OCR A Level Physics

Thermal Properties of Materials

Your notes

Contents

- Thermal Equilibrium
- Measurement of Temperature
- Solids, Liquids & Gases
- Brownian Motion
- Internal Energy
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Thermal Equilibrium

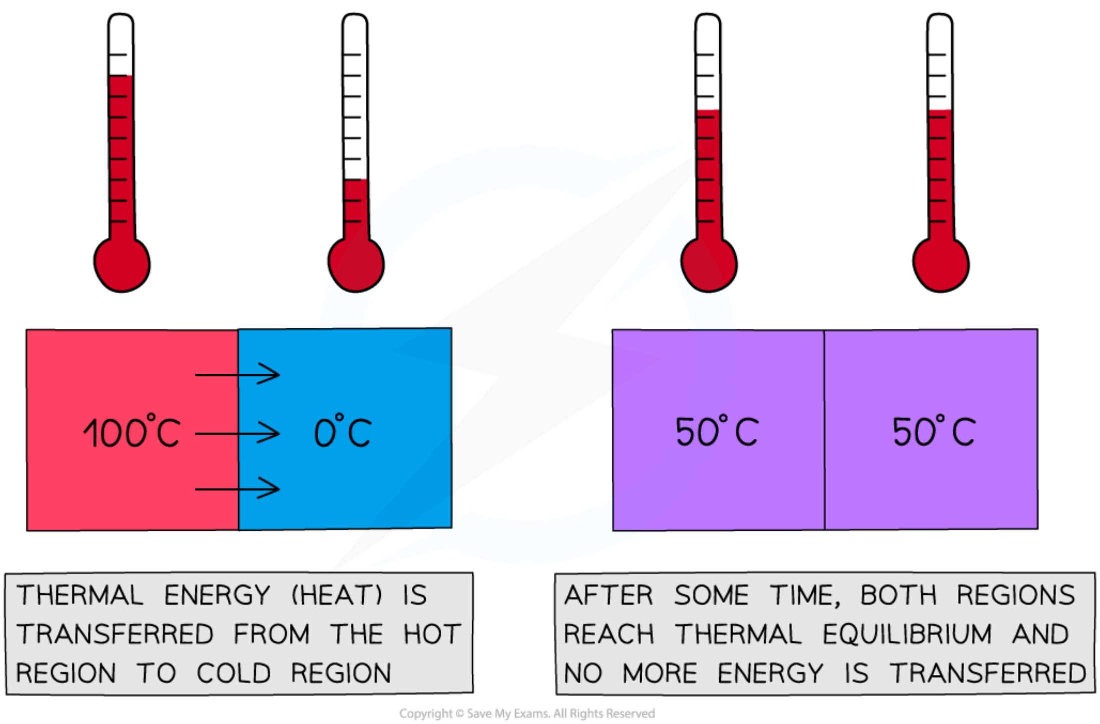
Your notes

Defining Thermal Equilibrium

- Thermal energy is **always** transferred from a hotter region to lower region
- Thermal equilibrium is defined as:

When two substances in physical contact with each other no longer exchange any heat energy and both reach an equal temperature

- There is no longer thermal energy transfer between the regions



Two regions of different temperatures reaching thermal equilibrium after some time

- The two regions need to be in contact for this to occur
- The hotter region will cool down and the cooler region will heat up until they reach the same temperature
- The final temperature when two regions are in thermal equilibrium depends on the initial temperature difference between them

- An example of this is ice in room temperature water. The ice cubes heat up from the energy transfer from the water and the water cools down due to the ice until the water's temperature is in thermal equilibrium

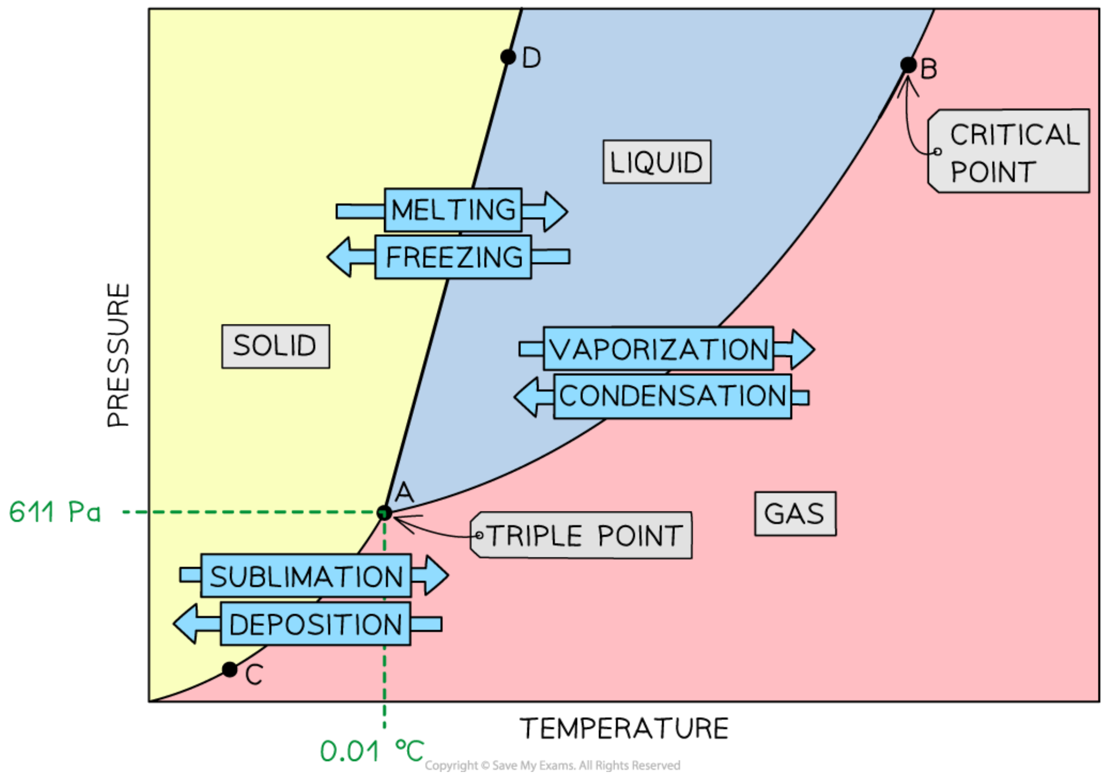
Your notes

Measurement of Temperature

Your notes

Scale of Thermodynamic Temperature

- Temperature is a number used to indicate the level of hotness of an object on some scale
- To measure temperature a scale is needed involving two fixed points at known temperatures
  - The temperature of other objects can then be defined as a position on this scale
- The Kelvin scale is known as the **thermodynamic scale** and was designed to overcome the problem with scales of temperature
- The thermodynamic scale is said to be an absolute scale that is not defined in terms of a property of any particular substance
- This is because thermodynamic temperatures **do not depend** on the property of any particular substance
- The fixed points on the **absolute temperature scale** are:
  - Triple point of pure water
    - The point where pure ice, pure water and pure water vapour all exist at the same temperature and pressure



- Absolute zero
  - The lowest possible temperature

Units of Temperature

- As an everyday scale of temperature, Celsius (°C) is the most familiar
- This scale is based on the properties of water - the freezing point of water was taken as 0 °C and the boiling point as 100 °C
  - However, there is nothing special about these two temperatures
  - The freezing and boiling point of water will actually change as its pressure changes
- The Celsius scale is used to measure the temperature in a liquid-in-glass thermometer
  - However, the expansion of the liquid might be non-linear
- Other temperature scales include:
  - Fahrenheit, commonly used in the US

