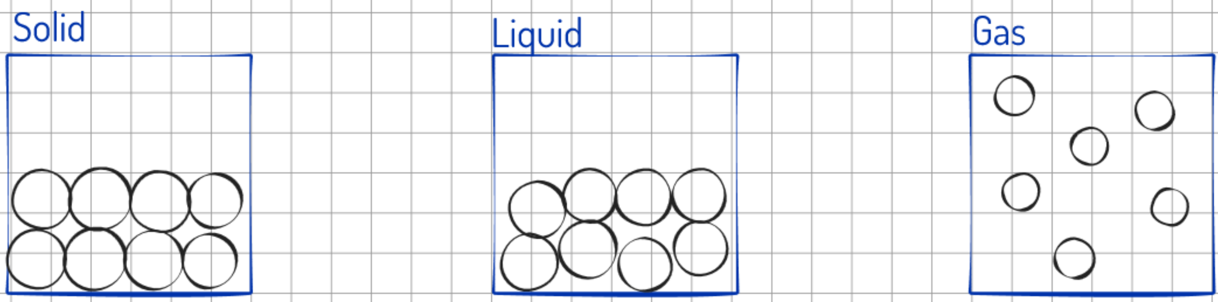
Kinetic Theory

8th Jan

Kinetic theory is describing the behaviour of an object in terms of the arrangement of particles.



Solid	Liquid	Gas
· Regular arrangement · Particles touching	· Irregular arrangement · Particles very close	· Space between particles
· Vibrate around fixed positions	· Can move over each other	· Random directions · Random speeds

Density

Density is a measure of the 'compactness' of a substance. It tells us the MASS of substance in a certain VOLUME.

$$\text{Density} = \frac{\text{mass}}{\text{Volume}} \qquad \rho = \frac{m}{V}$$

- m — in kilograms, kg
- V — in cubic metres, m^3
- ρ — in kilograms per cubic metre, kg/m^3

Note: sometimes mass may be given in grams and volume may be given in cubic centimetres. We may not always have to convert these units: READ THE QUESTIONS CAREFULLY for guidance.

There are 1,000,000 cm^3 in 1 m^3.

Hint: The steps for a calculation are always SUBSTITUTE, REARRANGE (if needed), EVALUATE.

1. A student measures the mass of a **10 m³** block of gold to be **500 kg**. What is the density of the gold? (2 marks)

$\rho = \frac{500}{10} = 50\ kg/m^3$

2. A lorry driver fills a **50 m³** container with **250 kg** of cooking oil. What is the density of the oil?

$\rho = \frac{250}{50} = 5\ kg/m^3$

(2 marks)

3. A piece of cork has a **mass of 24 kg** and a **density of 6 kg/m³**. What is the volume of the piece of cork?

$6 = \frac{24}{V}$ $\quad V = \frac{24}{6} = 4\ m^3$

(3 marks)

4. A carver begins work on a block of granite that has **volume of 1000 m³** and a **density of 5 kg/m³**. What is the mass of the block of granite?

$5 = \frac{m}{1000}$ $\quad m = 5 \times 1000 = 5000\ kg$

(3 marks)

5. A box has a **volume of 55 m³** and a **density of 5kg/m³**. What is the mass of the box?

$5 = \frac{m}{55}$ $\quad m = 5 \times 55 = 275\ kg$

(3 marks)

6. A wooden cylinder has a **density of 4 kg/m³** and a **mass of 48 kg**. What is the volume of the wooden cylinder?

$4 = \frac{48}{V}$ $\quad V = \frac{48}{4} = 12\ m^3$

(3 marks)

7. A wooden block has a **volume of 12 m³** and a **density of 3 kg/m³**. What is the mass of the wooden block?

$3 = \frac{m}{12}$ $\quad m = 3 \times 12 = 36\ kg$

(3 marks)

8. An ice block measuring **5m by 5 m by 5 m** has a density of **5kg/m³**. What is the mass of the ice block? (4 marks)

$V = 5 \times 5 \times 5 = 125\ m^3$ $\quad 5 = \frac{m}{125}$ $\quad m = 5 \times 125 = 625\ kg$

