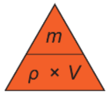
SP14-15: Particle model, Forces and Matter

1. Particles and density

State of matter	Solid, liquid or gas.
Physical change	A change in which no new substances are formed, such as changes of state.
Changes of state	Melting: solid → liquid Freezing: liquid → solid Evaporation: liquid → gas Condensation: gas → liquid Sublimation: solid → gas Deposition: gas → solid
Solid	Particles touching, neatly ordered, vibrating around a fixed point.
Liquid	Particles touching, random order, moving slowly.
Gas	Particles widely spaced, random order, moving fast.
Kinetic theory	The model that explains the properties of different states of matter in terms of the movement of particles.
Compress	To squash something together to make it shorter or smaller.
Conserved	A quantity that is kept the same throughout, for example a substance does not change mass when it changes state.
Changing state	Increasing temperature gives particles more (kinetic) energy, allowing them to break the forces of attraction.
Density	The mass of 1 m^3 of a substance. Units = kg / m^3 (but could be g / cm^3)
Density and state	Solid > liquid > gas, due to particles being closer together.

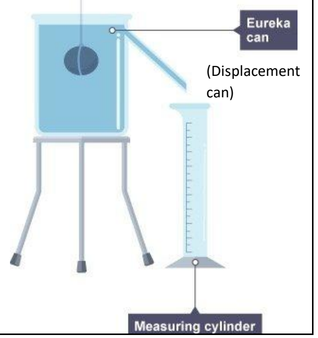
Density calculations	Density = mass / volume $\rho = m / v$  Density - kilograms per cubic metre (kg/m^3) Mass - kilograms (kg) Volume - metres cubed (m^3)

2. Core practical – Investigating densities

Core Practical - Aim	To measure the density of some solids and liquids
Core Practical – Density of liquids	Place a measuring cylinder on a balance and zero it. Add some liquid and record the mass and volume, Repeat with different liquids.

Core Practical – Density of solids

Record the mass of a solid object. Fill a displacement can and place the object in it, catching the water in a measuring cylinder. Record the volume collected.

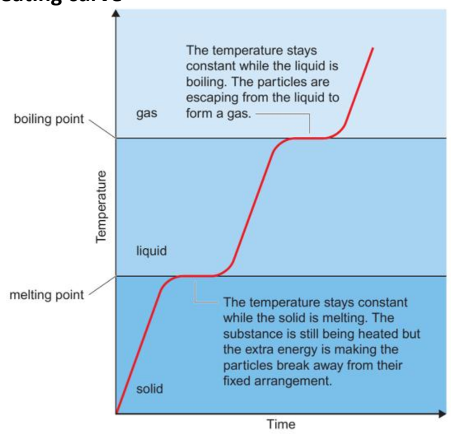


3. Energy and changes of state

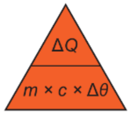
Thermal energy and motion	The hotter an object is, the faster its particles are moving (**more kinetic energy**).
Temperature	A measure of the average kinetic energy of the particles.
Temperature vs thermal energy	A very small hot object has less thermal energy than a very large cold object, because thermal energy is the energy of all the particles added up.
Thermal energy depends on…	Temperature, mass, material.

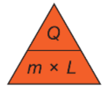
Specific heat capacity, Q	The amount of energy required to increase the temperature of 1 kg of a substance by 1 ^{o}C.
Specific latent heat of evaporation	The amount of energy required to change 1 kg of a substance (at its boiling point) from liquid to gas.
Specific latent heat of melting	The amount of energy required to change 1 kg of a substance (at its melting point) from solid to liquid.

Heating curve



4. Energy calculations

Temperature change calculations	Thermal energy change = mass x specific heat capacity x temperature change $\Delta Q = m \times c \times \Delta T$  Thermal energy change - joules (J) Mass - kilogram (kg) Specific heat capacity - joule per kilogram degrees Celsius (J/(kg ^{o}C)) Temp change - degrees Celsius (^{o}C)

State change calculations	Thermal energy = mass x specific latent heat $Q = m \times L$  Thermal energy – joules (J) Mass – kilogram (kg) Specific latent heat - joule per kilogram (J/kg)

