Physics Paper 1

- P1 – Energy
- P2 – Electricity
- P3 – Particle Model
- P4 – Radioactivity
- P5 – Fission and Fusion (TRIPLE ONLY)

GCSE Physics

ENERGY CHANGES

AQA (Trilogy) Topic P1

Physics Unit 1 key ideas

1. State the equation that links kinetic energy, mass and speed.
2. State the equation that links gravitational potential energy, mass, gravitational field strength and height.
3. If kinetic energy is 3200J, what was gravitational potential energy? Why?
4. State the units for the following: energy, mass, speed, specific heat capacity.
5. Define the term specific heat capacity.
6. State how to calculate efficiency of an appliance.
7. State what makes up the national grid.
8. State the function of a step up transformer.
9. State the function of a step down transformer.

Physics Unit 1 key ideas

1. State the equation that links kinetic energy, mass and speed. $KE = 0.5 \times m \times v^2$
2. State the equation that links gravitational potential energy, mass, gravitational field strength and height. $GPE = m \times g \times h$
3. If kinetic energy is 3200J, what was gravitational potential energy? Why? 3200 J, energy can't be created or destroyed
4. State the units for the following: energy J, mass kg, speed m/s, specific heat capacity J/kg°C.
5. Define the term specific heat capacity. Energy needed to increase the temperature of 1kg of a substance by 1°C
6. State how to calculate efficiency of an appliance. Efficiency = useful energy out/total energy in
7. State what makes up the national grid. Cables and transformers
8. State the function of a step up transformer. Increases potential difference and therefore decreases current, so less energy is transferred to the surroundings.
9. State the function of a step down transformer. Reduces potential difference to 230V to make it safe for use in homes.

Forms of energy

Energy type	Examples
Thermal/heat	
Light	
Sound	
Elastic	
Gravitational	
Kinetic	
Electrical	
Chemical	
Nuclear	

Forms of energy

Energy type	Examples
Thermal/heat	Anything hot! (Kettle, fire, human...)
Light	Light bulbs, Bunsen flame, torch...
Sound	Talking, TV, radio...
Elastic/Strain	Spring, elastic band, bouncy ball
Gravitational	Book on shelf, aeroplane (anything high up)
Kinetic	Anything that is moving
Electrical	Anything that uses electricity
Chemical	Batteries, food, matchstick, candle
Nuclear	Nuclear bomb, nuclear power station

Con[...]

Most wasted energy is in the form of heat.
EXAM PHRASE: wasted energy is transferred to the surroundings as heat

- Energy cannot [...] transferred or changed from one [...]

- A ball gains Gravitational Potential Energy when it is lifted above the ground, it is turned into kinetic energy when it is dropped and sound energy and thermal energy when it hits the ground.

What energy transfer are these **speakers** designed to carry out?

electrical energy → sound energy

What energy transfer are **wind turbines** in a wind farm designed to carry out?

kinetic energy → electrical energy

What energy transfer is a hydroelectric power station designed to carry out?

gravitational potential energy → electrical energy

Energy transfer in a television

An energy transfer diagram shows the input and output energies for a device. This includes all the useful and wasted forms of energy.

For example, in a television:

electrical → light, sound, heat

Wasted energy (heat)

Energy transfer in a radio

What are the main energy transfers in a radio?

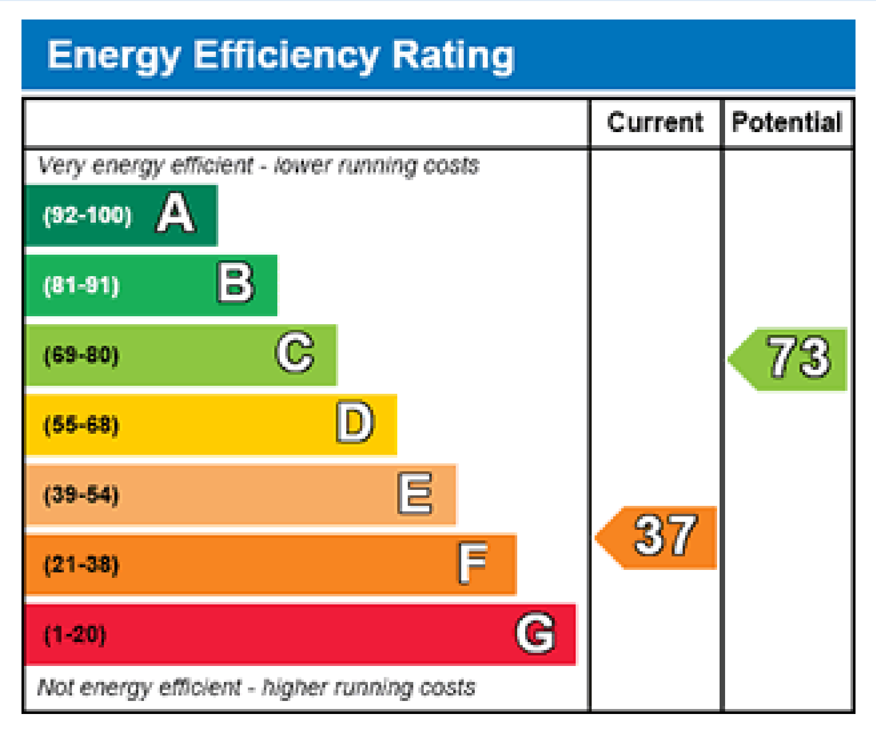
(Don't forget the wasted energy.)

electrical → sound, heat

Wasted energy

Efficiency

- Ideally consumers/business' want appliances that are more efficient
- They save money and produce more products for the same amount of money. (economical)
- Environmentally, less fossil fuels are burned so less Carbon Dioxide is released into the atmosphere



Efficiency

- For something to be more efficient more energy is transferred to what it is intended to do (useful energy).

$$\text{Efficiency} = \frac{\text{Useful Energy Output}}{\text{Energy Input}} \times 100\%$$

$$\text{Efficiency} = \frac{\text{Useful Power Output}}{\text{Power Input}} \times 100\%$$

- EXAM TIP: Small number divide by large number!

- You should always end up with a decimal before you multiply by 100.

A student finds some information about energy-saving light bulbs.

(a) A 30W light bulb uses 600J of electrical energy in a certain period of time. In that time, it produces 450 J of light energy. The rest of the energy is wasted.

(i) Calculate the energy wasted by the light bulb in this period of time.

600J– 450J = 150J

Wasted energy = 150 J

(1)

(ii) What happens to the energy wasted by the light bulb?

It is transferred to the surroundings in the form of heat.

(1)

(iii) Calculate the efficiency of this light bulb.

$$Efficiency = \frac{400J}{600J}$$

Efficiency = $0.75 \; or \; 75\%$

(2)

Exam Question

(a) Use words from the box to complete each sentence.

chemical	**light**	**kinetic**	**electrical**	**sound**

In the batteries, ____Chemical____ energy is transferred to

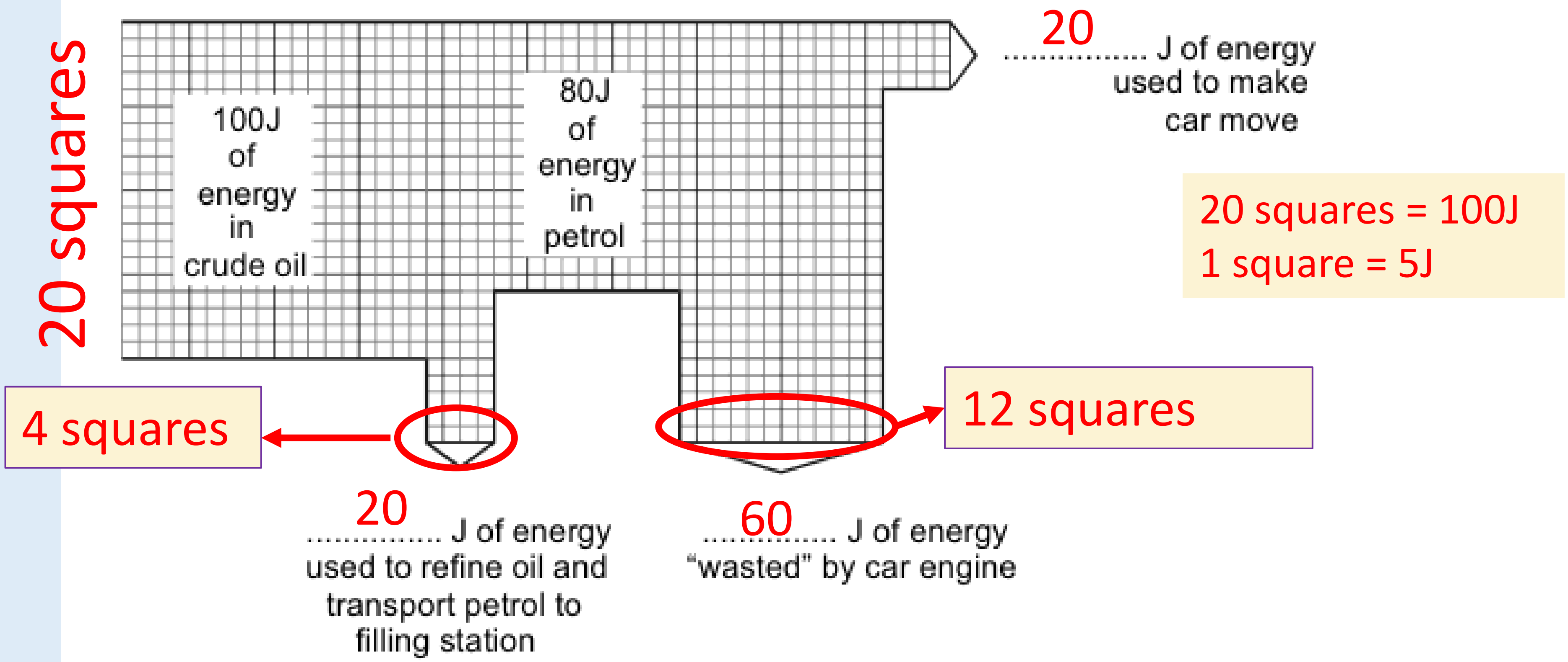
____Electrical____ energy in the wires.

The fan has ____kinetic____ energy as it rotates.

(3)

The diagram shows what happens to each 100 joules of energy from crude oil when it is used as petrol in a car.

The widths of the arrows show exactly how much energy is transferred in each particular way.

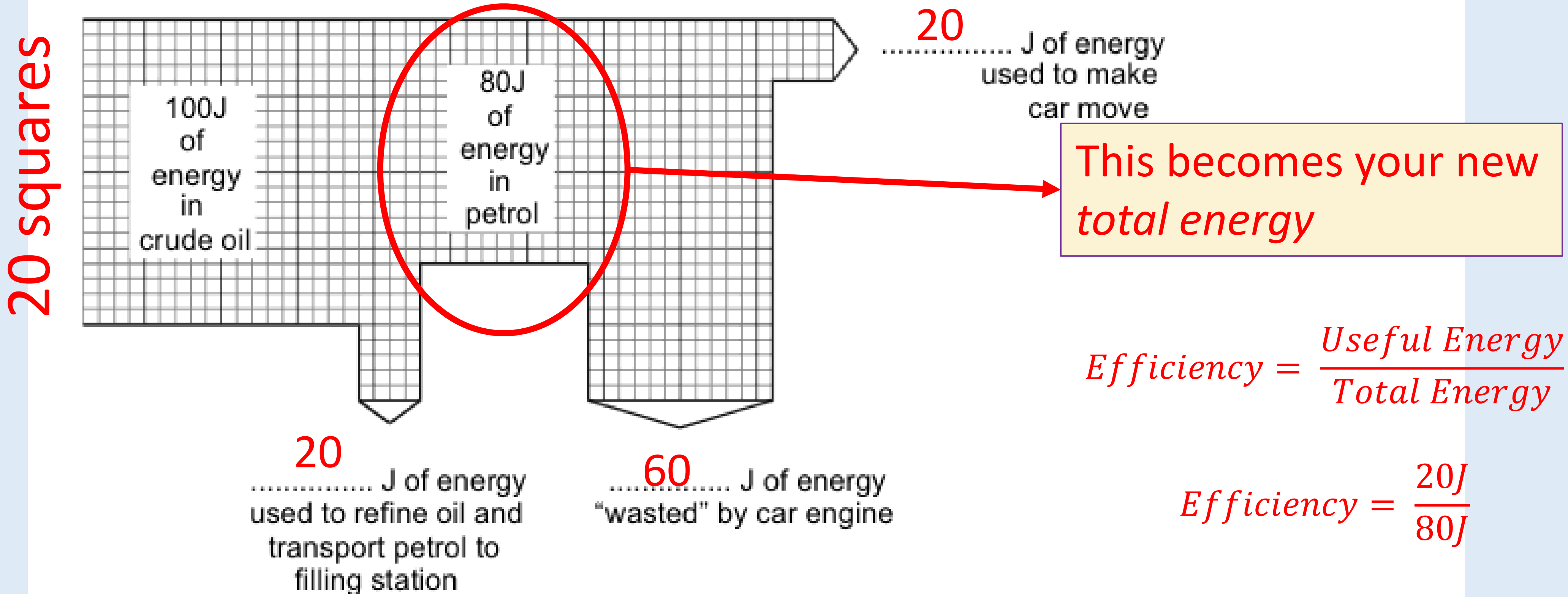


(a) Complete the diagram by adding the correct energy value alongside each arrow.

(2)

The diagram shows what happens to each 100 joules of energy from crude oil when it is used as petrol in a car.

The widths of the arrows show exactly how much energy is transferred in each particular way.



$$Efficiency = \frac{Useful\ Energy}{Total\ Energy}$$

$$Efficiency = \frac{20J}{80J}$$

$$Efficiency = 0.2\ or\ 25\%$$

(b) Calculate how efficient the car engine is at transferring the energy **from petrol** into useful movement.

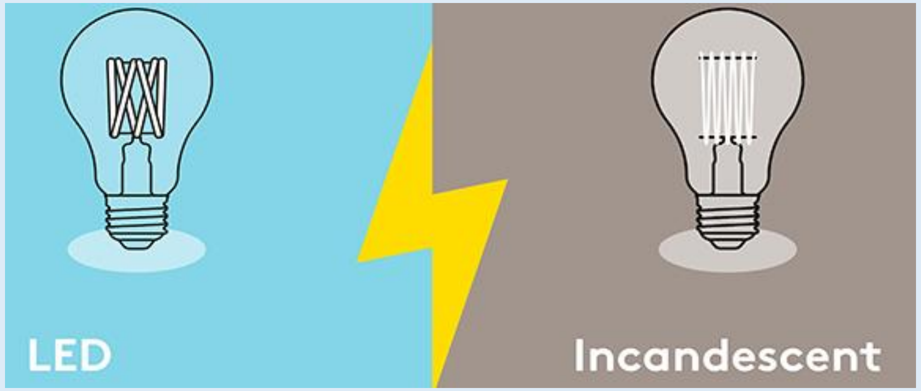
Show clearly how you work out your answer.

HT: Increasing the efficiency of a device

- The total input energy/power will usual be constant.

- Suggesting improvements must be in the form of increasing the amount useful energy.

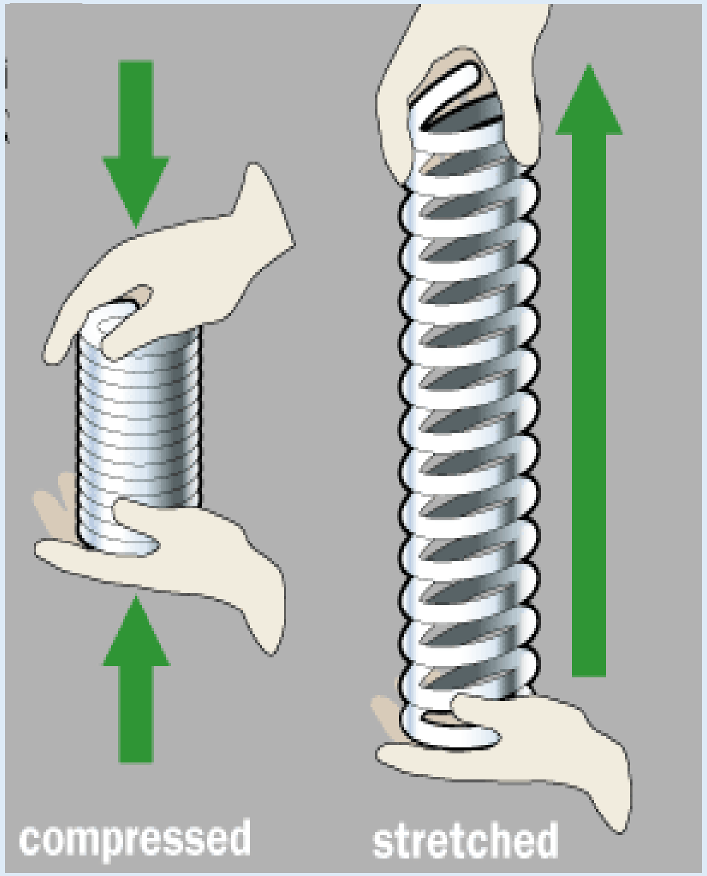
- Often improvements are reducing wasted energy by:
- Lower electrical resistance (reduces heat production) devices such as LED bulbs instead of filament lamps.
- Reducing friction (smaller surface area of a contact surface)
- Reducing heat loss

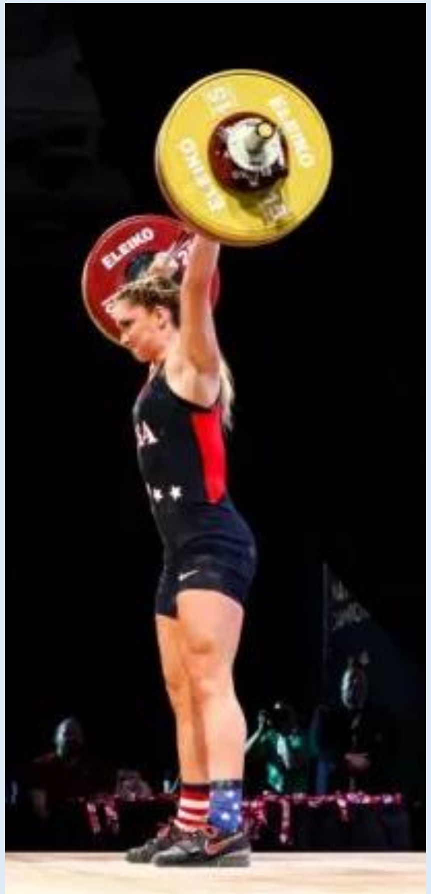


Doing work!

All of these movements require work!

Energy is put into the system (the object)





Doing work!

- EXAM TIP: the work done is equal to the kinetic energy, GPE or Elastic potential energy

Work Done

- When an object is moved there must be work done to move this object. A force must be applied over a certain distance.

Work Done

$$Work\ Done = Fs$$

$$Work\ Done = Force\ x\ distance$$

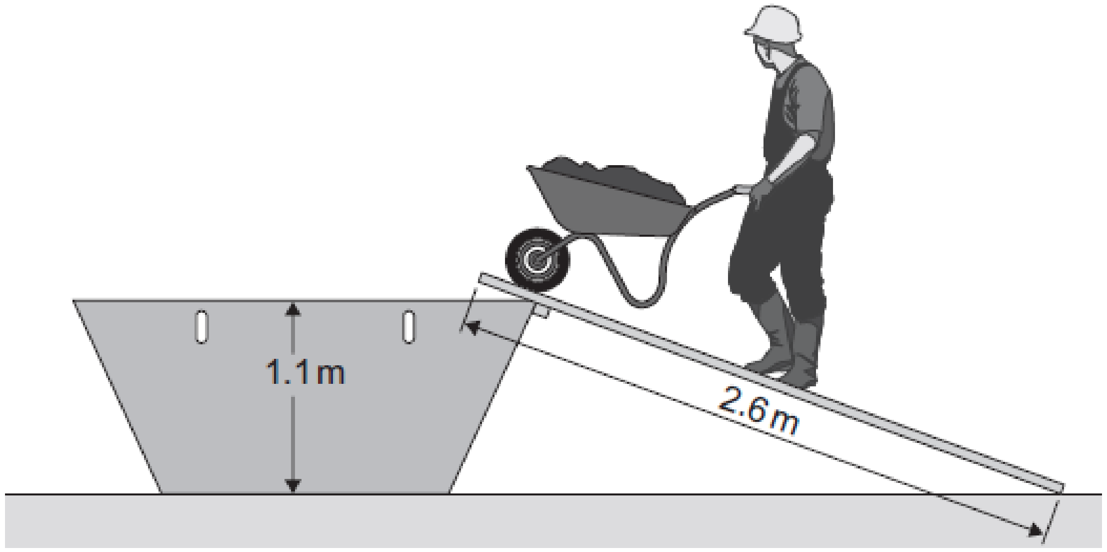
J N m

Exam Question

F= 220N
s = 2.6m

$$Work\ done = Fs$$
$$Work\ done = 220N\ x\ 2.6m$$
$$Work\ done = 572J$$

(a) The diagram shows a builder using a plank to help load rubble into a skip.



The builder uses a force of 220 N to push the wheelbarrow up the plank.

Use information from the diagram to calculate the work done to push the wheelbarrow up the plank to the skip.

Show clearly how you work out your answer.

____

____

Work done = ______572______ J

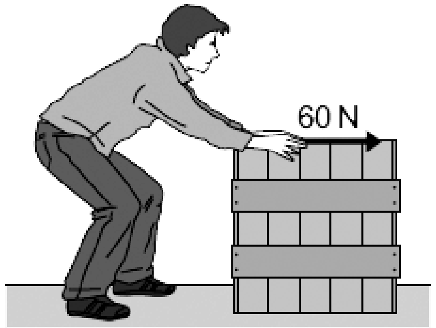
(2)

Exam Question

F= 60N
s= 28m

$$Work\ done = Fs$$
$$Work\ done = 60N\ x\ 28m$$
$$Work\ done = 1680J$$

The diagram shows a worker using a constant force of 60 N to push a crate across the floor.



My Revision Notes AQA GCSE Physics for A* – C,
Steve Witney, © Philip Allan UK

(b) Calculate the work done by the worker to push the crate 28 metres.

Show clearly how you work out your answer and give the unit.

Choose the unit from the list below.

joule **newton** **watt**

____

____

Work done = 1680 ____________

(3)

(Total 6 marks)

Kinetic Energy

$$Kinetic\ Energy = \frac{1}{2}mv^2$$

$$Kinetic\ Energy = 0.5\ x\ mass\ x\ velocity^2$$

J

Kg

m/s

Exam Question

Velocity (v) = 20m/s
Mass (Kg) = 1600kg

$$Kinetic\ Energy = \frac{1}{2}mv^2$$

$$E_K = \frac{1}{2}\ x\ 1600\ x\ 202$$
$$E_K = 320\ 000J$$

(b) A car is travelling at a speed of 20 m/s when the driver applies the brakes. The car decelerates at a constant rate and stops.

(i) The mass of the car and driver is 1600 kg.

Calculate the kinetic energy of the car and driver before the brakes are applied.

Kinetic energy = $320\ 000J$ J

(2)

(ii) How much work is done by the braking force to stop the car and driver?

Work done = $320\ 000J$ J

(1)

Exam Question

Velocity 1 (v_1) = 18m/s
Velocity 2 (v_2) = 13m/s
Mass (Kg) = 300kg

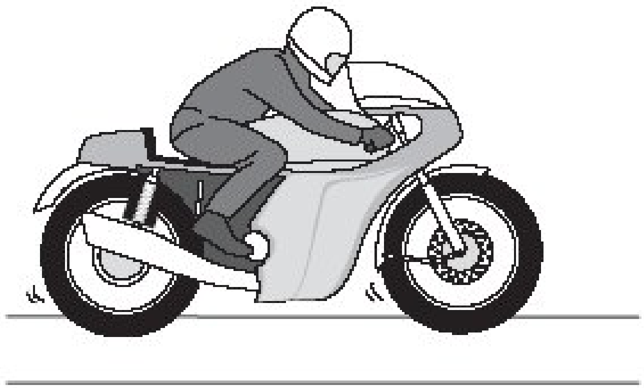
$$Kinetic\ Energy = \frac{1}{2}m{v_1}^2$$

$$E_K = \frac{1}{2}\ x\ 300\ x\ 182$$
$$E_K\ at\ 18m/s = 48600J$$

$$Kinetic\ Energy = \frac{1}{2}m{v_2}^2$$

$$E_K = \frac{1}{2}\ x\ 300\ x\ 32$$
$$E_K\ at\ 13m/s = 1350J$$

The diagram shows a motorbike of mass 300 kg being ridden along a straight road.



The rider sees a traffic queue ahead. He applies the brakes and reduces the speed of the motorbike from 18 m/s to 3 m/s.

(a) Calculate the kinetic energy lost by the motorbike.

Show clearly how you work out your answer.

____

____

____

____

Kinetic energy lost = ____________________ J

(2)

(b) (i) How much work is done on the motorbike by the braking force?

____

(1)

Exam Question

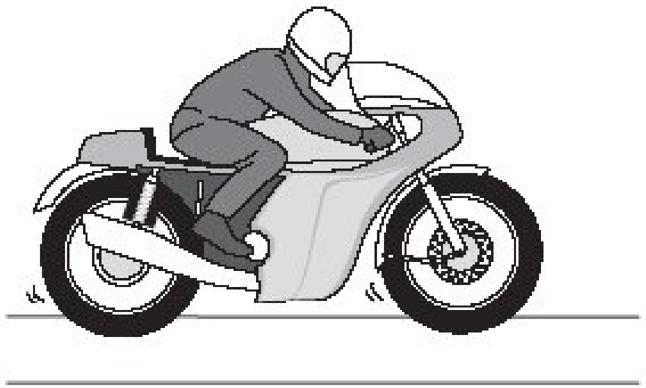
Velocity 1 (v_1) = 18m/s
Velocity 2 (v_2) = 3m/s
Mass (Kg) = 300kg

$$E_K\, at\ 18m/s = 48600J$$
$$E_K\, at\ 3m/s = 1350J$$

Kinetic Energy lost = E_k at 18m/s – E_k at 13m/s

Kinetic Energy lost = 48600J – 25350J
Kinetic Energy lost = 47250J

The diagram shows a motorbike of mass 300 kg being ridden along a straight road.



The rider sees a traffic queue ahead. He applies the brakes and reduces the speed of the motorbike from 18 m/s to 3 m/s.

(a) Calculate the kinetic energy lost by the motorbike.

Show clearly how you work out your answer.

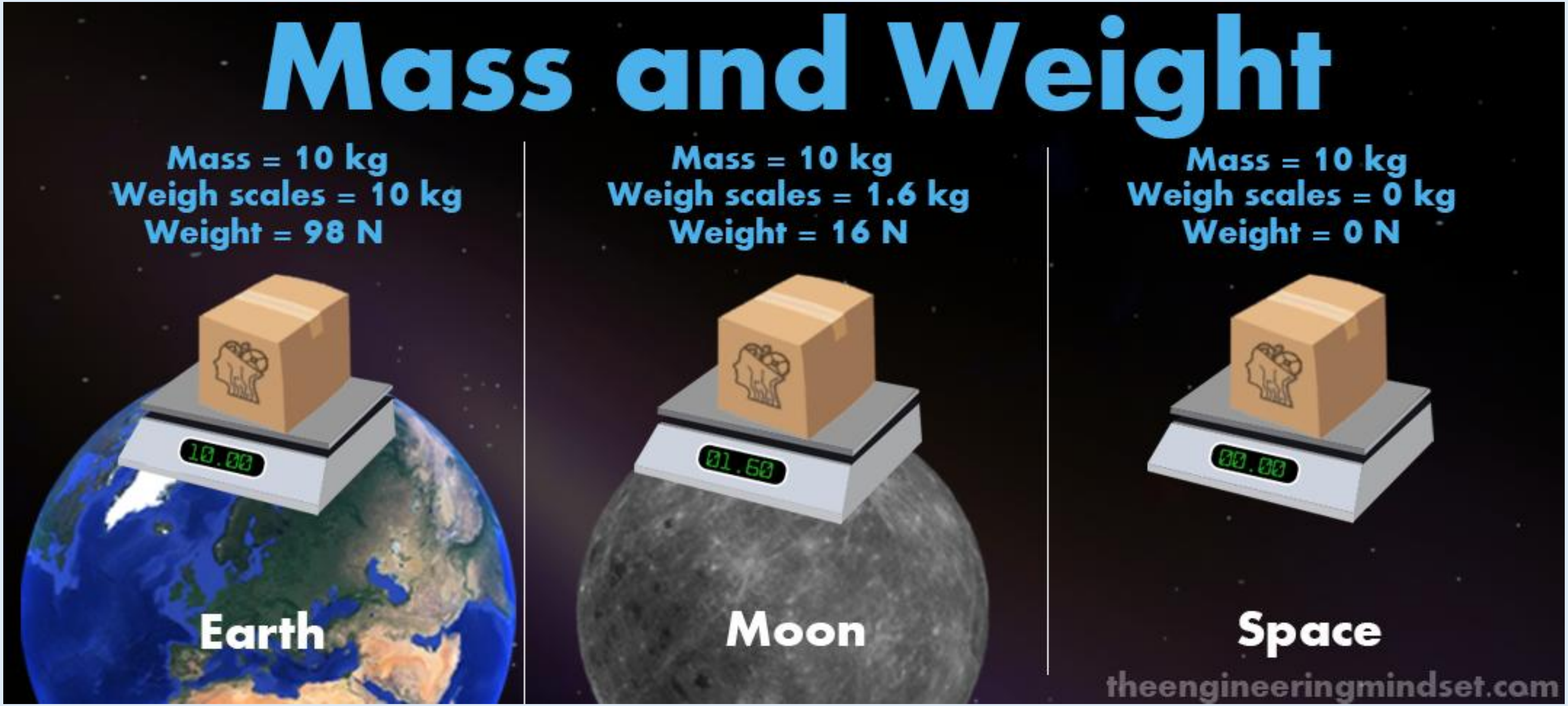
Kinetic energy lost = 47250J J

(2)

(b) (i) How much work is done on the motorbike by the braking force?