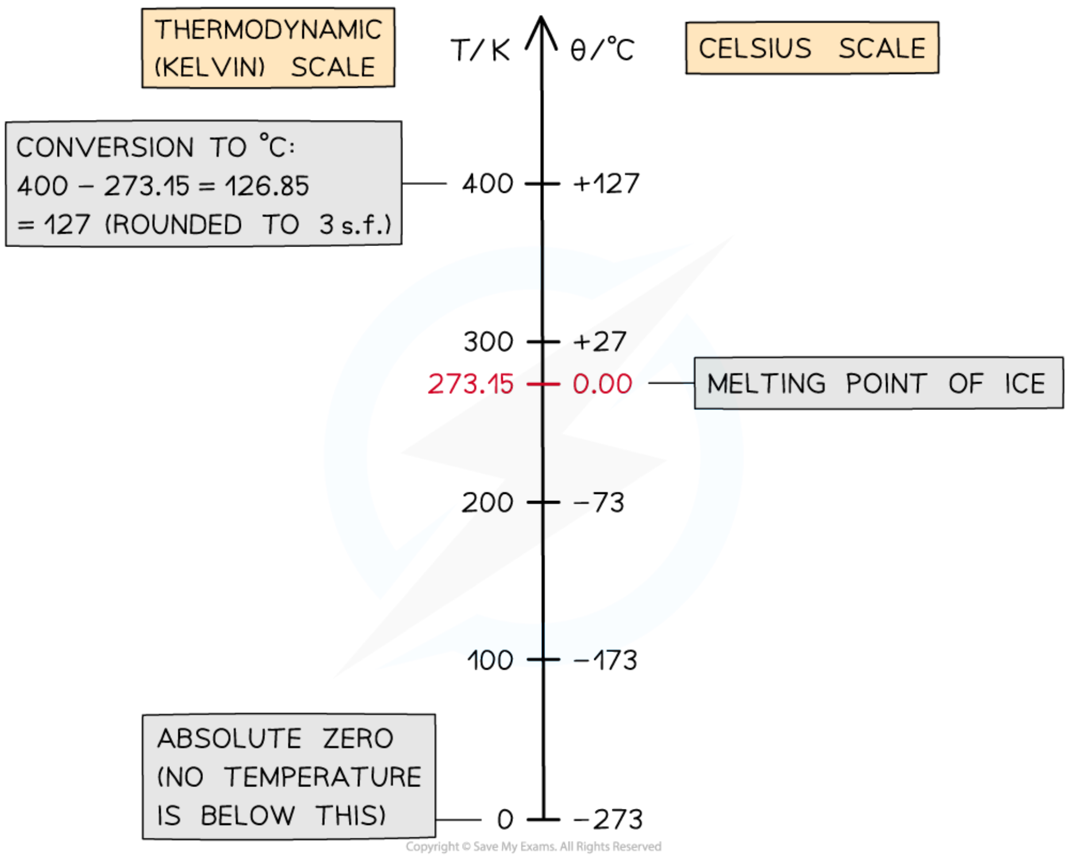
- Kelvin, used in thermodynamics

The Kelvin Scale

- To convert between temperatures θ in the Celsius scale, and T in the Kelvin scale, use the following conversion:

$$\theta / °C = T / K - 273.15$$

$$T / K = \theta / °C + 273.15$$



Conversion chart relating the temperature on the Kelvin and Celsius scales

- The divisions on both scales are equal. This means:

A change in a temperature of 1 K is equal to a change in temperature of 1 °C

Worked Example

Your notes

In many ideal gas problems, room temperature is considered to be 300 K. What is this temperature in Celsius?

Answer:

Step 1: State the conversion between Kelvin and Celcius

$$\theta / °C = T / K - 273.15$$

Step 2: Substitute in value of 300 K and calculate the value in Celcius

$$300 K - 273.15 = 26.85 °C$$

Your notes

Examiner Tips and Tricks

If you forget in the exam whether it's +273.15 or −273.15, just remember that 0 °C = 273.15 K. This way, when you know that you need to +273.15 to a temperature in degrees to get a temperature in Kelvin. For example: 0 °C + 273.15 = 273.15 K.

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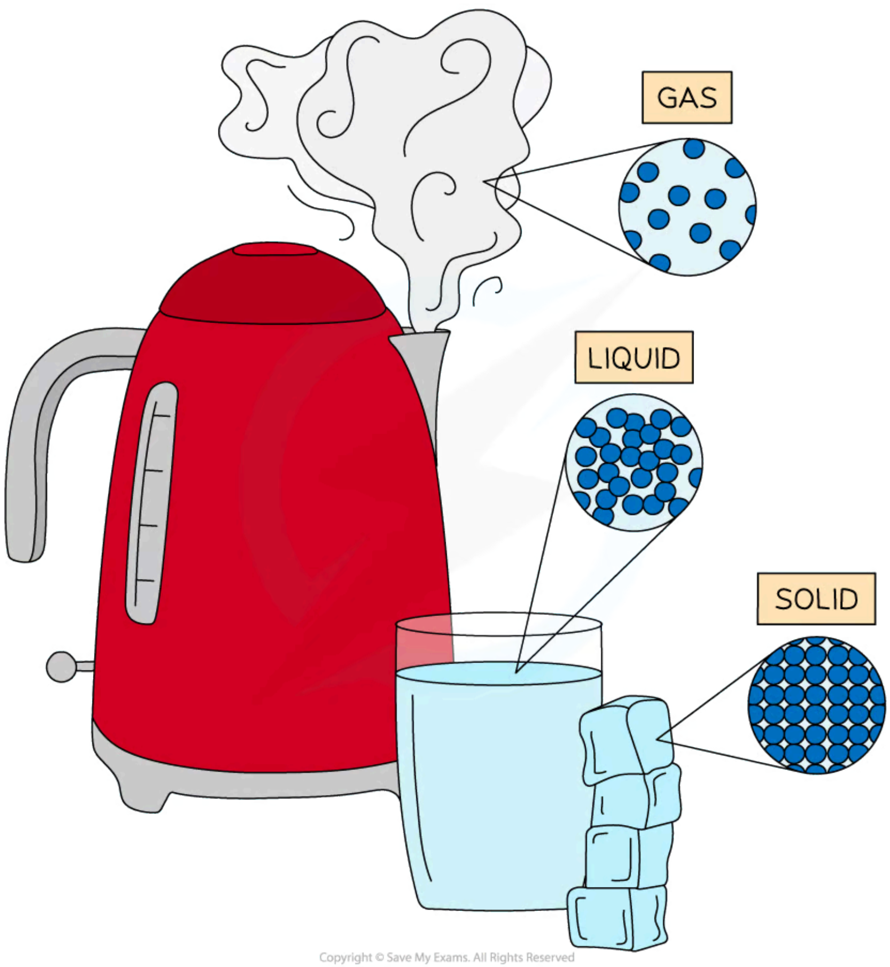
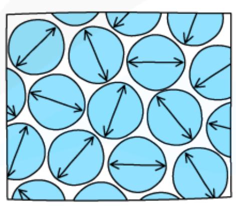
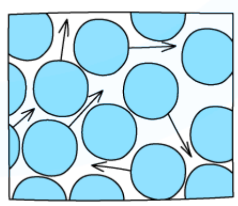
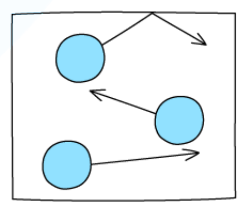
Solids, Liquids & Gases

- The three states of matter are **solid**, **liquid** and **gas**



Water has three states of matter; solid ice, liquid water and gaseous steam. The difference between each state is the arrangement of the particles

Your notes

State of Matter	Solid	Liquid	Gas
Particle arrangement	Fixed pattern (lattice structure)	Random	Random
Space between particles	No space	Some space	Large space
Intermolecular forces	Strong	Weak	Negligible
Particle movement	Vibrate about fixed position	Flow past each other	Move around at different speeds
Particle energy	Low	Medium	High
Substance shape	Fixed	Not fixed	Not fixed
Substance volume	Fixed	Fixed	Not fixed
Substance density	High	Medium	Low
2-D diagram of particle arrangement			

Kinetic Model for Solids, Liquids & Gases

- The **kinetic theory of matter** is a model that attempts to explain the properties of the three states of matter
  - In this model, particles are assumed to be small solid spheres

Solids

- Particles in solids:
  - Are held together by **strong intermolecular forces**
  - Are **closely packed**

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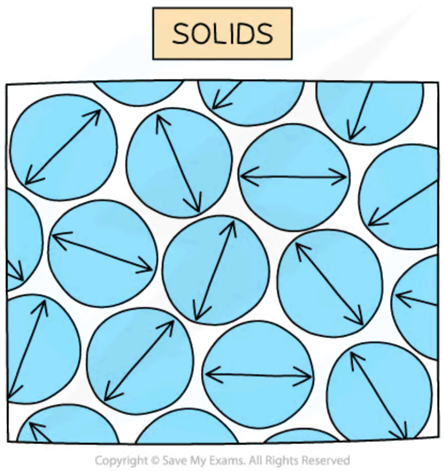
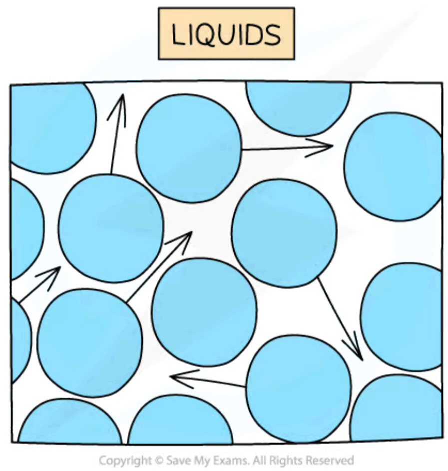
- Are arranged in a fixed pattern (**lattice structure**)
- Can only **vibrate** about their fixed positions
- Have low energies compared to particles in liquids and gases