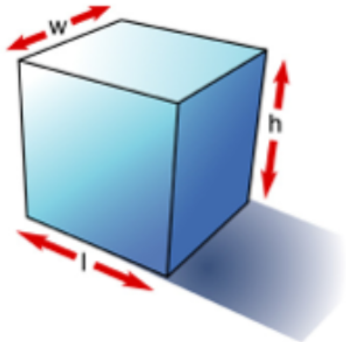
GCSE Physics Required Practical 5: Density

You will make and record appropriate measurements in order to determine the density of a regular and irregular shaped object.

Equipment: 30cm ruler, digital balance, various cubes (aluminium, brass, plastic etc), displacement can, block to place displacement can on, measuring cylinder, paper towels, various irregularly shaped objects.

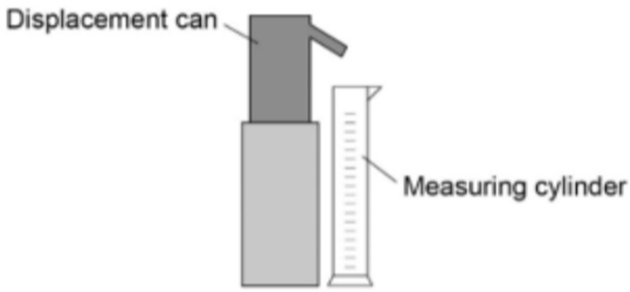
Method 1: Density of a regular shaped object

1. Ensure the digital balance reads 0.00. Place the regular shaped cube onto the digital balance and record its mass, having first converted the value into kilograms (kg) (by dividing the mass in g by 1000).
2. Measure the length, width and height of the cube in mm.
3. Divide these values by 1000 to convert them to metres (m)
4. Multiply the length, width and height together in order to determine the volume of the cube in metres cubed (m^3).
5. Use the equation: $Density, \rho = \frac{mass,m}{volume,v}$ to calculate the density of the block you measured



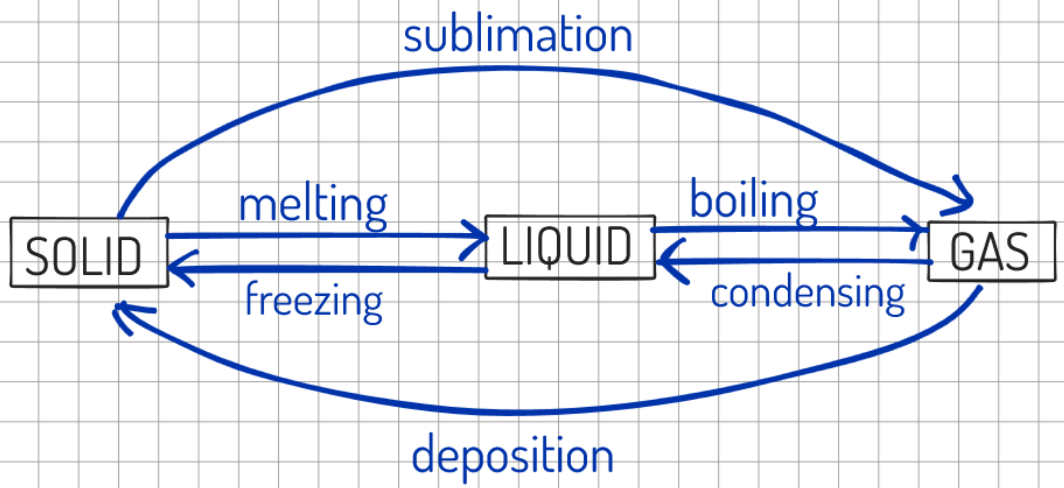
Method 2: Density of an irregular shaped object

