P5 Heat and Particles Revision

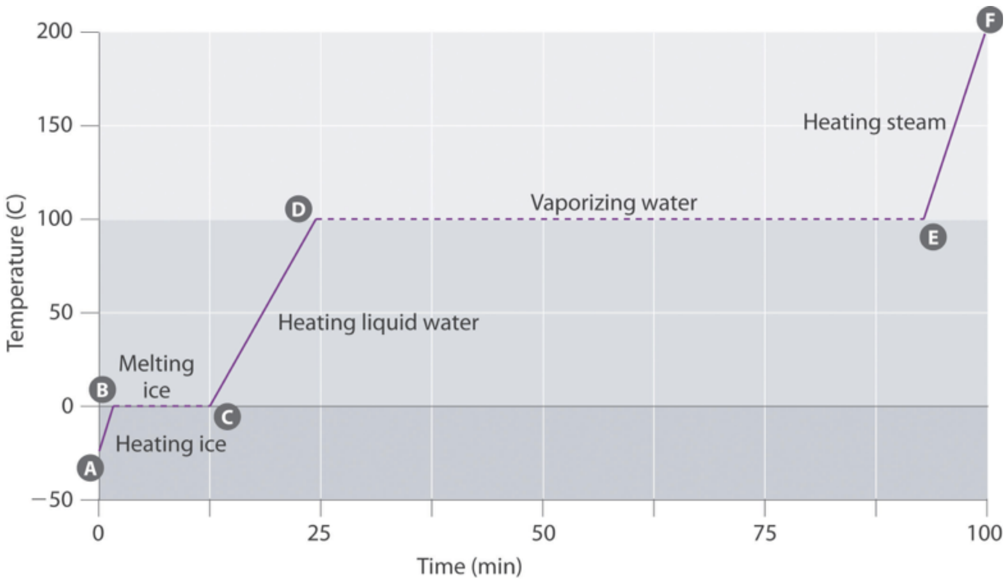
Kinetic Model of Matter:

States of matter

State	Size	Shape
Solid	occupies a fixed volume	has a fixed shape
Liquid	occupies a fixed volume	takes the shape of its container
Gas	expands to fill its container	takes the shape of its container

Changes of state

melting - from solid to liquid
boiling - from liquid to gas
condensing - from gas to liquid
freezing - from liquid to solid



(BBC bitesize)

take ice from the deep freeze and heat it at a steady rate:

- ice warms up to 0˚C, then remains the same while it melts
- ice floating in the water and the melted ice are both at 0˚C
- When all of the ice has melted, the water’s temperature starts to rise
- at 100˚C, the temperature remains steady. water is boiling to form steam
  - this takes longer than melting because it takes more energy to boil the water than to melt the ice.

heat the material more and eventually the particles have sufficient energy for all the attractive forces between particles to be overcome. And the material changes state.

temperature remains the same when changing states even though energy is being supplied

Arrangement of particles:

State	Arrangement of particles	Movement of particles
Solid	• packed closely together • particles in close contact with each other	• vibrate at a fixed position • when heat is added, they gain more energy to vibrate

Liquid	• packed less closely together • particles in close contact with most of its neighbors • more jumbled and disorderly	• move around within the liquid • both vibrating and moving from place to place
Gas	• widely separated • no longer in contact, unless they collide	• moving freely • bouncing off one another and off the walls of container

- Liquids take up the shape of their container, because their particles are free to move about within the bulk of the liquid
- Gases fill their container, because their particles can move freely about
- Solids retain their shape, because the particles are packed tightly together
- Gases diffuse from place to place, because the particles are freely mobile.
- Dissolved substances diffuse throughout a liquid. In higher temperature, the particles move faster and substances diffuse more quickly because of the kinetic energy gained from heat.
- Solids expand when they melt. The particles are slightly further apart in a liquid than in a solid.
- When molecules are no longer vibrating, we cannot cool matter down any further. This occurs at -273˚C. It is the absolute zero when no more energy can be extracted from molecules making up matter.

Forces and the kinetic theory:
intermolecular force of attraction: solid > liquid > gas

Factors that affect the rate of evaporation:
- higher temperature
- greater surface area
- moving air e.g. wind (particles are blown away quickly after they escape from water so that they cannot fall back into the water)

Gases and kinetic theory:
- When temperature increases, the particles move faster. They have more kinetic energy, therefore they collide with the walls more often, exerting a greater force, therefore the pressure increases.
- When the box is made smaller, the volume of gas decreases and its pressure increases. Because the gas particles have been squashed into a smaller volume. So they will collide with the walls of the container more frequently, creating an increased pressure.

Boyle's Law
- Doubling the pressure has the effect of halving the volume
- increasing pressure —> decreasing volume / pressure is inversely proportional to volume
- pressure x volume is constant
- initial pressure x initial volume = final pressure x final volume **($P_1V_1=P_2V_2$)**
- The volume of a fixed mass of gas is inversely proportional to its pressure, provided its temperature remains constant.

Thermal Properties of Matter:

temperature: a measure of the average kinetic energy of individual particles
internal energy: total energy of all of the particles
thermal equilibrium: when energy is not being transferred from one to the other

Thermal expansion:
The intermolecular forces in between the molecules become weaker since heat gives it energy to move around.

