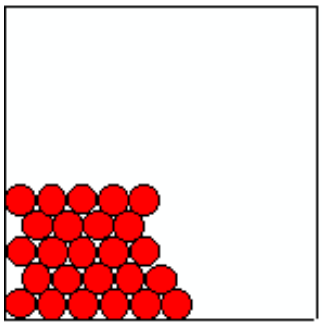
Topic 3 Particles in matter

3.1.1 Density

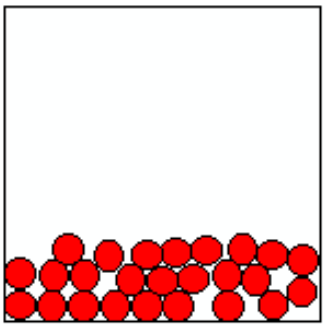
Density = $\frac{\text{mass}}{\text{volume}}$ kg/m^3 kg m^3

see practical : determining the density of materials

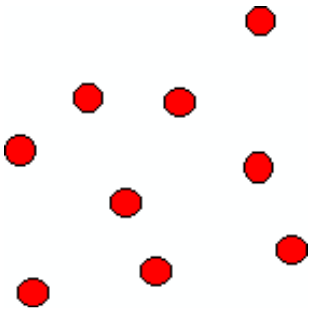
Density describes the closeness of the particles in a substance



Solids



Liquids

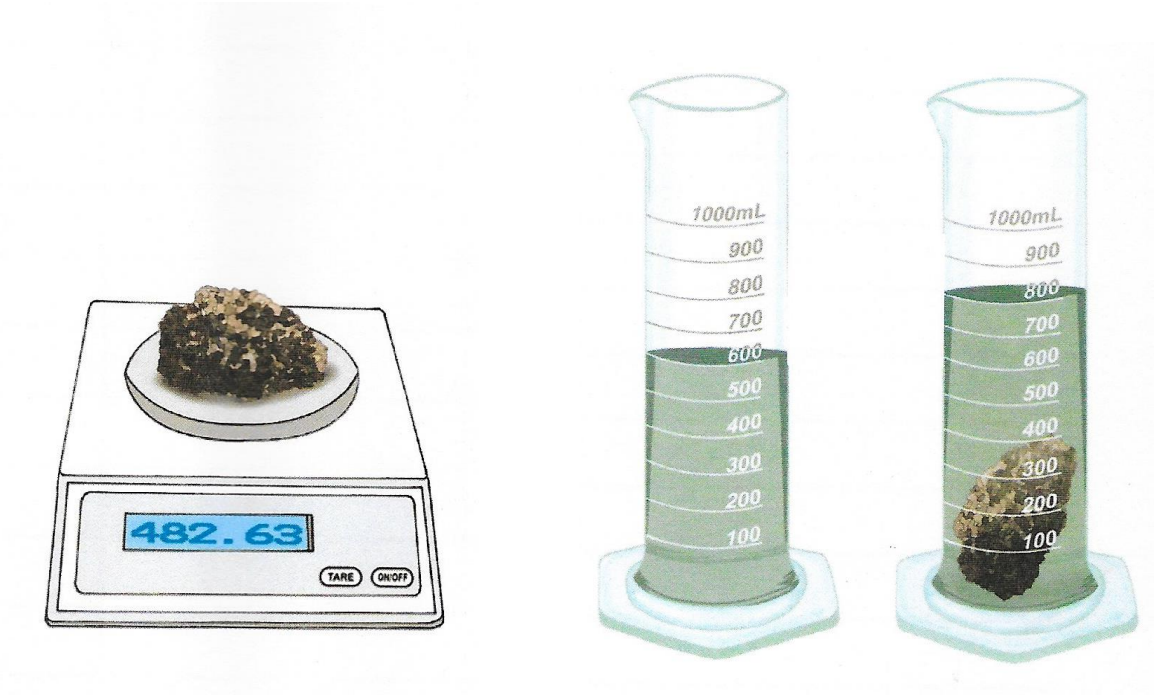


Gases

closely packed	less close	far apart
barely moving	moving past each other	moving fast and randomly

Practise what you have learned :-

1. What is the density of the rock shown in the following two pictures ?



2. A student pours 40ml of water into a measuring cylinder. She then drops a 50g mass, made of aluminium, into the measuring cylinder and the water level rises to 58.5ml.

(a) What was the volume of the aluminium ?

(b) Work out the density of aluminium

She then places a block of wood on a top pan balance and it reads 36g.
She then puts 40ml of water in another identical measuring cylinder and drops the block of wood into it, which floats. She uses another 50g mass, identical to the first one, to make the wood sink. The water level, when the wood and mass are in it, rises to 98.5ml.

(c) What was the volume of the wood ?