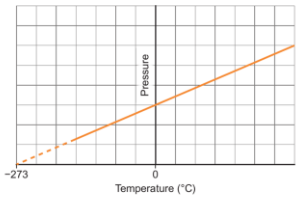
5. Core practical – Investigating water

Core Practical - Aim	To investigate the temperature change as ice melts, and measure specific heat capacity of water.
Core Practical – Melting ice	Place some ice in a boiling tube, measure the temperature then place the tube in a beaker of hot water from a kettle, kept warm by Bunsen, and measure temperature every 60s until fully melted.
Core Practical – Melting ice results	Temperature rises steadily at first but levels out during melting.
Core Practical – finding the specific heat capacity	Place a polystyrene cup on a balance, zero it, mostly fill with water then measure the mass. Measure the temp. Use an immersion heater connected to a Joulemeter to warm the water for 5 minutes and measure the temperature again.
Core Practical - problems	Heat energy moves! Use **insulation** and **lids** to stop this happening

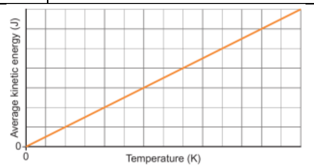
6. Gas temperature and pressure

Gas pressure	Every time a gas particle hits a surface it pushes with a small force; gas pressure is the sum of these forces.
Pressure	The force on a certain area. It is measured in pascals or N/m^2.
Increasing gas pressure	- increase the number of particles - increase the temperature of the gas - decrease the volume of the gas

Increasing temp increases gas pressure	Temp ↑ = particle speed ↑. particle speed ↑= more collisions particle speed ↑= harder collisions so gas pressure ↑
Pascals, Pa	The unit of pressure: 1 Pa = 1 N/m^2
Absolute zero, 0 K	The coldest possible temperature at which the pressure of a gas drops to zero and the particles stop moving. It is −273 °C or 0 K.
Kelvins	Measures temperatures relative to absolute zero: 0 K = absolute zero.
Kelvins and degrees Celsius	A kelvin is the same size as a degree Celsius, but 0 K = -273^{O}C, 273 K = 0 ^{O}C
Converting K to ^{O}C	subtract 273 (add 273 to go ^{o}C to K)
Gas pressure and temp	Gas pressure is directly proportional to temperature in K.

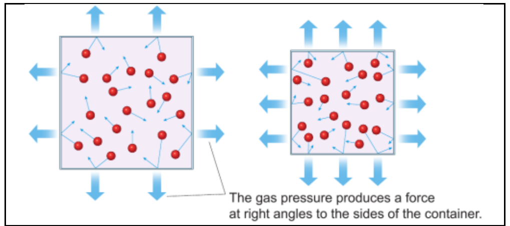


Average kinetic energy and temperature	Average kinetic energy is directly proportional to temperature in K.



7. Gas pressure and volume

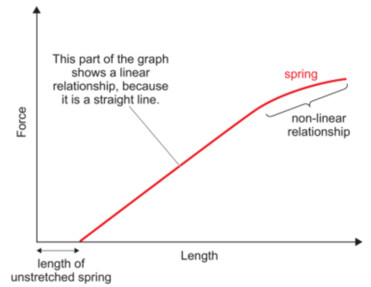
Pressure and volume	Reducing volume (squeezing) increases pressure. Increasing volume reduces pressure.
Pressure volume explanation	Volume ↓ Collisions with side of container ↑ Pressure ↑



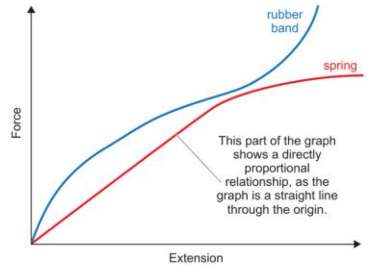
PV calculations	$p_1 \times V_1 = p_2 \times V_2$ p_1 = pressure at start (Pa) V_1 = volume at start (m^3) P_2 = pressure at end (Pa) V_2 = volume at end (m^3)
Work done	A measure of the energy transferred when a force acts through a distance.
Bicycle pump (HT)	A force moves through a distance So work is done So energy is transferred to heat So the pump gets hotter