47250J

(1)


Mass and Weight
Mass = 10 kg
Weigh scales = 10 kg
Weight = 98 N
10.00
Earth
Mass = 10 kg
Weigh scales = 1.6 kg
Weight = 16 N
01.60
Moon
Mass = 10 kg
Weigh scales = 0 kg
Weight = 0 N
00.00
Space
theengineeringmindset.com

Mass vs Weight

- Mass (m) is the amount of the matter in an object (stuff)
  - Measured in Kilograms (Kg)

- Weight (W) is the force of gravity on that mass
  - Measured in Newtons (N)

$$Weight = mg$$
$$Weight = mass\ x\ gravitational\ field\ strength$$

N Kg N/Kg

Exam Question

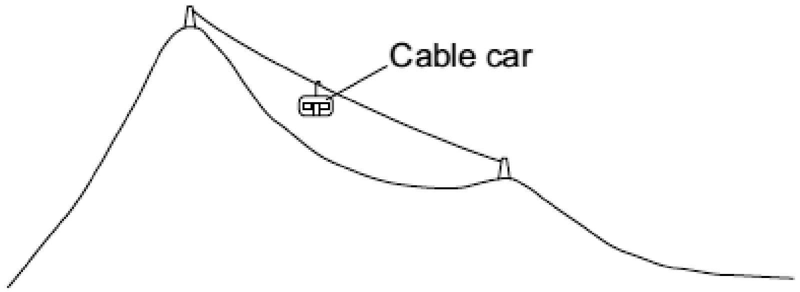
- m = 7500kg
- g= 10N/kg

$$Weight = mg$$

$$Weight = 7500kg\ x\ 10N/Kg$$

$$Weight = 75000N$$

(a) The diagram shows a cable car used to take skiers to the top of a mountain.



(i) The total mass of the cable car and skiers is 7500 kg.

Calculate the weight of the cable car and skiers.

gravitational field strength = 10 N/kg

Show clearly how you work out your answer and give the unit.

____

____

Weight = ____ $75000N$ ____

(3)

Exam Question

- F = 75000N
- s = 800m

$$Work = Fs$$

$$Work = 75000N\ x\ 800m$$

$$Work = 60\ 000\ 000J$$

(ii) The cable car moves at a constant speed. It lifts skiers through a vertical height of 800 metres in 7 minutes.

Calculate the work done to lift the cable car and skiers.

Show clearly how you work out your answer.

____

____

Work done = 60 000 000 J

(2)

Gravitational Potential Energy

- When an object is lifted above the ground there is a gain in potential energy. It is often called the *change* in gravitational potential energy. It is the same thing.

- The work done to put it there is equal to GPE.

Gravitational Potential Energy: Formula

$$Gravitational\ Potential\ Enegy = mgh$$

$$Gravitational\ Potential\ Enegy = mass\ x\ gravitational\ field\ strength\ x\ height$$

J Kg N/Kg m

Exam Question

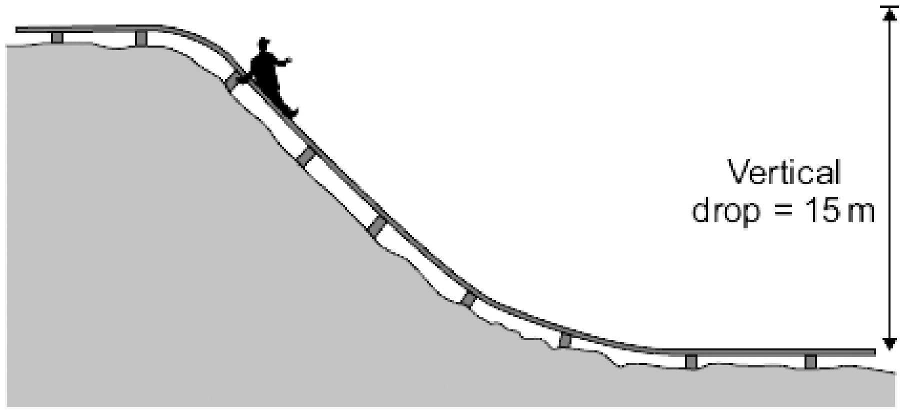
- m= 90kg
- g = 10N/kg
- h = 15m

$$GPE = mgh$$

$$GPE = 90 \; x \; 10 \; x \; 15$$

$$GPE = 13\,500J$$

The miners working in a salt mine use smooth wooden slides to move quickly from one level to another.



(a) A miner of mass 90 kg travels down the slide.

Calculate the change in gravitational potential energy of the miner when he moves 15 m vertically downwards.

gravitational field strength = 10 N/kg

Show clearly how you work out your answer.

____

____

Change in gravitational potential energy = 13 500 J

(2)

Exam Question HT

$$GPE = E_K$$

$x2$ $$13\,500 = \frac{1}{2} x\ 90\ x\ v^2$$ $x2$

$$2\ x\ 13\,500 = 90\ x\ v^2$$

÷ 90 ÷ 90

$$\frac{2\ x\ 13\,500}{90} = v^2$$

√v √v

$$\sqrt{\frac{2\ x\ 13\,500}{90}} = 17.32 m/s$$

(b) Calculate the **maximum** possible speed that the miner could reach at the bottom of the slide.

Show clearly how you work out your answer.

Give your answer to an appropriate number of significant figures.

____

____

____

____

Maximum possible speed = 17 m/s

(3)

You always go with the LOWEST significant figures.

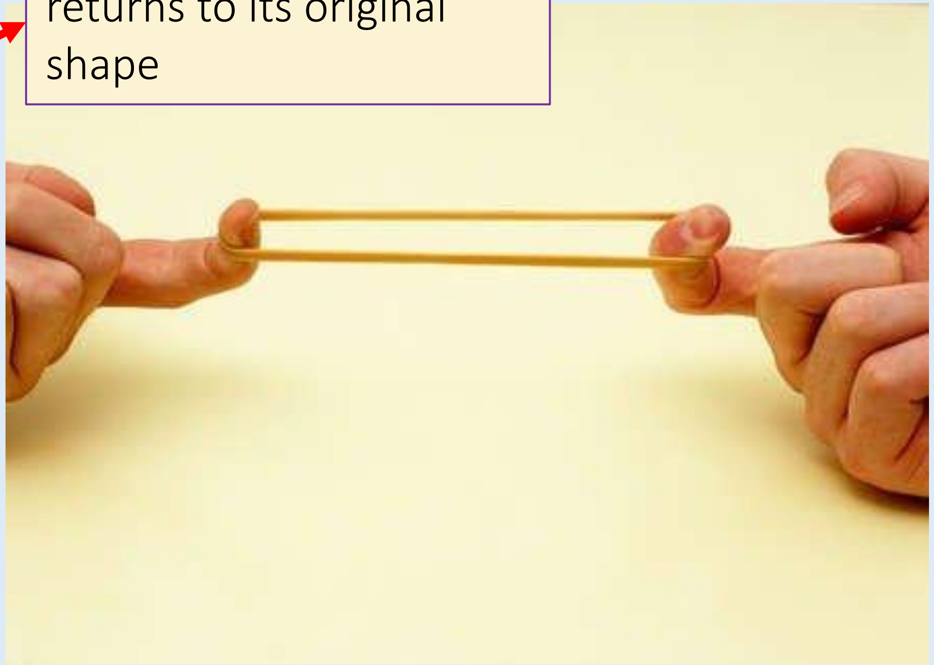
More than likely this will be 2 s.f.

Compressing and stretching springs or other elastic objects!

- Work is done when a spring is stretched/compressed.

- Work done= elastic potential energy
  - (as long as limit of proportionality is not exceeded)

The point when an object stops behaving elastically and no longer returns to its original shape



GIVEN IN YOUR EXAM!

Elastic Potential Energy (E_P) Formula

$$E_P = \frac{1}{2}ke^2$$

Spring Constant = tells you how much work is required to stretch or compress and object. The bigger this number the greater the work required.

$$E_P = \frac{1}{2}\ x\ spring\ constant\ x\ extension^2$$

J

N/m

m

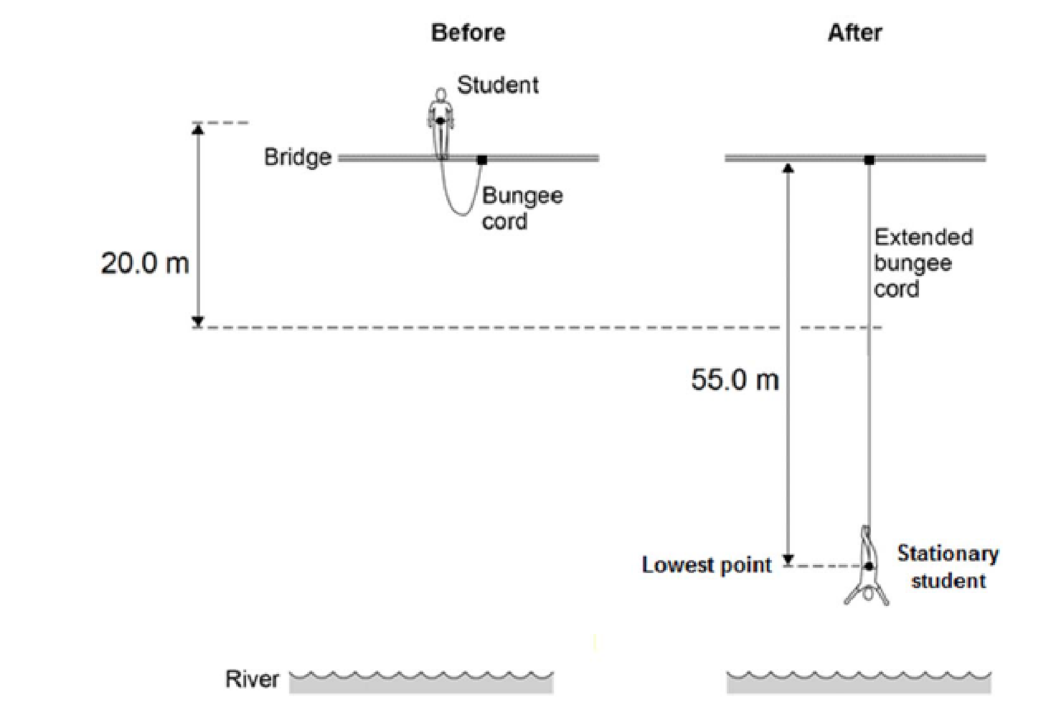
Exam Question

- k= 40N/m
- e = 35m

$$E_P = \frac{1}{2}ke^2$$

$$E_P = \frac{1}{2}x\ 40\ x\ 352$$

$$E_P = 24\ 500J$$



(c) At the lowest point in the jump when the student is stationary, the extension of the bungee cord is 35 metres.

The bungee cord behaves like a spring with a spring constant of 40 N / m.

Calculate the energy stored in the stretched bungee cord.

Use the correct equation from the Physics Equations Sheet.

___

___

___

Energy = 24 500 J

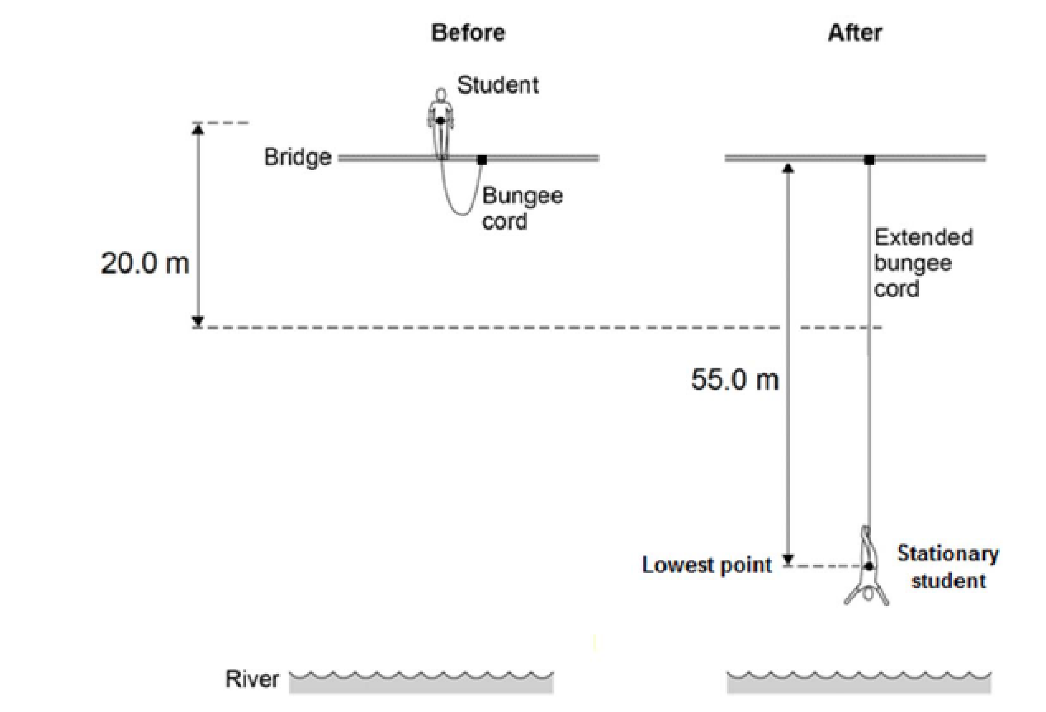
Exam Question HT

- k= ?
- e = 55m-20m = 35m
- E_P = 24.5kJ → 24.5×10^3J or 24 500J

$$E_P = \frac{1}{2}ke^2$$

$$\frac{2\ x\ EP}{e^2} = k$$

$$\frac{(2\ x\ 24.5x103)}{35^2} = 40\ N/m$$



(e) At the lowest point in the jump, the energy stored by the stretched bungee cord is 24.5 kJ.

The bungee cord behaves like a spring.

Calculate the spring constant of the bungee cord.

Use the correct equation from the Physics Equation Sheet.

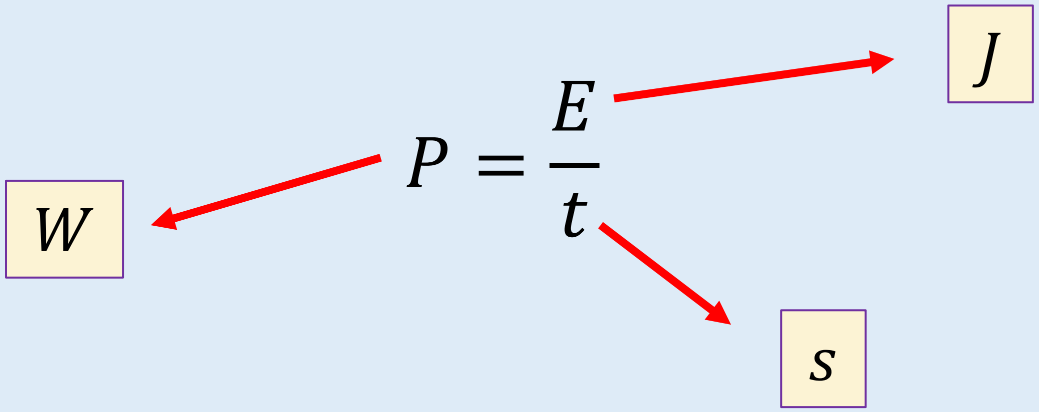
Spring constant = 40 N / m

(3)

I got the POWER! Watt do you mean?!

- Power is the rate of energy transfer. The more powerful an appliance the more energy transferred in a given period of time.

$$Power = \frac{Energy}{time} \text{ or } Power = \frac{Work}{time}$$



Exam Question

- E = 2240J
- t = 2.8s

$$P = \frac{E}{t}$$

$$P = \frac{2240J}{2.8s}$$

$$P = 800W$$

The student did 2240 J of work going from the bottom of the stairs to the top of the stairs.

The student took 2.8 seconds to run up the stairs.

(i) Calculate the power the student developed when running up the stairs.

____

____

Power = $800W$ W

(2)

Exam Question

- h = 0.40m
- m= 65kg
- t = 60s
- Chin ups = 12
- g = 10N/kg

$$W = Fs$$

$$W = (65x10)\ x\ 0.40$$

W = 260J x 12 chin ups

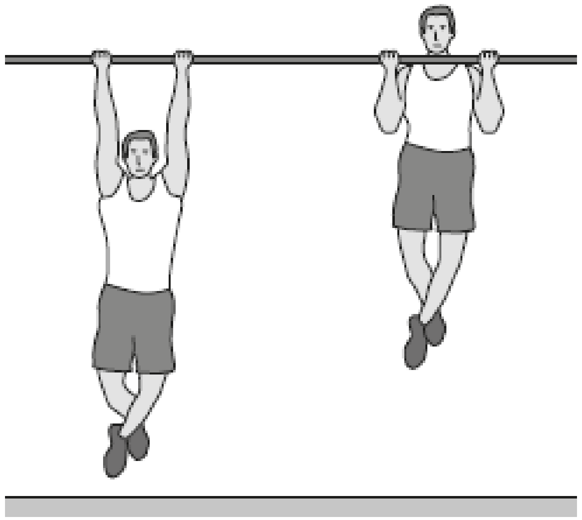
$$P = \frac{E}{t}$$

$$P = \frac{3120J}{60s}$$

$$P = 52W$$

(c) The student in **Figure 3** is doing an exercise called a chin-up.

Figure 3



Each time the student does one chin-up he lifts his body 0.40 m vertically upwards.
The mass of the student is 65 kg.
The student is able to do 12 chin-ups in 60 seconds.

Calculate the power developed by the student.

Gravitational field strength = 10 N/kg

Exam Question

- P = 2 000 000W → 2 000kW
- t = 6hrs

$$P = \frac{E}{t}$$

$$E = Pt$$

$$E = 2000 \ x \ 6$$

$$E = 12\ 000J$$

A single wind turbine has a maximum power output of 2 000 000 W.

The wind turbine operated continuously at maximum power for 6 hours.

Calculate the energy output in kilowatt-hours of the wind turbine.

____

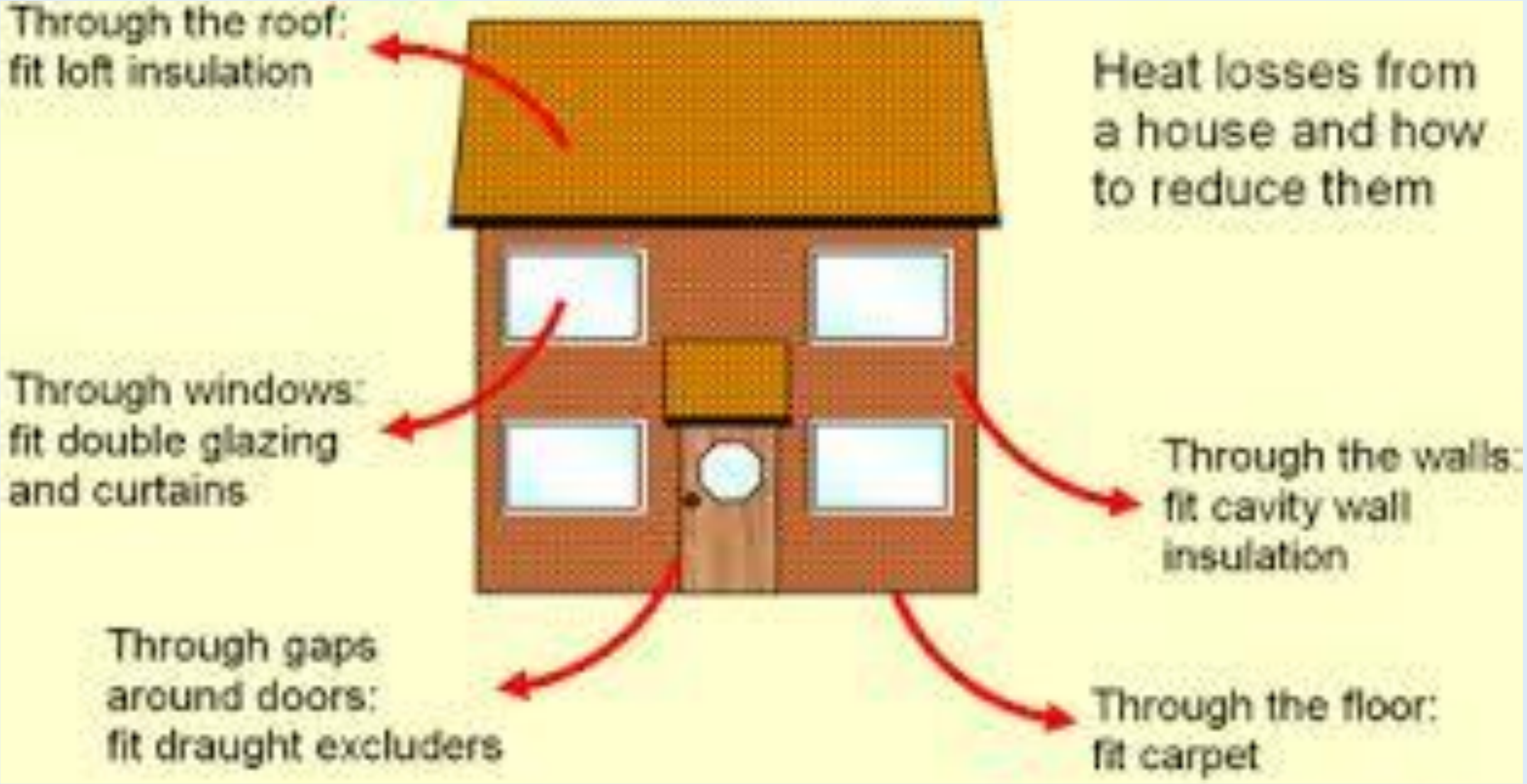
____

____

Energy output = $12\ 000J$ kWh

(2)

Reducing heat loss in houses



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Specific Heat Capacity

- The energy required to raise the temperature of a 1kg mass by 1 °C

$$\Delta E = mC\Delta\theta$$

Δ = change in..

$Change\ in\ energy\ transferred\ = mass\ x\ specific\ heat\ capacity\ x\ change\ in\ temperature$

J

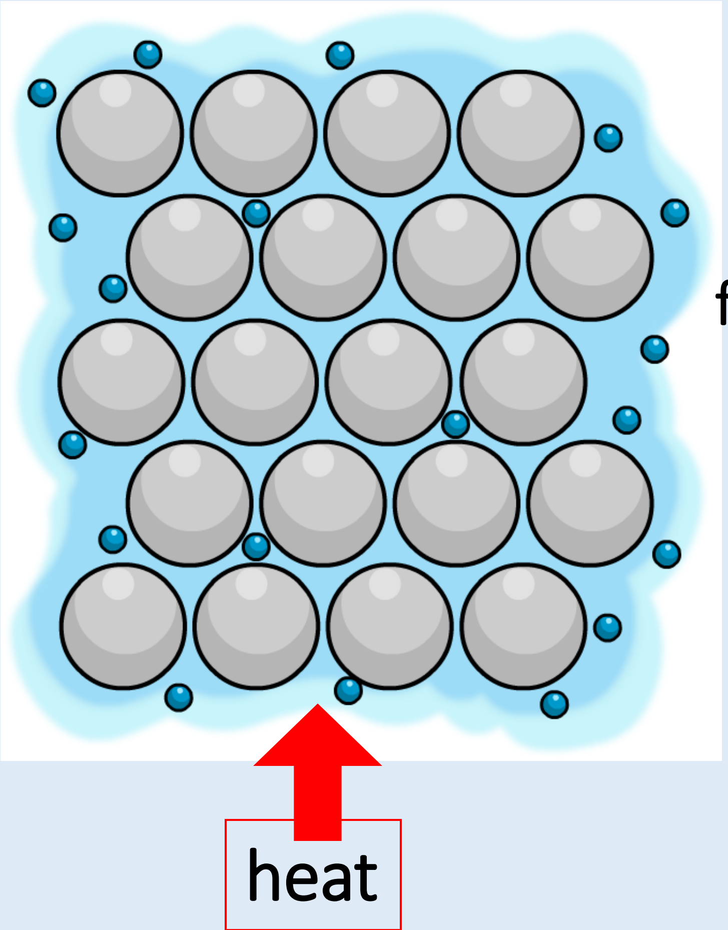
kg

J/kg °C

°C

Why are metals such good conductors?

The outer electrons of metal atoms are not attached to any particular atom. They are **free** to move between the atoms



When a metal is heated, the **free electrons** gain **kinetic energy**

This means that the free electrons move **faster** and **travel through the gaps** between the ions

When they **collide** with the metal ions, they **pass on the energy** and the **heat energy is transferred**

This makes heat transfer in metals very efficient.

Under the same conditions, different materials heat up and cool down at different rates.

(a) What is meant by specific heat capacity?

The energy required to raise the temperature of a unit mass of a substance by 1°C

....

....

(2)

(b) Quenching' is a process used to change the properties of steel by cooling it rapidly.

The steel is heated to a very high temperature and then placed in a container of cold water.

(i) A metalworker quenches a steel rod by heating it to a temperature of 900 °C before placing it in cold water. The mass of the steel rod is 20 kg.

The final temperature of the rod and water is 50 °C.

Calculate the energy transferred from the steel rod to the water.

Specific heat capacity of steel = 420 J / kg °C.

....

$E=mc\Delta\theta$

$E= 20 \times 420 \times (50-900)$

$E= 20 \times 420 \times (-850)$

Energy transferred = E= -7,140,000J J

(3)

(ii) The temperature of the steel rod eventually returns to room temperature.

Compare the movement and energies of the particles in the steel rod and in the air at room temperature.

In steel, the particles vibrate about fixed positions, where in air the particles can move freely. The particles in the air have more kinetic energy than the particles in the steel.

(3)

(ii) particles in the air have more (kinetic) energy than the particles in the steel

allow particles in the air have a greater speed.

1

steel

particles vibrate (about fixed positions)

1

air

particles move freely

1

(iii) When the steel rod is being quenched, the temperature of the water rises to 50 °C. After a few hours the water cools down to room temperature.

Some of the cooling of the water is due to evaporation.

Explain in terms of particles how evaporation causes the cooling of water.

The most energetic particles have energy to escape from the surface of the water. This means the mean energy of the remaining particles decreases. As energy decreases, temperature decreases.

(4)

(ii) the most energetic particles

accept molecules for particles throughout

accept the fastest particles

1

have enough energy to escape from (the surface of) the water

1

therefore the mean energy of the remaining particles decreases

accept speed for energy

1

as energy decreased, temperature has decreased

1

A 'can-chiller' is used to make a can of drink colder.

Figure 1 shows a can-chiller.

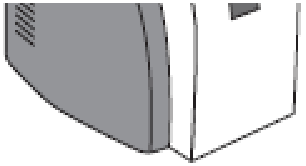
Figure 1

(a) 20 790 (J)

*an answer of 21 000 (J) (2 s.f.) gains **2** marks*

*allow **1** mark for correct substitution:*
ie E = 0.33 × 4200 × 15 provided no subsequent step shown

2



(a) The can-chiller decreases the temperature of the liquid in the can by 15 °C.
The mass of liquid is 0.33 kg.
The specific heat capacity of the liquid is 4200 J / kg °C.

Calculate the energy transferred from the liquid as it cools.

....

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

E= 0.33 x 4200 x 15
....

E= 20,790J

Energy = ... J

(2)

(b) Complete the following sentence.

The specific heat capacity of a substance is the amount of energy required to change the ......temperature...... of one kilogram of the substance by one degree Celsius.

(1)

(c) To calculate the specific heat capacity of a material, the mass of the material needs to be measured.

State the name of a measuring instrument used to measure mass.

......balance......

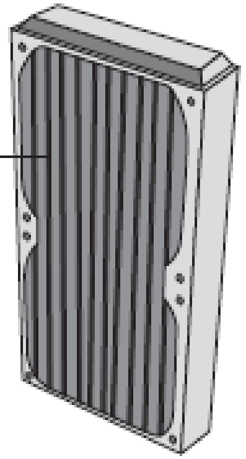
(1)

accept scales

*do **not** accept a scale*
*do **not** accept weighing scales*
*do **not** accept newtonmeter*
*do **not** accept spring balance*

(d) The back of the can-chiller has cooling fins, as shown in **Figure 2**.

Figure 2



The cooling fins increase the rate of energy transfer from the can-chiller to the surroundings.

Complete the following sentences.

The cooling fins are a Dark/black/grey colour because that makes them good emitters of infrared radiation.

The large surface area of the cooling fins allows the air around the can-chiller to gain energy quickly and rise, transferring energy by convection .

(2)

(e) (i) The energy input to the can-chiller is the same as the energy output. This shows that energy is conserved.

Complete the following sentence.

Energy can be transferred usefully, stored or dissipated, but cannot be

..created.............. or destroyed.

(1)

(ii) The temperature of the can of drink decreases while it is in the can-chiller.

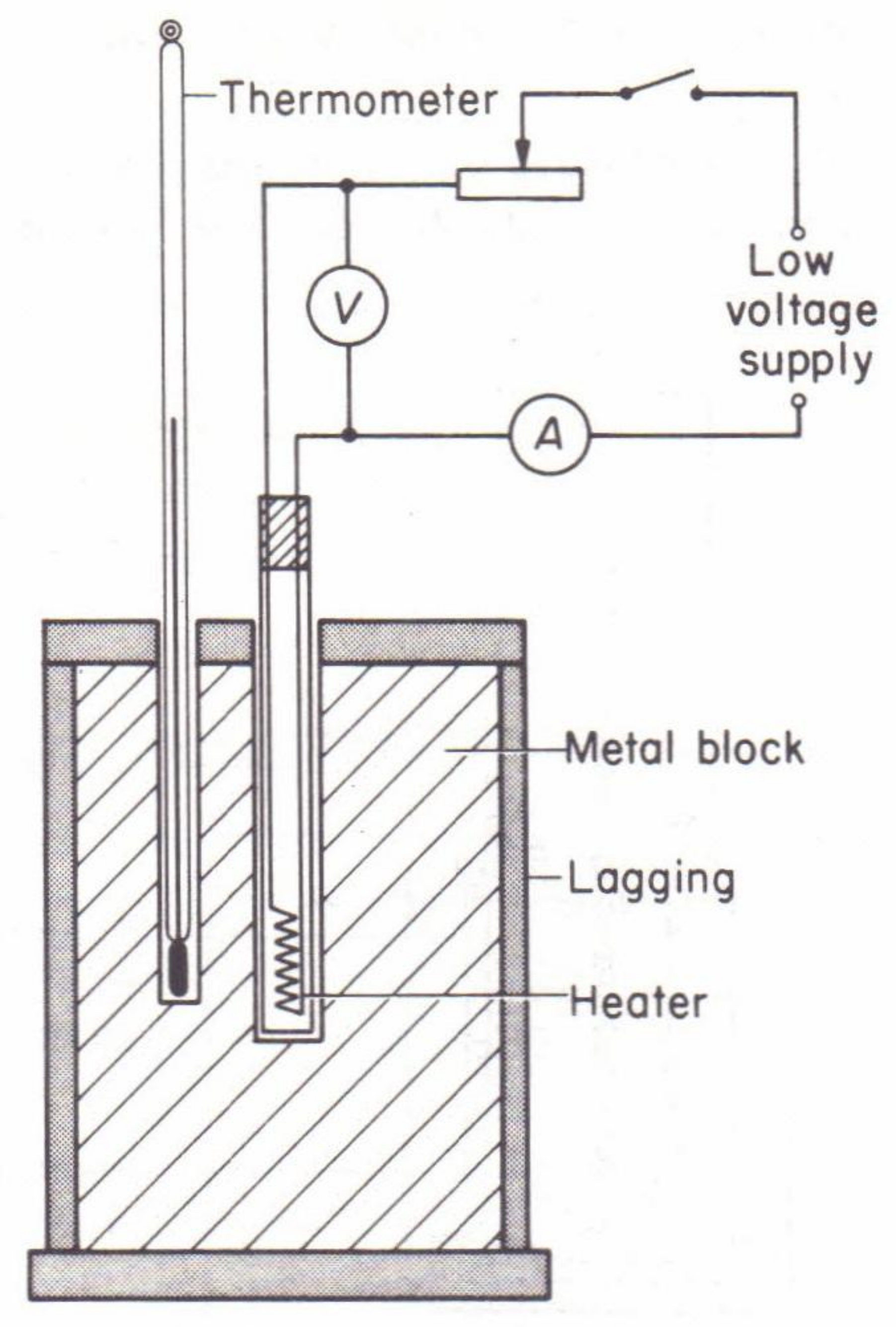
What happens to the temperature of the air around the cooling fins?