1. Ensure the digital balance reads 0.00. Place the irregular shaped object onto the digital balance and record its mass in g.
2. Convert this mass into kilograms (kg) by dividing it by 1000.
3. Place displacement can on the block and fill with water until it just starts to come out of the spout
4. Place the measuring cylinder under the spout.
5. Place irregular shaped object into displacement can such that the volume of water displaced by the object now pours into the measuring cylinder. Record this volume in millilitres.
6. To convert the volume from millilitres (ml) to metres cubed (m^3), divide the value in millilitres by 1,000,000 (1 million).
7. Use the equation: $Density, \rho = \frac{mass,m}{volume,v}$ to calculate the density of the block you measured



Internal Energy

16th Jan

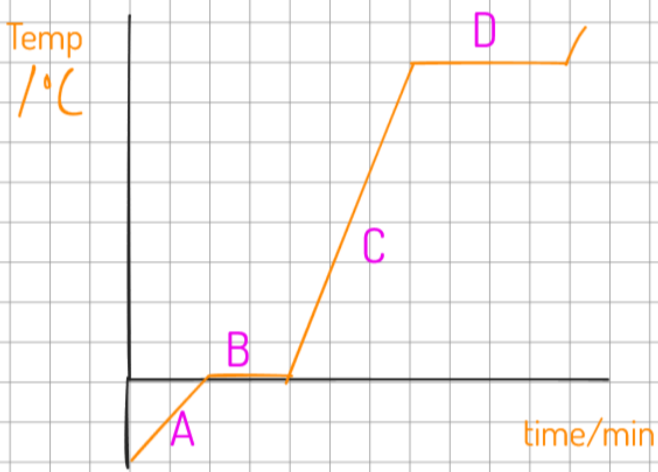


The INTERNAL ENERGY of a substance is the SUM OF THE KINETIC ENERGY of the particles and THE POTENTIAL ENERGY of the particles.

When a substance is heated the INTERNAL ENERGY increases. When a substance cools its internal energy decreases.

The TEMPERATURE of a substance is a measure of the AVERAGE KINETIC ENERGY of its particles.

As a substance is heated we either increase the kinetic energy of the particles or increase the potential energy of the particles.



A: Solid. Average kinetic energy increases.

B: Melting. Potential energy increases as forces between particles are overcome

C: Liquid. Average kinetic energy increases.

D: Boiling. Potential energy increases. Force are overcome. Substance becomes a gas.

Specific Heat Capacity

22nd Jan

The energy required to change the temperature of a substance depends on:

- mass
- the change in temperature
- the type of material

Each type of substance has its own SPECIFIC HEAT CAPACITY.

Specific Heat Capacity: the energy required to change the temperature of 1 kg of a substance by 1 °C.

Energy = mass x specific heat capacity x change in temperature

$$\Delta E = m c \Delta \theta$$

ΔE = change in energy   in Joules, J

$\Delta \theta$ = change in temperature   in celsius, °C

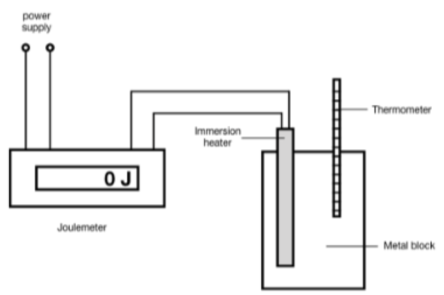
m = mass   in kilograms, kg

c = specific heat capacity   in joules per kilogram degree celsius, J / kg °C

GCSE Physics Required Practical 1: Specific Heat Capacity

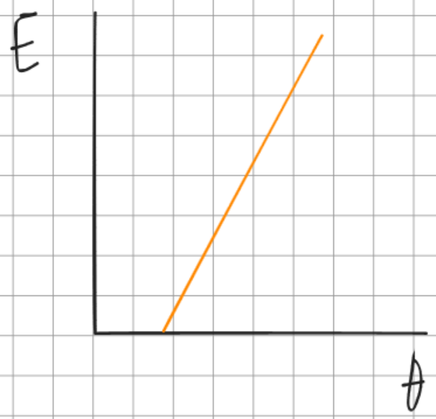
You will conduct an investigation to determine the specific heat capacity of a metal. This investigation involves using a heating element that transfers energy to a metal block to raise its temperature. The energy transferred to the block will be measured using a joulemeter. You are going to measure the energy supplied to the block and its temperature every minute for 10 minutes and use your data to plot a graph. The specific heat capacity of the metal can then be found from the gradient of the graph.

