5 x c x 20
30600 = 1500 x c

$$\frac{30600}{30} = c$$
$$c = 1020\ J/kg°C$$

Specific Latent Heat

The **specific latent heat** of a substance is the energy required to change the state of one kilogram of the substance with no change in temperature.

Specific latent heat of fusion – change of state from solid to liquid.
Specific latent heat of vaporisation – change of state from liquid to vapour.

This equation you don't need to learn but you do need to apply.

$\Delta E = m \times L$

ΔE = change in thermal energy (J)

m = mass (normally kg)

L = specific latent heat of the substance in *(J/kg)*

Example 1: Applying the E = m x L equation.

Determine the energy required to melt 3.5kg of Iron if it has a specific latent heat of fusion of 272,000J/kg.

E = *m* x L

E= *3.5 x* 272,000

E = 952,000J

Example 2: Rearranging the E = m x L equation.

A bucket fof ice at 0°C needs 1,800,000 J of heat energy to melt it. The latent heat of fusion of ice is 336 000 J/kg. Determine the mass of ice. Give your answer to three significant figures.

E = m x L

$$1{,}800{,}000 = \mathrm{m} \times 336{,}000$$

$$\frac{1{,}800{,}000}{336{,}000} = m$$

$$\mathrm{m} = 5.3571428kg$$

$$\mathrm{m} = 5.36kg$$

Calculating energy changes for changes in temperature and changes in state

If a substance changes state and temperature, we need to find the energy to change its state as well as change its temperature.

Total energy = Energy to increase its temperature + Energy to change its state.

Example

A kettle is used to change the temperature of 1.5kg of water from 20^0C to 100^0C. Calculate the energy required to change the temperature and change the state of the water.
Specific Heat Capacity of water is $4200/kg$°C
Specific latent heat of fusion of ice = 2,268,000 J/kg

$\Delta E = m \times c \times \Delta\theta + m \times L$

$\Delta\theta = 100 - 20 = 80°C$

$\Delta E = 1.5 \times 4200 \times 80 + 1.5 \times 2{,}268{,}000$

$\Delta E = 3{,}906{,}000J$

$\Delta E = 3{,}900{,}000J$ (2sf)

Example 2

525,000J of thermal energy is transferred to 0.2kg of water.
The water increases in temperature and then changes state and becomes steam.
Calculate temperature change of the water.
Specific Heat Capacity of water is $4200/kg$°C
Specific latent heat of fusion of ice is 2,268,000 J/kg

$\Delta E = m \times c \times \Delta\theta + m \times L$

$525{,}000 = 0.2 \times 4200 \times \Delta\theta + 0.2 \times 2{,}268{,}000$

$525{,}000 = 840 \times \Delta\theta + 453{,}600$

$525{,}000 - 453{,}600 = 840 \times \Delta\theta$

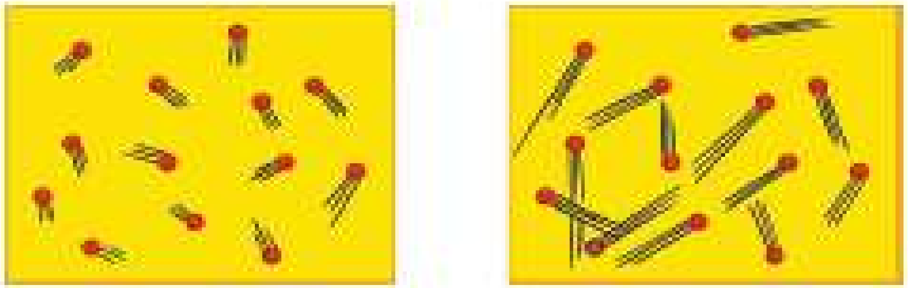
$71400 = 840 \times \Delta\theta$

$\frac{71400}{840} = \Delta\theta$

$\Delta\theta = 85°C$

Internal energy

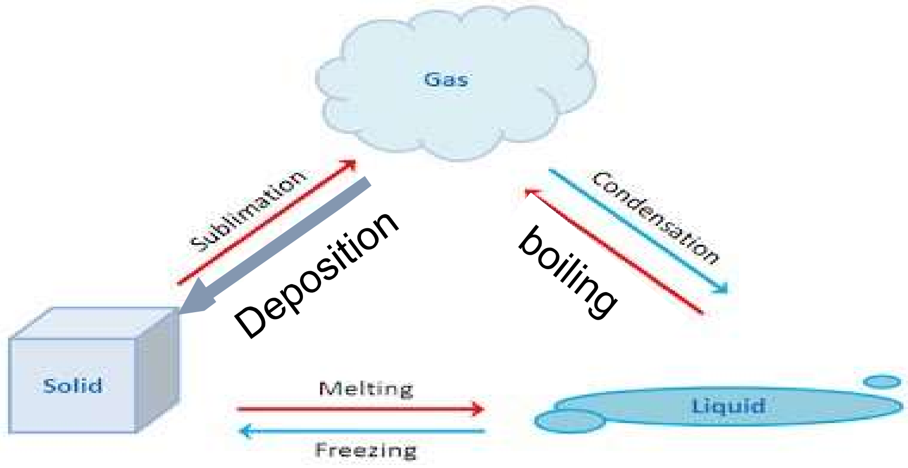
Particles within a system have kinetic energy when they vibrate or move around. The particles also have a potential energy store. The total internal energy of a system is the kinetic and potential energy stores.