..................increases..

(1)

REQUIRED PRACTICAL

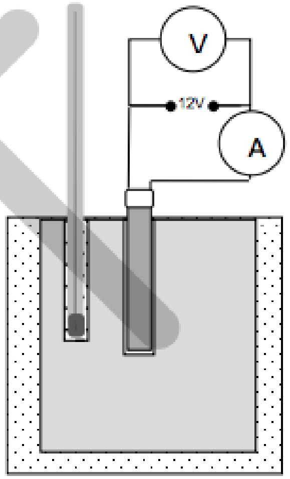
- Variables:
- Control Variable: mass of the block, starting temperature, time the block is heated for
- Independent Variable: substance material
- Dependent Variable: the specific heat capacity of different materials.
- Reasons for poor results: energy is lost to the surroundings, makes the specific heat capacity lower than expected



REQUIRED PRACTICAL

You should read these instructions carefully before you start work.

1. Measure and record the mass of the copper block, in kg.
2. Place a heater in the larger hole in the block. Connect the ammeter, power pack and heater in series.
3. Connect the voltmeter across the power pack.
4. Put a small amount of water in the other hole using the pipette.
5. Put the thermometer in this hole.
6. Switch the power pack to 12 V and switch it on.
7. Record the ammeter and voltmeter readings. These shouldn't change during the experiment.
8. Measure the temperature and switch on the stop clock.
9. Record the temperature every minute for 10 minutes. Your results table will need three columns. Notice that the time is measured in seconds, so the column will go 0, 60, 120, etc.



Time in seconds	Work done in J	Temperature in ˚C

12. Plot a graph of temperature in °C against work done in J.
13. Draw a line of best fit. Take care as the beginning of the graph may be curved.
14. Calculate the gradient of the straight part of your graph.
15. The heat capacity of the block is 1/gradient.
16. The specific heat capacity is the heat capacity divided by the mass of the block in kg. Work out the specific heat capacity of the material of the block.
17. If you can, repeat this experiment for other blocks such as aluminium and iron. There is a suggestion that if metal blocks have the same mass, the bigger the volume: the bigger the specific heat capacity. Is this true for the blocks you tested?

Energy Resources

Energy resource	description	advantages	disadvantages
Biofuel			
Nuclear			
Wave			
Wind			
hydroelectric			
tidal			
solar			
Geothermal			
Fossil fuels			Non renewable

Renewable resources are easily replaced

Carbon capture (CCS) can be expensive but are used to capture and store carbon dioxide.

Hydroelectric	Upland reservoir could run dry
Wind, waves	Wind and waves too weak on very calm days
Tidal	Height of tide varies both on a monthly and yearly cycle
Solar	No solar energy at night, and variable during the day

TRIPLE ONLY: INSULATION PRACTICAL

- Variables:
- Control Variable:
  - volume of water, starting temperature, surface area of insulation

- Independent Variable:
  - Insulation material
- Dependent Variable:
  - Temperature change

TRIPLE ONLY: INSULATION PRACTICAL

1. Put the small beaker inside the larger beaker.
2. Use the kettle to boil water. Put 80 ml of this hot water into the small beaker.
3. Use a piece of cardboard as a lid for the large beaker. The cardboard must have a hole for the thermometer.
4. Insert the thermometer through the hole in the cardboard lid so that its bulb is in the hot water.
5. Record the temperature of the water and start the stopwatch.
6. Record the temperature of the water every 3 minutes for 20 minutes Add your results to a table such as the one below.

Material used for insulation	Temperature in °C				
	At the start	After 5 minutes	After 10 minutes	After 15 minutes	After 20 minutes
No insulation					
Bubble wrap granules					
Newspaper					
Polystyrene					
Sawdust					

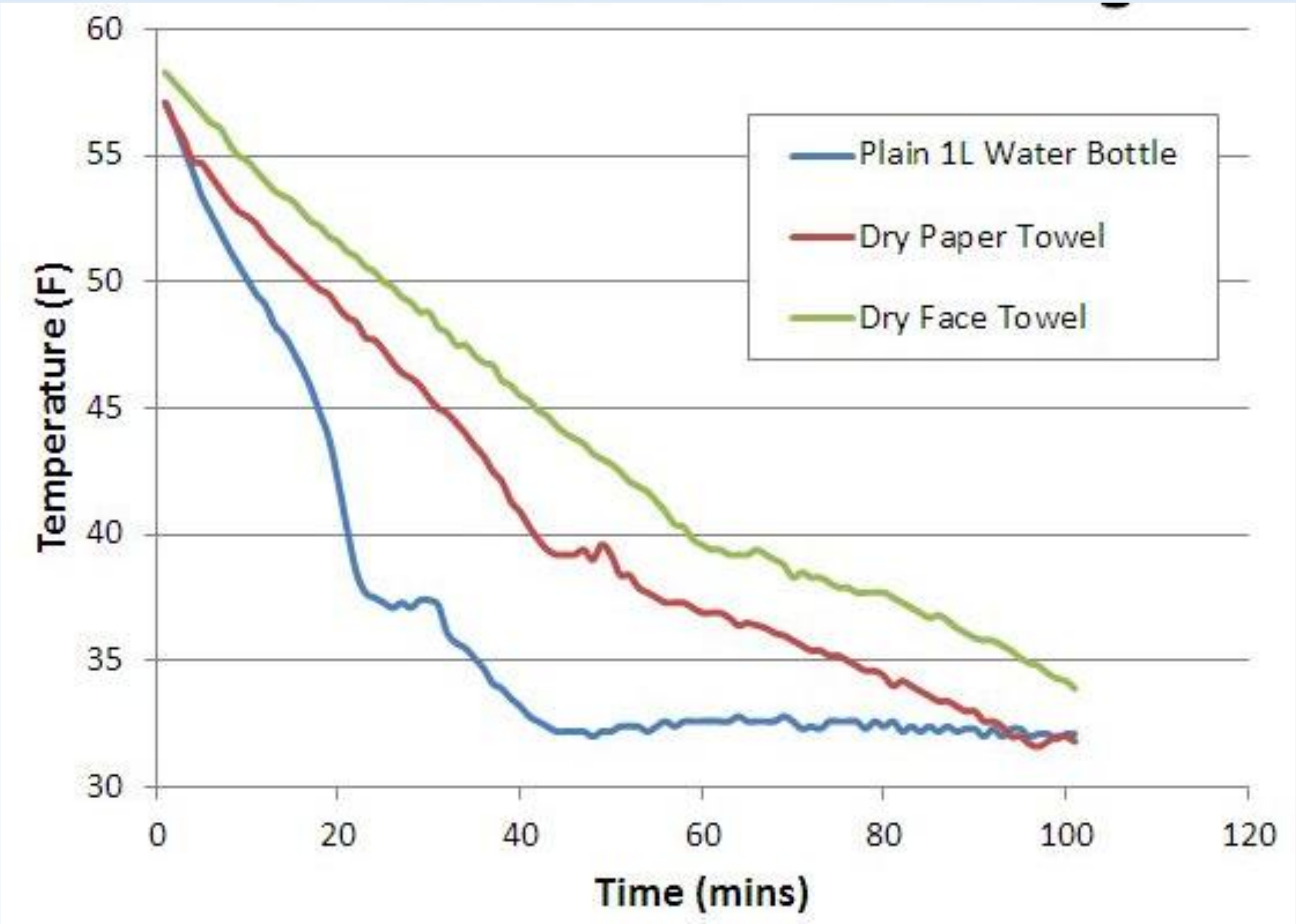
7. Repeat steps **1–6** using the different materials each time to fill the space between the small and large beaker.

   Make sure you use the same volume of water each time.
8. Plot cooling curve graphs for each material with:

- 'Temperature in °C' on the y-axis
- 'Time in minutes' on the x-axis.

Use your graphs to determine which material is the best insulator.

TRIPLE ONLY: INSULATION RESULTS



TRIPLE ONLY: INSULATION PRACTICAL

- You could also do a similar experiment increasing the layers of insulation.

- Control Variable : the material
- Independent Variable : the amount of layers used.
- Dependent Variable : temperature change.

TRIPLE ONLY: Temperature difference

- The larger the temperature difference between an object and its surroundings, the larger the rate of heat transfer.

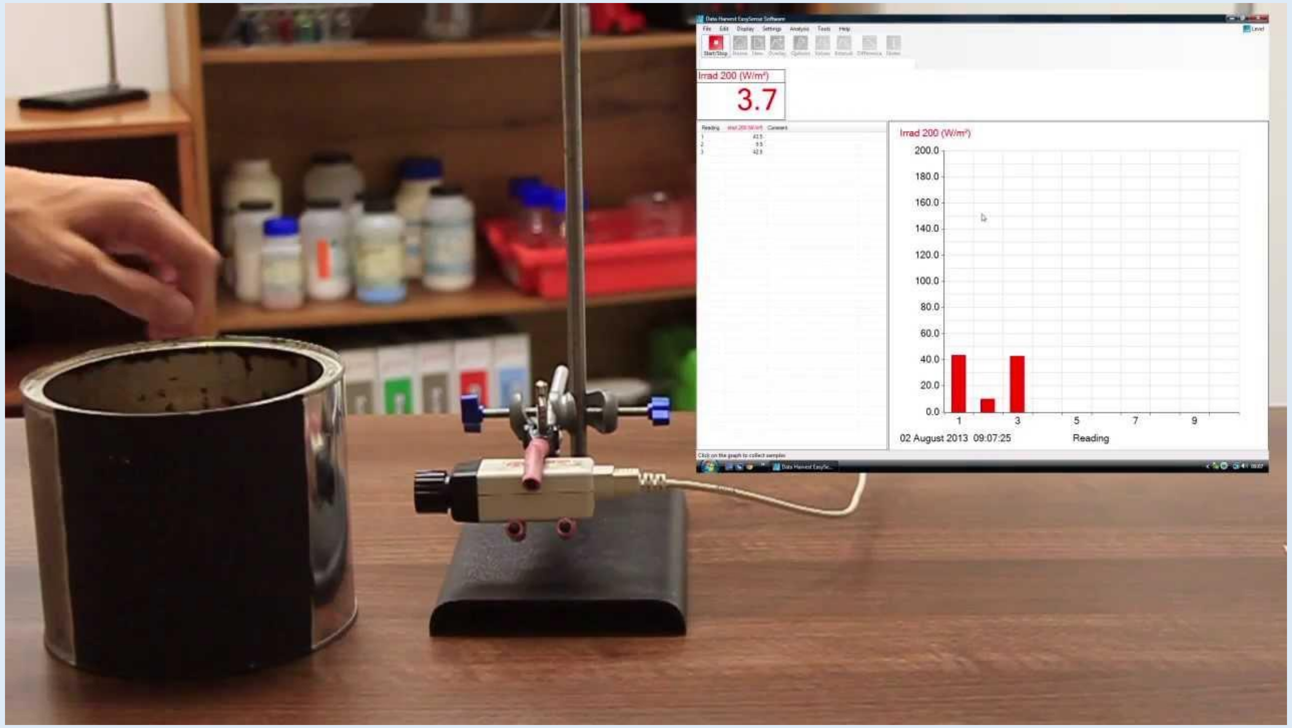
- The ‘hot’ water cooled down a lot faster than the ‘warm’ water as there was a larger temperature difference between the water and the surroundings.

Thermal Absorption

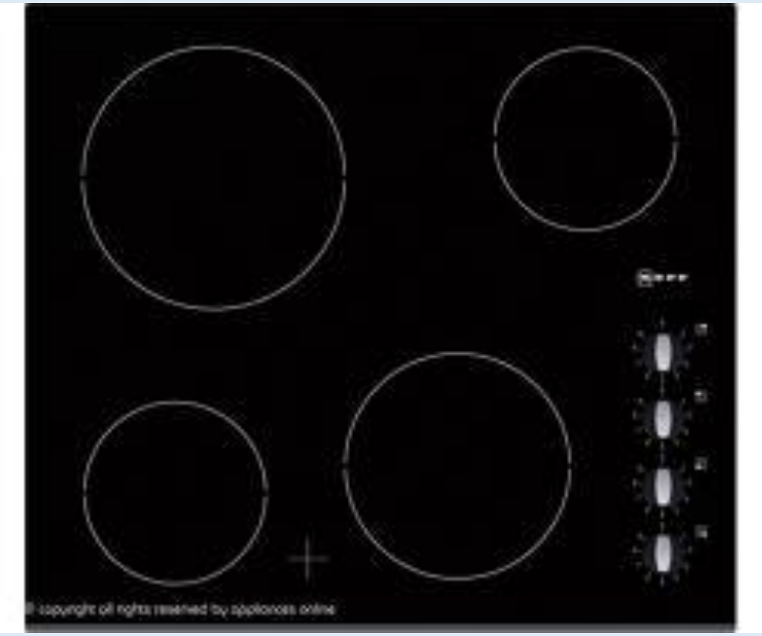
- Different colours absorb and emit heat in different amounts.

- What do these keywords absorb and emit mean?

- Absorb = take in
- Emit = give out



Thermal absorption and emission



- Black is the best thermal absorber of radiation.

- Black is ALSO the best emitter of radiation.

- Cooking hobs are usually dark colours as the surface emits thermal radiation well during cooking.

- Car radiators are often black to emit as much energy as possible to stay cool.

Thermal emission

- Silver surfaces are bad emitters of thermal radiation.

A student finds some information about energy-saving light bulbs.

(a) A 30W light bulb uses 600J of electrical energy in a certain period of time. In that time, it produces 450 J of light energy. The rest of the energy is wasted.

(i) Calculate the energy wasted by the light bulb in this period of time.

600J– 450J = 150J

Wasted energy = 150 J

(1)

(ii) What happens to the energy wasted by the light bulb?

It is transferred to the surroundings in the form of heat.

(1)

(iii) Calculate the efficiency of this light bulb.

$$Efficiency = \frac{400J}{600J}$$

Efficiency = $0.75 \text{ or } 75\%$

(2)

Exam Question

(a) Use words from the box to complete each sentence.

chemical	**light**	**kinetic**	**electrical**	**sound**

In the batteries, ______ *Chemical* ______ energy is transferred to

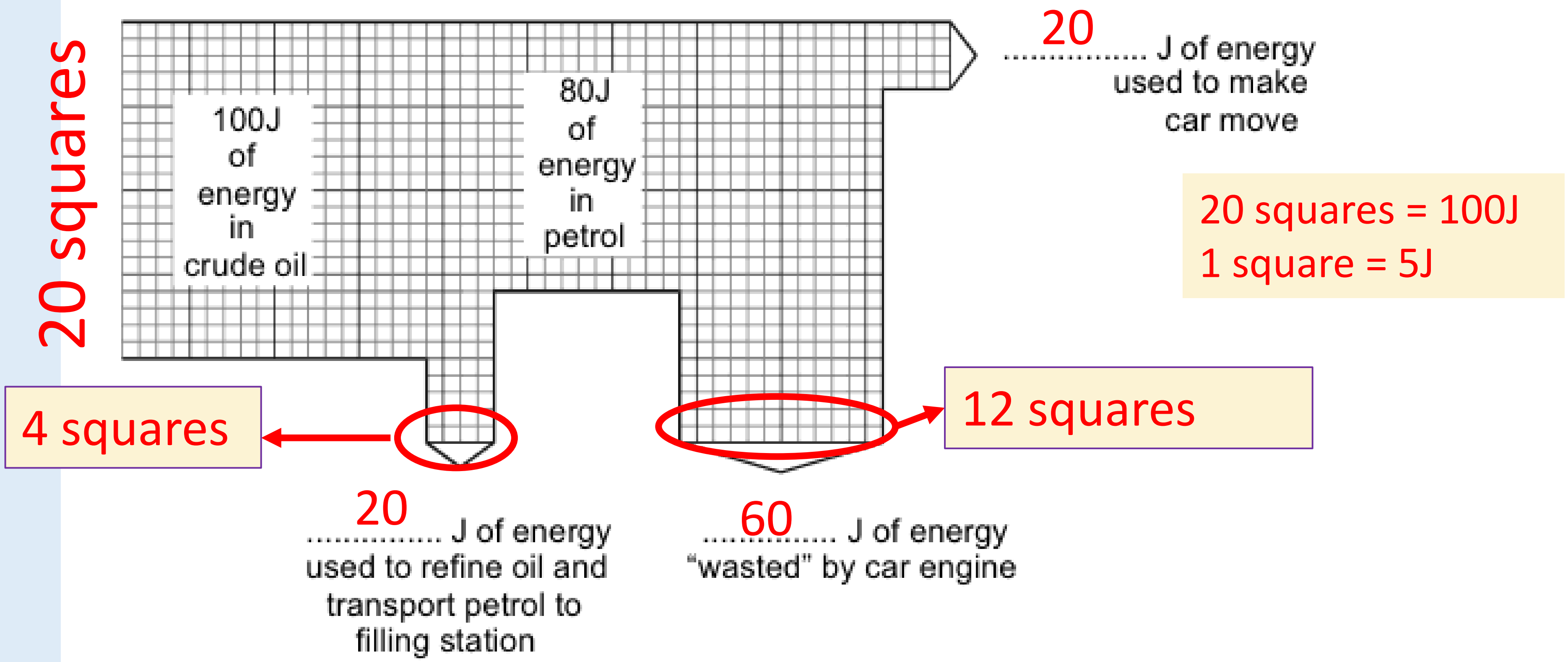
______ *Electrical* ______ energy in the wires.

The fan has ______ *kinetic* ______ energy as it rotates.

(3)

The diagram shows what happens to each 100 joules of energy from crude oil when it is used as petrol in a car.

The widths of the arrows show exactly how much energy is transferred in each particular way.

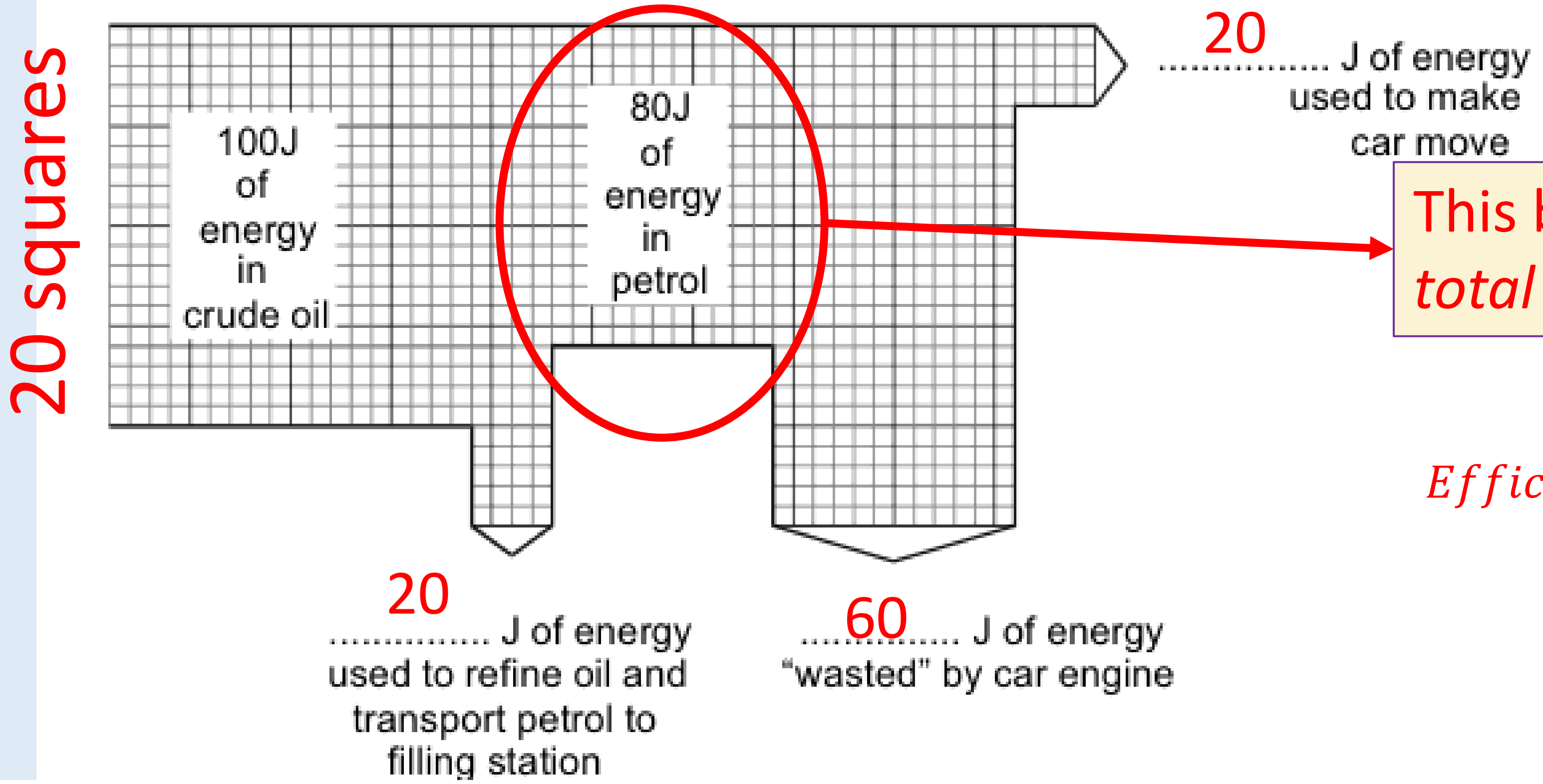


(a) Complete the diagram by adding the correct energy value alongside each arrow.

(2)

The diagram shows what happens to each 100 joules of energy from crude oil when it is used as petrol in a car.

The widths of the arrows show exactly how much energy is transferred in each particular way.



This becomes your new *total energy*

(b) Calculate how efficient the car engine is at transferring the energy **from petrol** into useful movement.

Show clearly how you work out your answer.

$$Efficiency = \frac{Useful\ Energy}{Total\ Energy}$$

$$Efficiency = \frac{20J}{80J}$$

$$Efficiency = 0.2\ or\ 25\%$$

Exam Question

Velocity (v) = 20m/s
Mass (Kg) = 1600kg

$$Kinetic\ Energy = \frac{1}{2}mv^2$$

$$E_K = \frac{1}{2}\ x\ 1600\ x\ 202$$

$$E_K = 320\ 000J$$

(b) A car is travelling at a speed of 20 m/s when the driver applies the brakes. The car decelerates at a constant rate and stops.

(i) The mass of the car and driver is 1600 kg.

Calculate the kinetic energy of the car and driver before the brakes are applied.

Kinetic energy = $320\ 000J$ J

(2)

(ii) How much work is done by the braking force to stop the car and driver?

Work done = $320\ 000J$ J

(1)

Exam Question

Velocity 1 (v_1) = 18m/s
Velocity 2 (v_2) = 13m/s
Mass (Kg) = 300kg

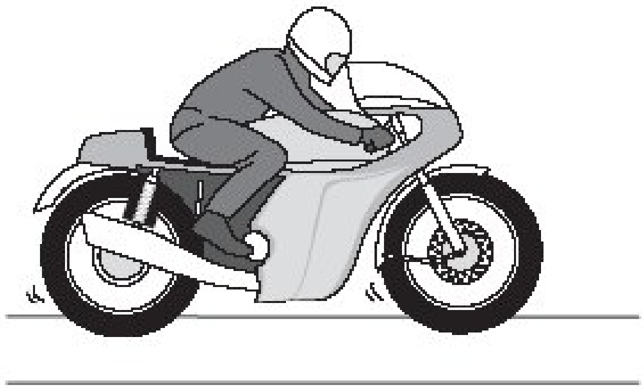
$$Kinetic\ Energy = \frac{1}{2} m{v_1}^2$$

$$E_K = \frac{1}{2}\ x\ 300\ x\ 182$$
$$E_K\ at\ 18m/s = \color{red}{48600J}$$

$$Kinetic\ Energy = \frac{1}{2} m{v_2}^2$$

$$E_K = \frac{1}{2}\ x\ 300\ x\ 32$$
$$E_K\ at\ 13m/s = 1350\color{red}{J}$$

The diagram shows a motorbike of mass 300 kg being ridden along a straight road.



The rider sees a traffic queue ahead. He applies the brakes and reduces the speed of the motorbike from 18 m/s to 3 m/s.

(a) Calculate the kinetic energy lost by the motorbike.

Show clearly how you work out your answer.

____

____

____

____

Kinetic energy lost = ______________________ J

(2)

(b) (i) How much work is done on the motorbike by the braking force?

____

(1)

Exam Question

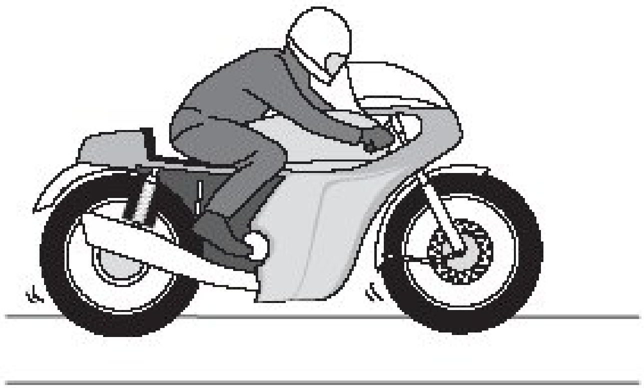
Velocity 1 (v_1) = 18m/s
Velocity 2 (v_2) = 3m/s
Mass (Kg) = 300kg

$$E_K \, at \, 18m/s = 48600J$$
$$E_K \, at \, 3m/s = 1350J$$

Kinetic Energy lost = E_k at 18m/s – E_k at 13m/s

Kinetic Energy lost = 48600J – 25350J
Kinetic Energy lost = 47250J

The diagram shows a motorbike of mass 300 kg being ridden along a straight road.



The rider sees a traffic queue ahead. He applies the brakes and reduces the speed of the motorbike from 18 m/s to 3 m/s.

(a) Calculate the kinetic energy lost by the motorbike.

Show clearly how you work out your answer.

____

____

____

____

Kinetic energy lost = 47250J J

(2)

(b) (i) How much work is done on the motorbike by the braking force?

47250J

(1)

Exam Question

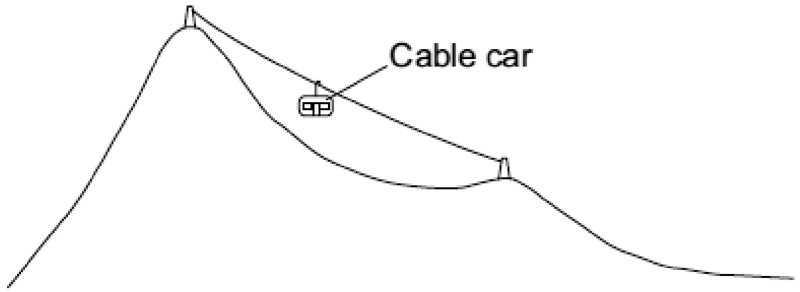
- m = 7500kg
- g= 10N/kg

$$Weight = mg$$

$$Weight = 7500kg\ x\ 10N/Kg$$

$$Weight = 75000N$$

(a) The diagram shows a cable car used to take skiers to the top of a mountain.



(i) The total mass of the cable car and skiers is 7500 kg.

Calculate the weight of the cable car and skiers.

gravitational field strength = 10 N/kg

Show clearly how you work out your answer and give the unit.

____

____

Weight = $75000N$

(3)

Exam Question

- F = 75000N
- s = 800m

$$Work = Fs$$

$$Work = 75000N\ x\ 800m$$

$$Work = 60\ 000\ 000J$$

(ii) The cable car moves at a constant speed. It lifts skiers through a vertical height of 800 metres in 7 minutes.

Calculate the work done to lift the cable car and skiers.

Show clearly how you work out your answer.

____

____

Work done = 60 000 000 J

(2)

Exam Question

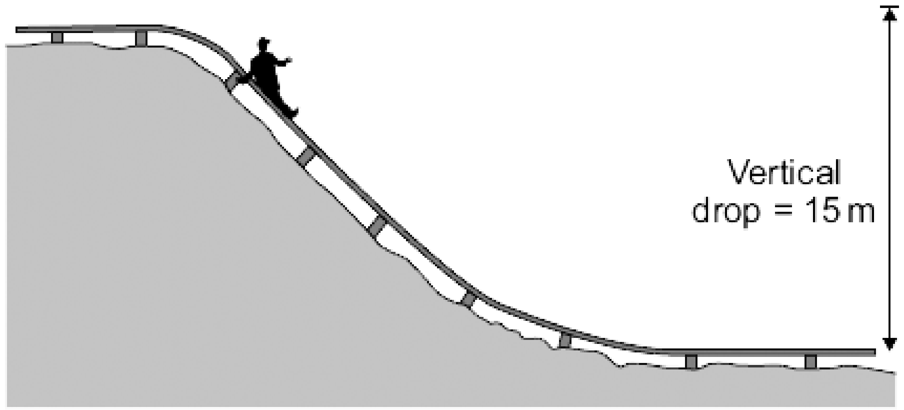
- m= 90kg
- g = 10N/kg
- h = 15m

$$GPE = mgh$$

$$GPE = 90 \; x \; 10 \; x \; 15$$

$$GPE = 13\,500J$$

The miners working in a salt mine use smooth wooden slides to move quickly from one level to another.