Equipment: Metal block, insulation, thermometer, heater, power pack, joulemeter, 4 leads, mass balance



Method:

1. Measure the mass of the metal block (in kg) and record in your book
2. Wrap the block in an insulating layer, leaving the holes in the top exposed
3. Place a thermometer in the hole in the block and measure the initial temperature of the block (leave the thermometer for a few minutes so the temperature stabilises)
4. Connect the heater to the 'load' terminals of the joulemeter. Connect the power pack to the 'source' terminals of the joulemeter.
5. Place the heater into the hole in the top of the metal block.
6. Adjust the joulemeter so its display is reading Energy and Time
7. Switch the heater on and press start on the joulemeter. The energy and time readings should start to go up.
8. Record the energy supplied and the temperature of the block every minute for 10-15 minutes.
9. After ten to fifteen minutes, switch off the heater and pack all equipment away. Take care when handling the heater as it will still be hot.



$$\Delta E = mc\Delta\theta$$

$$\frac{\Delta E}{\Delta\theta} = mc$$

This means the GRADIENT of this graph can be used to find the SPECIFIC HEAT CAPACITY.

Gradient = $\frac{\Delta y}{\Delta x} = \frac{\Delta E}{\Delta\theta}$ = mass x specific heat capacity

Typically the values for SHC from this experiment are OVERESTIMATES.

In our calculation we assumed that all of the energy transferred into the heater was transferred to the metal block.
In reality, some energy is transferred to the surroundings. We try to minimise this by insulating the metal block.

Specific Latent Heat

5th Feb

Specific latent heat: The energy required to CHANGE THE STATE of 1 kg of a substance.

SLH 'of fusion' relates to changes of state between solid and liquid

SLH 'of vaporisation' relates to changing between liquid and gas.

Energy = mass x specific latent heat

$$E = mL$$

- E in joules, J
- m in kilograms, kg
- L in joules per kilogram, J/kg

Note: the mass used must be the mass of substance that changed state

Energy transfer between hot and cold

11th Feb

Energy is ALWAYS transferred from a hotter region/object to a colder region/object.

Energy can be transferred by WAVES - we call this RADIATION. Hot objects emit a lot of INFRARED RADIATION.

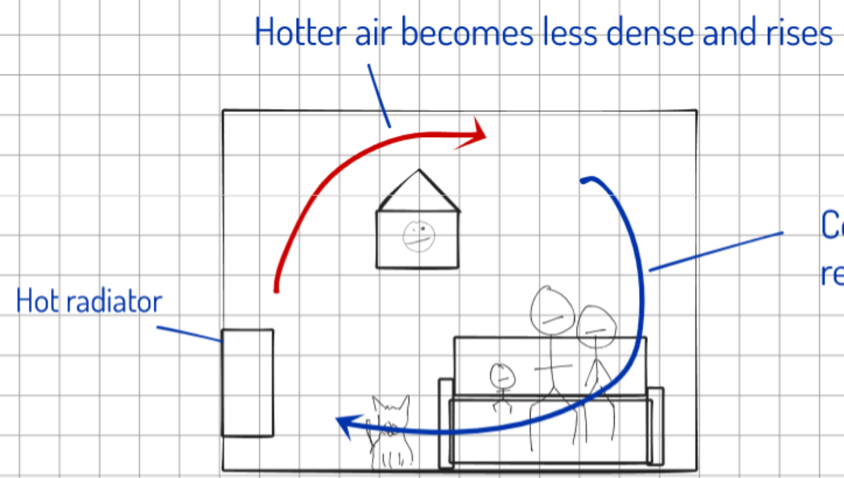
The process of energy transfer THROUGH SOLIDS is called CONDUCTION.