- As a result of the arrangement and behaviour of their particles, solids:
  - Have a fixed shape (although some solids can be deformed when forces are applied)
  - Have a fixed volume
  - Are very difficult to compress
  - Have higher densities than liquids and gases

Liquids

- Particles in liquids:
  - Are held together by **weaker intermolecular forces** compared to the forces between particles in solids
  - Are **closely packed**
  - Are **randomly** arranged (i.e. there is no fixed pattern)
  - Can **flow** past each other
  - Have higher energies than particles in solids, but lower energies than gas particles



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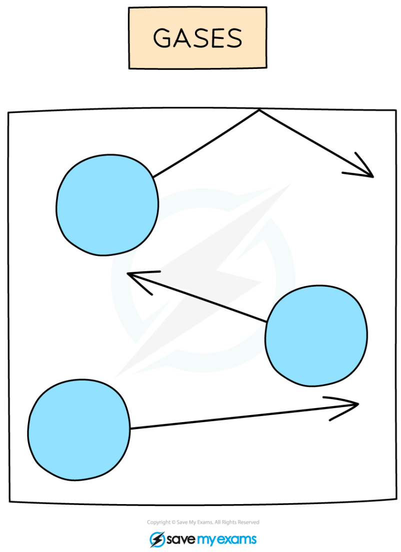
- As a result of the arrangement and behaviour of their particles, liquids:
  - Do not have a fixed shape and take the shape of the container they are held in
  - Have a fixed volume
  - Are difficult to compress
  - Have lower densities than solids, but higher densities than gases

Gases

- Particles in gases:
  - Have **negligible intermolecular forces** between them
  - Are **far apart** (the average distance between the particles is ~10 times greater than the distance between the particles in solids and liquids)
  - Are **randomly** arranged
  - Move around in **all directions** at a variety of speeds, occasionally **colliding** with each other and with the walls of the container they are in
  - Are negligible in size compared to the volume occupied by the gas
  - Have higher energies than particles in solids and liquids

Your notes



In a gas, particles can move around freely in all directions (shown by the arrows).

- As a result of the arrangement and behaviour of their particles, gases:
  - Do not have a fixed shape and take the shape of the container they are held in
  - Do not have a fixed volume and expand to completely fill the available volume
  - Can be compressed
  - Have the lowest densities (~1000 times smaller than the densities of solids and liquids)

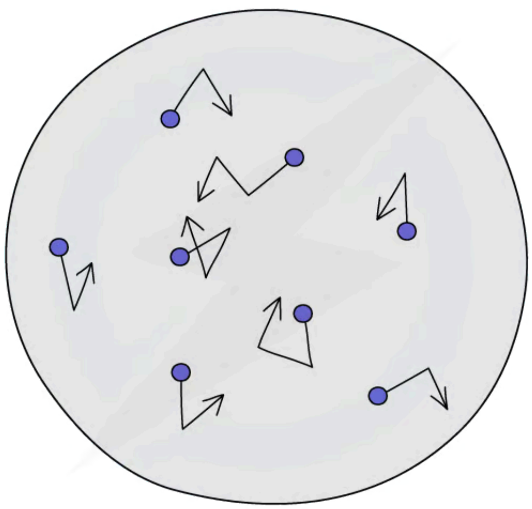
Brownian Motion

Your notes

Brownian Motion

- Brownian motion of particles is the phenomenon when:

  Small particles (such as pollen or smoke particles) suspended in a liquid or gas are observed to move around in a constant, random motion

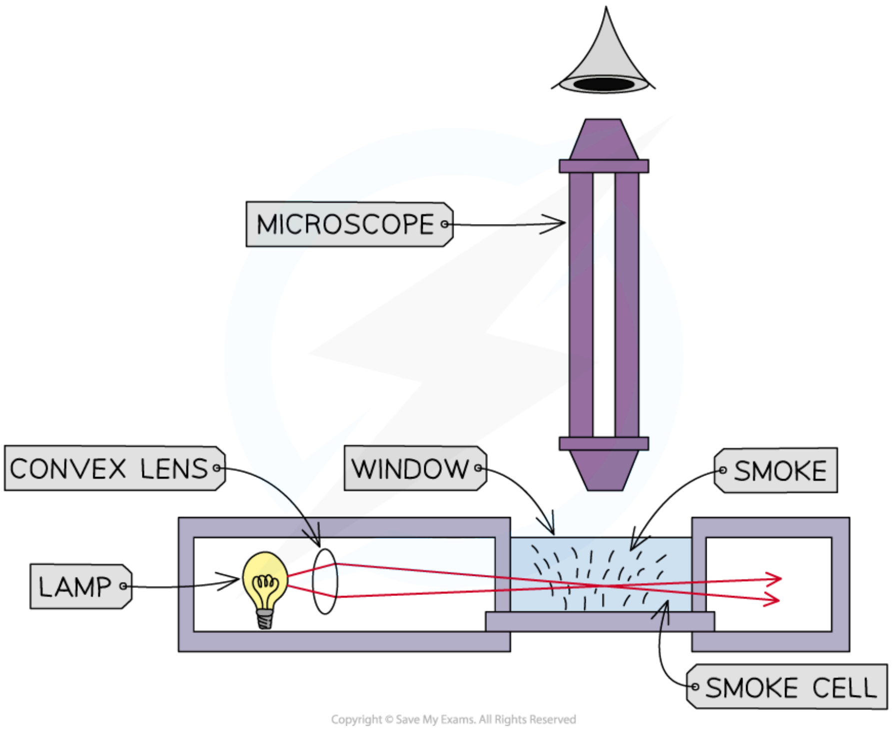


Brownian motion is the erratic motion of small particles when observed through a microscope

- Brownian motion:
  - Can be observed in a smoke cell under a microscope
  - Provides evidence for the existence of molecules in a gas or liquids
- The particles are said to be in random motion, which means that they have:
  - A range of speeds
  - No preferred direction of movement
- The observable particles in Brownian motion are significantly bigger than the molecules that cause the motion
  - In most cases, these are observed practically as smoke particles in air

Your notes

- The air particles cause the observable motion of the smoke particles
- This means that the air particles are small and light and the smoke particles are large and heavy



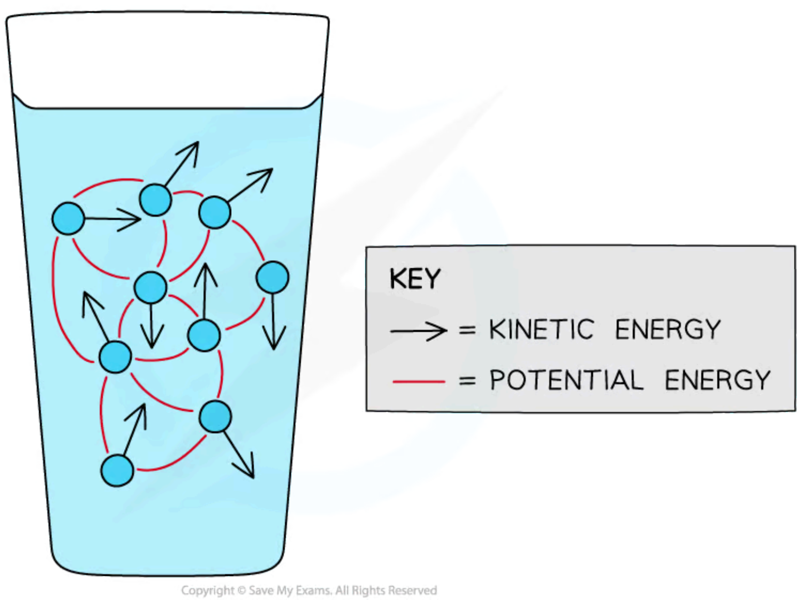
- The collisions cause larger particles to change their speed and direction randomly
    - This effect provides important evidence concerning the behaviour of molecules in a gas, especially the concept of pressure
- The smaller molecules are able to affect the larger particles in this way because:
    - They are travelling at a speed much higher than the larger particles
    - They have a lot of momentum, which they transfer to the larger particles when they collide