(a) A miner of mass 90 kg travels down the slide.

Calculate the change in gravitational potential energy of the miner when he moves 15 m vertically downwards.

gravitational field strength = 10 N/kg

Show clearly how you work out your answer.

____

____

Change in gravitational potential energy = ____13 500____ J

(2)

Exam Question HT

$$GPE = E_K$$

$x2$ $$13\,500 = \frac{1}{2} x\ 90\ x\ v^2$$ $x2$

÷ 90 $$2\ x\ 13\,500 = 90\ x\ v^2$$ ÷ 90

√v $$\frac{2\ x\ 13\,500}{90} = v^2$$ √v

$$\sqrt{\frac{2\ x\ 13\,500}{90}} = 17.32 m/s$$

(b) Calculate the **maximum** possible speed that the miner could reach at the bottom of the slide.

Show clearly how you work out your answer.

Give your answer to an appropriate number of significant figures.

____

____

____

____

Maximum possible speed = 17 m/s

(3)

You always go with the LOWEST significant figures.

More than likely this will be 2 s.f.

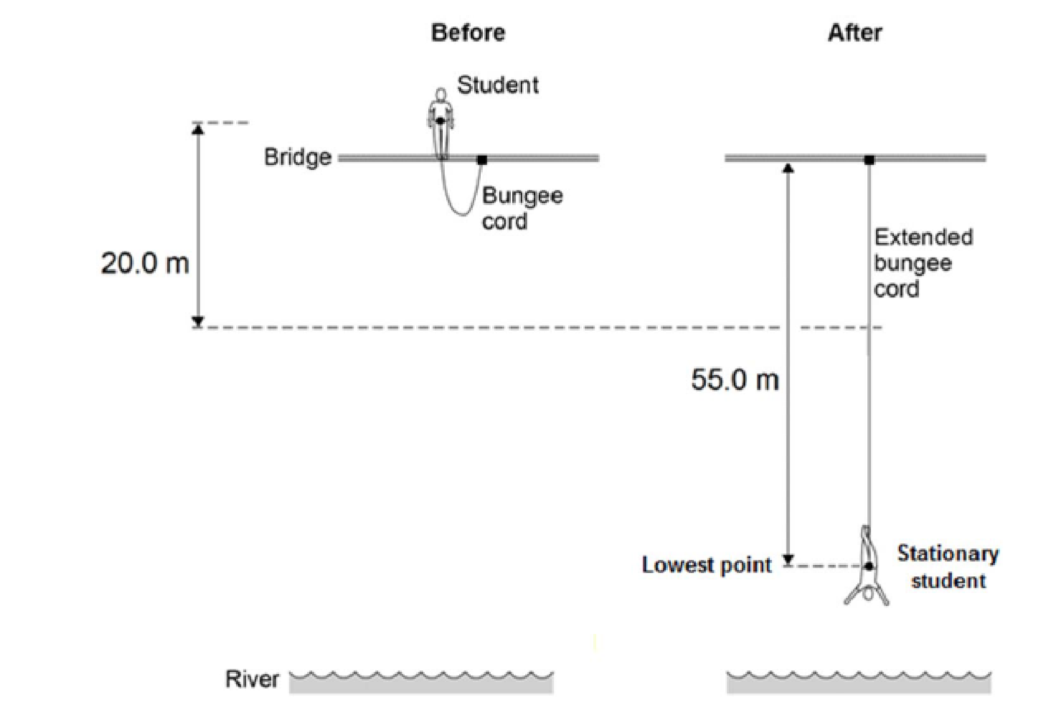
Exam Question

- k= 40N/m
- e = 35m

$$E_P = \frac{1}{2}ke^2$$

$$E_P = \frac{1}{2}x\ 40\ x\ 352$$

$$E_P = 24\ 500J$$



(c) At the lowest point in the jump when the student is stationary, the extension of the bungee cord is 35 metres.

The bungee cord behaves like a spring with a spring constant of 40 N / m.

Calculate the energy stored in the stretched bungee cord.

Use the correct equation from the Physics Equations Sheet.

____

____

____

Energy = 24 500 J

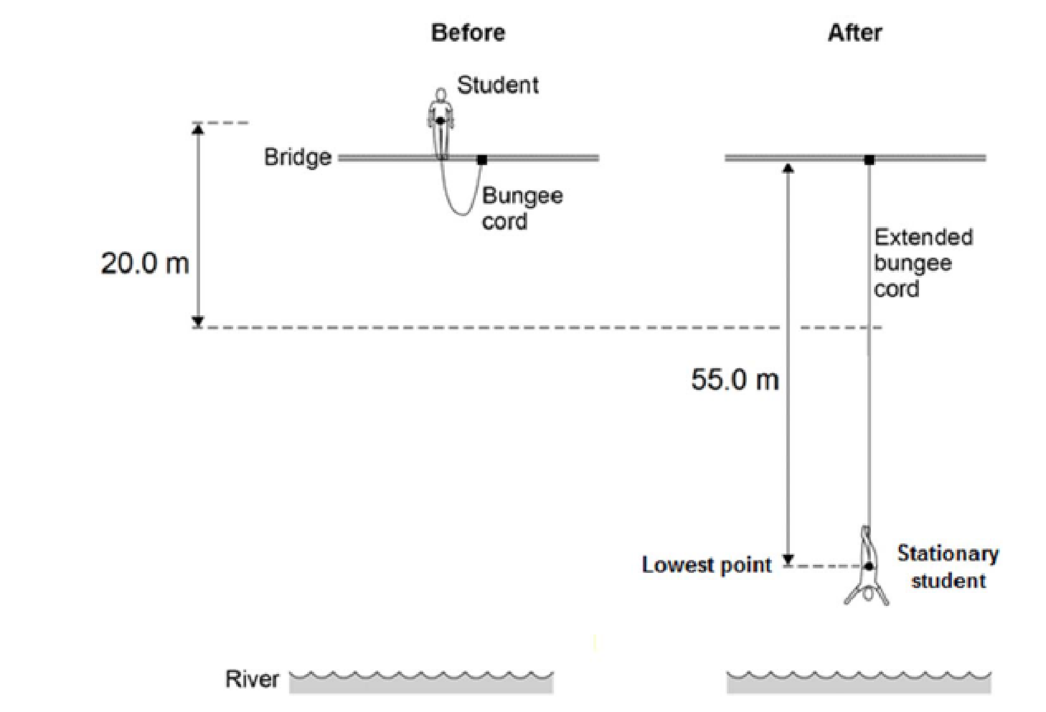
Exam Question HT

- k= ?
- e = 55m-20m = 35m
- E_P = 24.5kJ → $24.5 x 10^3$J or 24 500J

$$E_P = \frac{1}{2} k e^2$$

$$\frac{2 \; x \; EP}{e^2} = k$$

$$\frac{(2 \; x \; 24.5x103)}{35^2} = 40 \; N/m$$



(e) At the lowest point in the jump, the energy stored by the stretched bungee cord is 24.5 kJ.

The bungee cord behaves like a spring.

Calculate the spring constant of the bungee cord.

Use the correct equation from the Physics Equation Sheet.

Spring constant = 40 N / m

(3)

Exam Question

- E = 2240J
- t = 2.8s

$$P = \frac{E}{t}$$

$$P = \frac{2240J}{2.8s}$$

$$P = 800W$$

The student did 2240 J of work going from the bottom of the stairs to the top of the stairs.

The student took 2.8 seconds to run up the stairs.

(i) Calculate the power the student developed when running up the stairs.

____

____

Power = $800W$ W

(2)

Exam Question

- h = 0.40m
- m= 65kg
- t = 60s
- Chin ups = 12
- g = 10N/kg

$$W = Fs$$

$$W = (65x10)\ x\ 0.40$$

W = 260J x 12 chin ups

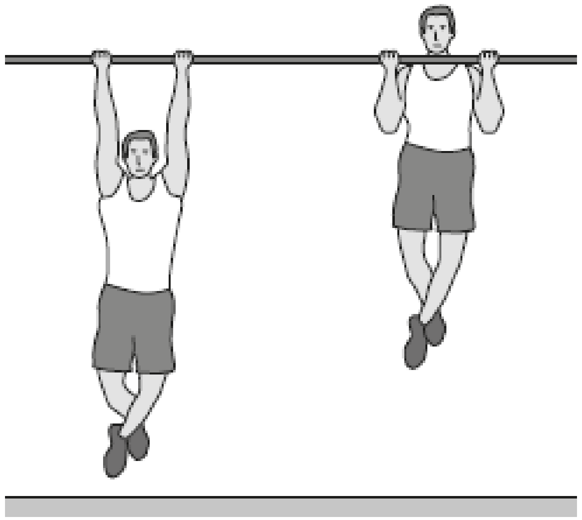
$$P = \frac{E}{t}$$

$$P = \frac{3120J}{60s}$$

$$P = 52W$$

(c) The student in **Figure 3** is doing an exercise called a chin-up.

Figure 3



Each time the student does one chin-up he lifts his body 0.40 m vertically upwards.
The mass of the student is 65 kg.
The student is able to do 12 chin-ups in 60 seconds.

Calculate the power developed by the student.

Gravitational field strength = 10 N/kg

Exam Question

- P = 2 000 000W → 2 000kW
- t = 6hrs

$$P = \frac{E}{t}$$

$$E = Pt$$

$$E = 2000 \; x \; 6$$

$$E = 12\ 000J$$

A single wind turbine has a maximum power output of 2 000 000 W.

The wind turbine operated continuously at maximum power for 6 hours.

Calculate the energy output in kilowatt-hours of the wind turbine.

____

____

____

Energy output = $12\ 000J$ kWh

(2)

Under the same conditions, different materials heat up and cool down at different rates.

(a) What is meant by specific heat capacity?

The energy required to raise the temperature of a unit mass of a substance by 1°C

(2)

(b) Quenching' is a process used to change the properties of steel by cooling it rapidly.

The steel is heated to a very high temperature and then placed in a container of cold water.

(i) A metalworker quenches a steel rod by heating it to a temperature of 900 °C before placing it in cold water. The mass of the steel rod is 20 kg.

The final temperature of the rod and water is 50 °C.

Calculate the energy transferred from the steel rod to the water.

Specific heat capacity of steel = 420 J / kg °C.

$E = mc\Delta\theta$

$E = 20 \times 420 \times (50-900)$

$E = 20 \times 420 \times (-850)$

$E = -7{,}140{,}000J$

Energy transferred = E= -7,140,000J J

(3)

(ii) The temperature of the steel rod eventually returns to room temperature.

Compare the movement and energies of the particles in the steel rod and in the air at room temperature.

In steel, the particles vibrate about fixed positions, where in air the particles can move freely. The particles in the air have more kinetic energy than the particles in the steel.

(3)

(ii) particles in the air have more (kinetic) energy than the particles in the steel

allow particles in the air have a greater speed.

1

steel

particles vibrate (about fixed positions)

1

air

particles move freely

1

(iii) When the steel rod is being quenched, the temperature of the water rises to 50 °C. After a few hours the water cools down to room temperature.

Some of the cooling of the water is due to evaporation.

Explain in terms of particles how evaporation causes the cooling of water.

The most energetic particles have energy to escape from the surface of the water. This means the mean energy of the remaining particles decreases. As energy decreases, temperature decreases.

(4)

(ii) the most energetic particles

accept molecules for particles throughout

accept the fastest particles

1

have enough energy to escape from (the surface of) the water

1

therefore the mean energy of the remaining particles decreases

accept speed for energy

1

as energy decreased, temperature has decreased

1

A 'can-chiller' is used to make a can of drink colder.

Figure 1 shows a can-chiller.

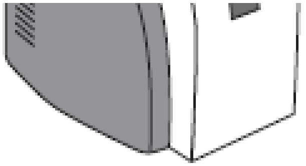
Figure 1

(a) 20 790 (J)

*an answer of 21 000 (J) (2 s.f.) gains **2** marks*

*allow **1** mark for correct substitution:*
ie E = 0.33 × 4200 × 15 provided no subsequent step shown

2



(a) The can-chiller decreases the temperature of the liquid in the can by 15 °C.
The mass of liquid is 0.33 kg.
The specific heat capacity of the liquid is 4200 J / kg °C.

Calculate the energy transferred from the liquid as it cools.

$E = mc\Delta\theta$

$E = 0.33 \times 4200 \times 15$

E= 20,790J

Energy = ... J

(2)

(b) Complete the following sentence.

The specific heat capacity of a substance is the amount of energy required to

change the ....temperature.......... of one kilogram of the

substance by one degree Celsius.

(1)

(c) To calculate the specific heat capacity of a material, the mass of the material needs to be measured.

State the name of a measuring instrument used to measure mass.

..........balance..........

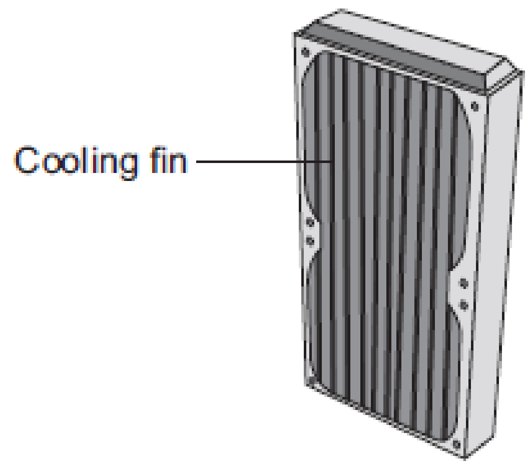
(1)

accept scales

*do **not** accept a scale*
*do **not** accept weighing scales*
*do **not** accept newtonmeter*
*do **not** accept spring balance*

(d) The back of the can-chiller has cooling fins, as shown in **Figure 2**.

Figure 2



The cooling fins increase the rate of energy transfer from the can-chiller to the surroundings.

Complete the following sentences.

The cooling fins are a Dark/black/grey colour because that makes them good emitters of infrared radiation.

The large surface area of the cooling fins allows the air around the can-chiller to gain energy quickly and rise, transferring energy by convection .

(2)

(e) (i) The energy input to the can-chiller is the same as the energy output. This shows that energy is conserved.

Complete the following sentence.

Energy can be transferred usefully, stored or dissipated, but cannot be

..created.............. or destroyed.

(1)

(ii) The temperature of the can of drink decreases while it is in the can-chiller.

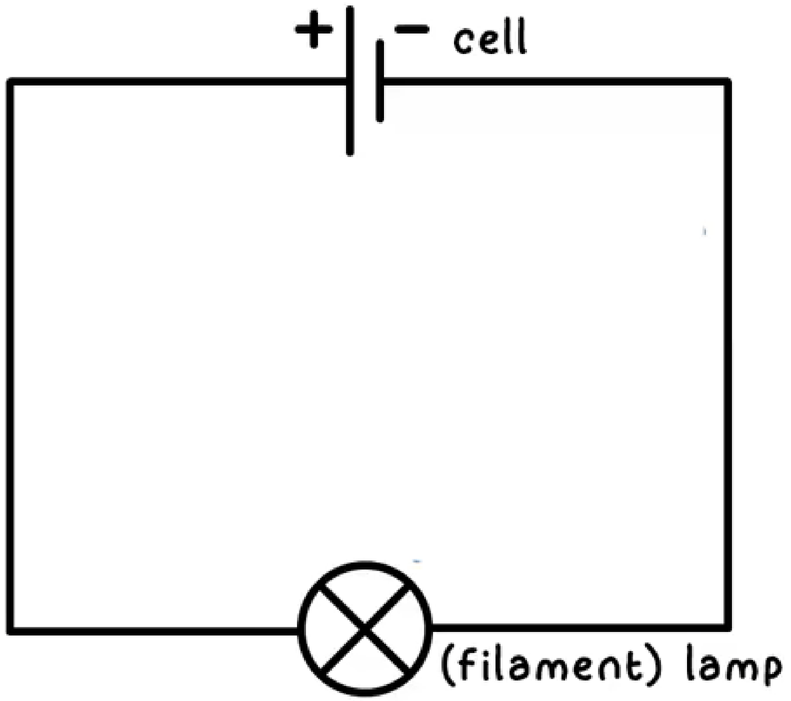
What happens to the temperature of the air around the cooling fins?

..................increases..

(1)

ELECTRICAL CIRCUITS

Energy is supplied to ELECTRONS by a cell/battery or mains electricity, which then move through the wires to transfer energy.
Cells/batteries have a store of chemical potential energy.

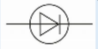
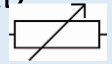
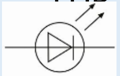
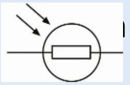
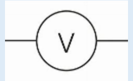
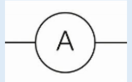


Physics Unit 1 key ideas

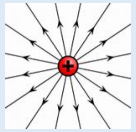
1. Draw the circuit symbol for the following components: diode, variable resistor, LED, LDR, voltmeter, ammeter
2. State where a voltmeter must go in a circuit
3. State the equation that links potential difference, current and resistance
4. Describe how to investigate how the length of a wire affects resistance
5. Draw the IV graphs for the following: a resistor, a filament lamp and a diode
6. State how to measure resistance of a component in a circuit
7. State the equation that links power, current and potential difference
8. State the effect of increasing temperature of a wire on resistance
9. State the difference between DC and AC
10. State the colour of each wire: earth, live, neutral
11. State the equation that links power, energy transferred and time
12. State how to calculate efficiency of an appliance.
13. State what makes up the national grid.
14. State the function of a step up transformer.
15. State the function of a step down transformer.
16. Describe what causes a person's hair to stand on end when they go down a slide.
17. State what is meant by the term isolated object.
18. Describe how current can flow between an object and the Earth.
19. Draw the electric field lines from an isolated positive charge.

Separates only

Physics Unit 1 key ideas

1. Draw the circuit symbol for the following components: diode , variable resistor , LED , LDR , voltmeter  ammeter 

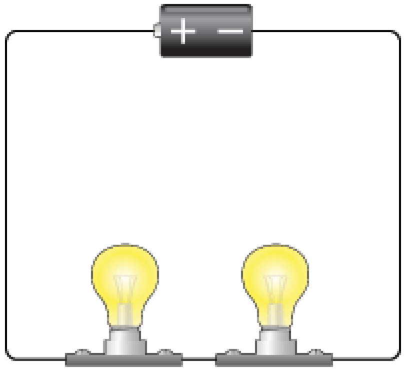
2. State where a voltmeter must go in a circuit. In parallel to the component
3. State the equation that links potential difference, current and resistance. V = IR
4. Describe how to investigate how the length of a wire affects resistance. Set up test circuit with variable resistor (to control the potential difference and keep low so it doesn't overheat the wire), an ammeter to measure current, a voltmeter to measure p.d. Change the length of the wire and measure current and p.d. each time. Calculate resistance using V = IR
5. Draw the IV graphs for the following: a resistor, a filament lamp and a diode. (See PPoint)
6. State how to measure resistance of a component in a circuit. Measure current and p.d., calculate using V = IR
7. State the equation that links power, current and potential difference. P = IV
8. State the effect of increasing temperature of a wire on resistance. Increases resistance of the wire as more collisions of electrons.
9. State the difference between DC and AC. DC – one direction, AC – changes direction
10. State the colour of each wire: earth green/yellow, live brown, neutral blue.
11. State the equation that links power, energy transferred and time. E = P t
12. State how to calculate efficiency of an appliance. Efficiency = useful energy out/total energy in
13. State what makes up the national grid. Cables and transformers
14. State the function of a step up transformer. Increases potential difference and therefore decreases current, so less energy is transferred to the surroundings.
15. State the function of a step down transformer. Reduces potential difference to 230V to make it safe for use in homes.
16. Describe what causes a person's hair to stand on end when they go down a slide. Static electricity – friction causes electrons to be transferred from the slide to the person. The slide becomes positively charged, the person becomes negatively charged and as all hairs have the same charge they repel eachother.
17. State what is meant by the term isolated object. An object that has no path for electric charge to travel to Earth.
18. Describe how current can flow between an object and the Earth. There has to be a potential difference, which induces a current, allowing charge to flow. This causes an electric shock.
19. Draw the electric field lines from an isolated positive charge.



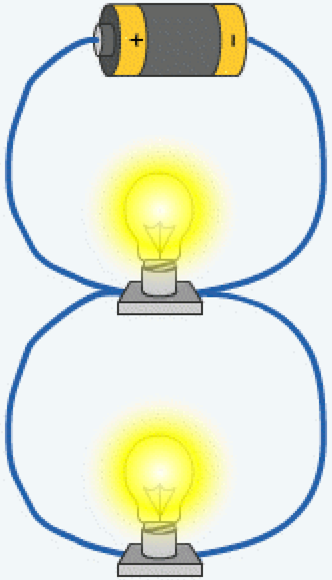
switch (open)	lamp
switch (closed)	fuse
cell	voltmeter
battery	ammeter
diode	thermistor
resistor	LDR
variable resistor	
LED	

Convert the following diagram into circuit diagrams

Series

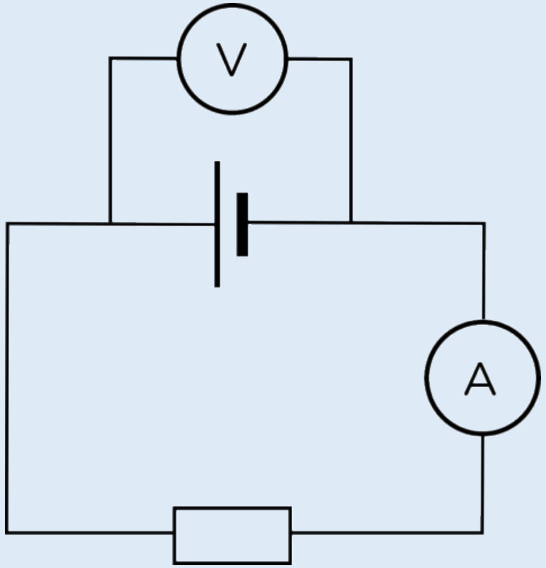


Parallel



Ammeters are placed in series

Voltmeters are placed in parallel

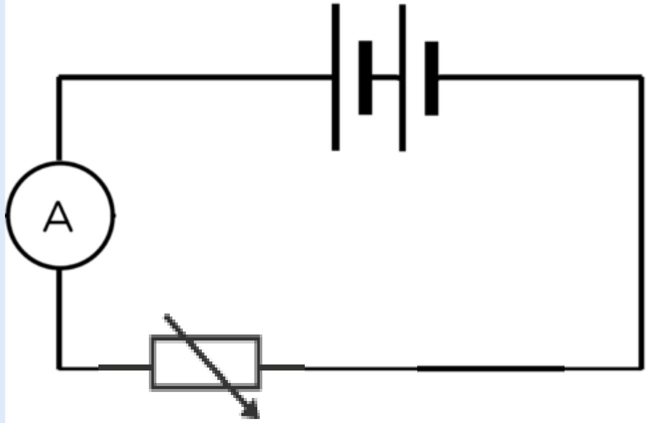


Exam Question

(b) An ammeter was in a series circuit with two cells and a variable resistor.

The ammeter showed a reading of 0.3 A.

(i) Draw a circuit diagram for the circuit.



Candidates who drew the circuit diagram neatly, using a ruler, were usually able to obtain at least one mark for part (b)(i); those who drew the circuit diagram freehand often left gaps in the circuit and scored zero. Very few candidates knew the correct symbol for a variable resistor.

(2)

(ii) What will happen to the reading on the ammeter if the resistance of the variable resistor is **increased?**

decrease

....

(1)

(Total 5 marks)

Circuit definitions

- Current – the flow of charge per second in a circuit
  - measured in Amps, A
  - by an ammeter, A
  - represented by I
- Potential Difference – Energy per unit charge.
  - Measured in volts, V
  - by a voltmeter, V
  - represented by V
- Resistance – the measure of how difficult it is for current to flow.
  - Measured in ohms, Ω,
  - represented by R.
  - Can be worked out from the potential difference divided by current.

Equations: Current

$$I = \frac{Q}{t}$$

$$Current = \frac{Charge}{time}$$

C

A

s

Exam Question

- I = 0.25A
- V = 230V
- Circuit = Series
- t= 5min → 300s

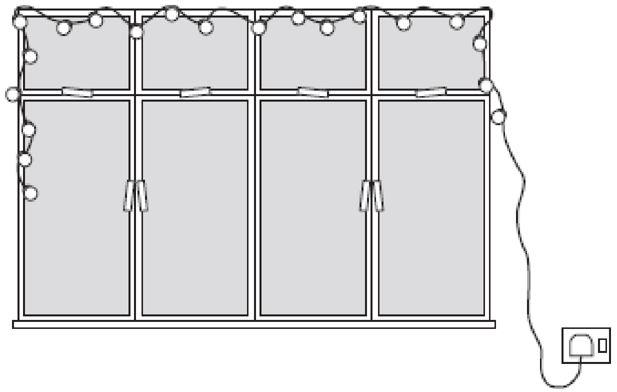
$$I = \frac{Q}{t}$$

$$Q = It$$

$$Q = 0.25 \, x \, 300$$

$$Q = 75C$$

A set of lights consists of 20 lamps connected in series to the 230 V mains electricity supply.



(a) When the lights are switched on and working correctly, the current through each lamp is 0.25 A.

(i) What is the total current drawn from the mains supply?

0.25A

(1)

(ii) Calculate the charge passing through **one** of the lamps in 5 minutes.

Show clearly how you work out your answer and give the unit.

Total charge = $75C$

Charge Flow

- Work is done when charge flows in a circuit.
- The amount of energy transferred by electrical work can be calculated using the equation:

$$E = QV$$

$$Energy = Charge \; x \; Voltage$$

J

C

V

Energy Question

- How much energy is transferred when 10C flows through a lamp with 230V applied across it

$$E = QV$$

$$E = 10C\ x\ 230$$

$$E = 2300J$$

Exam Question

- V = 230V
- E = 4200J
- C=?

$$E = QV$$

$$Q = \frac{E}{V}$$

$$Q = \frac{4200}{230}$$

$$Q = 18.26C$$
$$Q = 18.3C$$

(f) The mains electricity supply is at 230 V.

A different heater transfers 4200 J of energy.

Calculate the charge flow through the heater.

____

____

____

Charge flow = 18.3 C

(3)

Calculating Voltage

$$V = IR$$

$$Voltage = Current\ x\ Resistance$$

V

A

Ω

Exam Question

- P = 24W
- V = 12V
- I = 0.8A
- R = 2.5 Ω

$$V = IR$$

$$V = 0.8\ x\ 2.5$$

$$V = 2V$$

(a) The resistance of a 24 W, 12 V filament lamp depends on the current flowing through the lamp. For currents up to 0.8 A, the resistance has a constant value of 2.5 Ω.

(i) Use the equation in the box to calculate the potential difference across the lamp when a current of 0.8 A flows through the lamp.

potential difference = current × resistance

Show clearly how you work out your answer.

____

____

Potential difference = 2 V

Exam Question

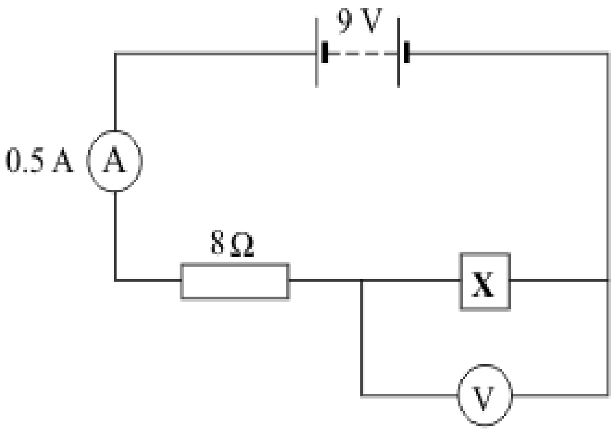
- V = 9V
- I = 0.5A
- R = 8Ω

$$V = IR$$

$$V = 0.5A \; x \; 8\Omega$$

$$V = 4V$$

(a) The circuit diagram drawn below includes a component labelled **X**.



(i) Calculate the potential difference across the 8 ohm resistor.

Show clearly how you work out your answer.

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____

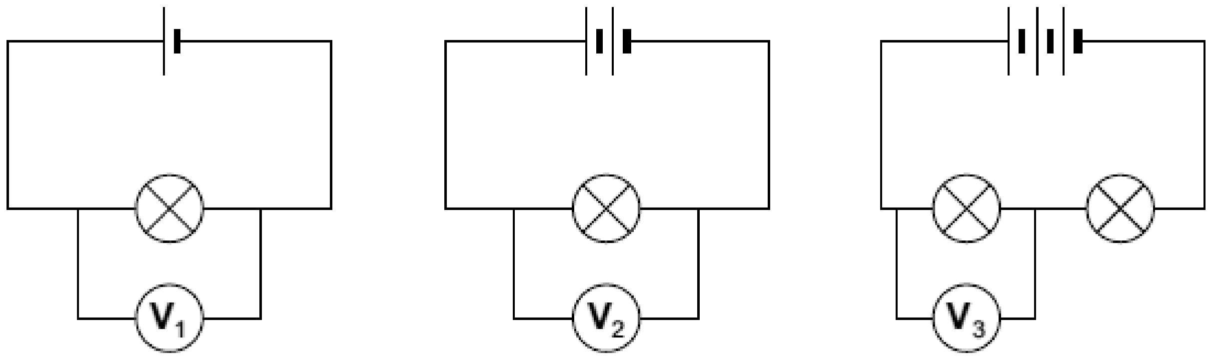
Potential difference = 4 volts (2)

Exam Question

- Lamps are the same
- Cell V= 1.5V

$$3\ x\ 1.5V = 4.5V$$

(a) The lamps in the circuits drawn below are all identical.
Each of the cells has a potential difference of 1.5 volts.



(i) What is the potential difference across the 3 cells that are joined in series?

