Triple Science - Physics

SP14-15 Knowledge organiser

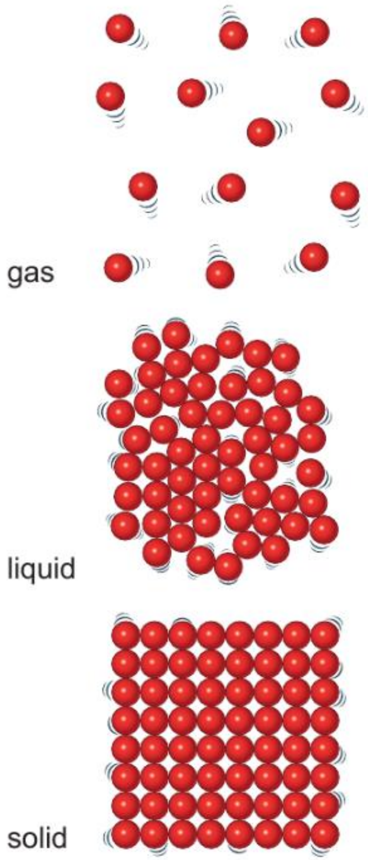
P14-15: Particle model, forces and matter

Lesson sequence

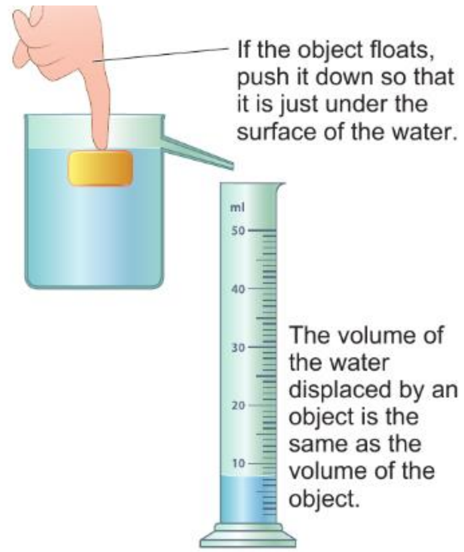
1. Particles and density
2. Core practical – investigating densities
3. Energy and state changes
4. Energy calculations
5. Core practical – investigating water
6. Gas temperature and pressure
7. Gas pressure and volume
8. Bending and stretching
9. Extension and energy transfers
10. Core practical – investigating springs
11. Pressure in fluids
12. Pressure and upthrust

1. Particles and density	
State of matter	Solid, liquid or gas.
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.
Forces of attraction	Forces holding particles close to each other: strong in solids, weak in liquids, gone in gases.

Changing state	Increasing temperature gives particles more (kinetic) energy, allowing them to break the forces of attraction.
Density	The mass of 1 cm^3 of a substance. Units = kg / m^3
Density and state	Solid > liquid > gas, due to particles being closer together.
Density calculations	Density = mass / volume ρ = m / v Density = kilograms per cubic metre Mass = kilograms Volume = metres cubed

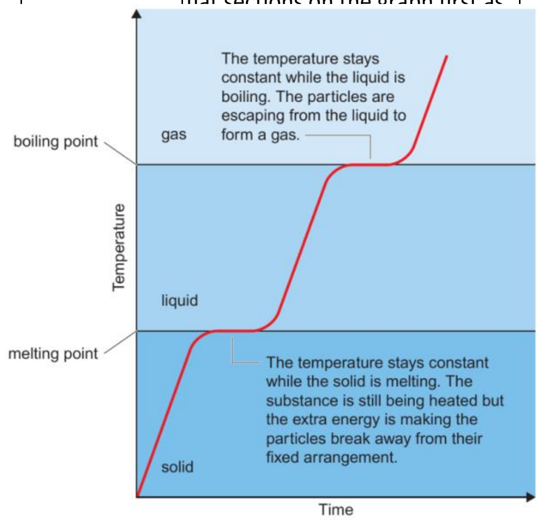


2. Core practical – investigating densities	
Aim	To measure the density of some solids and liquids
Density of liquids	Place a measuring cylinder on a balance and zero it. Add some liquid and record the mass and volume, Repeat with different liquids.
Density of solids	Record the mass of a solid object. Fill a displacement can and place the object in it, catching the water in a measuring cylinder. Record the volume collected.
Density calculations	Divide the mass by the volume.