8. Bending and stretching

Elastic distortion	When something returns to its original shape after force is applied.
Elastic	An elastic material changes shape when there is a force on it but returns to its original shape when the force is removed.
Inelastic distortion	An inelastic material changes shape when there is a force on it but does not return to its original shape when the force is removed.
Extension	The amount by which a spring or other stretchy material has stretched. It is worked out from the stretched length minus the original length.
Direct proportion	Doubling A doubles B, a graph of B vs A **straight line through the origin**.
Metal spring force vs extension	**DIRECTLY PROPORTIONAL** while it is **ELASTIC** Until high forces when **NON-LINEAR**

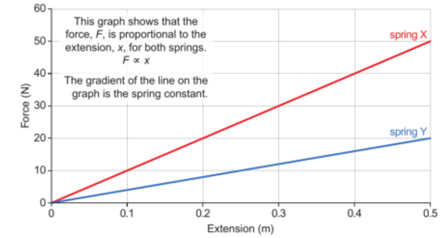


Linear relationship	A relationship between two variables shown by a straight line on a graph. For a linear relationship the line does not have to go through the origin.
Non-linear relationship	A relationship between two variables that does not produce a straight line on a graph.
Rubber band Force vs extension	**NON-LINEAR**

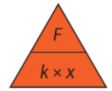


9. Extensions and energy transfers

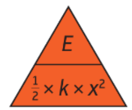
Spring constant	A measure of the strength of a spring: unit - newton per metre (N/m)
Spring constant and graphs	The spring constant is the gradient of a graph of force vs extension.



Force and extension calculations	Force = spring constant x extension F = k × X Force – newtons (N) Spring constant – newton per metre (N/m) Extension – metres (m)



Extension is greater when…	Force is higher, spring constant is lower
Work done	The energy transferred by a force.
Spring energy calculations	Energy transferred in stretching = ½ x spring constant x extension^2 E = ½ x k x X^2 Energy - joules (J) Spring constant – newton per metre (N/m) Extension – metres (m)



10. Core practical – Investigating springs

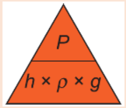
Core Practical - Aim	To explore how increasing the force affects the extension of a spring.
Core Practical - Setup	Suspend a spring or rubber band from a clamp stand and fix a metre ruler in place so the ‘0’ is level with the bottom of the spring/band.
Core Practical – Measurements	Hang a 100 g (1 N) mass from the rubber band / spring, and measure the extensions. Repeat up to 1 kg.

Core Practical - Variations	Repeat with different springs or wires or other materials
Core Practical - Calculations	Calculate spring constant as: Spring constant = force / extension

11. Pressure in Fluids

Atmospheric pressure pattern	The pressure exerted by the weight of the air around us. High at sea level, low further up because less weight of air pushing down (as in any fluid).
Pressure in fluids	Pressure from fluid + pressure from air
Force from pressure	Acts 'normal' (90^o) to any surface in the fluid
Pressure Calculation	Pressure = Force/Area p = F / A  Pressure – pascals (Pa) or newton per metre squared (N/m^2) Force – newtons (N) Area – metres squared (m^2)
Factors affecting fluid pressure	• Depth • Fluid density … because these change the **weight** of fluid above
Pressure examples	- snow shoe big area to reduce pressure and stop sinking - pin, decrease area, increase pressure - submarine, thick walls to cope with increased pressure

12. Pressure and upthrust (higher only)

Pressure at different depths calculation	Pressure = density × gravity × height $p = \rho \times g \times h$  p – pascals (Pa) or newton per metre squared (N/m^2) ρ - kilogram per metre cubed (kg/m^3) g – newton per kilogram (N/kg), 10 N/kg (Earth) h - metres (m)
Upthrust	- experienced by an object when partly or fully submerged - equal to the weight of the fluid displaced A force that pushes things up in liquids and gases.
Object Floats	When upthrust equals weight. Density of object is less than fluid
Object Sinks	When upthrust is smaller than weight. Density of object is greater than fluid
Displace	To push out of the way.

Lesson	Memorised?
1. Particles and density	
2. Core practical – Investigating densities	
3. Energy and changes of state	
4. Energy calculations	
5. Core practical – Investigating water	
6. Gas temperature and pressure	
7. Gas pressure and volume	
8. Bending and stretching	
9. Extensions and energy transfers	
10. Core practical – Investigating springs	
11. Pressure in fluids	
12. Pressure and upthrust (higher only)	