____

Potential difference = $4.5V$ V

(1)

Circuit Rules

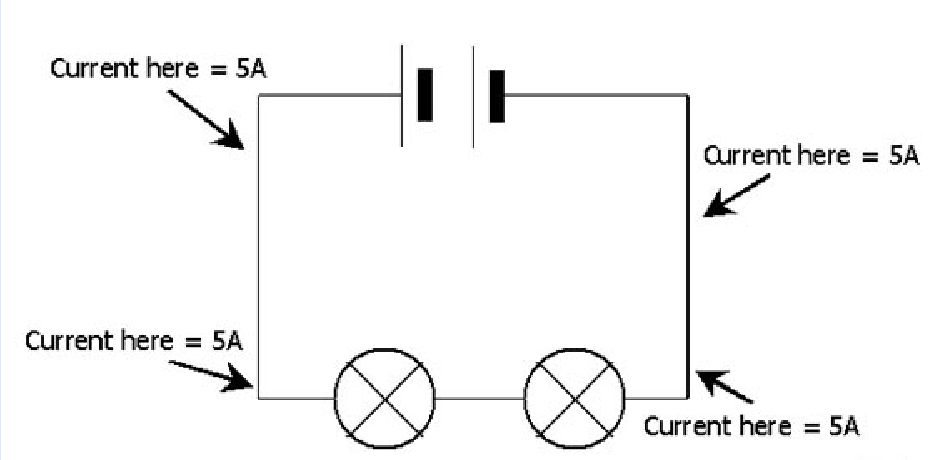
Series

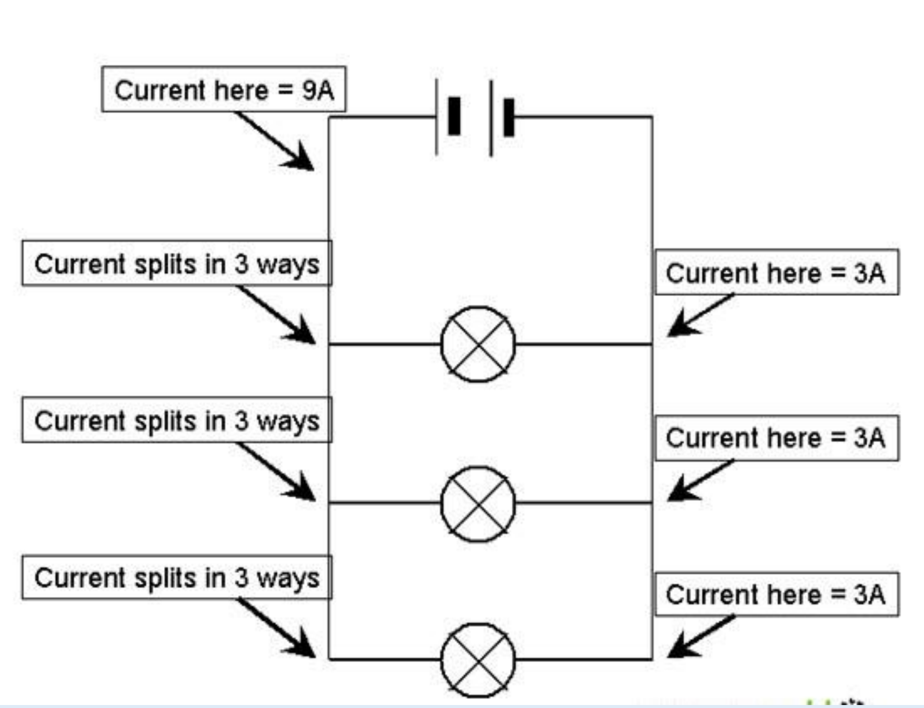
- Current stays the same
- Potential difference is shared between components
- Total resistance = $R_1 + R_2$

Parallel

- Current splits
- Potential difference stays the same
- Total Resistance is less than an the lowest individual resistor

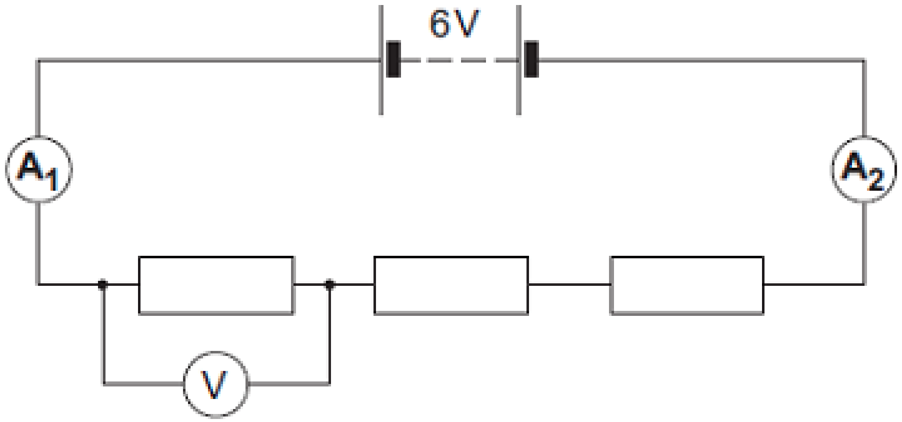
Current in series and parallel





Current in series

(ii) The same circuit has now been set up with two ammeters.



Draw a ring around the correct answer in the box to complete the sentence.

	smaller than	
The reading on ammeter **A_2** will be	equal to	the reading on ammeter **A_1**.
	greater than	

(1)

Ohms Law

- The current through a resistor, at a constant temperature, is directly proportional to the potential difference across the resistor.

$$R = \frac{V}{I}$$

V

$$Resistance = \frac{Voltage}{Current}$$

Ω

I

Factors effecting resistance

- How long the wire is
- How thick the wire is
- How many components there are
- How hot the wire is

REQUIRED PRACTICAL: Length of wire and resistance

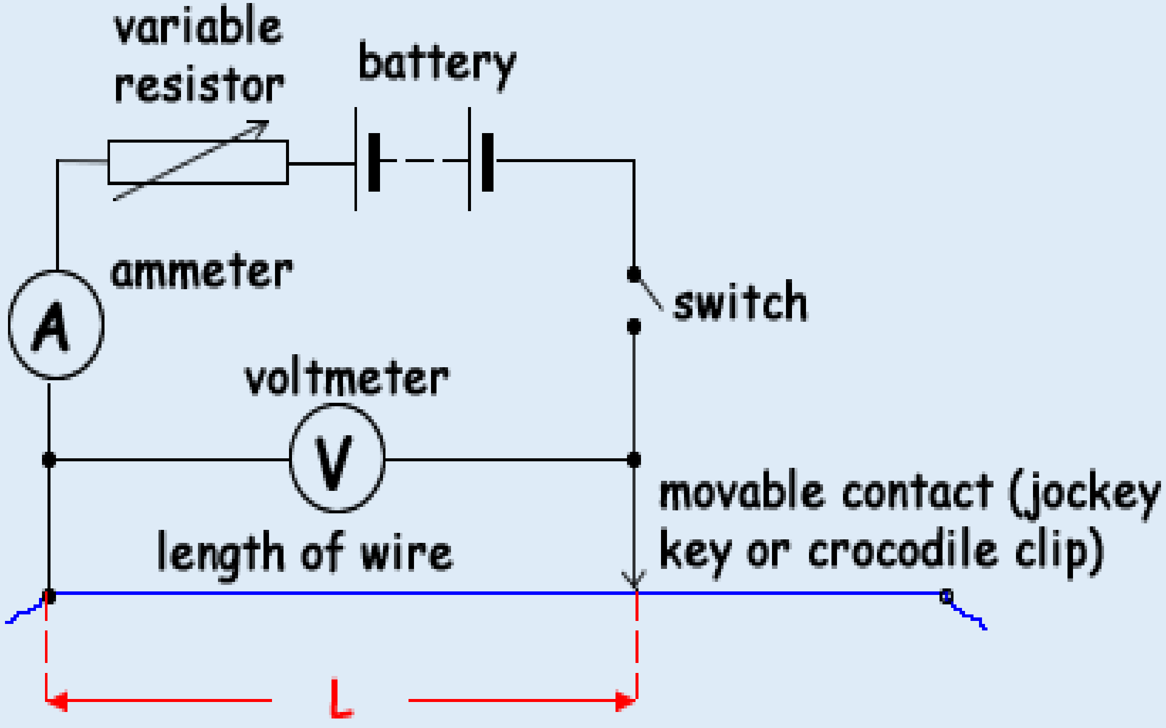
1. Connect the circuit.

   It may be helpful to start at the positive side of the battery or power supply. This may be indicated by a red socket.
2. Connect a lead from the red socket to the positive side of the ammeter.
3. Connect a lead from the negative side of the ammeter (this may be black) to the crocodile clip at the zero end of the ruler.
4. Connect a lead from the other crocodile clip to the negative side of the battery. The main loop of the circuit is now complete. Use this lead as a switch to disconnect the battery between readings.
5. Connect a lead from the positive side of the voltmeter to the crocodile clip the ammeter is connected to.
6. Connect a lead from the negative side of the voltmeter to the other crocodile clip.
7. Record on a table the:
   - length of the wire between the crocodile clips
   - the readings on the ammeter
   - the readings on the voltmeter.
8. Move the crocodile clip and record the new ammeter and voltmeter readings. Note that the voltmeter reading may not change.

   Repeat this to obtain several pairs of meter readings for different lengths of wire.
9. Calculate and record the resistance for each length of wire using the equation:

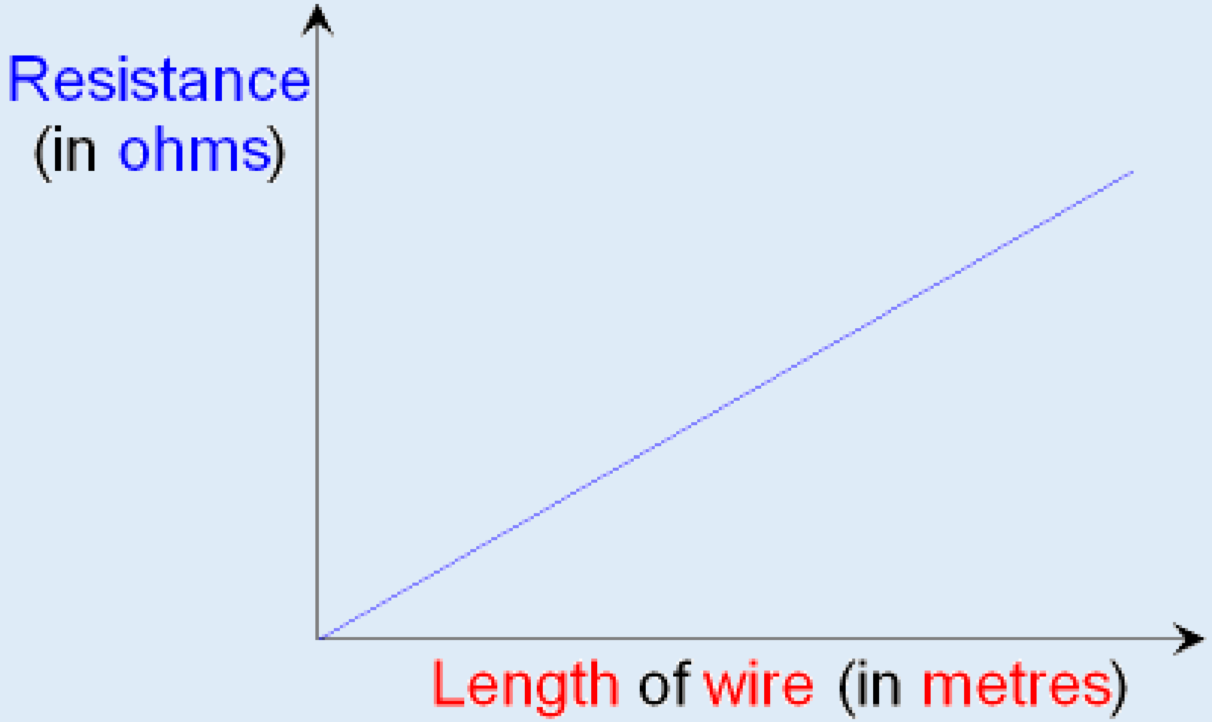
$$\text{resistance in } \Omega = \frac{\text{potential difference in V}}{\text{current in A}}$$

10. Plot a graph with:
    - 'Resistance in Ω' on the y-axis
    - 'Length of wire in cm' on the x-axis.
11. You should be able to draw a straight line of best fit although it may not go through the origin.

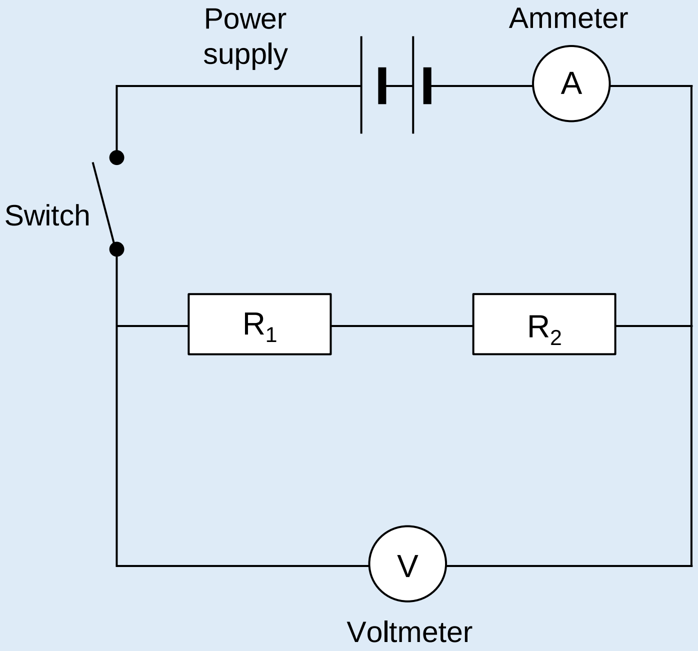


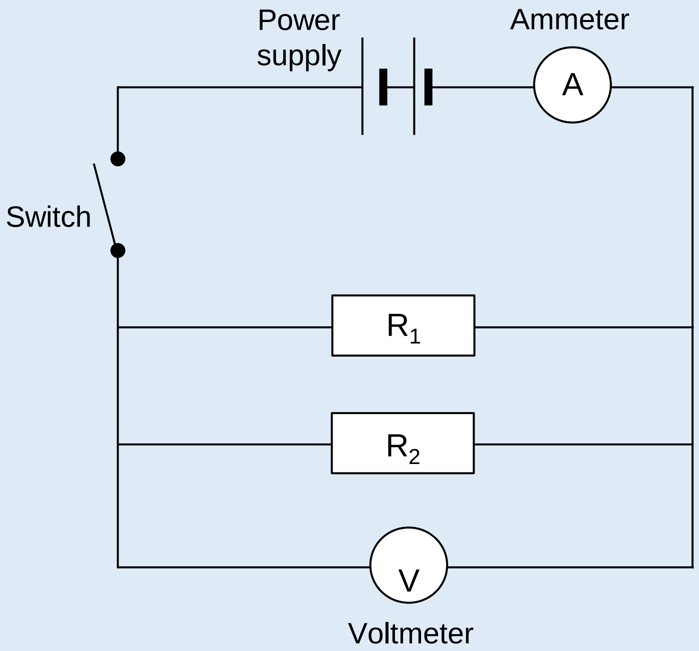
REQUIRED PRACTICAL: Results

- Resistance of wire proportional to length
- Hard to get 0 error as crocodile clip
- Low p.d. as short length of wire current will increase dramatically



REQUIRED PRACTICAL: Resistors

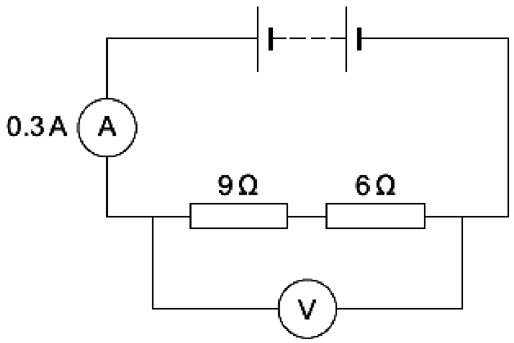




Resistance Total: Series

- RT series = sum of all resistors
- RT = 9 + 6
- RT = 15 Ω

(a) The diagram shows a simple circuit.

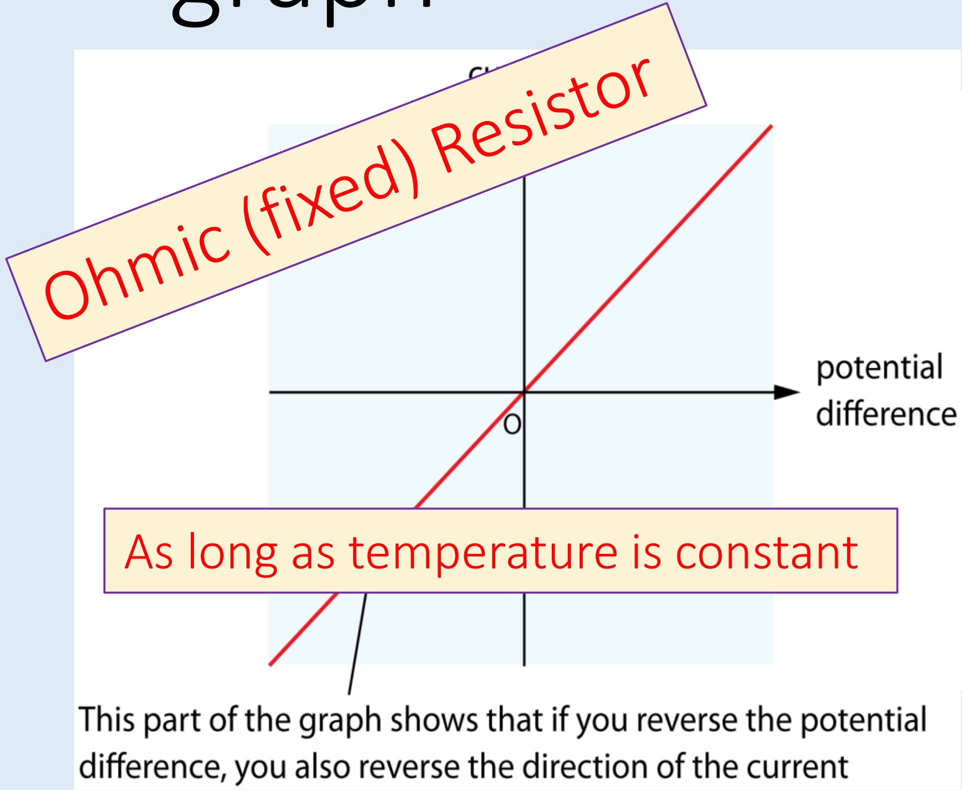


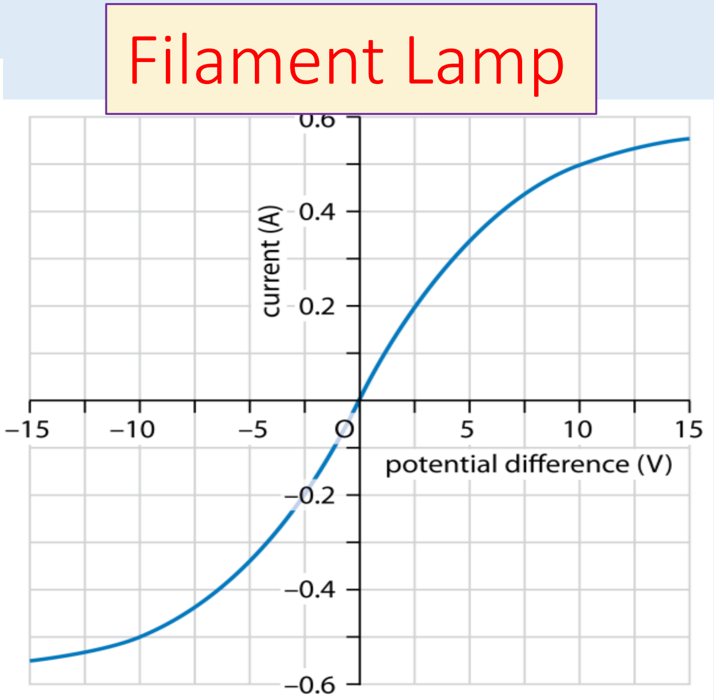
(i) Calculate the total resistance of the two resistors in the circuit.

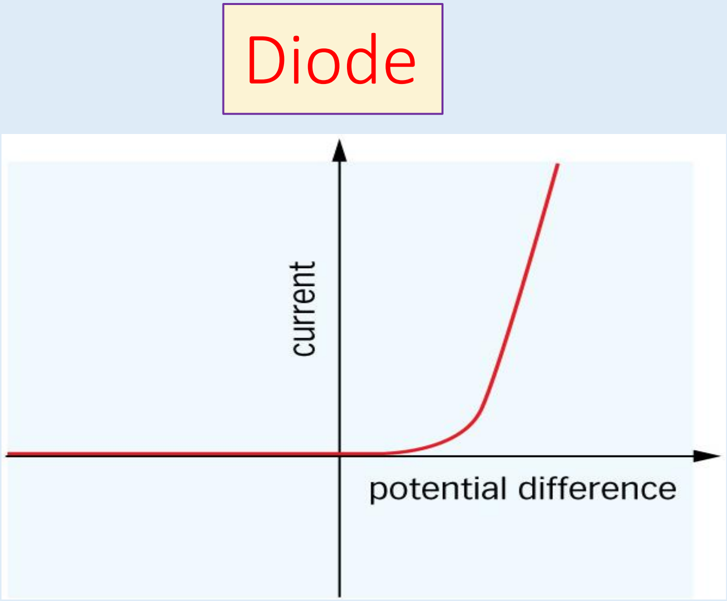
Total resistance = 15 Ω Ω

(1)

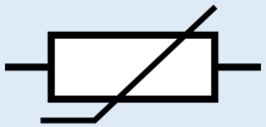
I/V Graphs: Name the component for each graph



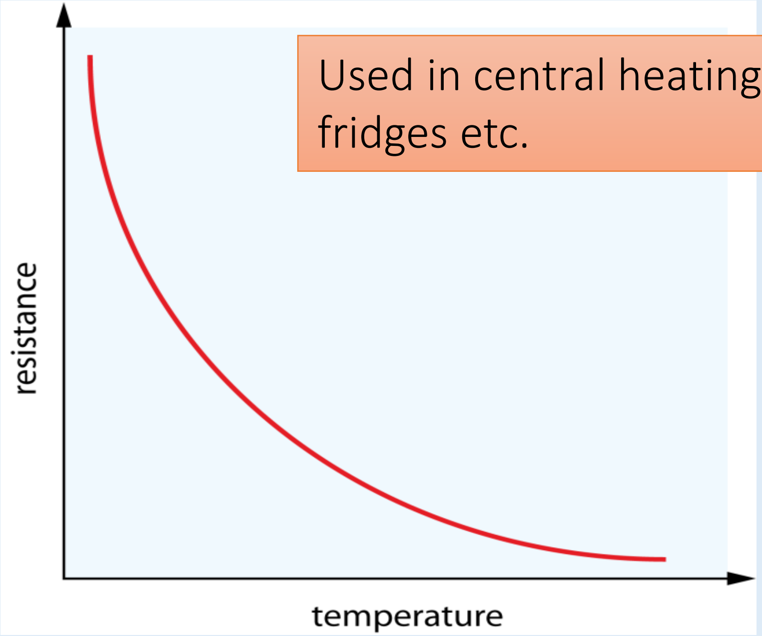




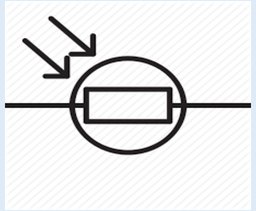
Thermistors and LDR (Light Dependent Resistor)



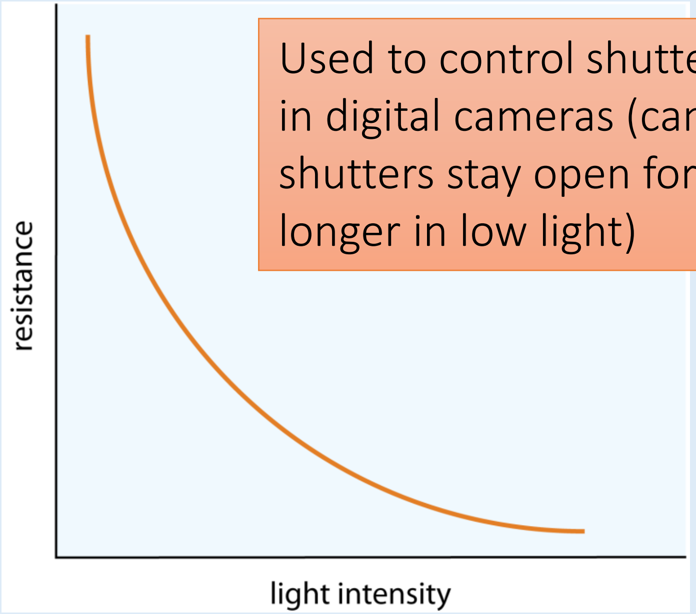
Resistance depends on temperature. As temperature increases, resistance decreases.



Used in central heating, fridges etc.



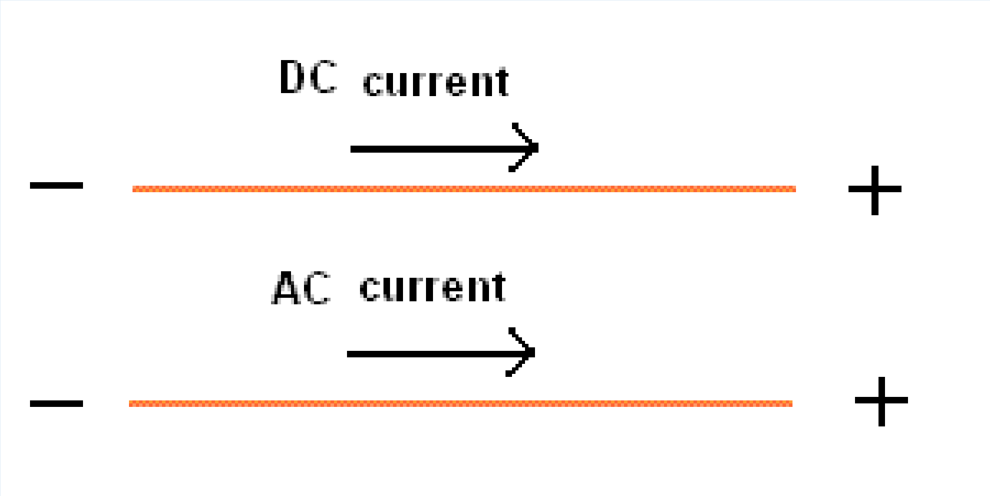
Resistance depends on light intensity. As light intensity increases, resistance decreases.



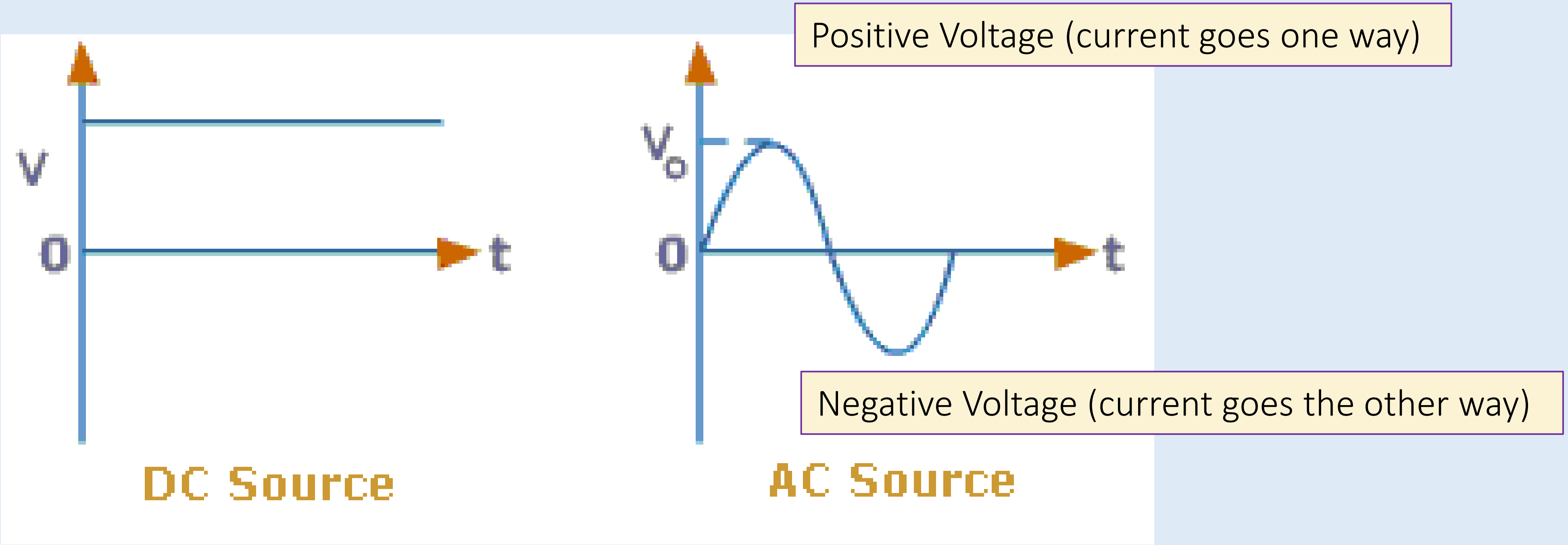
Used to control shutters in digital cameras (camera shutters stay open for longer in low light)

AC vs DC

- AC = Alternating Current
  - The potential difference of mains electricity changes direction. The potential difference changes polarity (it can be + or -)
  - Mains Electricity (electricity from the plug) is AC and at $50H_z$ that is changing direction 50 times each second
- DC = Direct Current
  - The potential difference across cells and batteries is always in the same direction. The potential difference does not change polarity (+ or -).
  - batteries and solar cells are all DC



Representing AC and DC in a graph

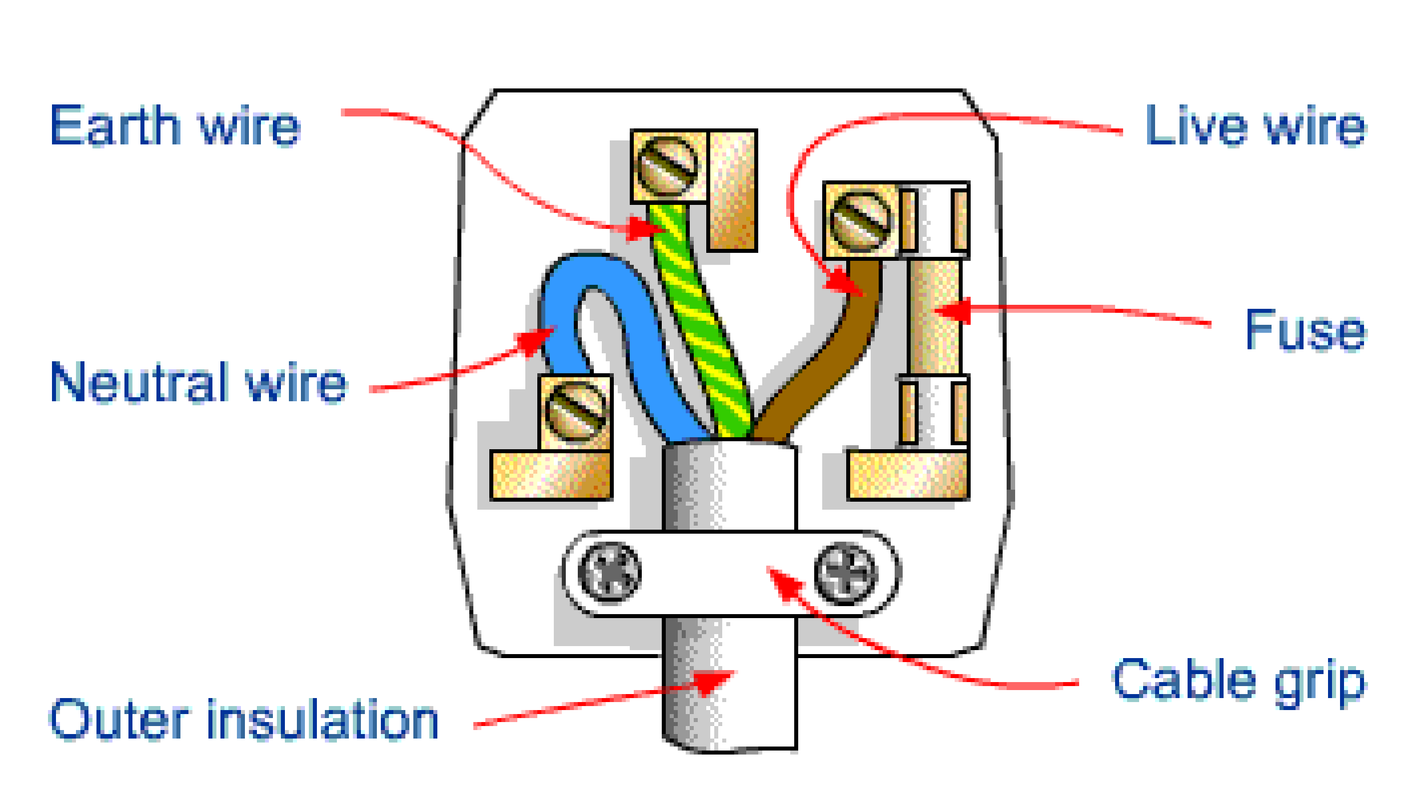


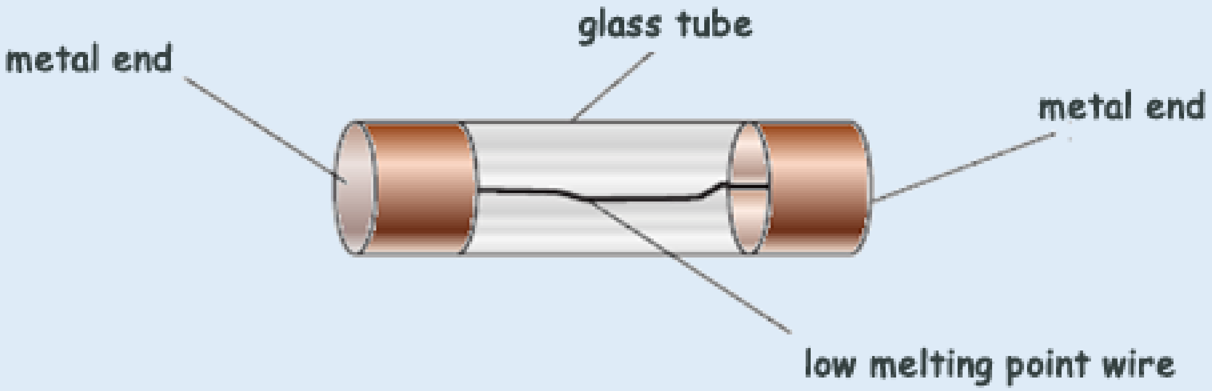
Mains Electricity

- Mains electricity is an a.c. supply.
- In the UK it has a frequency of 50 Hz
- Voltage = 230 V.