Your notes

Internal Energy

Internal Energy

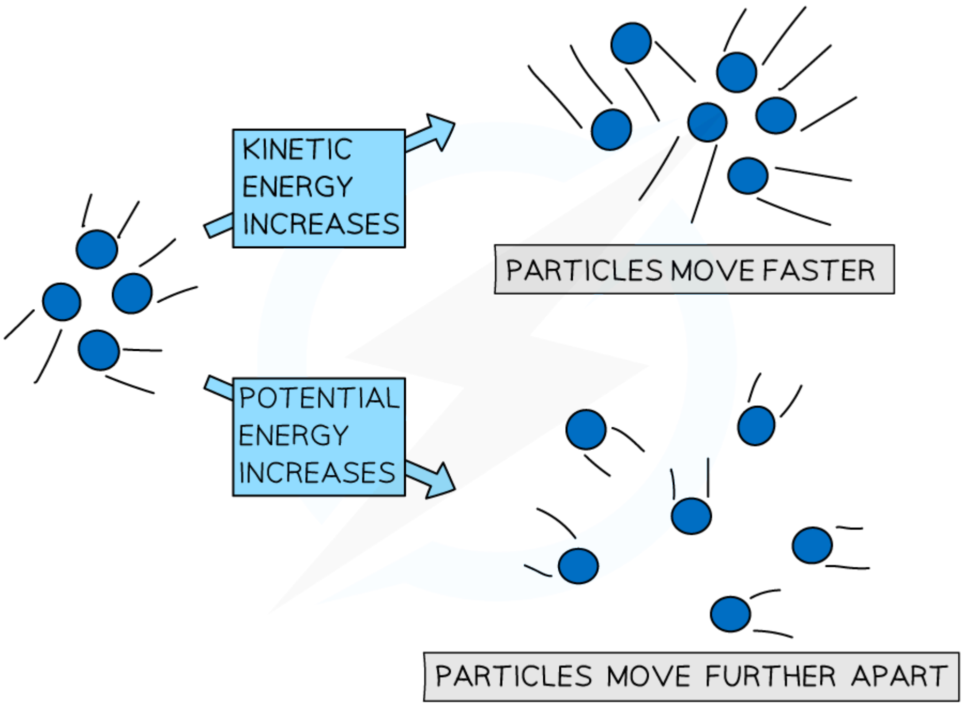
- Energy can be classified into two forms: kinetic or electrostatic potential energy
- The molecules of all substances contain both kinetic and electrostatic potential energies
  - Kinetic energy is determined by the speed and mass of the molecules and gives the material its temperature
  - Electrostatic potential energy is due to the separation between the molecules and their position within the structure



- The amount of kinetic and electrostatic potential energy a substance contains depends on its phase of matter (solid, liquid or gas)
  - This is known as internal **energy**
- The internal energy of a substance is defined as:

The sum of the randomly distributed kinetic and potential energies of atoms or molecules within a substance

Your notes



- The symbol for internal energy is *U*, with units of **Joules** (J)
- Particles are randomly distributed, meaning they all have different speeds and the separation between each molecule varies
- The internal energy of a system is determined by:
  - **Temperature**
    - Higher temperature means greater kinetic energy
    - Lower temperature means less kinetic energy
  - The **random motion** of molecules
  - The **phase of matter**: gases have the highest internal energy, solids have the lowest
  - **Intermolecular forces** between the particles
    - Stronger intermolecular forces mean higher potential energy
    - Weaker intermolecular forces mean lower potential energy
    - The strength of the intermolecular forces is linked to the phase (solid, liquid, gas) of the substance

- The internal energy of a system increases by:
  - **Doing work** on it
  - **Adding heat** to it
- The internal energy of a system decreases by:
  - **Losing heat** to its surroundings
  - **Changing phase** from a gas to liquid or liquid to solid

Examiner Tips and Tricks

Always remember internal energy is made up of both the kinetic and electrostatic potential energy of the particles in a substance.

Absolute Zero

- On the thermodynamic (Kelvin) temperature scale, absolute zero is defined as:

  The lowest temperature possible. Equal to 0 K or –273.15 °C

- It is not possible to have a temperature lower than 0 K
  - This means a temperature in Kelvin will **never** be a negative value
- Absolute zero is defined as:

  The temperature at which the molecules in a substance have zero kinetic energy

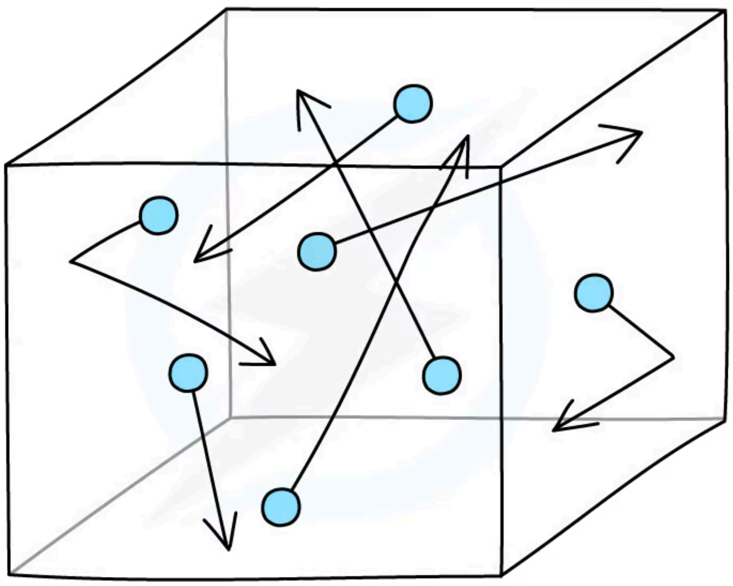
- This means for a system at 0 K, it is not possible to remove any more energy from it
- Even in space, the temperature is roughly 2.7 K, just above absolute zero

Internal Energy and Temperature

- When a substance is heated, its **internal energy** (sometimes referred to as thermal energy or heat) increases
- As a substance's internal energy increases, so will its temperature
  - **The higher the temperature of a substance, the more internal energy it possesses**

Your notes

Your notes



As the temperature of a substance is increased, the total energy of the molecules (the internal energy) increases

- Since temperature is a measure of the average kinetic energy of the molecules, only an **increase in the average kinetic energy of the molecules** will result in an **increase in temperature** of the substance
  - Due to thermal expansion, when the temperature of a substance increases, the potential energy of the molecules also increases
- Temperature and internal energy are **directly proportional** to each other
  - A decrease in temperature will result in a proportional decrease in internal energy

$$\Delta U \propto \Delta T$$

- Where:
  - ΔU = change in internal energy (J)
  - ΔT = change in temperature (K)

Worked Example

A student suggests that when an ideal gas is heated from 50 °C to 150 °C, the internal energy of the gas is trebled.

State and explain whether the student's suggestion is correct.

Answer:

Step 1: State the relationship between internal energy and temperature

- The internal energy of an ideal gas is directly proportional to its temperature, when the temperature is in Kelvin

$$\Delta U \propto \Delta T$$

Step 2: Determine whether the change in temperature is in Kelvin

$$50\ ^{o}C + 273.15 = 323.15\ K$$

$$150\ ^{o}C + 273.15 = 423.15\ K$$

Step 3: Calculate the ratio between the two temperatures

$$\frac{423.15}{323.15} = 1.3$$

Step 4: State a conclusion

- The temperature change, in Kelvin, does **not** treble
- Since $\Delta U \propto \Delta T$, the internal energy also does not treble
- Therefore, the student's conclusion is **incorrect**

Examiner Tips and Tricks

Remember that a change in internal energy does not necessarily correspond to a change in temperature.