3. Energy and changes of state	
Thermal energy and motion	The hotter an object is, the faster its particles are moving.
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 ºC.
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	As you heat a substance, the temperature rises steadily, with flat sections on the graph first as



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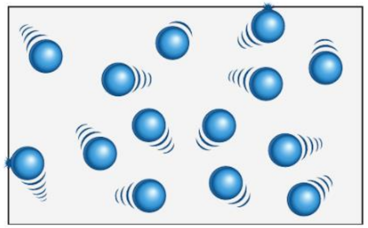
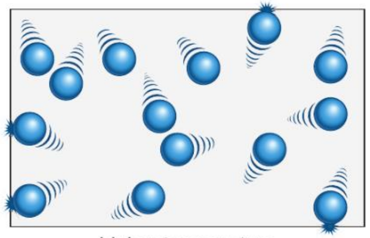
4. Energy calculations	
Temperature change calculations	Thermal energy change = mass x specific heat capacity x temperature change ΔQ = m x c x ΔT Thermal energy change = J Mass = kg Specific heat capacity = J / kg Temp change = ^{O}C
State change calculations	Thermal energy = mass x specific latent heat Q = m x L Thermal energy = J Mass = kg Specific latent heat = J / kg

5. Core practical – investigating water	
Aim	To investigate the temperature change as ice melts, and measure specific heat capacity of water.
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.
Melting ice results	Temperature rises steadily at first but levels out during melting.
SHC	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.
SHC calculations	SHC = energy used / (mass x temp change)



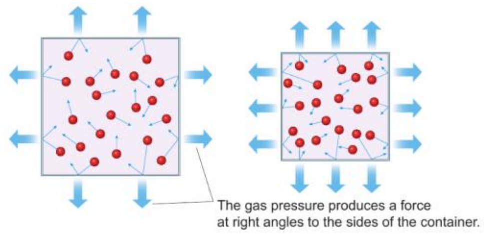
lower temperature



higher temperature

6. Gas temperature and pressure	
Temperature	A measure of the average kinetic energy of the particles.
Gas pressure	Every time a gas particle hits a surface it pushes with a small force; gas pressure is the sum of these forces.
Increasing gas pressure	Gas pressure increases with temperature and number of particles.
Pascals, Pa	The unit of pressure: 1 Pa = 1 N / m^2
Absolute zero, 0K	The coldest possible temperature when particles completely stop moving.
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

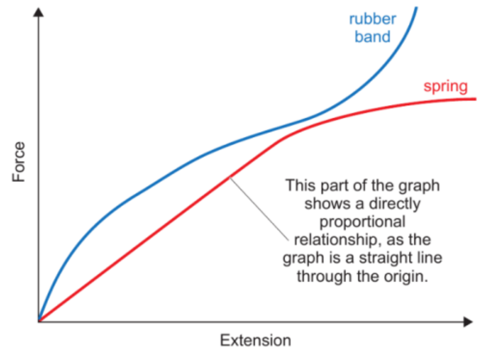
Converting K to ^{O}C	Subtract 273
Converting ^{O}C to K	Add 273
Gas pressure and Kelvins	Gas pressure is directly proportional to temperature in K.
Absolute zero and gas pressure	Pressure is 0 Pa at 0 K because the particles are not moving.



7. Gas pressure and volume	
Work done	The energy transferred by a force.
Calculating wok doe	Work done = force x distance E = F x d Work done = joules Force = newtons Distance = metres
Volume	**Volume** is the quantity of three-dimensional space enclosed by a closed surface

8. Bending and stretching	
Elastic	When something returns to its original shape after force is applied.
Inelastic	When something doesn't return to its original shape after force is applied.
Elasticity and force size	Some objects are elastic when a small force is applied, but inelastic when a large force is applied.
Extension	The increase in length of a spring when a force is applied.