The Plug

- The live wire carries the alternating potential difference from the supply.
- The neutral wire completes the circuit.
- The earth wire is a safety wire to stop the appliance becoming live.



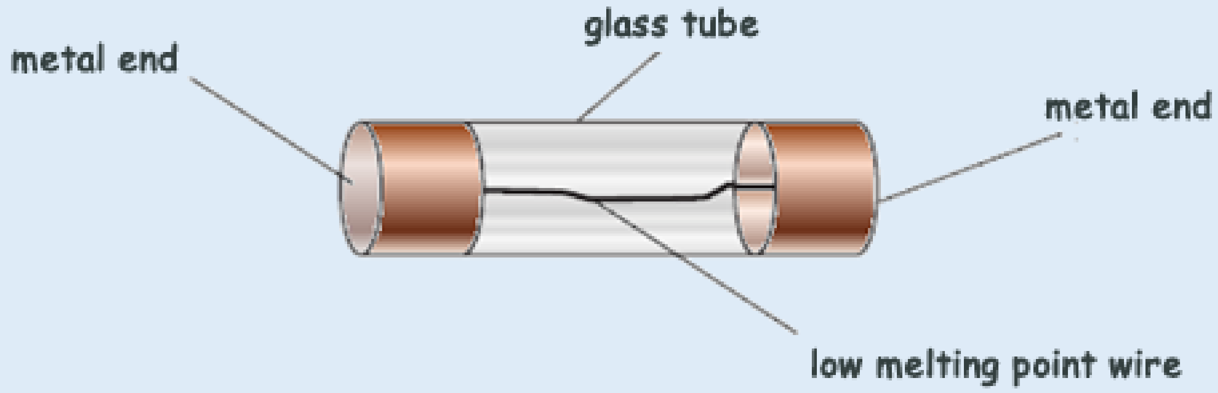


The Fuse

- The fuse breaks the circuit if a fault in an appliance causes too much current flow.

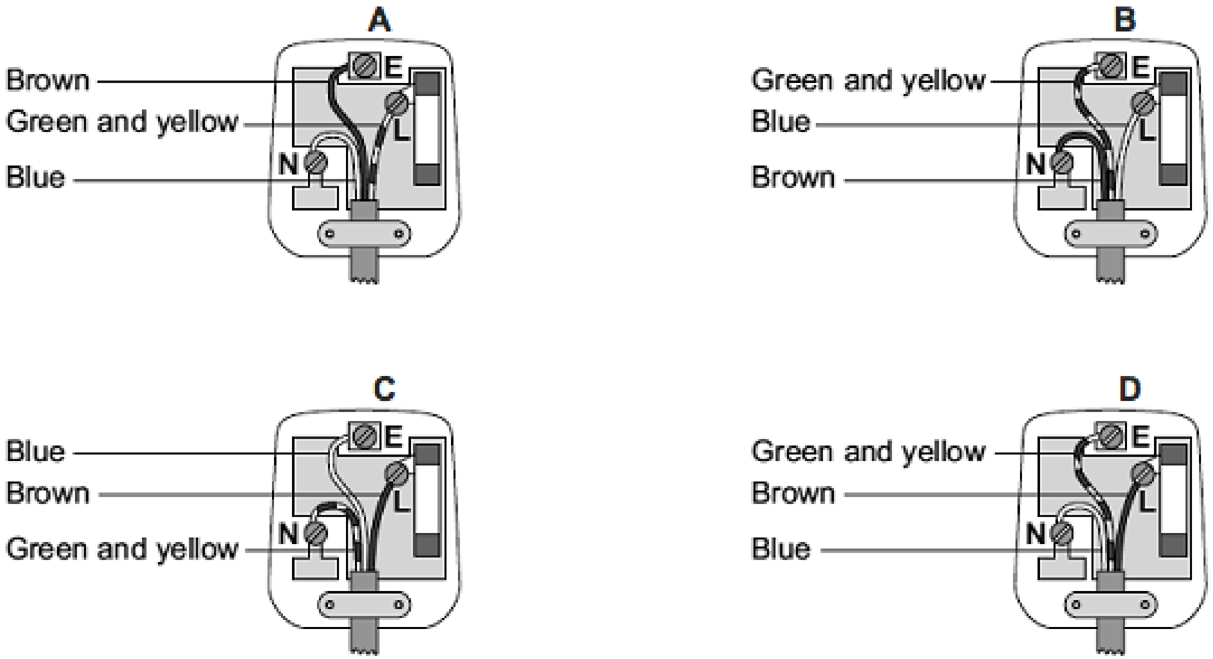
- The fuse contains a piece of wire that melts easily.
- If the current going through the fuse is too great, the wire heats up until it melts and breaks the circuit.

- If the device works at 3A, use a 5A fuse
- If the device works at 10A, use a 13A fuse



Exam Question

Write your answer, **A**, **B**, **C** or **D**, in the box.



The plug that is correctly wired is D

(1)

Electrical Power

- The power of a device is related to the potential difference across it and the current through it by the equation:

$$P = V\,I$$

$$power = potential\ difference\ x\ current$$

W

V

I

Exam Question

- V = 230V
- I = 6.5A
- P = ?

$$P = V\,I$$
$$P = 230 \times 6.5$$
$$P = 1495W$$

(d) The table shows the current drawn from the 230 volt mains electricity supply when different parts of the hairdryer are switched on.

	Current in amps
Fan only	1.0
Fan and heater 1	4.4
Fan and both heaters	6.5

Calculate the maximum power of the hairdryer.

Show clearly how you work out your answer and give the unit.

____

____

Maximum power = $1495W$

(3)

Exam Question

- V = 12V
- I = 3A
- P=?

$$P = V\,I$$
$$P = 12\,x\,3$$
$$P = 36W$$

(iii) The bulb is at full brightness when the potential difference across the bulb is 12 V.
The current through the bulb is then 3 A.

Calculate the power of the bulb when it is at full brightness and give the unit.

____

____

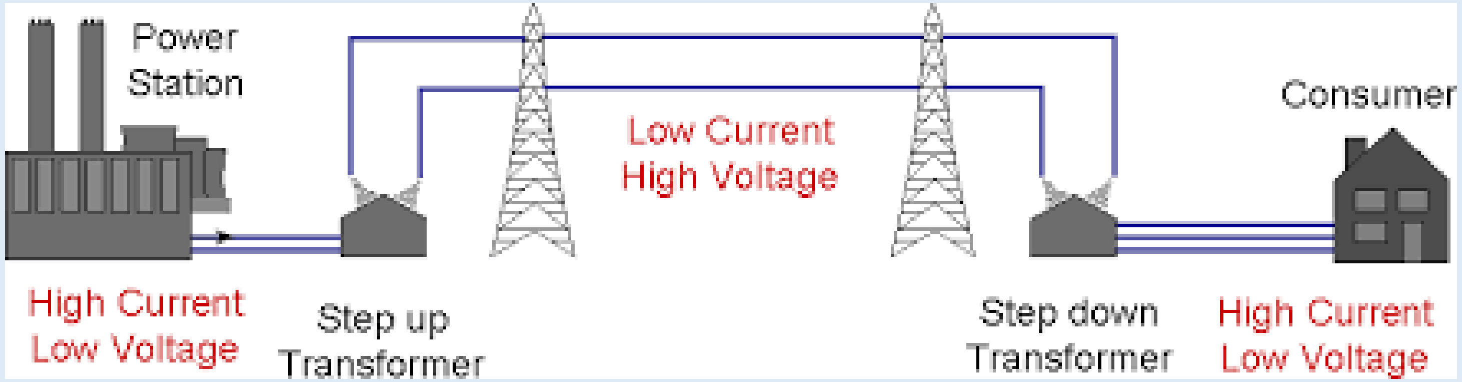
____

Power = $36W$

(3)

National Grid

- The National Grid is a system of cables and transformers linking power stations to consumers.
- Step-up transformers are used to increase the potential difference from the power station to the transmission cables and decrease current
- step-down transformers are used to decrease the potential difference and increase the current.



Power loss

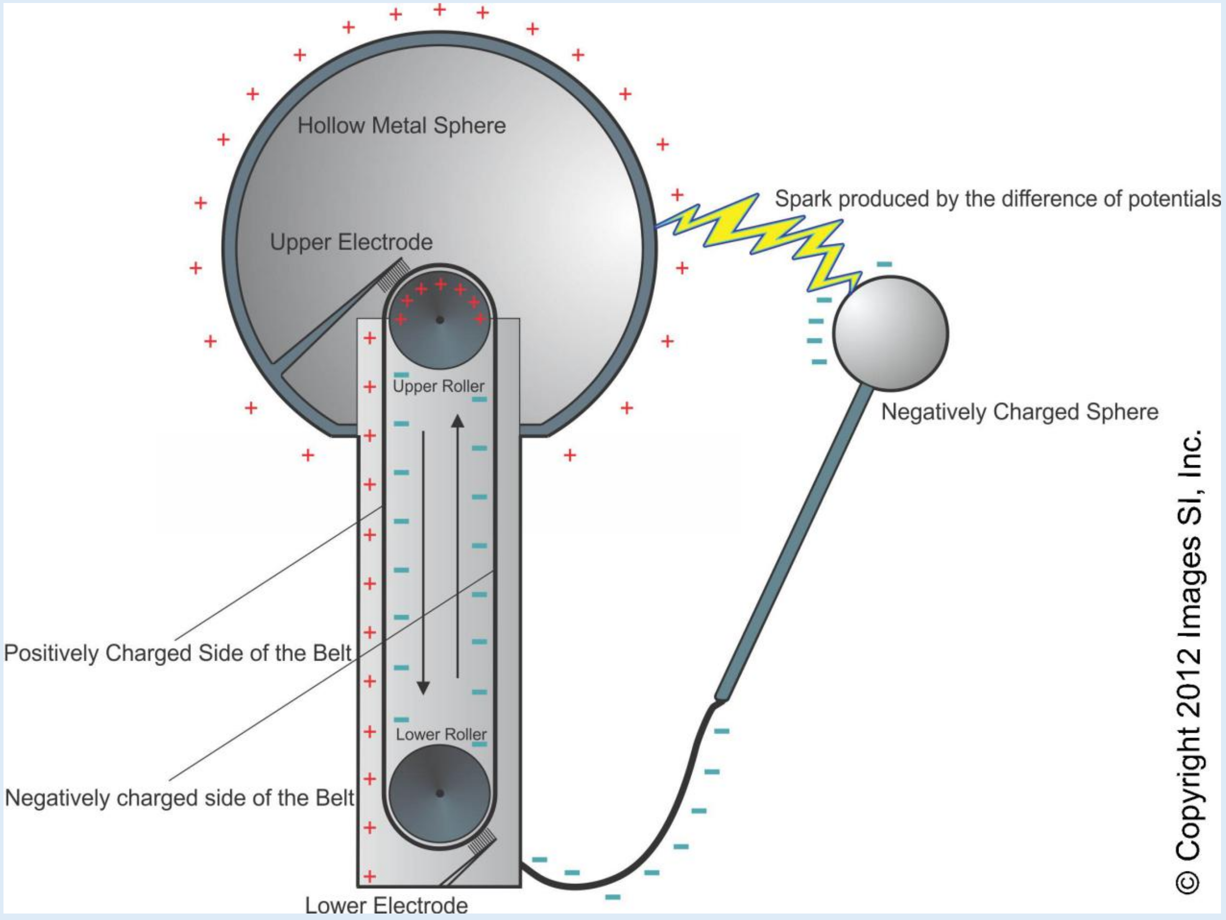
- Step up transformers are used to reduce the energy losses due to heating in the transmission cables

- To calculate power loss

$$P = I^2 R$$
$$Power = current^2 \, x \, Resistance$$

TRIPLE ONLY: Static Charges

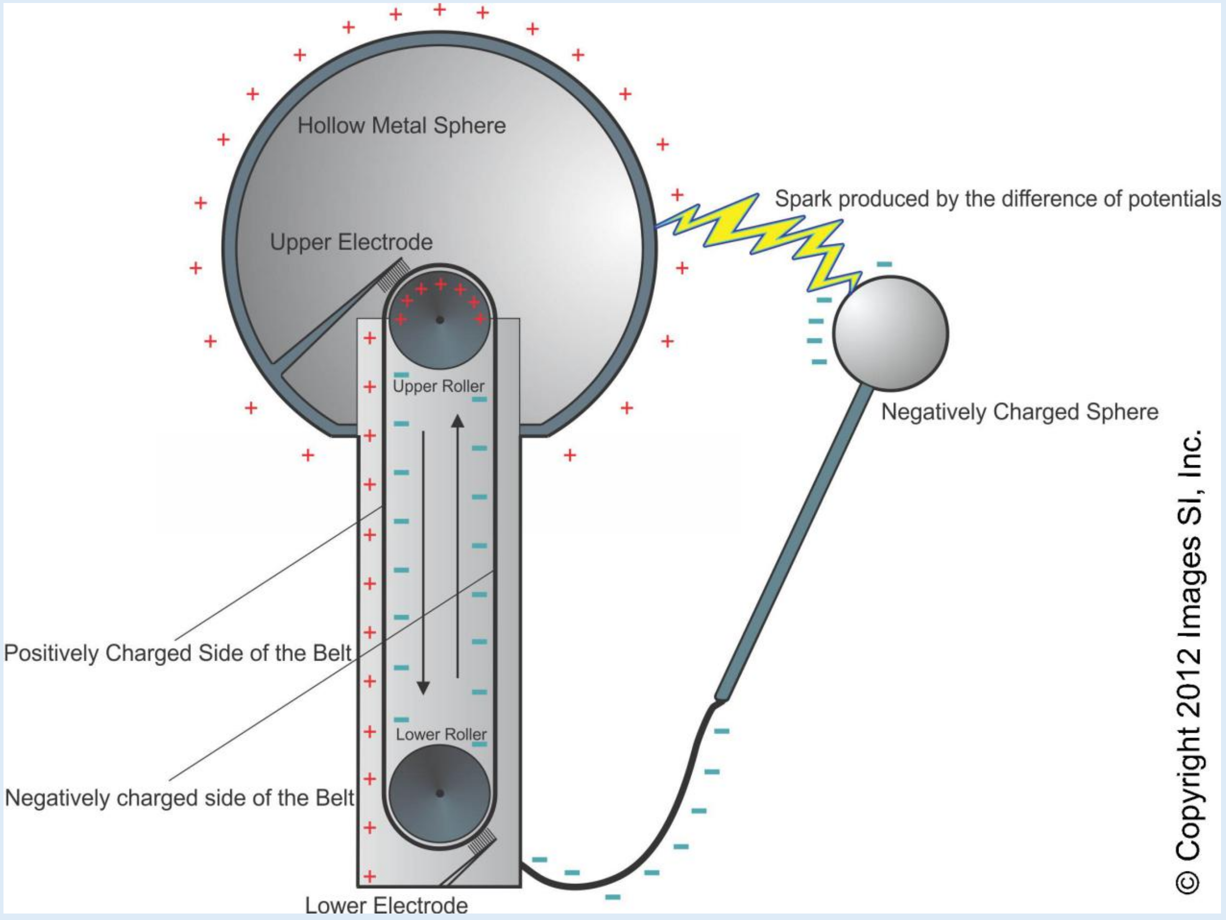
- When certain insulating materials are rubbed against each other they become electrically charged.
- Negatively charged electrons are transferred from one material and onto the other.
- The material that gains electrons becomes negatively charged.
- The material that loses electrons is left with an equal positive charge.



TRIPLE ONLY: Static Charges

- The greater the charge on an isolated object the greater the potential difference between the object and earth.

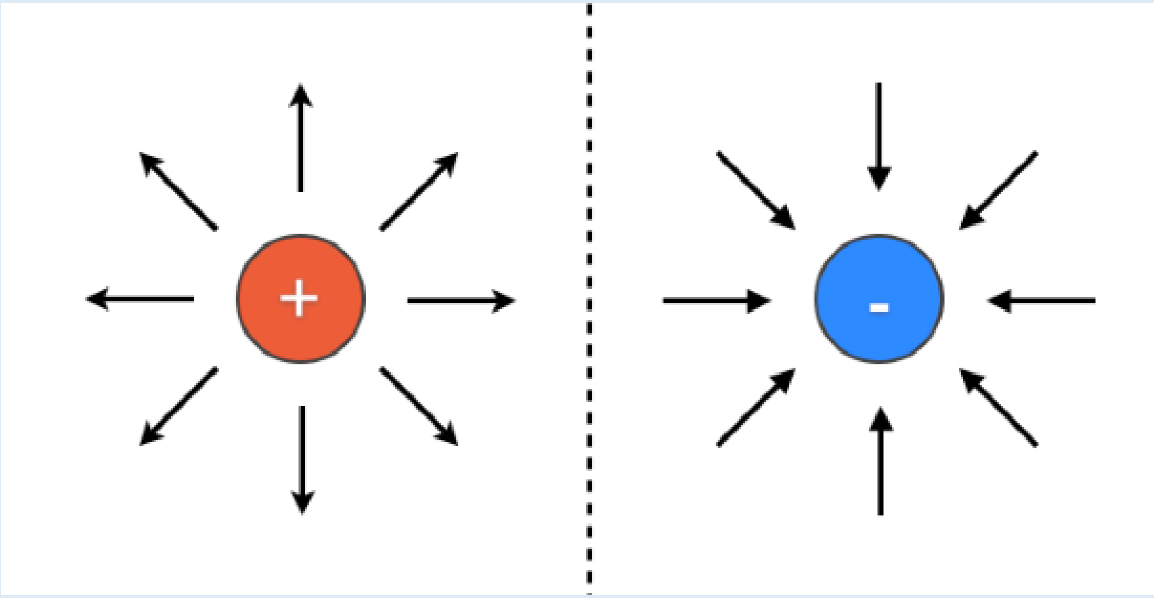
- If the potential difference becomes high enough a spark may jump across the gap between the object

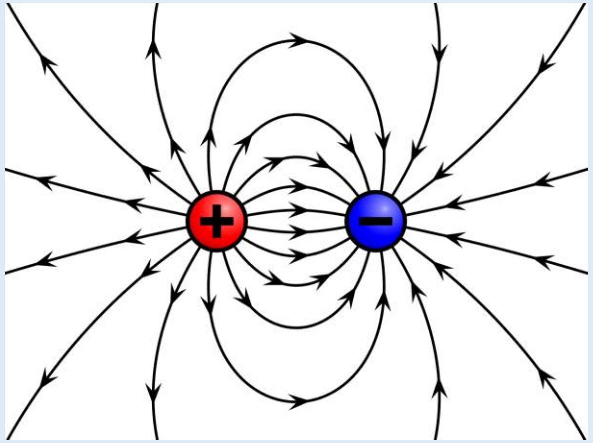


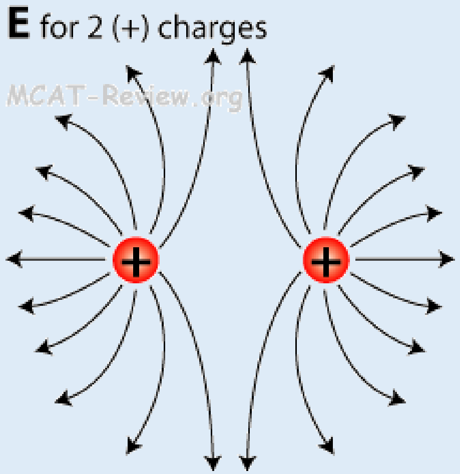
TRIPLE ONLY: Static Charges

- When two electrically charged objects are brought close together they exert a non-contact force on each other.

- Two objects that carry the same type of charge repel. Two objects that carry different types of charge attract.







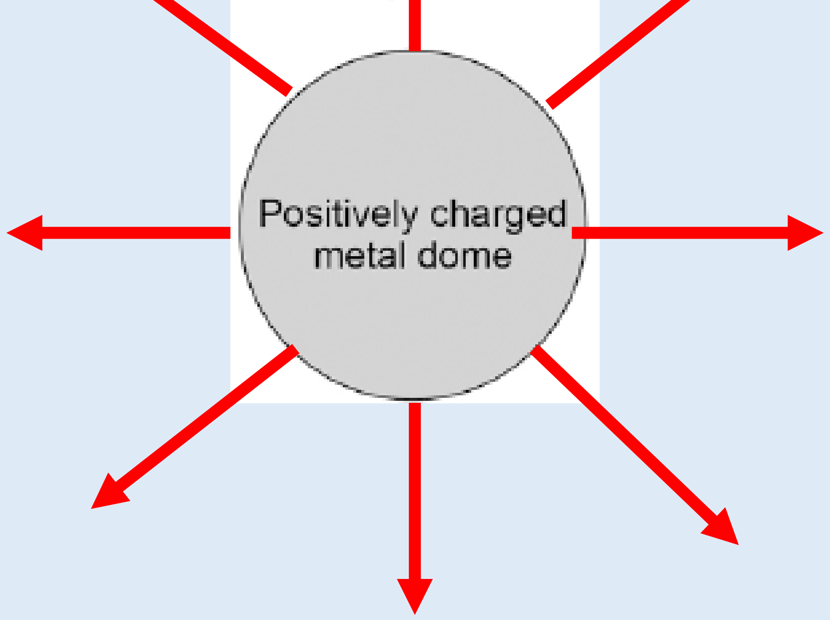
Exam Question

(b) **Figure 2** shows a plan view of the positively charged metal dome of a Van de Graaff generator.

Draw the electric field pattern around the metal dome when it is isolated from its surroundings.

Use arrows to show the direction of the electric field.

Figure 2

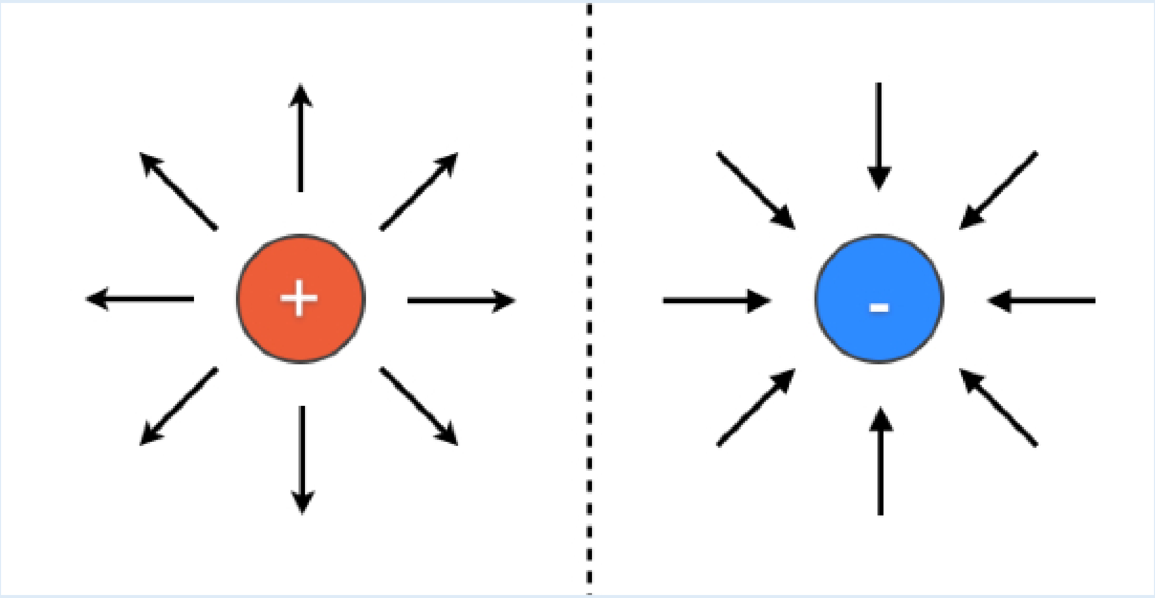


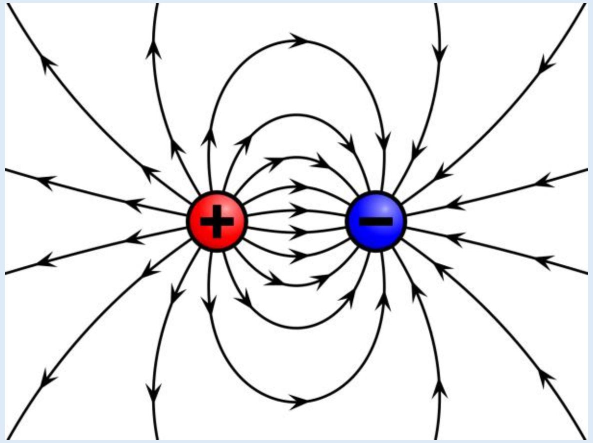
TRIPLE ONLY: Static Charges

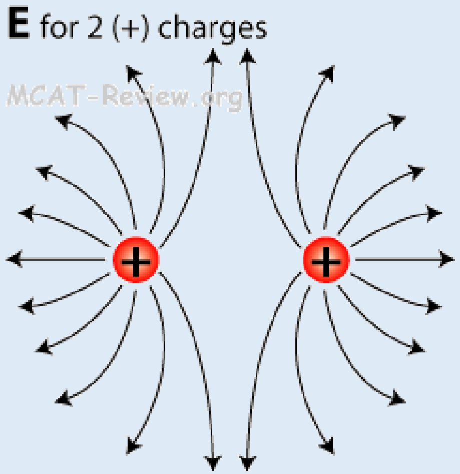
- The electric field is strongest close to the charged object.

- The further away from the charged object, the weaker the field.

- The concept of an electric field can be used to explain the non-contact force between charged objects as well as other electrostatic phenomena such as sparking.







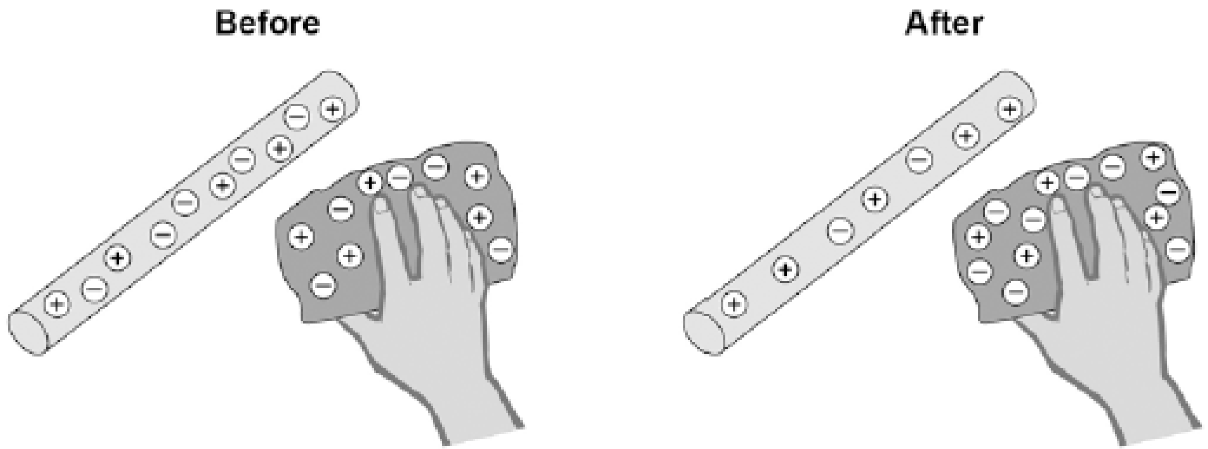
Exam Question

1. Friction (between cloth and rod) causes
2. electrons (to) move
3. from the acetate rod **or** to the cloth
4. overall charge on cloth is now negative
5. overall charge on rod is now positive

A student rubs an acetate rod with a cloth.