- A change in the average kinetic energy of the molecules corresponds to a change in temperature
- A change in the average electrostatic potential energy of the molecules does not affect temperature

Internal Energy and Phase Change

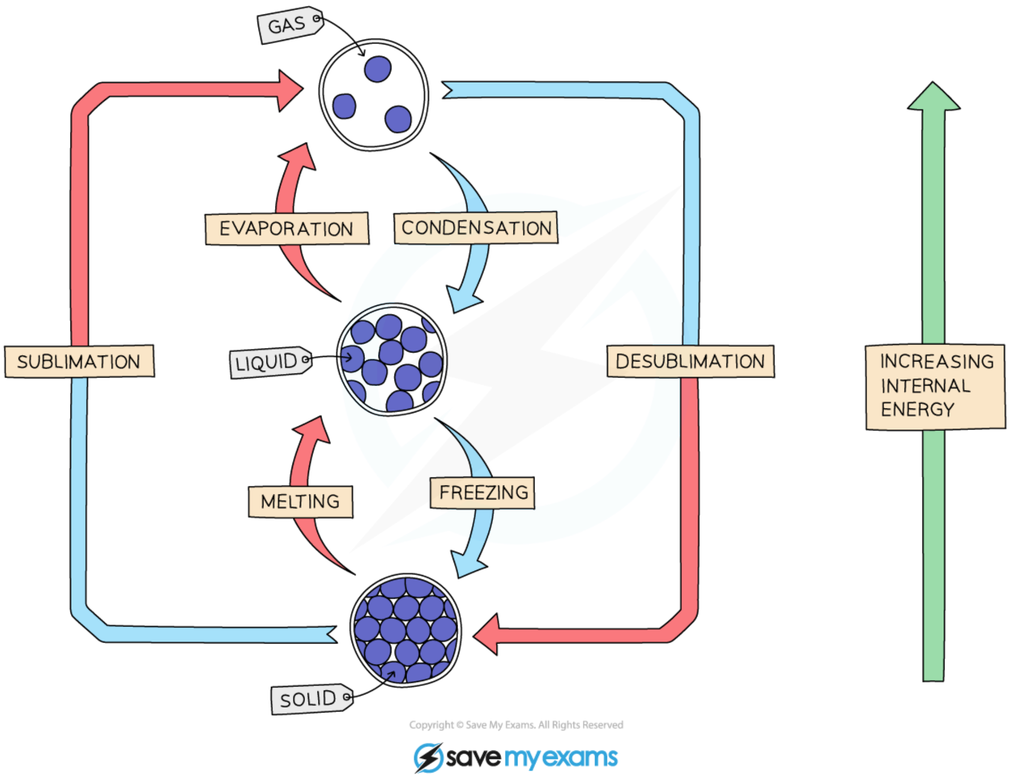
- A **phase change** is another way of saying a **change of state**
  - The states of matter are solid, liquid and gas

Your notes

- When a substance reaches a certain temperature, the kinetic energy of the molecules will stop increasing and the energy will go into increasing its electrostatic potential energy instead
- This breaks the bonds between the molecules, causing them to move further apart and
  - This leads to a **change of phase**
  - For example, liquid to gas
- When a substance changes its state from solid to liquid, or liquid to gas:
  - The **electrostatic potential energy** of the molecules **increases**,
  - The bonds between molecules break and the molecules move further apart
  - The **kinetic energy** remains the **same**, meaning that the **temperature** will remain the same, even though the substance is still being heated
- When a substance changes its state from gas to liquid, or liquid to solid:
  - The **electrostatic potential energy** of the molecules **decreases**,
  - Bonds form between molecules and the molecules move closer together
  - The **kinetic energy** remains the **same**, meaning that the **temperature** will remain the same, even though the substance is still being cooled

Your notes

Your notes



An increase in internal energy from heating can cause a change of state

Examiner Tips and Tricks

Remember that whilst a substance changes phase it does so at a constant temperature.

Specific Heat Capacity

Your notes

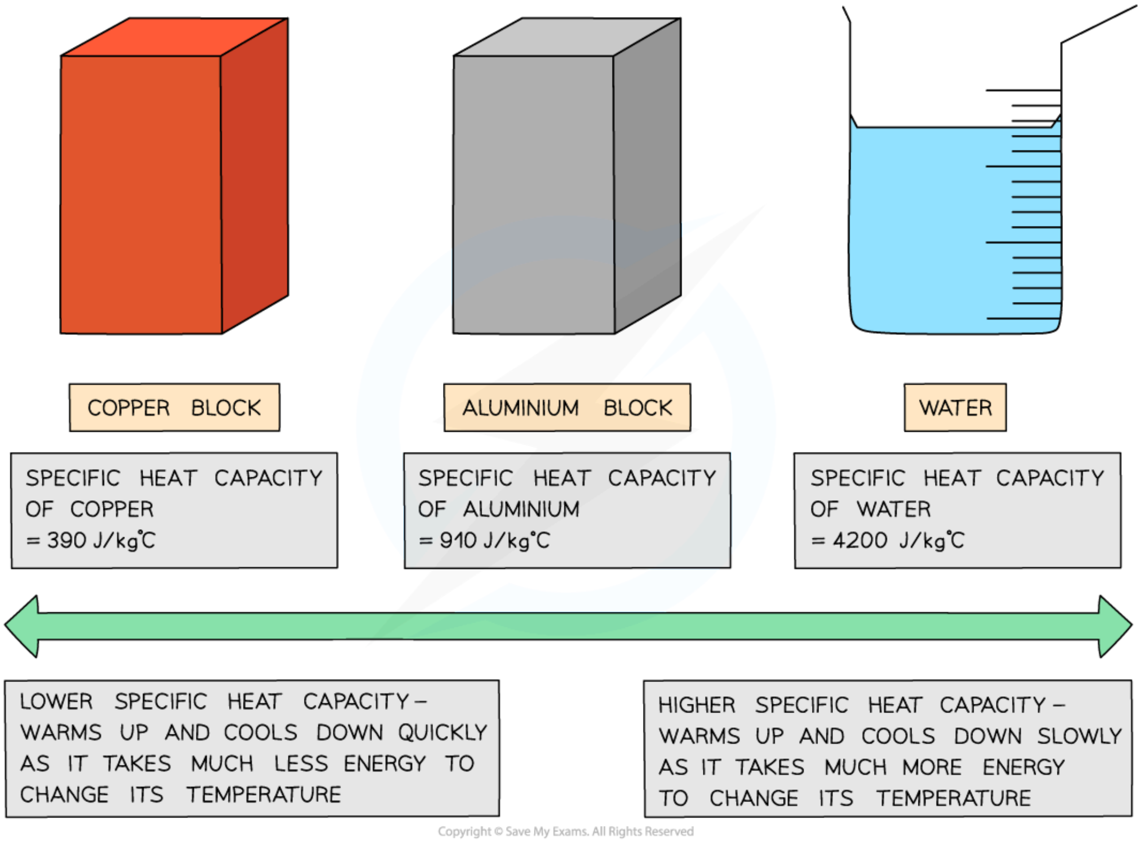
Specific Heat Capacity

- The specific heat capacity of a substance is defined as:

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

- This quantity determines the amount of energy needed to change the temperature of a substance
- The specific heat capacity is measured in units of **Joules per kilogram per Kelvin** (J kg^{-1} K^{-1}) or **Joules per kilogram per degree Celsius** (J kg^{-1} °C^{-1}) and has the symbol **c**
  - Different substances have different specific heat capacities
  - Specific heat capacity is mainly used when considering liquids and solids
- From the definition of specific heat capacity, it follows that:
  - The greater the mass of the material, the more thermal energy that will be required to raise its temperature
  - The greater the change in temperature, the higher the thermal energy required to achieve this change

Your notes



Low v high specific heat capacity

- If a substance has a **low** specific heat capacity, it heats up and cools down quickly
- If a substance has a **high** specific heat capacity, it heats up and cools down slowly
- The specific heat capacity of different substances determines how useful they would be for a specific purpose eg. choosing the best material for kitchen appliances

Table of values of specific heat capacity for various substances

Substance	Specific heat capacity / $J\,kg^{-1}K^{-1}$
Aluminium	910
Copper	390
Lead	126
Glass	500 – 680
Water	4200
Mercury	140

Your notes

- Good electrical conductors, such as copper and lead, have low specific heat capacities
  - This makes them excellent conductors of heat
  - It is due to their free electrons

Determining Specific Heat Capacity

- The amount of thermal energy Q needed to raise the temperature by $\Delta\theta$ for a mass m with specific heat capacity c is equal to:

$$E = mc\Delta\theta$$

- Where:
  - E = change in thermal energy (J)
  - m = mass of the substance (kg)
  - c = specific heat capacity of the substance ($J\,kg^{-1}K^{-1}$ or $J\,kg^{-1}\,°C^{-1}$)
  - $\Delta\theta$ = change in temperature (K or °C)

Your notes

Worked Example

A kettle has a power rating of 1.7 kW. A mass of 650 g of liquid at 25 °C is poured into the kettle.

When the kettle is switched on, it takes 3.5 minutes to start boiling.

Calculate the specific heat capacity of the liquid.