Direct proportion	Doubling A doubles B, a graph of B vs A goes through the origin.
Metal spring extension	The relationship between force and extension is linear and directly proportional, but becomes non-linear with large forces.
Rubber band extension	The relationship between force and extension is non-linear.



9. Extensions and energy transfers	
Spring constant	A measure of the strength of a spring: units = N/m
Spring constant and graphs	The spring constant is the gradient of a graph of force vs extension.
Force extension calculations	Force = spring constant x extension F = k x X Force = N Spring constant = N/m Extension = m
Extension is greater when…	Force is higher, spring constant is lower
Work done	The energy transferred by a force.

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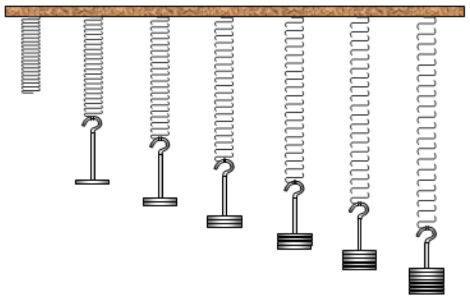
Spring energy calculations	Energy transferred in stretching = ½ x spring constant x extension^2 E = ½ x k x X^2 Energy = J Spring constant = N / m Extension = m

10. Core practical – investigating springs	
Aim	To explore how increasing the force affects the extension of a spring.
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.
Measurements	Hang a 100 g (1 N) mass from the rubber band / spring, and measure the extensions. Repeat up to 1 kg.
Variations	Repeat with different springs.
Calculations	Calculate spring constant as: Spring constant = force / extension



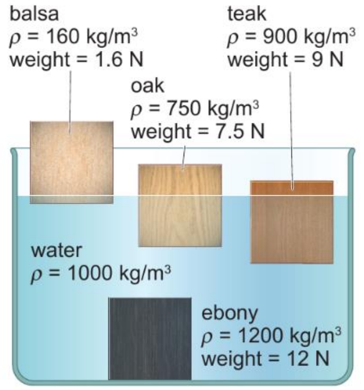
11. Pressure in fluids

Fluids	A fluid is a substance that continually deforms (flows) under an applied shear stress, or external force.
Pressure	Pressure is a measure of the force on a unit of surface areas, where the force is normal to the surface. Pressure, force and area are relayed by this equation: $\text{pressure (Pa)} = \frac{\text{force normal to the surface (N)}}{\text{area of surface (m}^2\text{)}}$
Normal	A line at right angles to a given line or surface.
Atmospheric pressure	The pressure exerted by the weight of the atmosphere, which at sea level is about 100,000Pa
Density	The degree of compactness of a substance.

atmospheric pressure	100 000 Pa
density of sea water	1030 kg/m^3
density of fresh water	1000 kg/m^3
gravitational field strength	10 N/kg

12. Pressure and upthrust	
Pressure in liquids	The pressure at any point in a fluid depends on the wight of the fluid above. pressure due to a column of liquid (Pa) = height of column (m) × density of liquid (kg/m³) × gravitational field strength (N/kg) $P = h \times \rho \times g$
Upthrust	The upward force that a liquid or gas exerts on a body floating in it.
Displaced	s an object's change in position, only measuring from its starting position to the final position.

Pressure difference	A manometer measures the pressure acting on a column of fluid. It is made from a U-shaped tube of liquid in which the difference in pressure acting on the two straight sections of the tube causes the liquid to reach different heights in the two arms.



Worked example

Look at photo D. There is an average of 0.75 m depth between the top and bottom surfaces of the shark.

a Calculate the difference in pressure between the top and bottom surfaces.

pressure difference = depth difference × ρ × g

= 0.75 m × 1030 kg/m^3 × 10 N/kg

= 7725 N/m^2

b This pressure difference will produce a net upthrust. Calculate the size of this force. The horizontal area of the bottom of the shark is 8 m^2.

force = pressure difference × area = 7725 N/m^2 × 8 m^2 = 61 800 N