(d) Work out the density of the wood

3.1.2 Changing state
3.2.3 Specific latent heat

To change a solid into a liquid (melt) or a liquid into a gas (boil) we ned to supply heat to weaken the forces holding the atoms together or break them down totally
To change a gas into a liquid (condense) or a liquid into a solid (freeze) we have to remove heat

When we change the state of matter there is no temperature change so the heat supplied or removed is called latent heat

Energy required for a change of state = mass x specific latent heat

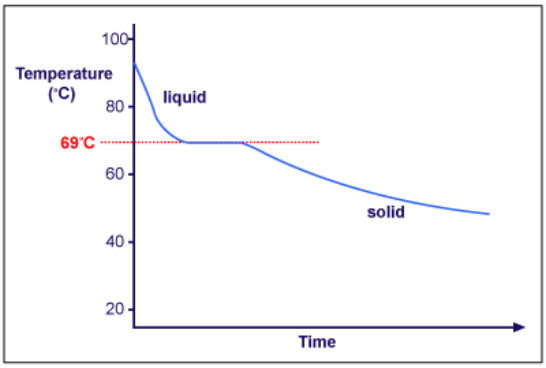
$$E = m \times L$$
J kg J/kg

If the change is solid to liquid (or vice versa) we use specific latent heat of fusion

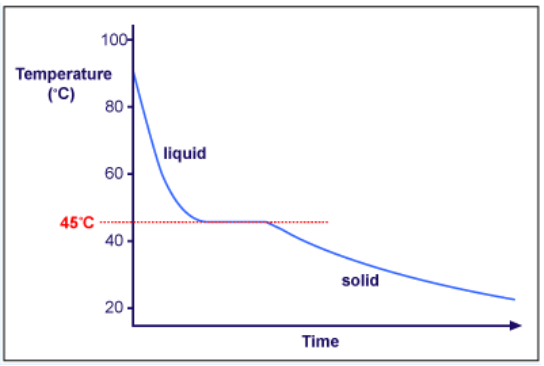
If the change is liquid to gas (or vice versa) we use specific latent heat of vaporisation

Practise what you have learned :-

1. The following graphs show what happens if liquid stearic acid and liquid salol are cooled



Stearic acid



Salol

What is happening to each liquid at the temperature indicated by the red line ?

2. The specific latent heat of fusion of a substance is 45 kJ/kg.
How much heat energy would you need to supply to change 4kg of the substance from a solid to a liquid ?

3. The specific latent heat of vaporisation of a substance is 6 MJ/kg.
How much heat energy would you need to supply to change 200g of the substance from a liquid to a gas ?

3.2.2 Temperature changes and Specific Heat Capacity

See practicals : measuring the specific heat capacity of a substance

If the heat going into or out of something is not changing its state, then it will be changing its temperature

Heat required = mass x specific heat capacity x temperature change
J kg J/kg°C °C

Practise what you have learned :-

1. The specific heat capacity of water is 4200 J/kg°C
   The specific heat capacity of aluminium is 910 J/kg°C
   200g of water, taken from a cold tap at 10°C, is heated in an aluminium saucepan of mass 500g that starts at 20°C, until the water starts to boil
   Work out how much heat is required.

   In practice more heat will be required than what you have calculated.
   Why ?

2. The specific heat capacity of ice is 2100 J/kg°C.
   The specific latent heat of fusion of ice is 334 kJ/kg.
   A 20g ice cube is taken from a freezer at -16°C and left to melt in a room that is at 25°C.

(a) What temperature will the water that is formed eventually reach ?

(b) Work out the heat energy that has to be absorbed from the air in the room for the complete process

ie : raising the ice to melting point

melting the ice

raising the water to room temperature

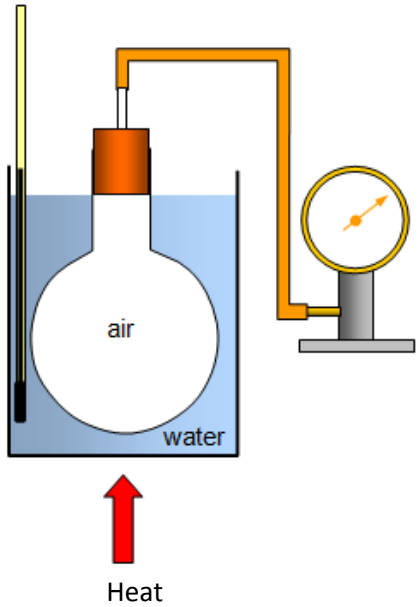
3.3 Particles and pressure

Pressure = $\frac{\text{Force}}{\text{Area}}$ N
Pascal, Pa m^2

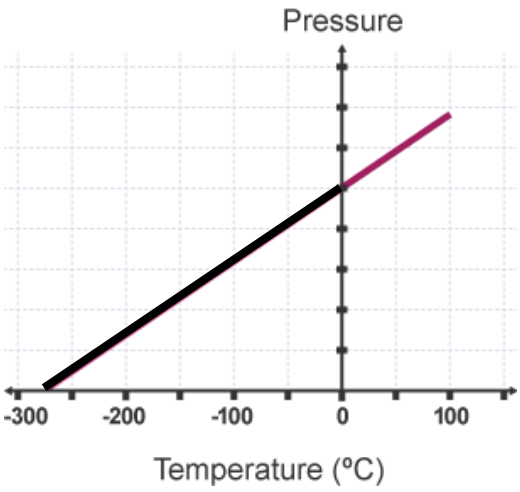
Particles in a gas are moving fast and randomly. They will hit the walls of any container they are in and exert force on the area of the walls, therefore gases exert pressure