Figure 1 shows the charges on the acetate rod and cloth before and after rubbing.

Figure 1



(a) Explain how rubbing an acetate rod with a cloth causes the rod and cloth to become charged.

GCSE Physics

PARTICLES

AQA (Trilogy) Topic P3

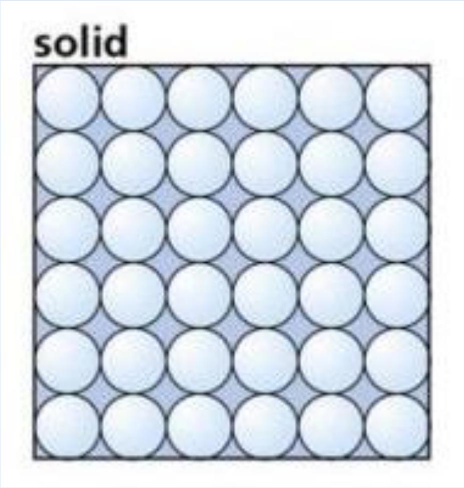
Physics Unit 1 key ideas

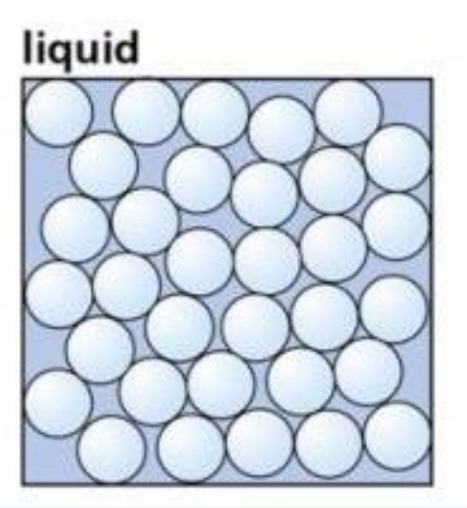
29. State the equation that links density, mass and volume.
30. Describe how to calculate the density of an irregular object.
31. State the equation that links pressure, volume and constant.
32. State what happens to gas pressure when volume is increased. Why?
33. Define the term specific latent heat.
34. State what type of energy temperature of a substance is related to.
35. Explain why temperature does not increase during a change of state.

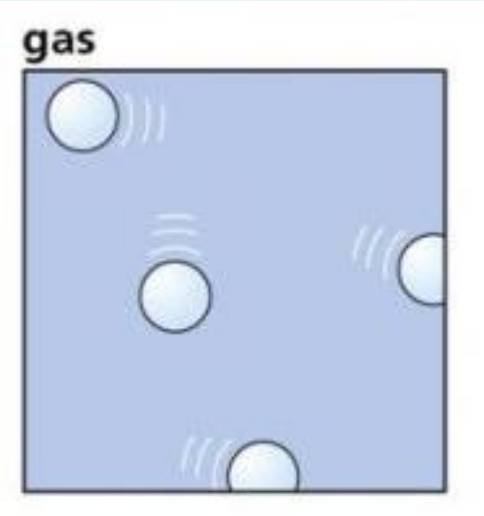
Physics Unit 1 key ideas

29. State the equation that links density, mass and volume. Density = mass/vol
30. Describe how to calculate the density of an irregular object. Weigh the object to find its mass. Fill a displacement can with water until it stops dripping from the spout. Place a measuring cylinder under the spout and drop in the object. The water displaced equals the volume of the object. Divide mass by volume. Units – kg/m^3
31. State the equation that links pressure, volume and constant. P v = constant
32. State what happens to gas pressure when volume is increased. Why? Pressure will decrease, as there will be fewer collisions of particles with the walls of the container.
33. Define the term specific latent heat. The energy needed to change the state of 1kg of a substance. (Flat line on graph, as temperature is not changing).
34. State what type of energy temperature of a substance is related to. Kinetic energy
35. Explain why temperature does not increase during a change of state. As the energy is not being transferred to KE, but is being used to break/make bonds whilst changing state.

P3: Particles and Matter





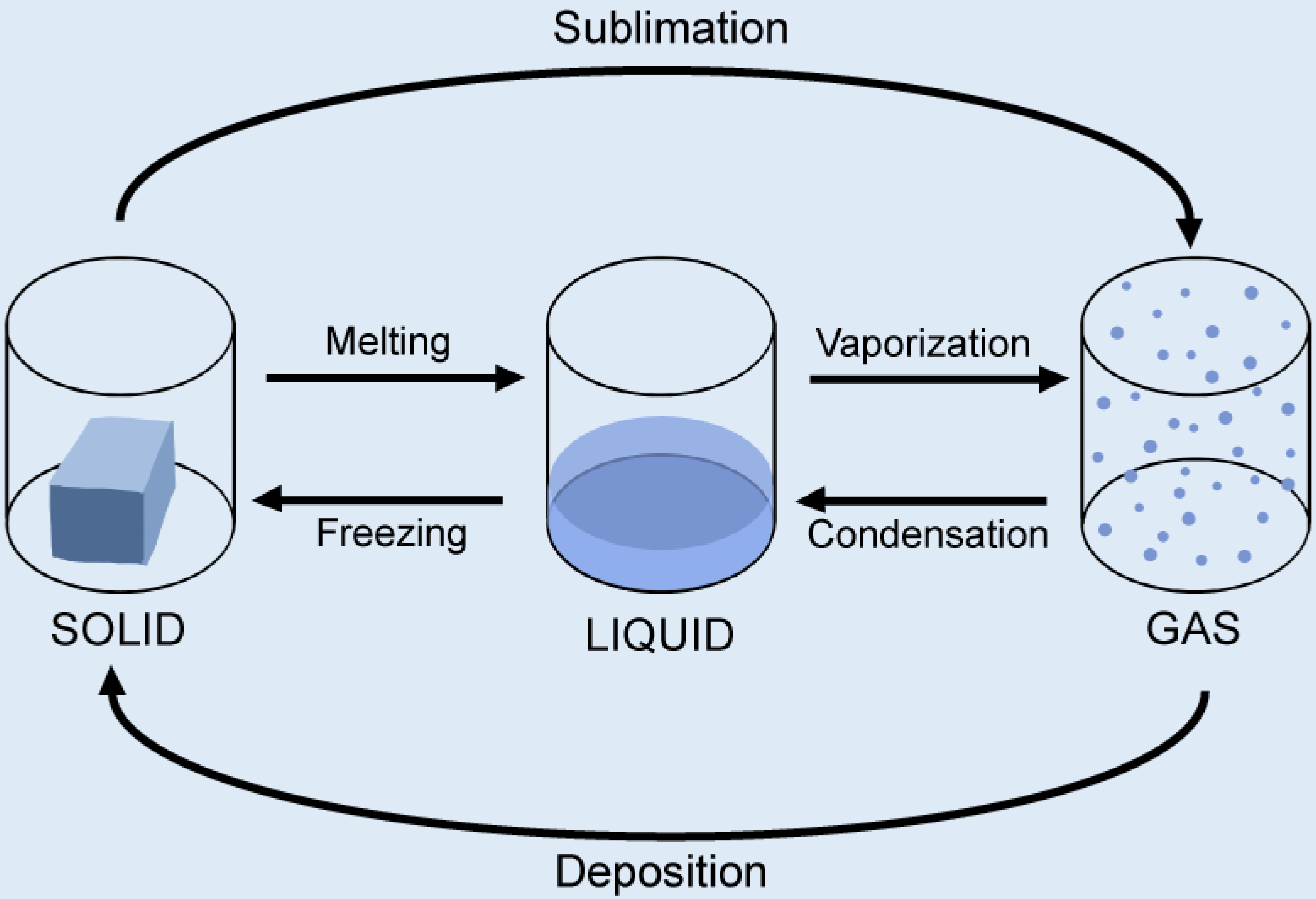


- Have definite shape
- Have definite volume
- **Particles** are touching and vibrate on their spot
- Strong attractive intermolecular forces b/w particles
- Low Kinetic Energy
- Does not compress.
- Organised rows and columns

- No definite shape
- Takes the shape of the bottom the container
- Definite volume
- Particles loosely arranged and slide over each other (50% touching)
- Med intermolecular force
- Med E_k.
- Does not compress.

- No definite shape, shape of container
- No definite volume spread out as far away from each other as possible. Very low density.
- Particles bounce around and collide with each other randomly at HIGH SPEEDS
- Very low intermolecular forces.
- High E_k
- CAN be compressed
- Volume increases with heat – Why?

Changing states



Density

Density is a measure of how much matter there is in a given volume

$$\rho = \frac{m}{v}$$

$$density = \frac{mass}{volume}$$

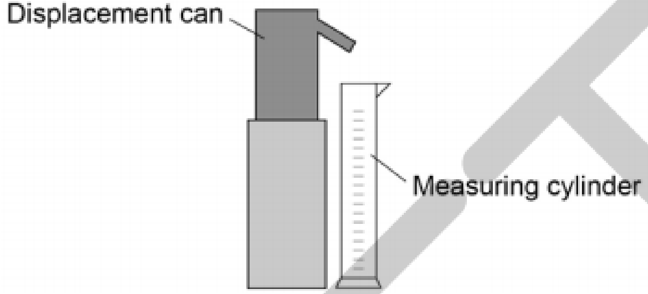
mass → kg

volume → m^3

density → kg/m^3

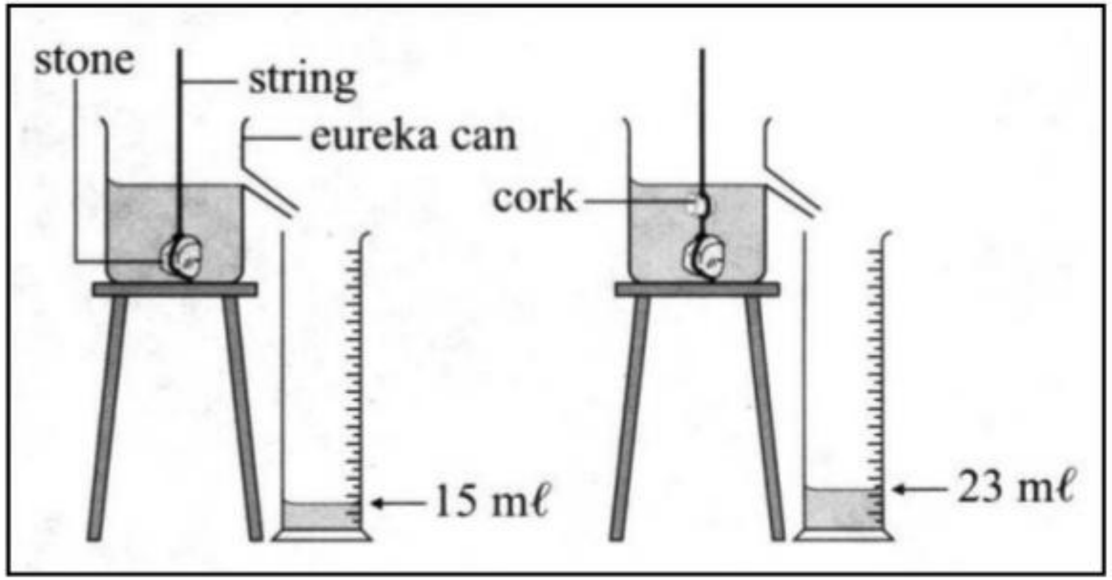
REQUIRED PRACTICAL: Find the density of regular and irregular objects

1. Measure the mass of one of the irregular shaped objects.



2. Record your result in a table. It will need extra columns for the volume, density and substance.
3. Place a displacement can on a brick. Put an empty beaker under the spout and fill the can with water. Water should be dripping from the spout.
4. When the water has stopped dripping, place a measuring cylinder under the spout. Choose the measuring cylinder you think will give the most precise reading.
5. Tie the object to a piece of cotton and very carefully lower it into the displacement can so that it is completely submerged. Collect all of the water that comes out of the spout in the measuring cylinder.
6. Measure and record the volume of the collected water; this is equal to the volume of the object.
7. Calculate and record the density of the object. Try to find out what substance it is made from.
8. Repeat for some of the other objects. Remember to refill the can each time.

WATER DISPLACEMENT METHOD
EUREKA CAN



REQUIRED PRACTICAL: Find the density of regular and irregular objects

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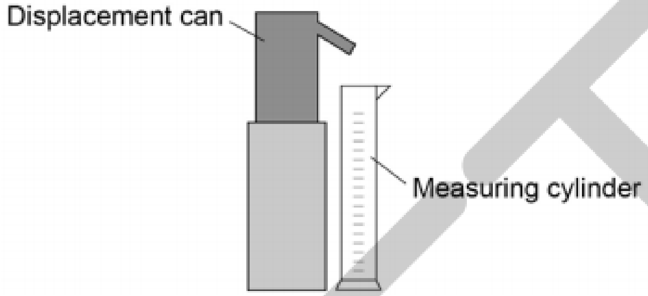

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7. Calculate and record the density of the object. Try to find out what substance it is made from.
8. Repeat for some of the other objects. Remember to refill the can each time.

1. Measure the length, width and height of each of the objects.
2. Record your results in a table. Include columns for volume, mass, density and substance.
3. Measure the mass of each object using the digital balance, and record the results.
4. Calculate and record the volumes (length x width x height).
5. Calculate and record the densities (mass ÷ volume).
6. Use this table to identify the substance each object is made from.

Exam Question

- m= 0.000254kg
- v=0.0141m^3
- ρ =?

$$\rho = \frac{m}{v}$$

$$\rho = \frac{0.000254}{0.0141}$$

$$\rho = 0.18\text{kg / m}^3$$

(d) The helium in the balloon has a mass of 0.00254 kg.

The balloon has a volume of 0.0141 m^3.

Calculate the density of helium. Choose the correct unit from the box.

m^3 / kg	**kg / m^3**	**kg m^3**

Density = 0.18 Unit kg / m^3

(3)

Internal Energy

- All objects/systems contain internal energy. It is the sum of the kinetic energy of the particles and the potential energy of the particles.

$$\text{Internal Energy} = E_K + E_P$$

- When an object or system is heated, its particles move more vigorously and its internal energy increases.

Specific Latent Heat of ...tion

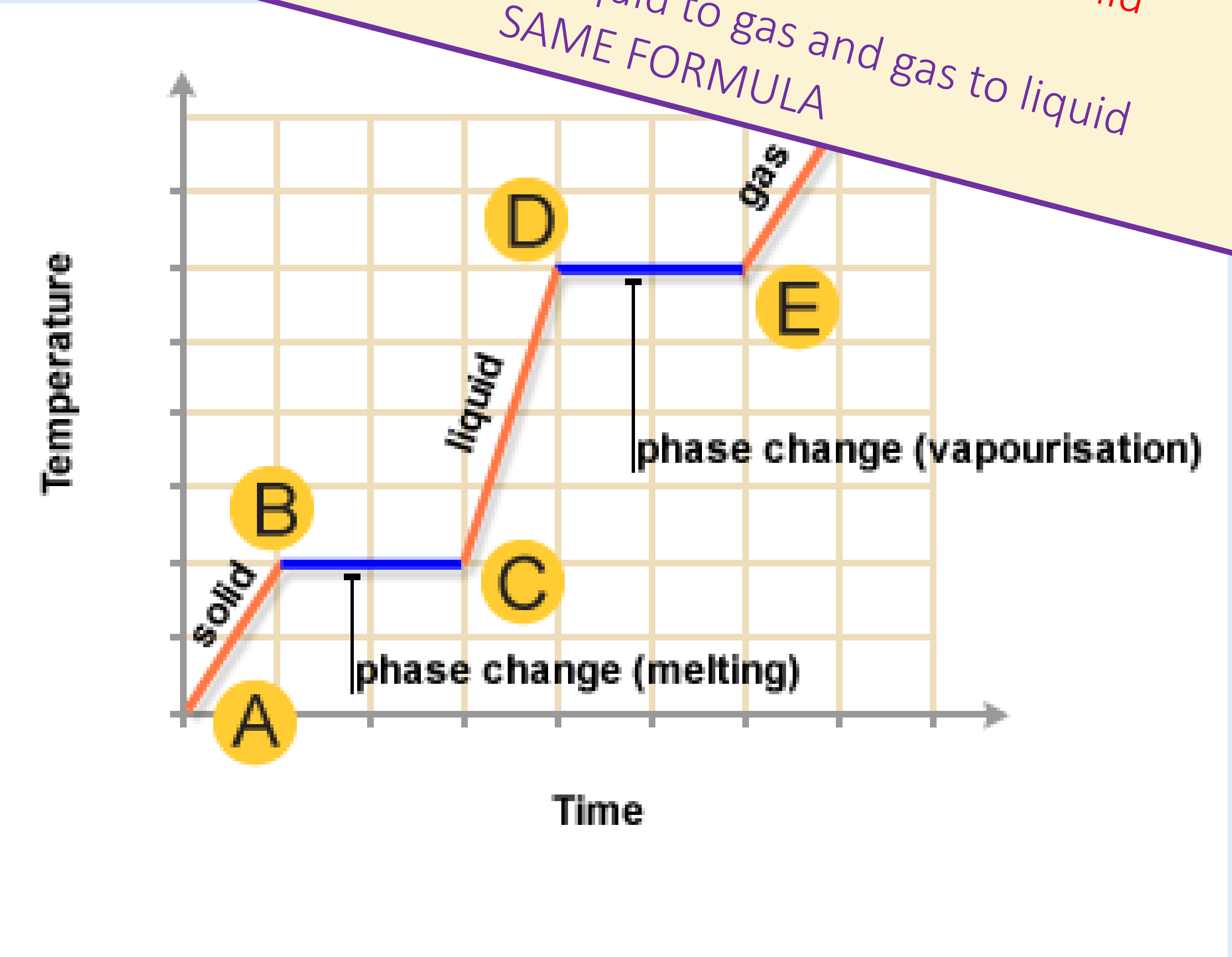
Fusion is for solid to liquid and liquid to solid

Vapourisation is liquid to gas and gas to liquid

SAME FORMULA

- The amount of energy required to change the state of a 1kg substance from solid to liquid with no change in temperature.

- Red Line = temperature increase
- Blue Line = temperature is constant (change state)



GIVEN IN YOUR EXAM!

Specific Latent Heat of Fusion

$$E = mL$$

$$Energy = mass\ x\ Latent\ heat\ of\ fusion$$

J $\quad$ Kg $\quad$ $\frac{J}{kg}$

Exam Question

- E=?
- m=15kg
- L=$3.4x10^5$J/kg

$$E = mL$$

$$E = 15\ x\ 3.4x105$$
$$E = 5.1 \times 106$$

(ii) Calculate the amount of energy required to melt 15 kg of ice at 0 °C.

Specific latent heat of fusion of ice = 3.4×10^5 J/kg.

____

____

Energy = 5.1×10^6 J

Pressure

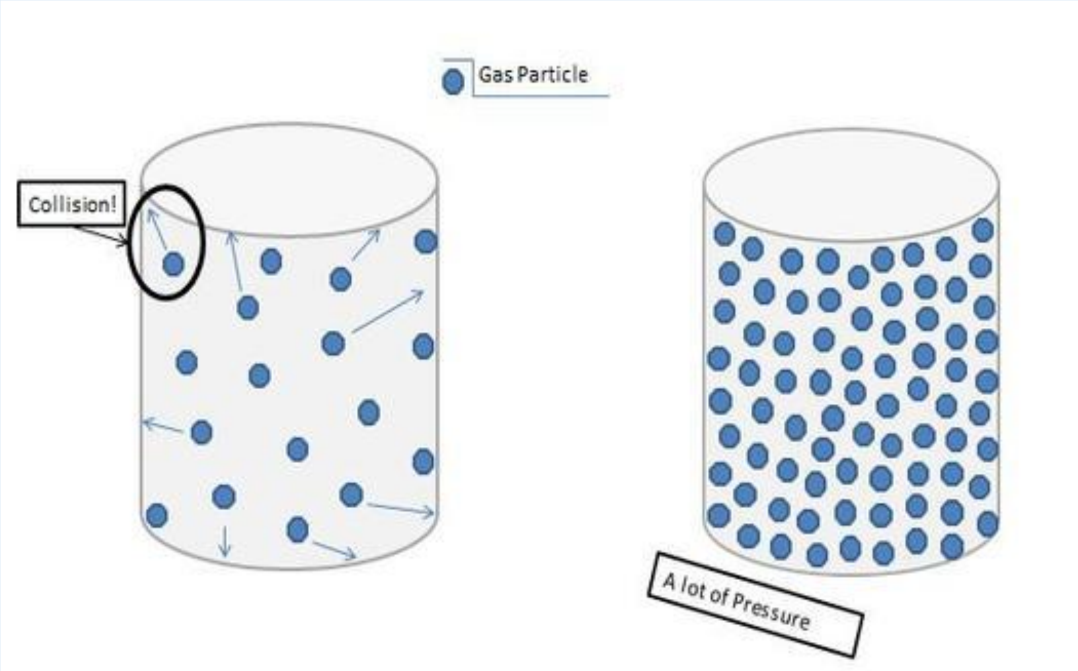
- The temperature of the gas is related to the average kinetic energy of the molecules.

- The higher the temperature, the greater the average kinetic energy and so the faster the average speed of the molecules.

Pressure: How particles exert pressure

- When the molecules collide with the wall of their container they exert a force on the wall.

- The total force exerted by all of the molecules inside the container on a unit area of the walls is the gas pressure.



Pressure law

- Changing the temperature of a gas, held at constant volume, changes the pressure exerted by the gas.

- Increase temperature increases the pressure.

- Decreases temperature decreases the pressure.

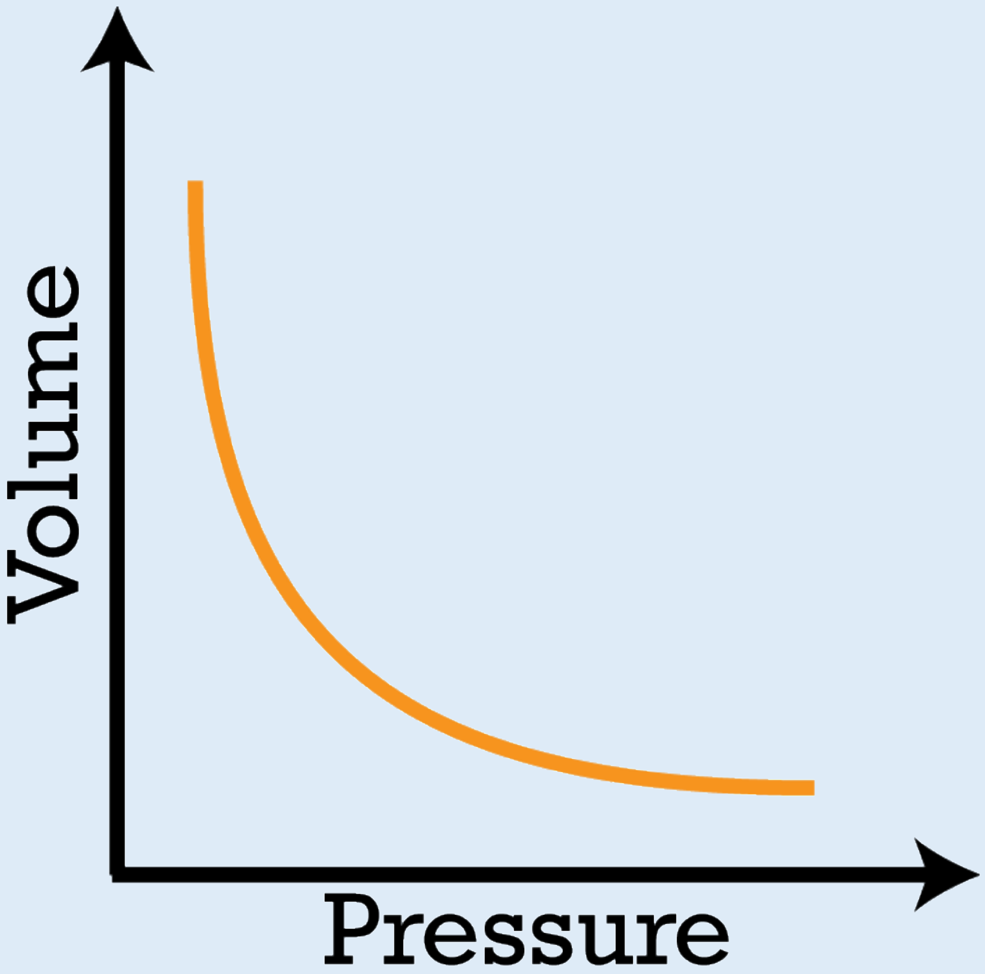
Pressure law

- Changing the temperature of a gas, held at constant volume, changes the pressure exerted by the gas.

$$p\,V = constant$$

TRIPLE: Boyle's law

- Increasing the volume in which a gas is contained, at constant temperature, can lead to a decrease in pressure.



TRIPLE: Pressure and work

- Doing work on a gas increases the internal energy of the gas and can cause an increase in the temperature of the gas.
- Particles gain energy
- Particles Kinetic energy increases, they move faster
- The collide with the walls of the container more frequently with more force
- Pressure increases

GCSE Physics

NUCLEAR PHYSICS

AQA (Trilogy) Topic P4

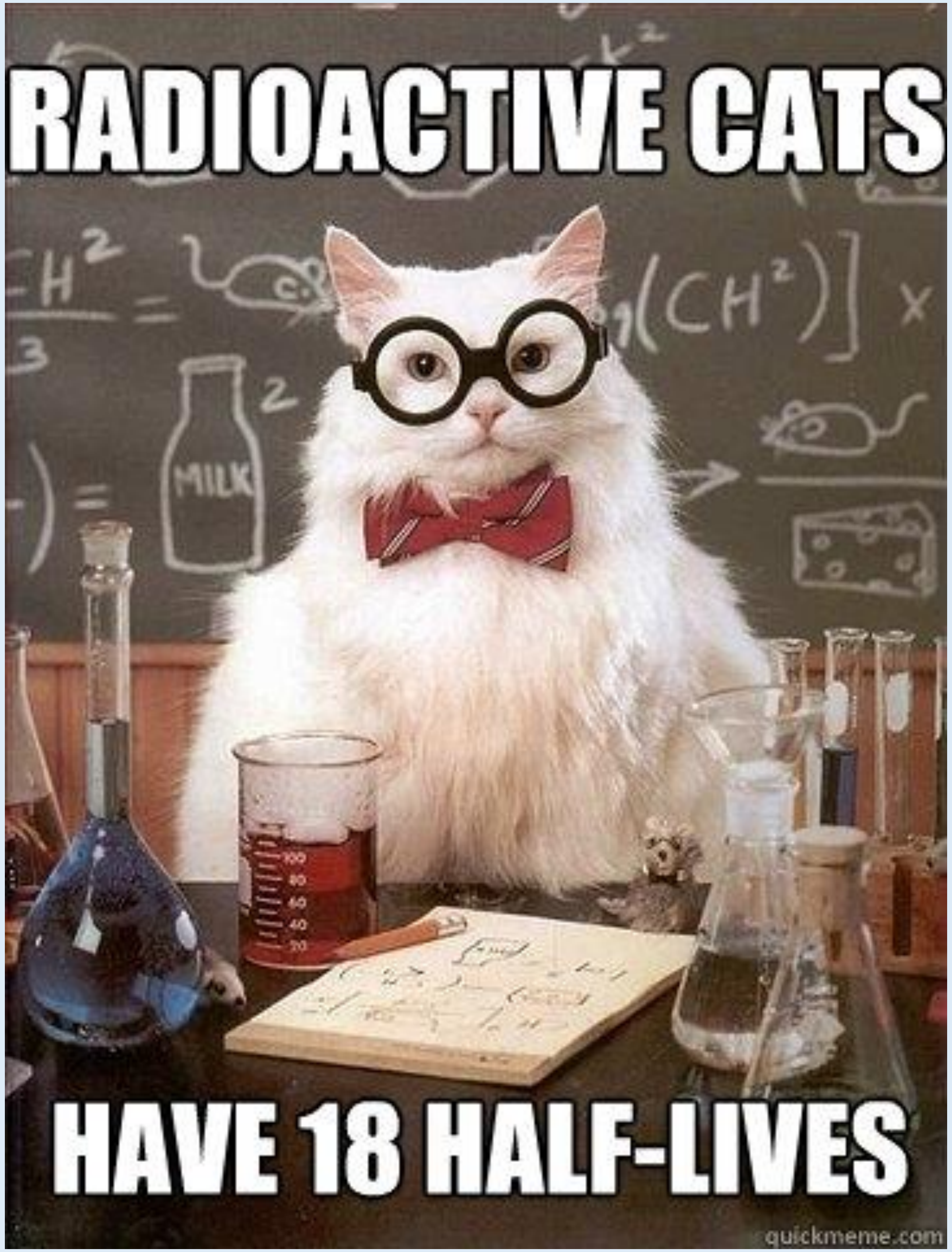
Physics Unit 1 key ideas

36. Describe and explain the findings of Rutherford’s experiment.
37. State what Neils Bohr suggested.
38. State three types of radiation.
39. Compare the ionising power of each type.
40. Compare the penetrating power of each type.
41. State the difference between irradiation and contamination.
42. State what properties a radioactive source would need for use in medical imaging
43. Define the term half life.
44. Describe the process of nuclear fission.
45. State the function of control rods in a nuclear reactor.