- rivets: hammered into the two holes in two metal plates, when it cools, it contracts and pulls the two plates together tightly
- bimetallic strip: bends as it gets hot. One metal expands more rapidly than the other. As the strip is heated, this metal expands rapidly, causing the strip to bend. The metal that expands more is on the outside of the curve. (used in thermostats and fire alarms)

Consequences:
- bridges and railway lines expand on hot days, they might buckle. This is why bridges are made in sections, with expansion joints between the sections so that when the bridge expands, the gaps between the sections decrease. Railway lines are made from a metal alloy that expands very little.
- glass containers may crack when hot liquid is placed in them

Expansion of gases:
- Gas particles in a cylinder
- when gas is heated, particles move faster and they push with greater force on the piston and push it upwards. (as temp increases, volume increases, pressure is constant)
- the pressure is constant because the upward force of the gas is balanced by the downward weight of the piston
- if the piston did not move, volume is constant when it is heated, pressure increases

Liquid expands faster than solids due to the weaker intermolecular forces, the particles are less packed, less energy is required to break the bond

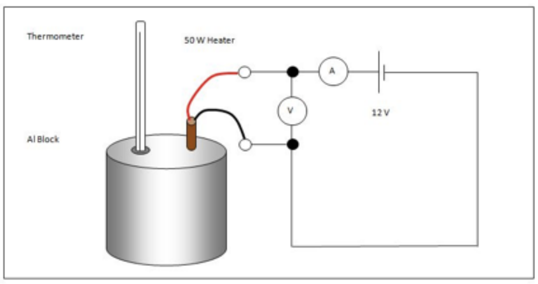
Real life example:
Power lines hang loose between poles
- wires are made up of copper which is a metal that conduct heat and electricity
- so they have delocalized electrons, when heat is applied, it provides energy to these electrons making them move out of their original shell thus expanding the atomic structure
- This overall expansion makes the entire wire expand to a certain extent (heat expansion in solids)
- When metal is cooled e.g. at night/winter, the atoms receive less or no energy from the sun making them go back to a more stable state —>contract to its initial or even smaller size
- wire undergoes expansion and contraction every day, if the wires were tightly held in the long run, they might get snapped due to the contraction it faces

similarly in railway tracks and roads

Thermal Capacity
- bricks have a high thermal capacity
- takes a lot of energy to raise their temperature by a certain amount
- heat up slowly and cool down slowly
- thermal capacity of an object depends on its material
- metal objects heat up easily —> low thermal capacity
- non-metals: glass, wood and plastics and liquids: water, oil have high thermal capacity

Specific heat capacity
- s.h.c. of a substance is the energy required to raise the temperature of 1kg of the substance by 1˚C.
- energy = mass x specific heat capacity x Δ temperature ($E=m \cdot c \cdot \Delta T$)
- J/(kg˚C) or J/kg/˚C

Measuring s.h.c:
- aluminum
- the 1kg aluminum block is heated by an electric



heater
- temperature is recorded at regular intervals
- block is covered in insulating material to reduce heat losses
- thermometer is inserted in the aluminum block to give readings
- graph shows as the temperature rises, more heat escapes to the surroundings and temperature rises more slowly

- weigh mass of aluminum block with a electronic balance
- set up a voltmeter parallel to the electric heater, since E=I•V•t
- set up an ammeter in series with the block
- time how long it takes for the aluminum's temperature to heat up and become stable
- work out the energy needed
- record the initial temperature (room temperature) and after, work out the difference to get ΔT
- $c = \frac{E}{m\Delta T}$
- result is too high because:
  - some energy is used in heating the heater itself rather than the block
  - heat escapes
  - it takes time for the heat to conduct through metal, thermometer only indicate the temperature of part of the block

<u>Latent heat</u>
The energy needed to change the state of a substance
The energy needed to change a liquid into a gas is called the latent heat of vaporization
The energy needed to change a solid into a liquid is called the latent heat of fusion
specific latent heat = energy supplied/mass

<u>Heat Transfer:</u>
- Conduction
- Convection
- Radiation

Thermal energy requires a temperature difference for the heat to be transferred
Conduction:
- in solid, liquid and gas
- Energy is transferred because of the vibrating atoms jostling on one another
- a flow of energy from hot end to cold end of the rod
- in metals, electrons move more freely, carrying electric and heat energy

Convection:
- only in liquid and guess
- when air is heated, density decreases since it expands, therefore it rises up
- convection current is the circulation of fluids
- energy is transferred through a material from a warmer place to a cooler place by the movement of the material itself.
- convection results from the expansion of a fluid when it is heated
- the particles in the hotter fluid have more kinetic energy

Radiation:
- does not require a medium/can travel through vacuum

The hotter an object, the more infrared radiation it gives out
infrared radiation
- produced by warm or hot objects
- a form of electromagnetic radiation
- travels through empty spaces (and air) in the forms of waves
- travels in straight lines

- warms the object that absorbs it
- is invisible to the naked eye
- can be detected by nerve cells in the skin
- dark and dull absorbs radiation, light and shiny reflects it (poor emitter AND absorber)

Consequences of heat transfer

- we may use a lot of energy to heat our homes during cold weather, and the energy simply escapes
- we eat food to supply energy we need to keep our bodies warm, but energy escapes from us at a very fast rate

Method	Why it works
thick curtains, draught excluders	stops convection currents, and so prevents cold air from entering and warm air from leaving
loft and underfloor insulating materials	prevents conduction of heat through floors and ceilings
double and triple glazing of windows	vacuum between glass panes cuts out losses by conduction and convection
city walls	reduces heat losses by conduction
foam or rock wool in wall cavity	further reduces heat losses by convection