Answer:

Step 1: State the known quantities

- Power = 1.7 kW = 1.7×10^3 W
  - Time = 3.5 minutes = 3.5 × 60 s = 210 s
  - Mass, m = 650 g = 0.65 kg
  - Temperature change, Δθ = 100 – 25 = 75 °C

Step 2: State the equation linking energy, power and time

$$\text{Energy} = \text{Power} \times \text{Time}$$

Step 3: Calculate the energy supplied

$$\text{Energy} = 1.7 \times 10^3 \times 210 = 3.57 \times 10^5 \text{ J}$$

Step 4: State the thermal energy equation

$$E = mc\Delta\theta$$

Step 5: Rearrange to make specific heat capacity the subject

$$c = \frac{E}{m\Delta\theta}$$

Step 6: Substitute in values and state the final answer

$$c = \frac{3.57 \times 10^5}{0.65 \times 75} = 7300 \text{ J kg}^{-1}\,°\text{C}^{-1}$$

Examiner Tips and Tricks

The difference in temperature Δθ will be exactly the same whether the temperature is given in Celsius or Kelvin. Therefore, there is no need to convert between the two since the **difference** in temperature will be the same for both units.

Procedures to Determine Specific Heat Capacity

Your notes

- In these experiments the following equation is used to determine the specific heat capacity of the substance:

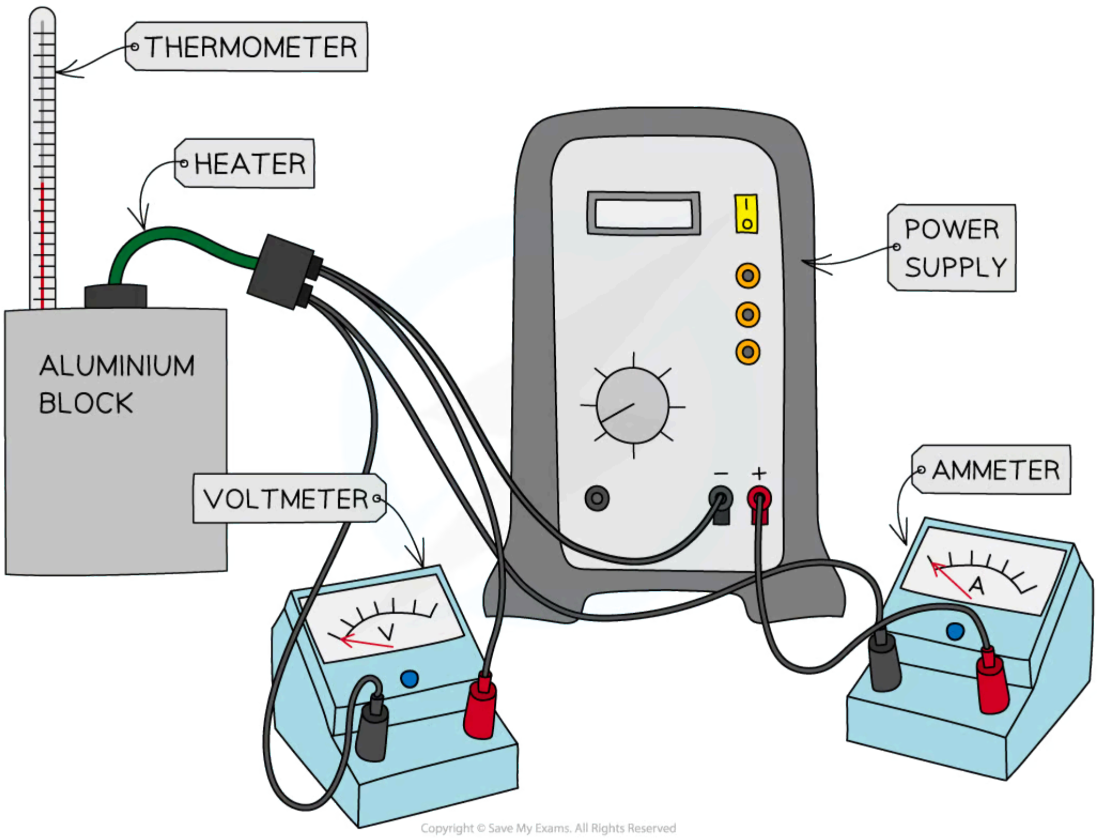
$$\text{SPECIFIC HEAT CAPACITY} = \frac{\text{HEAT SUPPLIED TO SUBSTANCE}}{\text{MASS} \times \text{CHANGE IN TEMPERATURE}}$$

Methods to Determine the Specific Heat Capacity of a Solid and a Liquid

Equipment List for a Solid:

- A block of the substance (preferably 1kg in mass)
- A thermometer
- An appropriate heater (e.g., an immersion heater)
- A power source
- A joule meter or a voltmeter, ammeter and stop-clock

Your notes



Apparatus to determine the specific heat capacity of a 1 kg Aluminium block

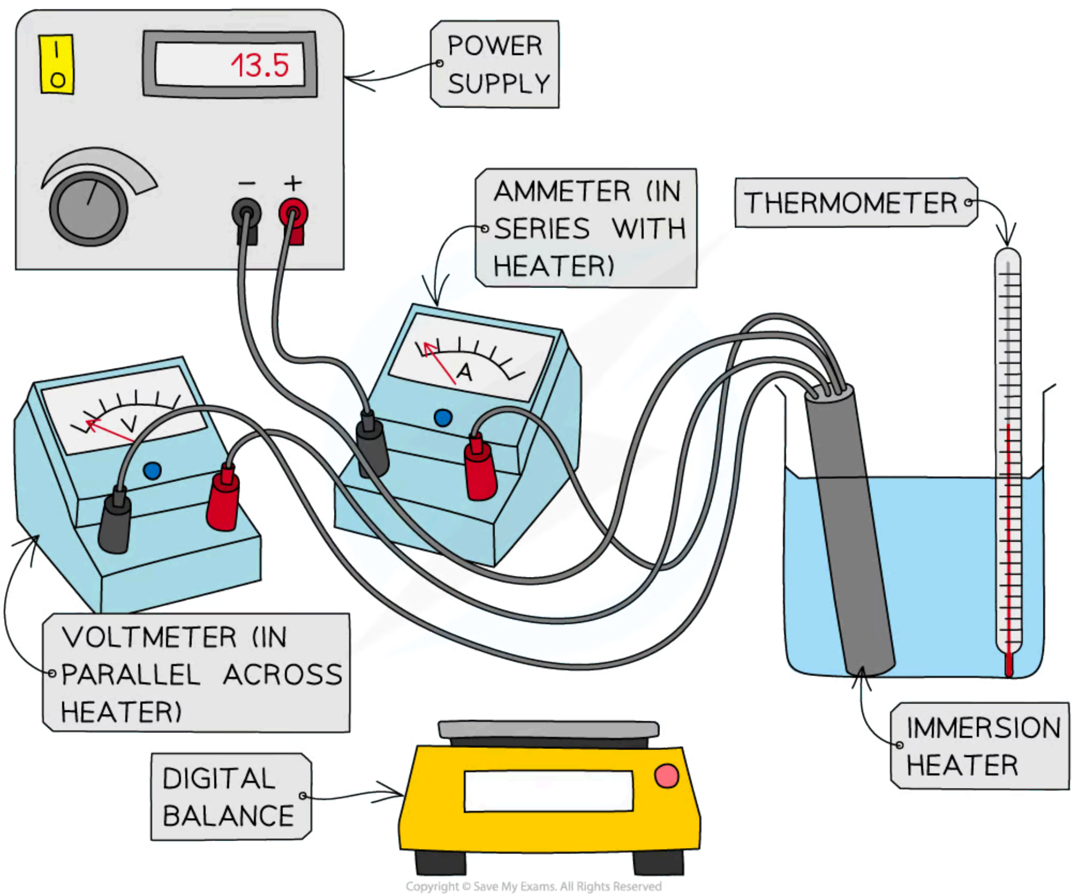
Method for a Solid

1. Assemble the apparatus as shown in the diagram above
2. Measure the initial temperature of the substance
   - Record the value
3. Turn on the power supply and start the stop-clock
4. Take readings of the voltage and current
   - Record these values
5. After 5 minutes (300 seconds) switch off the power supply, stop the stop-clock
6. Monitor the thermometer
   - Record the highest temperature reached

- This may be a few minutes after the power supply is switched off

Equipment List for a Liquid:

- A beaker of liquid (ideally containing 400 ml liquid)
- A thermometer
- An appropriate heater (e.g., an immersion heater)
- A power source
- A joule meter or a voltmeter, ammeter and stop-clock
- A digital balance



