Physics 3: Particle Theory of Matter

Key Word	Definition
changes of state	melting, freezing (solidifying), sublimating, evaporating or condensing
condensing	turning from a gas to a liquid
density	The mass of a material divided by its volume - Units kg/m^3.
eureka can	a can used to find the volume of water displaced by an irregular object
Evaporating / vaporisation	Turning from a liquid to a gas
freezing	turning from a liquid to a solid
internal energy	the energy stored by the particles that make up a material
melting	turning from a solid to a liquid
physical change	a change of state that is reversible
solidifying	turning from a liquid to a solid
specific heat capacity	the energy needed to increase the temperature of 1 kg of a substance by 1°C. Units J/kg°C.
specific latent heat	the energy needed to change the state of 1 kg of a substance without changing its temperature. Units J/kg.
state	solid, liquid or gas
sublimating	turning from a solid straight to a gas without melting

Section 2: Equations to learn

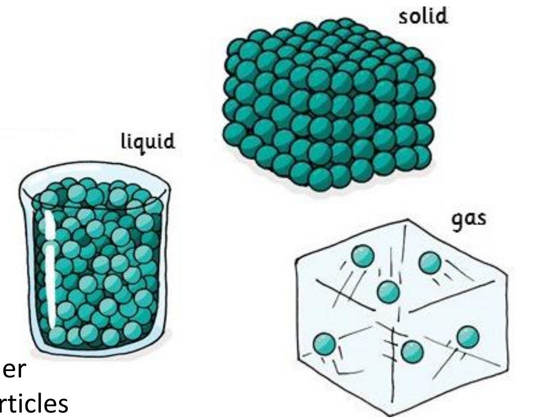
Calculation	Equation	Symbol equation	Units
density	density = mass ÷ volume	$\rho = m \div V$	kg/m^3
volume	volume = mass ÷ density	$V = m \div \rho$	m^3
mass	mass = density x volume	$m = V \times \rho$	kg
energy needed to change state	energy = mass x specific latent heat	$E = m \times L$	J
mass	mass = energy ÷ specific latent heat	$m = E \div L$	kg
specific latent heat	specific latent heat = energy ÷ mass	$L = E \div m$	J/kg
energy needed to heat up a substance	energy = mass x specific heat capacity x temperature change	$E = m \times c \times \Delta\theta$	J
mass	mass = energy ÷ (specific heat capacity x temp. change)	$m = E \div (c \times \Delta\theta)$	kg
temperature change	temperature change = energy ÷ (mass x specific heat capacity)	$\Delta\theta = E \div (m \times c)$	°C
specific heat capacity	specific heat capacity = energy ÷ (mass x temperature change)	$c = E \div (m \times \Delta\theta)$	J/kg°C

Section 3: States of Matter

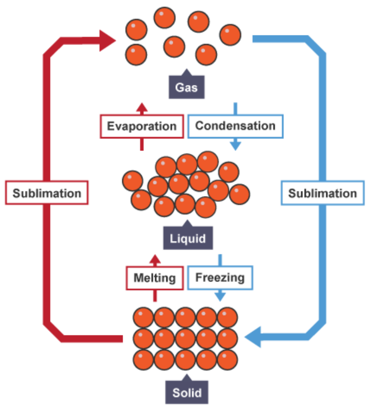
SOLIDS –
- Strong forces of attraction between particles.
- Particles vibrate around fixed positions.
- Can't be compressed because particles are very close together

LIQUIDS –
- Particles not in fixed positions, they can slip past each other hence a liquid takes the shape of the bottom of its container.
- Can't be compressed because particles are very close together

GASES –
- Very weak forces between particles
- Particles free to move randomly hence spread out to fill container
- Can be compressed because there are large spaces between particles

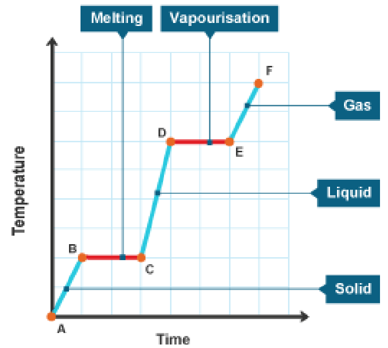


Section 4: changes of state



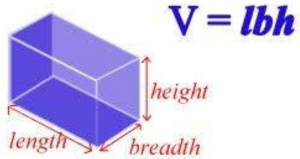
To change the state of a substance, you have to supply energy to increase the internal energy of the substance enough that you overcome the forces between particles. Changes of state happen at a constant temperature because the energy goes into breaking the "intermolecular bonds" between particles. The specific latent heat is the amount of energy you must supply to each 1kg of material to change its state.