Low Temperature High Temperature

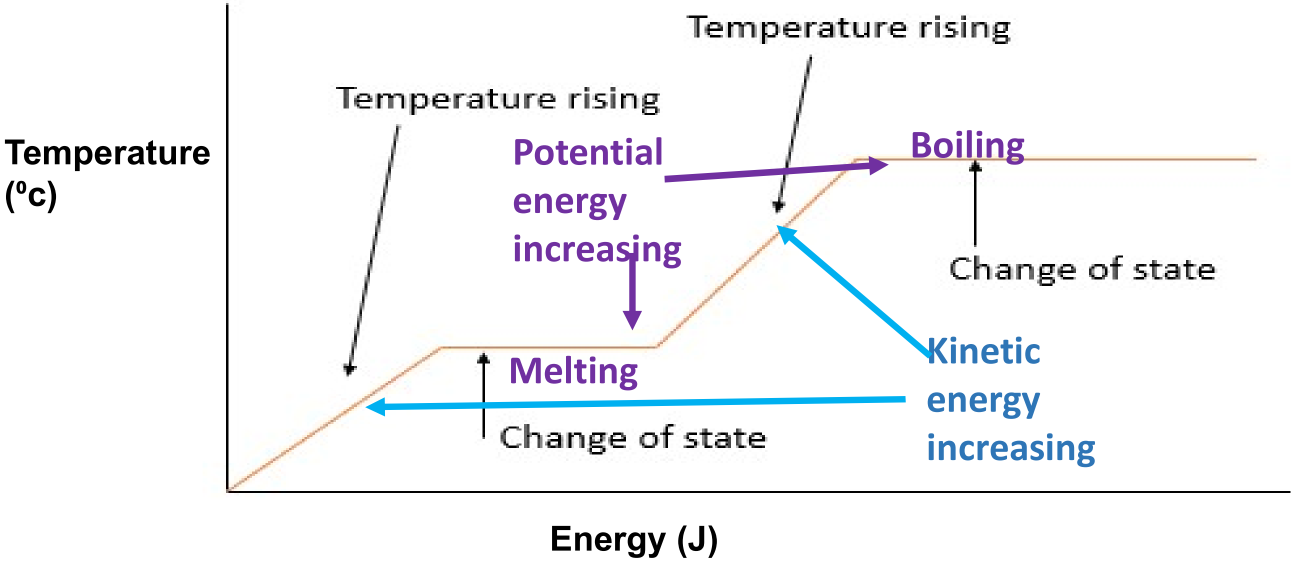
If the system is heated, the particles will gain more kinetic energy, so increasing the internal energy.

Changes in States of Matter



Deposition doesn't need to be known for GCSE Physics.

Temperature vs energy graph for water



Identifying when substance change in state

Oxygen boils at −183 °C and freezes at −218 °C
Nitrogen boils at −195 °C and freezes at −210 °C
Carbon dioxide sublimates at −78 °C

Each of these substances is cooled to a temperature of -185°C.

The following table below shows the state that each substance would be at -185°C.

Substance	State
Oxygen	Liquid
Nitrogen	Gas
Carbon dioxide	Solid

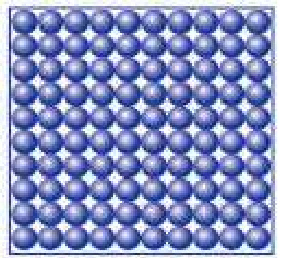
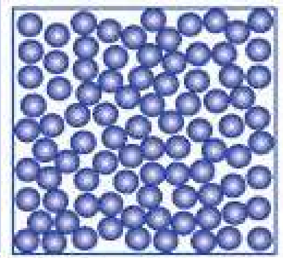
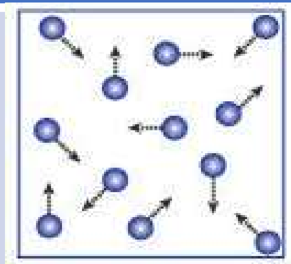
Explanation for why each substance is in these states of matter

Oxygen has a higher temperature than its freezing point but a lower temperature than its boiling point. Therefore, it is in its liquid state.

Nitrogen has a higher temperature than its freezing point and boiling point. Therefore, it is in its gas state.

Carbon dioxide has a lower temperature than its sublimation temperature. Therefore, it is in its solid state.

Properties of States of Matter

	Solids	Liquids	Gases
Particle Diagram			
Arrangement of particles	Regular	Irregular	Irregular
Movement of particles	Vibrate in fixed positions	Move relative to each other and slide past each other.	Move with a range of speeds and in random directions.
Forces between particles	Strong forces between particles	Medium forces between particles	Weak or no forces between particles

Pressure in gases

Move with a range of speeds and in random directions.

When molecules of a gas collide with a surface or each other, they exert a force and cause pressure.

If the molecules collide more frequently, this causes more pressure.

Heating a gas in a sealed container

If a gas is heated, the temperature of the gas molecules increases. Therefore, their average kinetic energy increases as well as their speed.

Therefore, they collide more frequently with the walls of their container. This causes a greater pressure.

Eventually, the pressure increases so much that it causes the container to explode.