Apparatus to determine the specific heat capacity of 400 ml of water

Method for a Liquid

1. Assemble the apparatus as shown in the diagram above

Your notes

Your notes

2. Measure the mass of the liquid
   - Record the value
3. Measure the initial temperature of the substance
   - Record the value
4. Turn on the power supply and start the stop-clock
5. Take readings of the voltage and current
   - Record these values
6. After 10 minutes (600 seconds) switch off the power supply, stop the stop-clock
7. Monitor the thermometer
   - Record the highest temperature reached
   - This may be a few minutes after the power supply is switched off

Analysis of the Results

- Calculate the change in temperature
  - This is the final temperature minus the initial temperature
- The heat supplied to the substance can be calculated using the equation:

energy = current (A) × voltage (V) × time (s)

- The equation for specific heat capacity can be used to calculate specific heat capacity

$$E = mc\Delta\theta$$

- Where:
  - E = change in thermal energy (J)
  - m = mass of the substance (kg)
  - c = specific heat capacity of the substance (J $kg^{-1} K^{-1}$ or J kg^{-1} °C^{-1})
  - $\Delta\theta$ = change in temperature (K or °C)

Evaluation

- Not all of the heat supplied by the heater will go into the substance
  - Some heat will be lost to the surroundings
  - This means that the value for energy supplied will be too large

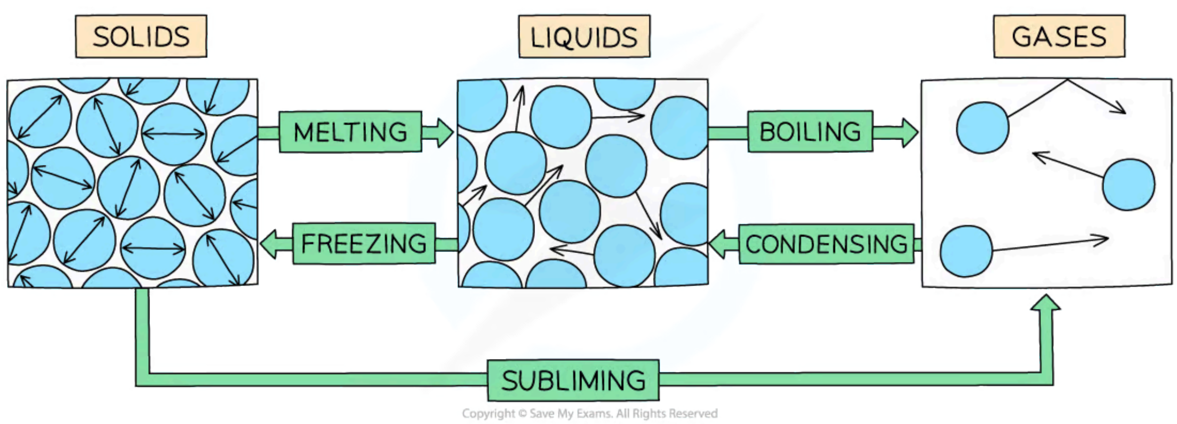
- This results in too high a value for specific heat capacity
- There may be fluctuations in the power supply
    - Take several periodic measurements of the voltage and current
    - Calculate an average of these values

Specific Latent Heat

Your notes

Specific Latent Heat of Fusion & Vaporisation

- Energy is required to change the **state** of substance
- Examples of changes of state are:
  - Melting = solid to liquid
  - Evaporation/vaporisation/boiling = liquid to gas
  - Sublimation = solid to gas
  - Freezing = liquid to solid
  - Condensation = gas to liquid



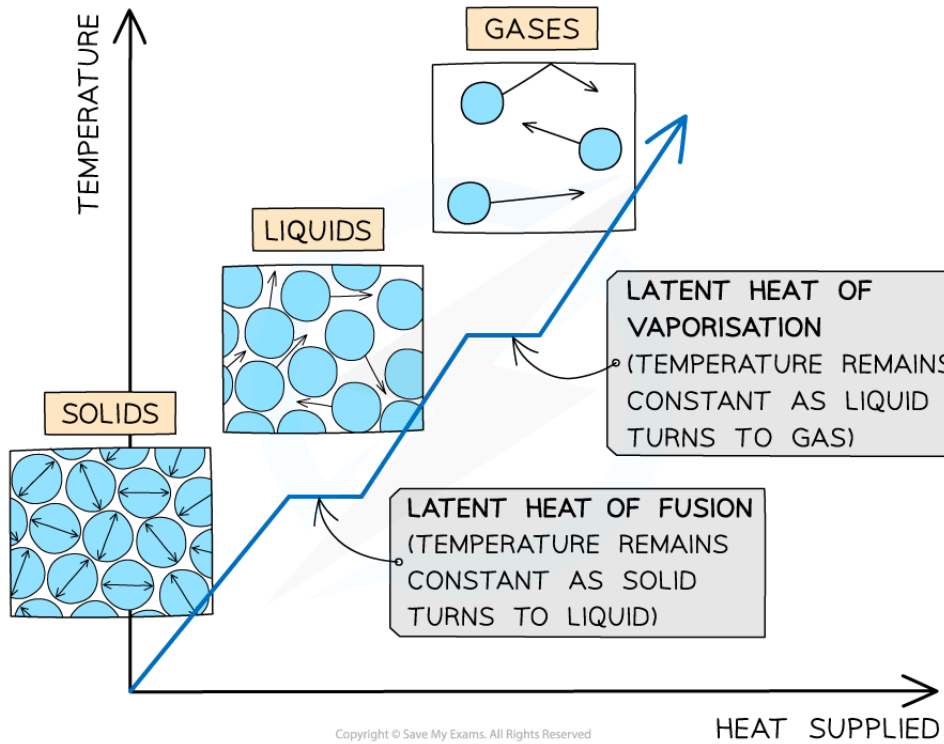
The example of changes of state between solids, liquids and gases

- When a substance changes state, there is **no temperature change**
- The energy supplied to change the state is called the **latent heat** and is defined as:

  The thermal energy required to change the state of 1 kg of mass of a substance without any change of temperature

- There are two types of latent heat:
  - Specific latent heat of **fusion** (melting)

- Specific latent heat of **vaporisation** (boiling)



The changes of state with heat supplied against temperature. There is no change in temperature during changes of state

- The specific latent heat of **fusion** is used when a solid is melting or a liquid is freezing
    - It is defined as:

    The thermal energy required to convert 1 kg of solid to liquid with no change in temperature

- The specific latent heat of **vaporisation** is used when a liquid is vapourising or a gas is condensing
    - It is defined as:

    The thermal energy required to convert 1 kg of liquid to gas with no change in temperature

Determining Specific Latent Heat

- The amount of energy *E* required to melt or vaporise a mass of *m* with latent heat *L* is:

$$E = mL$$

- Where:

Your notes

  - E = amount of thermal energy to change the state (J)
  - L = latent heat of fusion or vaporisation (J kg^{-1})
  - m = mass of the substance changing state (kg)
- **Specific latent heat of fusion** is represented by L_f
- **Specific latent heat of vaporisation** is represented by L_v
- The values of latent heat for water are:
  - Specific latent heat of fusion = 330 kJ kg^{-1}
  - Specific latent heat of vaporisation = 2.26 M J kg^{-1}
- Therefore, evaporating 1 kg of water requires roughly **seven times** more energy than melting the same amount of ice to form water
- The reason for this is to do with intermolecular forces:
  - **When ice melts**: energy is required to increase the molecular separation until they can flow freely over each other
  - **When water boils**: energy is required to completely separate the molecules until there are no longer forces of attraction between the molecules,
    - This requires much more energy

Worked Example

The energy needed to boil a mass of 530 g of a liquid is 0.6 MJ.

Calculate the specific latent heat of the liquid and state whether it is the latent heat of vaporisation or fusion.