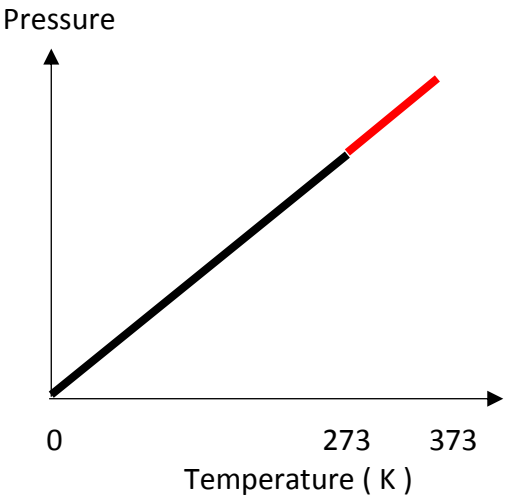
If we heat a gas its particles move more so the gas will exert more pressure and take up more volume

If the gas is in a sealed container (at constant volume) and we heat it, then the pressure is proportional to the temperature in Kelvin



Pressure gauge



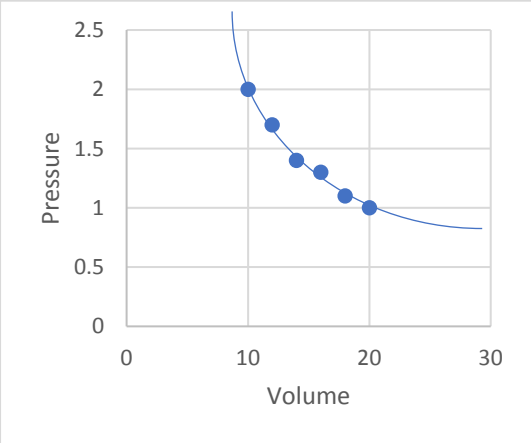


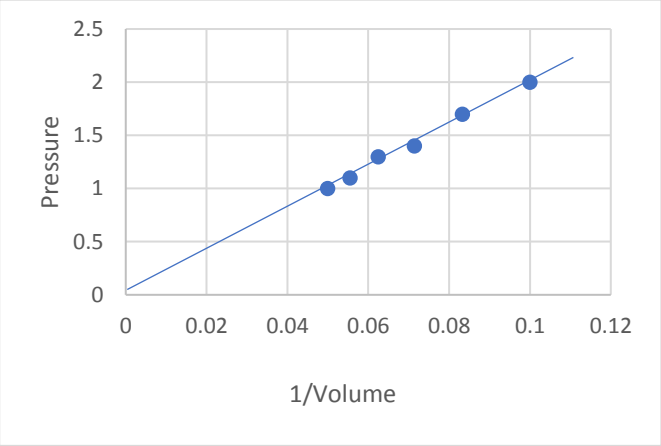
Temperature in Kelvin = Temperature in °C + 273

Pressure and volume, temperature constant Physics only

If we compress a gas at constant temperature,
ie push its particles into a smaller space
then the pressure increases
the particles hit the walls of their container more often

The pressure is inversely proportional to the volume
Halving the volume doubles the pressure





$P \propto \frac{1}{V}$

$P = \text{constant} \times \frac{1}{V}$

$PV = \text{constant}$

(gradient of the line)

$P_1V_1 = P_2V_2$

Practise what you have learned :-

1. A gas in a sealed container is heated. Complete the following paragraph and explain why the pressure of the gas increases

   If the gas is heated, its particles move _____ and hit the walls of the container _____ .
   Pressure = Force / Area
   The pressure increases because the _____ increases.

2. A gas in a sealed container is cooled. Explain why the pressure decreases

3. A gas is at a temperature of -73^{o}C. It exerts a pressure of 50 000 Pa.
   What will the pressure be if the gas is heated, at constant volume, to 127^{o}C ?

4. A gas having a volume of 50cm^3 is in a syringe and the atmospheric pressure is 100 000 Pa. If the piston is pushed in so that the gas is compressed down to 25cm^3, what will the pressure inside the syringe be ?

   Work out the pressure inside the syringe if the gas is compressed to 20cm^3 ?

5. The man in the picture is holding a helium balloon
   Normal atmospheric pressure = 100 000 Pa

The balloon has a volume of 5m^3

The man lets go of the balloon and it rises to a height of 5.5km where the pressure is 500mbar.

What happens to the volume of the balloon ?