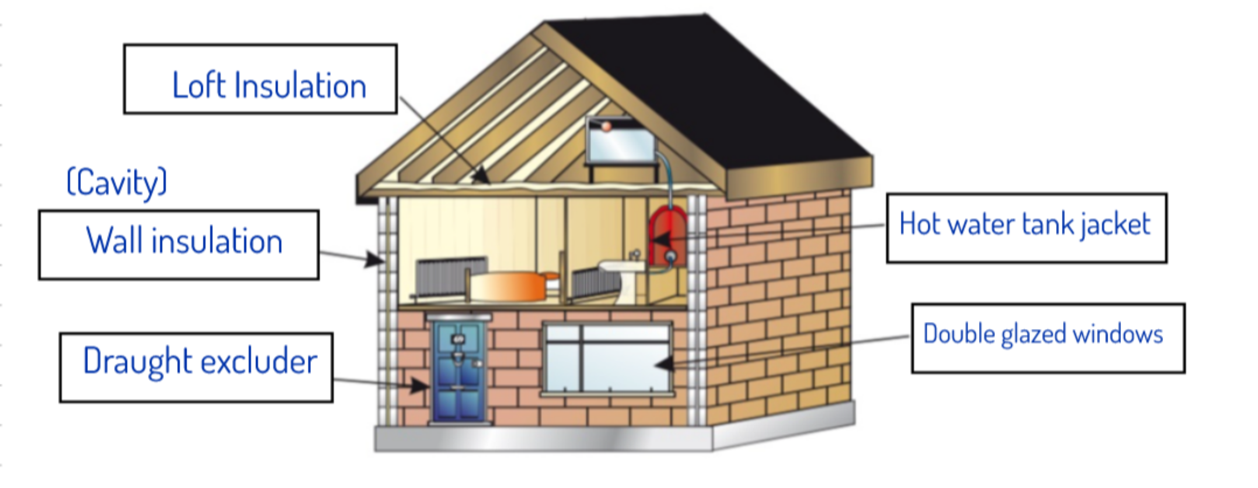
The rate (how quickly) of energy transfer depends on the THERMAL CONDUCTIVITY of the materials involved.

METALS have a HIGH THERMAL CONDUCTIVITY as conduction happens quickly.

NON-METALS (plastics, glass, wood etc) have a LOW THERMAL CONDUCTIVITY.

Energy is transferred from hotter regions to cooler regions in FLUIDS (liquids and gases) via CONVECTION.





Pressure in Gases

13th Feb

When particles of a gas collide with the walls of a container they EXERT A FORCE on it.

This creates PRESSURE.

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

$$p = \frac{F}{A}$$

- p – in newtons per square metre, N/m^2 or pascals, Pa
- F – in newtons, N
- A – in square metres, m^2

Pressure and Volume of Gases

26th Feb

The volume of a gas is INVERSELY PROPORTIONAL to its pressure.

In basic terms: increasing the pressure decreases the volume

More specifically DOUBLING the pressure would HALVE the volume.

We can prove this relationship using a graph of pressure against volume.

If multiplying a value of pressure by its corresponding value of volume always gives the same answer then they are INVERSELY PROPORTIONAL.

pressure x volume = constant

Increasing the TEMPERATURE of a gas increases the AVERAGE KINETIC ENERGY of its particles.

This increases the rate of collisions with the walls of any container.

This means a GREATER FORCE and a GREATER PRESSURE.

When we COMPRESS a gas we DO WORK and its TEMPERATURE INCREASES.

GCSE Required Practical 2: Thermal Insulation 6th March

Dependent variable: temperature - measured with thermometer

Independent variable: Type of insulation OR thickness of insulation

Control variables: volume of water in beakers, whichever of the possible independent variables we did not choose i.e. thickness if we are changing type, starting temperature of water

The material that either change temperature the least in a fixed time, or took the longest time to drop by a fixed temperature is the best insulator.

The best insulator has the LOWEST THERMAL CONDUCTIVITY.