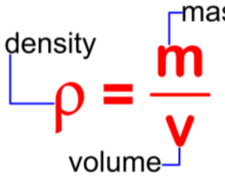
Energy = mass x specific latent heat

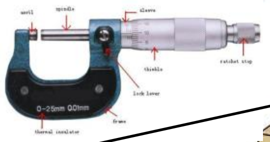


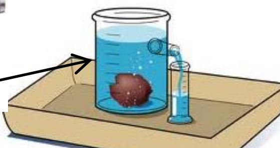
Section 5: Measuring density

To measure density, you must find the mass of the object using a top-pan balance, and find its volume. For a regular object e.g. a cuboid, measure the length, breadth and height using a ruler (resolution 1mm) or a Vernier caliper (resolution 0.1mm) or micrometer (resolution 0.01mm).









For an irregular (weird shape) object, use displacement: fill a eureka can with water, drop in the object and use a measuring cylinder to measure the volume of water displaced.

Section 6: Particle explanation of gas pressure

Particles are in constant random motion and AVERAGE particle kinetic energy depends on temperature. When particles collide with the container walls, they exert a force on the container. Pressure is force divided by area, so all the forces due to collisions of particles against the container walls causes pressure.

If you heat up a fixed mass of gas (same number of particles) gas inside a fixed volume container, its particles move faster (greater average kinetic energy) so they exert a larger force and the pressure increases.

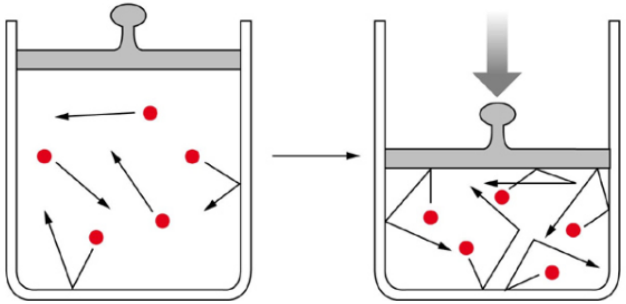
If you reduce the volume of a gas but keep the temperature the same, the container is smaller so the particles don't have to travel as far between collisions with the container walls. There are more collisions per second so the force on the container walls increases, and the pressure increases.

Another way of explaining this is that the volume of the container is smaller, the area of the inside is smaller too so Force/Area gives a larger answer for pressure.

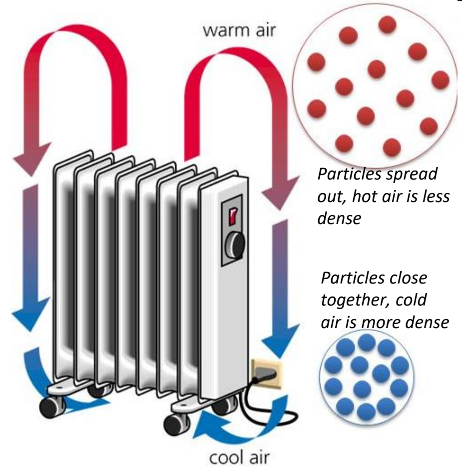
Pressure x volume = constant

This formula works for a constant mass of gas at a constant temperature. You might see it written as:

$$P_1V_1 = P_2V_2$$



Section 7: Particle explanation of convection



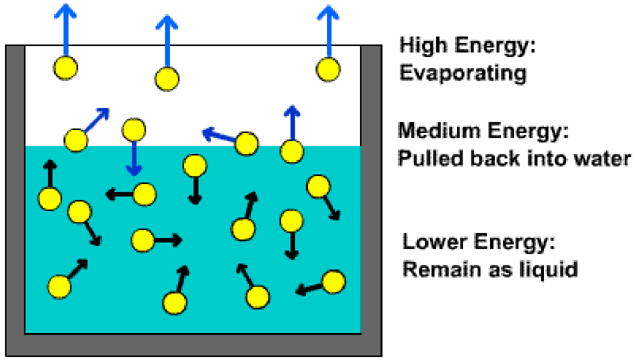
EXAM TIP: Make it REALLY clear when you are talking about particles and when you are talking about the fluid (gas or liquid) as a whole.

The particles do NOT get less dense, the gas does!

Gas heats up, particles average kinetic energy increases and particles spread out. This makes the density of the fluid (gas or liquid) less, so hot, less dense fluid rises and cold, more dense fluid sinks.

Section 8: Particle explanation of evaporation

The particles in a liquid have a **range** of kinetic energy. The particles with the **most energy** have enough kinetic energy to **leave the surface** of the liquid. This means that the **AVERAGE** kinetic energy of the particles that are still in the liquid decreases. Temperature depends on the average kinetic energy of the particles. This is why sweat cools your skin.



Test your knowledge

The barrel of a bicycle pump contains 100cm^3 of air at a pressure of 100kPa. The pump is sealed and compressed to a volume of 25cm^3 . Calculate the new pressure of the gas.

You drop some nail-polish remover on your hand. Explain why it makes your hand feel cold.

The specific latent heat of fusion (melting) of ice is 334 **kJ/kg**.

(a) How much energy would need to be supplied to melt 10kg of ice?

(b) Describe how the temperature of the ice behaves while it melts.

(c) What happens to the energy supplied to the ice?