Answer:

Step 1: State the known values

- Mass, m = 530 g = 0.53 kg
  - Energy supplied = 0.6 MJ = 0.6×10^6 J

Step 2: State the specific latent heat equation

$$E = mL$$

Step 3: Rearrange for latent heat

Your notes

$$L = \frac{E}{m}$$

Step 4: Substitute in the values

$$L = \frac{0.6 \times 10^6}{0.53} = 1.132 \times 10^6 \text{ J kg}^{-1} = 1.1 \text{ MJ kg}^{-1} \, (2 \, s.f.)$$

Step 5: State whether the value is the specific latent heat of vaporisation or fusion

- L is the **latent heat of vaporisation** because the change in state is from liquid to gas (boiling)

Examiner Tips and Tricks

Use these reminders to help you remember which type of latent heat is being referred to:

- Latent heat of fusion = imagine 'fusing' the liquid molecules together to become a solid
- Latent heat of vaporisation = "water vapour" is steam, so imagine vaporising the liquid molecules into a gas

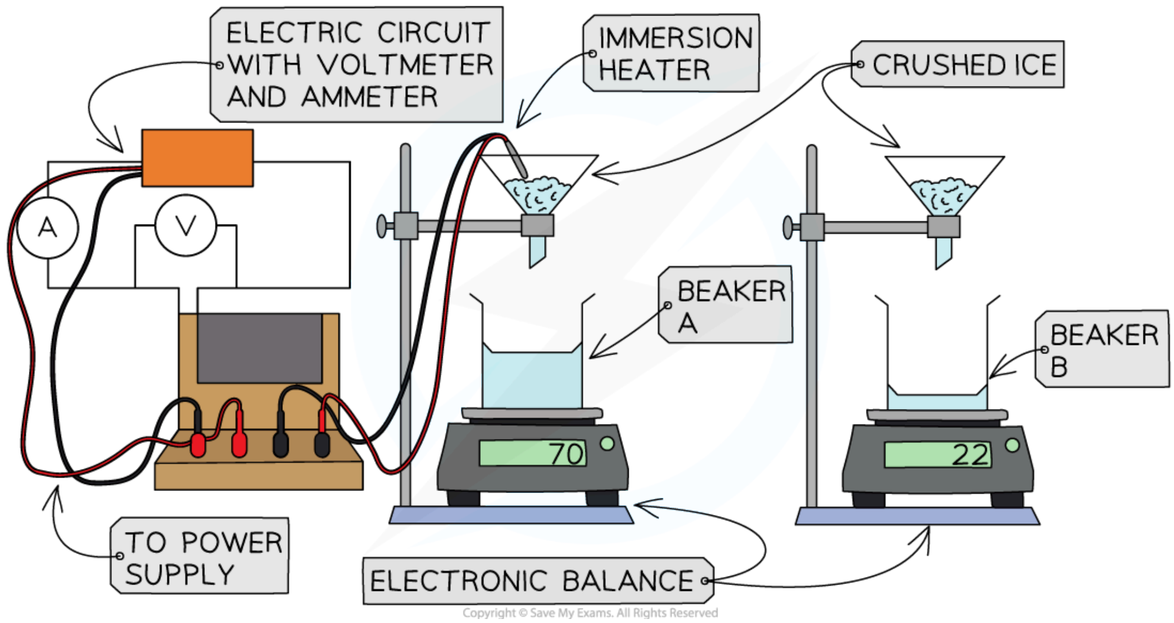
Procedures to Determine Specific Latent Heat

Determining the Specific Latent Heat of Fusion, L_f

Equipment List

- Crushed ice
- Two funnels with filter paper
- Three retort stands
- Two thermometers
- Two electric balances
- An appropriate heater (e.g., an immersion heater)
- A power source
- A voltmeter, ammeter and stop-clock

Method



- Place a beaker on each balance
  - Leaving the beaker on the balance, zero the scale
- Arrange a funnel, clamped above each beaker
- Set up an immersion heater
  - Connect to the power source
  - Add an ammeter in series and a voltmeter in parallel
- Place the immersion heater in one of the funnels
- Measure out 50–100g of ice
  - Add the same mass of ice to each beaker
  - Record this value
- Turn on the immersion heater and start the stop watch
- Record the potential difference and current
- After a suitable period of time (around 5–10 minutes) remove the funnels, stop the stop watch and turn off the heater
- Record the mass of water in the beaker

Your notes

Analysis

- The energy supplied to the ice can be calculated using the equation:

energy = current x potential difference x time

- Using the values for current, potential difference and time, calculate the energy supplied
- The specific latent heat of fusion can be calculated using the equation:

energy = mass x specific latent heat

- The change mass is equal to the mass of water collected
  - To take into account melting due to heat transfer from the surroundings find the difference in mass between the two beakers of water
  - This gives the change in mass due to the energy supplied by the heater
- Calculate the mass of the melted ice and convert it into kg
  - $\Delta m = m_A - m_B$
  - Mass in g ÷ 1000 = Mass in kg
- Calculate the specific latent heat of fusion of ice to water using the equation for specific latent heat

Evaluation

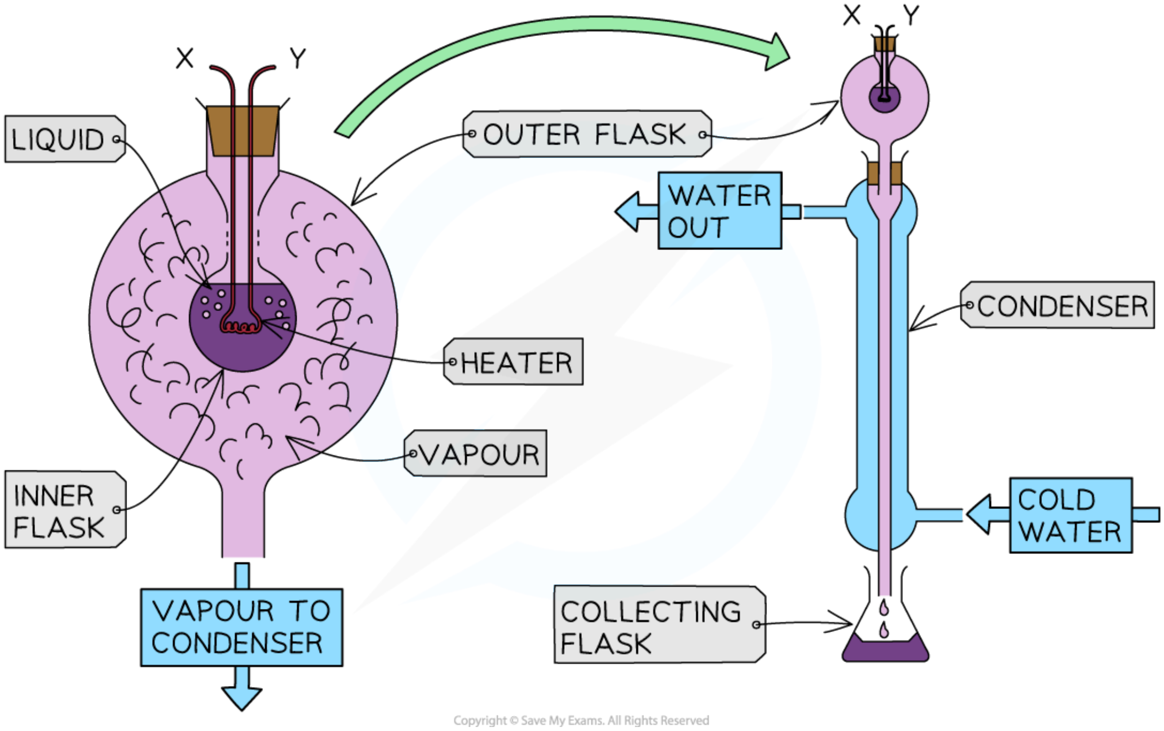
- Errors may be introduced due to precision of the instruments
- Water may be absorbed by the filter paper
  - This will reduce the mass and therefore give a higher value for specific latent heat

Determining the Specific Latent Heat of Vaporisation, L_V

Equipment List

- A double-walled glass vessel with an inner flask containing water
- An appropriate electric heater (e.g., an immersion heater)
- A condenser with a collecting flask
- A power source
- A voltmeter, ammeter and stop-clock
- An electric balance

Method



- Connect the double-walled glass vessel to the condenser
  - Place the collecting flask at the end of the condenser
- Set up an immersion heater
  - Connect to the power source
  - Add an ammeter in series and a voltmeter in parallel
- Place the immersion heater in the fluid
- Turn on the immersion heater and start the stop watch
- Record the potential difference and current
- After a suitable period of time (around 5–10 minutes), stop the stop watch and turn off the heater
- Record the mass of water collected in the conical flask

Analysis

- The energy supplied to the water can be calculated using the equation:

energy = current x potential difference x time

- Using the values for current, potential difference and time, calculate the energy supplied
- The specific latent heat of vaporisation can be calculated using
  - The mass of water collected
  - The energy supplied calculated
  - The equation:

energy = mass x specific latent heat

Evaluation

- Errors may be introduced due to precision of the instruments
- Not all of the vapour which enters the condenser may make it to the beaker

Your notes