Physics Unit 1 key ideas

21. 36. Describe and explain the findings of Rutherford's experiment. Alpha particle scattering experiment – fired alpha partices at gold foil. Most went through – atom is mainly empty space. Some bounced back – positive mass in the centre.
37. State what Neils Bohr suggested. That electrons were specific distances from the nucleus.
38. State three types of radiation. Alpha, beta, gamma
39. Compare the ionising power of each type. Alpha – most ionising as largest, Beta – less ionising than alpha, more than gamma, Gamma – least ionising as a wave, not a particle.
40. Compare the penetrating power of each type. Alpha – least penetrating as largest and cannot travel far through air (stopped by paper), Beta, more penetrating than alpha, less than gamma (stopped by thin sheet of aluminium), Gamma, most penetrating as it is a wave and travels the furthest (stopped by thick lead).
41. State the difference between irradiation and contamination. Irradiation is exposure to radiation, but it doesn't touch you. Contamination is when you come in to contact with radioactive substances.
42. State what properties a radioactive source would need for use in medical imaging Short half life, low ionising power, (both mean less damage to cells) highly penetrating (can be detected outside of the body)
43. Define the term half life. Time taken for count rate to halve.
44. Describe the process of nuclear fission. Neutron absorbed by nucleus, releasing 2 or more neutrons, energy, and the nucleus splits into 2 smaller nuclei
45. State the function of control rods in a nuclear reactor. To absorb neutrons and therefore control the rate of nuclear fission – rods are lowered to slow down the chain reaction.

P4: Radioactivity



Mass Number

Number of protons

+

Number of neutrons

ALWAYS THE BIGGER ONE!

4

He

2

Atomic number

Number of protons

Number of electrons

What is going on here?

$^{1}_{1}H$ $^{2}_{1}H$ $^{3}_{1}H$

Isotopes and Ionising

- The same element with different numbers of neutrons. They have the same proton number.

- Ionisation is when radiation from a radioactive substance knocks electrons out of atoms. The atoms then become charged.

- This process may be harmful to living cells.

Decay

- When atoms become unstable (by having too few or too many neutrons) they become unstable

- An unstable nucleus will decay, emit (giving out) radiation and then will become more stable

Measuring radiation

Count rate: The activity that is captured by a Geiger Muller Tube (GM Tube).

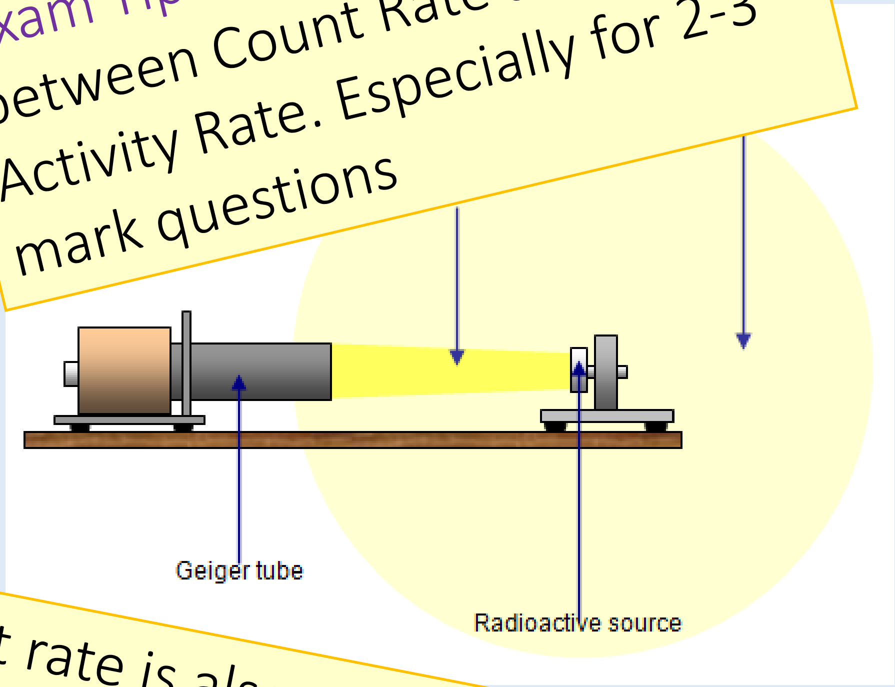
Count rate is always much less than the activity of the source.

Activity: the rate at which a source of unstable nuclei decays, measured in decays per second.

The unit for activity is the Becquerel (Bq)

1 Becquerel = 1 decay per second

Exam Tip: Know the difference between Count Rate and Activity Rate. Especially for 2-3 mark questions



Count rate is also measured in Becquerel.

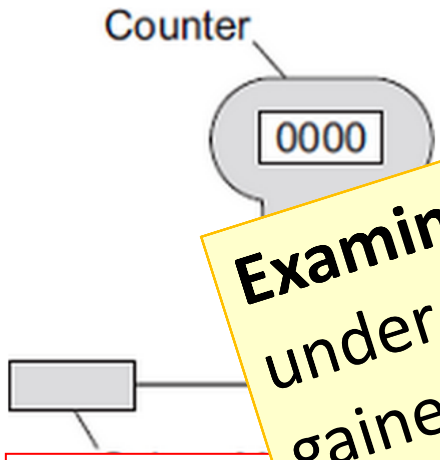
Radiation	Symbol	Charge	Characteristics	Mass	Ionising Power	Speed	Penetrating power	Hazadous
Alpha	α							
Beta	β							
Gamma	γ					t		

Health and Safety precautions during the radioactivity demo

- What precautions do you think your teacher took to keep you safe from the radiation?
  - Low level radioactive samples were used
  - You were kept away from the samples
  - The sources were never pointed directly at anyone
  - The samples are counted, signed in and signed out so that they do not go missing
  - The samples were only out for a minimum amount of time.
  - The teacher wore gloves. Why when it can penetrate skin?
  - No powdered samples are used as these could be inhaled

A teacher used a Geiger-Műller (GM) tube and counter to measure the background radiation in her laboratory. The teacher reset the counter to zero, waited one minute and then took the count reading. The teacher repeated this two more times.

The three readings taken by the teacher are given in the table.



Count

Examiner's comment: Just under two thirds of students gained this mark.

…**one** box.

…r did not reset the counter to

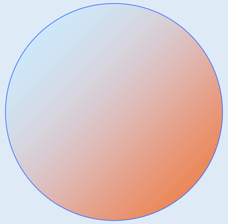
☐

(b) (i) Radioactive decay is a random process

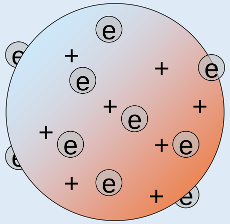
The temperature in the laboratory changed.

☐

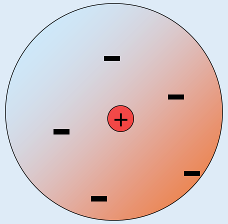
Models of the Atom



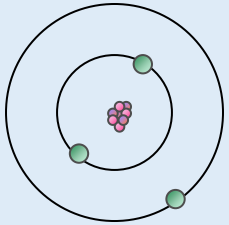
Greek model (400 B.C.)



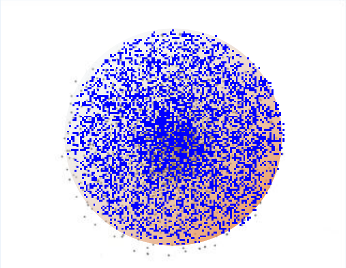
Thomson's plum-pudding model (1897)



Rutherford's model (1909)



Bohr's model (1913)



Charge-cloud model (present)

1803 John Dalton pictures atoms as tiny, indestructible particles, with no internal structure.

1897 J.J. Thomson, a British scientist, discovers the electron, leading to his "plum-pudding" model. He pictures electrons embedded in a sphere of positive electric charge.

1911 New Zealander Ernest Rutherford states that an atom has a dense, positively charged nucleus. Electrons move randomly in the space around the nucleus.

1913 In Niels Bohr's model, the electrons move in spherical orbits at fixed distances from the nucleus.

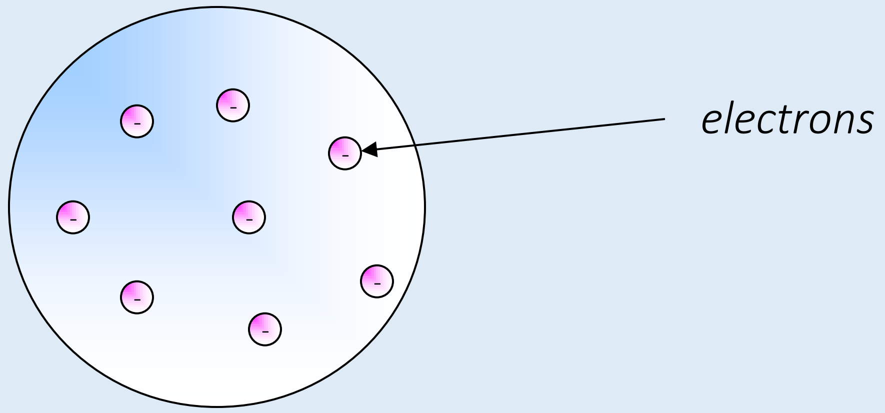
1926 Erwin Schrödinger develops mathematical equations to describe the motion of electrons in atoms. His work leads to the electron cloud model.

1800 1805 .... 1895 1900 1905 1910 1915 1920 1925 1930 1935 1940 1945

1932 James Chadwick, a British physicist, confirms the existence of neutrons, which have no charge. Atomic nuclei contain neutrons and positively charged protons.

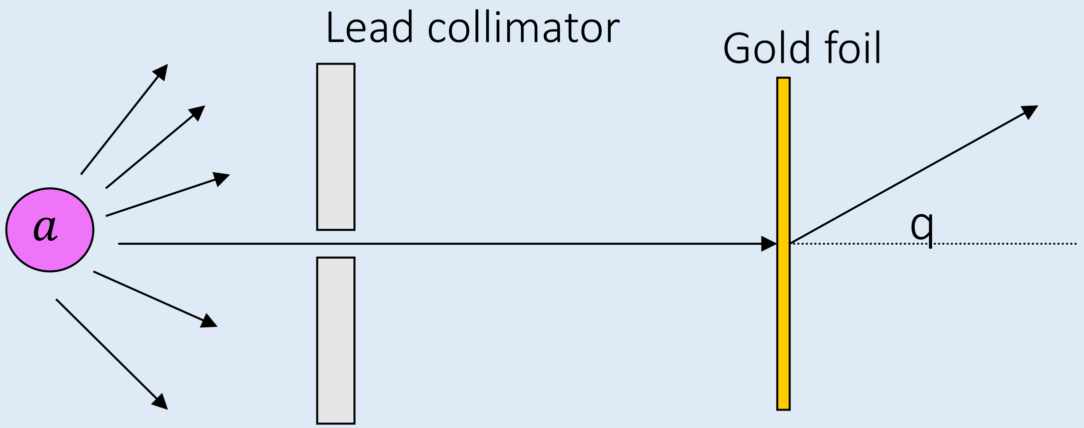
Thomson Model of the Atom

- J.J. Thomson discovered the electron and knew that electrons could be emitted from matter (1897).
- William Thomson proposed that atoms consist of small, negative electrons embedded in a sea of positive charge.
- The electrons were like currants in a plum pudding.
- This is called the 'plum pudding' model of the atom.

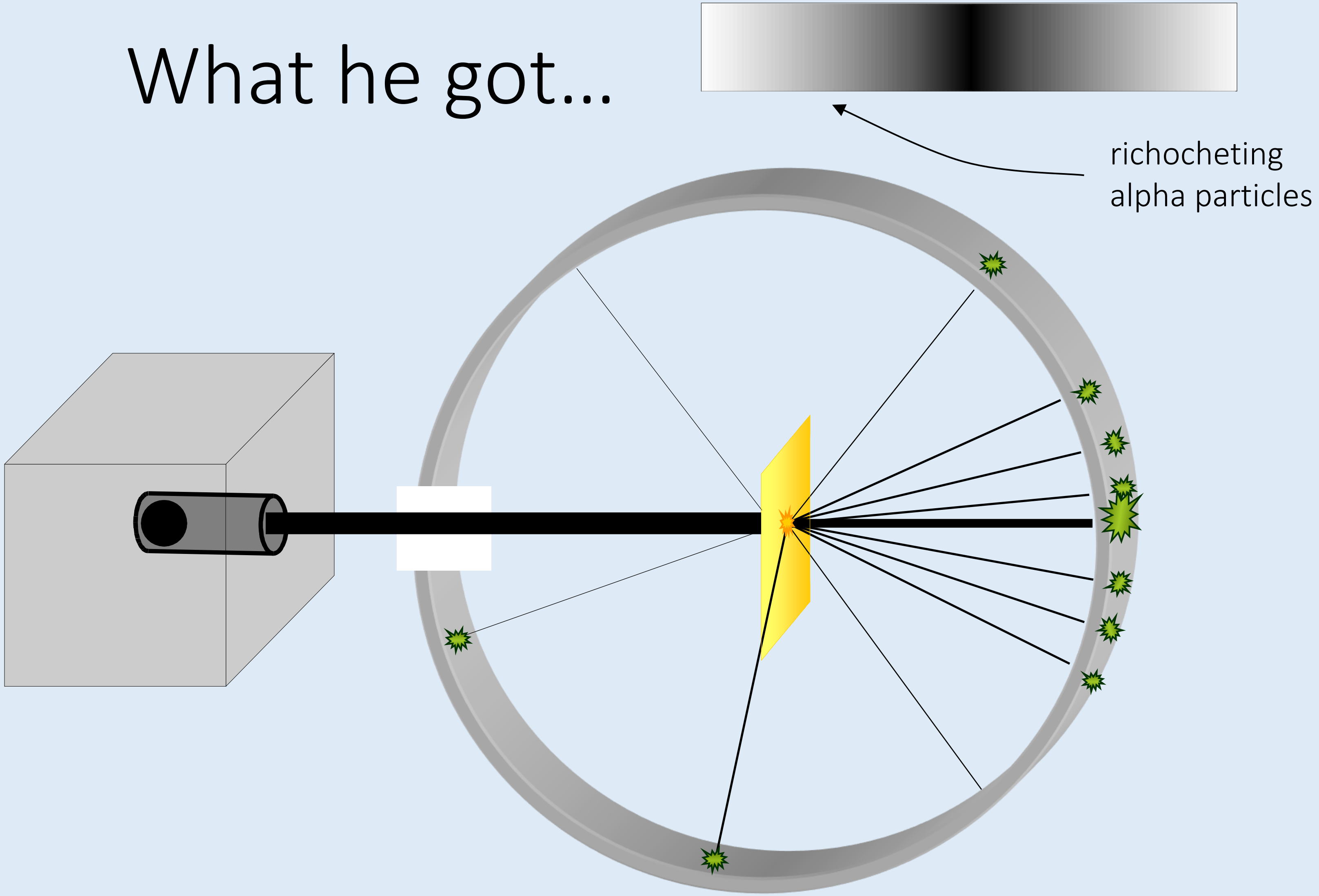


Rutherford ‘Scattering’

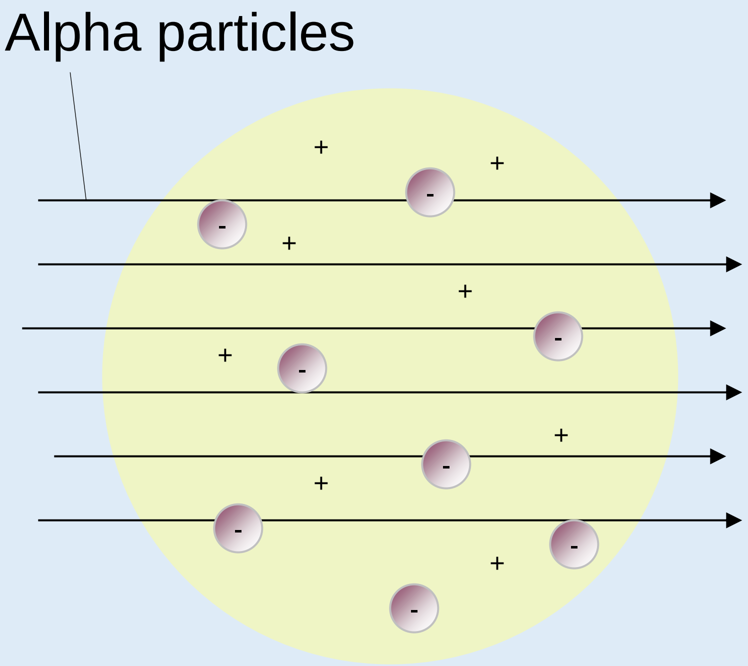
- In 1909 Rutherford undertook a series of experiments
- He fired a (alpha) particles at a very thin sample of gold foil
- According to the Thomson model the a particles would only be slightly deflected
- Rutherford discovered that they were deflected through large angles and could even be reflected straight back to the source



What he got...

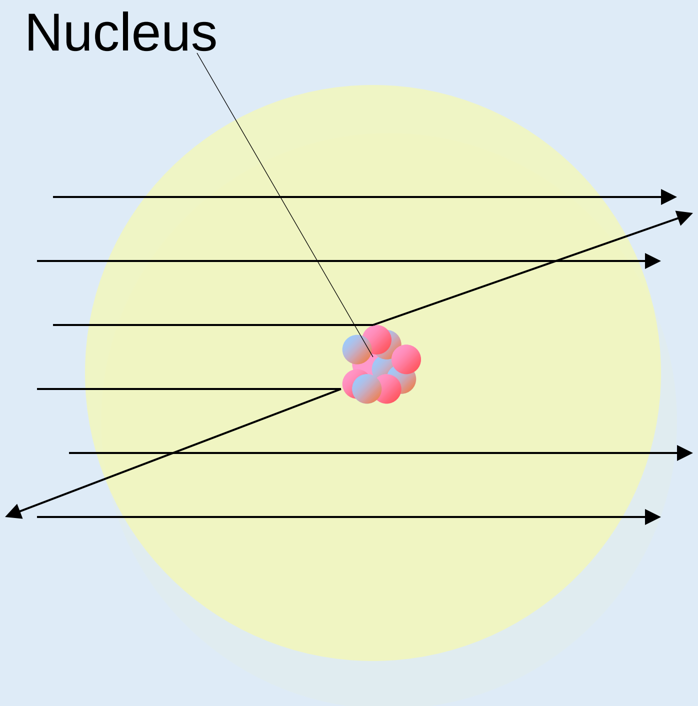


Explanation of Alpha-Scattering Results



Plum-pudding atom

Thomson’s model



Nuclear atom

Rutherford’s model

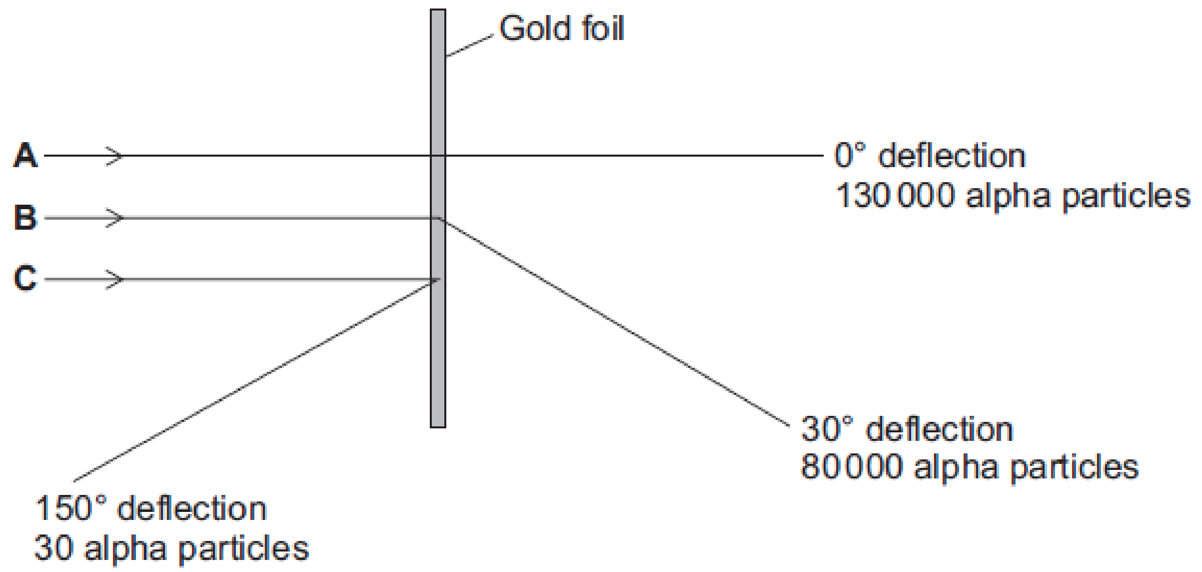
Rutherford’s conclusions

A – most of atom is empty space

B – nucleus is positive so repels alpha particles

C – nucleus is very small and has a concentrated mass

alpha particles deflected through each angle is also given.



(i) Using the nuclear model of the atom, explain the three paths, **A**, **B** and **C**.

A ____

____

B ____

____

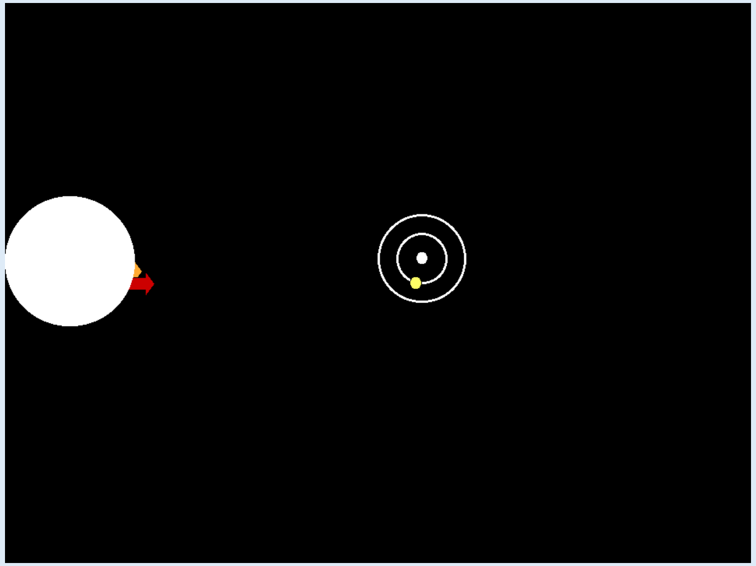
C ____

____

(3)

What happens when EM interacts with atoms?

- Excited!
- It absorbs the energy photon/electromagnetic wave
- And moves further away from the nucleus.
- It releases the same energy when if moves back towards the nucleus



Not t

This number is the atomic mass

This is our radioactive element. You will need to remember the mass/atomic number and symbol

$$^{241}_{95}Am \rightarrow {}^{237}_{93}Np + {}^{4}_{2}\alpha$$

241 = 237 + 4

95 = 93 + 2

This number is the atomic number

Let’s do one more…

$$^{14}_{6}C \rightarrow \, ^{14}_{7}N + \, ^{0}_{-1}\beta$$

$$^{14}_{6}C \rightarrow \, ^{14}_{7}N + ?$$

$$14 = 14 + ?$$

$$6 = 7 + ?$$

1. Turn it into two simple equations. Remember the → can be thought of as an = sign

2. Solve the top one first. This is our Atomic Mass

4. What radioactive element has:
atomic mass of 0
atomic number of -1?

An atom of the isotope radon-222 emits an alpha particle and decays into an atom of polonium.

An alpha particle is the same as a helium nucleus. The symbol below represents an alpha particle.

$$^{4}_{2}\text{He}$$

Examiner's comments: The majority of the students gained both marks.

(i) How ... trons are there in an alpha particle?

Nu...

Number of neutrons

(ii) The decay of radon-222 can be represented by the equati...

Complete the equation by writing the correct number in ea...

$$^{222}_{86}\text{Rn} \longrightarrow \,^{\square}_{\square}\text{Po} + \text{alpha particle}$$

(i) 2

2

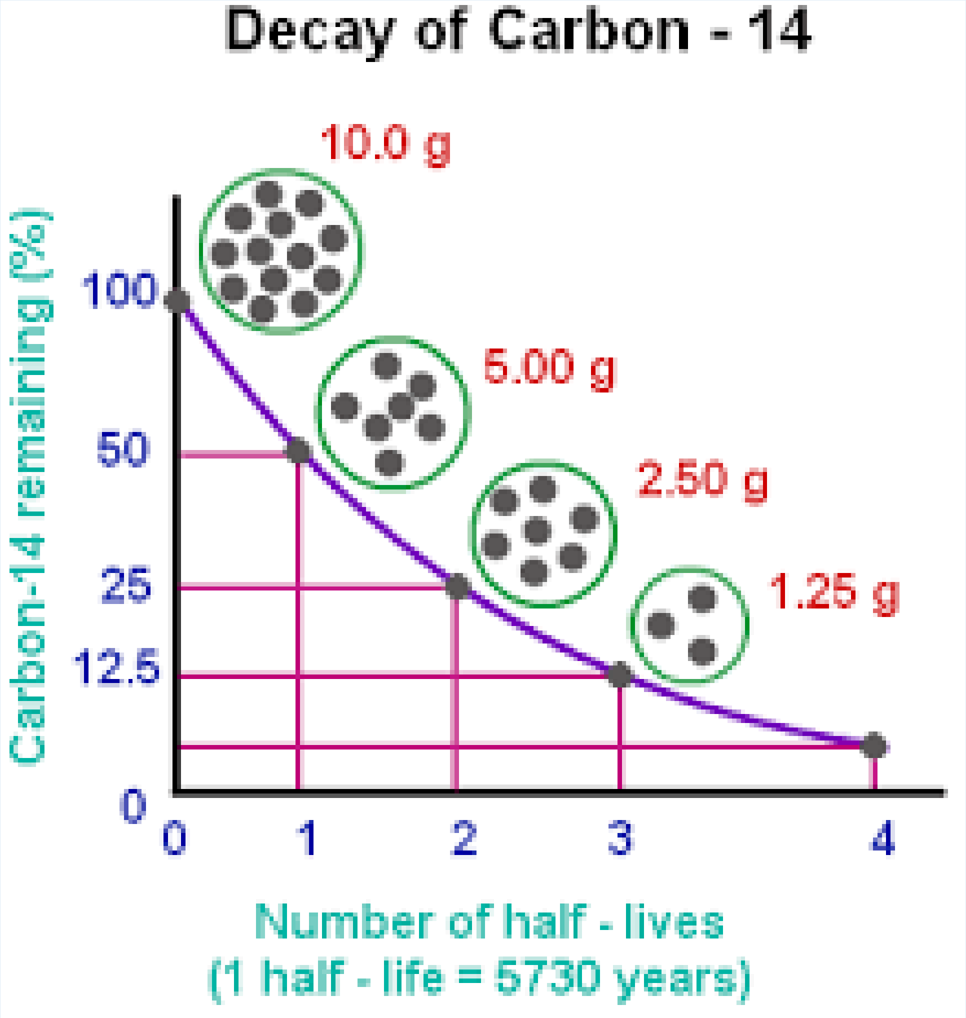
(ii) 218

correct order only

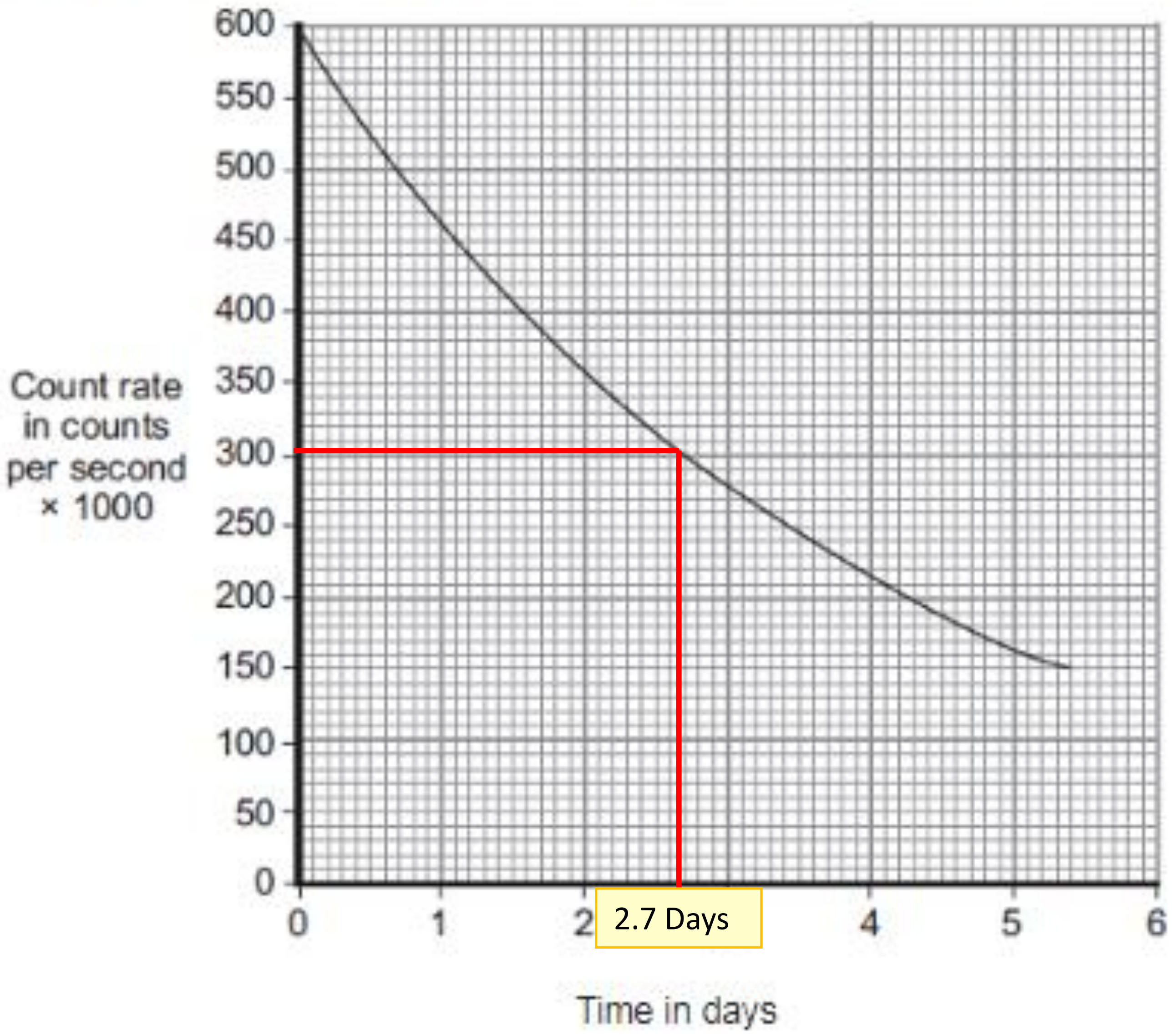
84

Half life

The average time it takes for the number of nuclei of the isotope to halve.



(b) The graph shows how the count rate from a sample of gold-198 changes with time.



Use the graph to calculate the half-life of gold-198.

Show clearly on the graph how you obtain your answer.

Word problem…

A radioactive isotope of lead has a half-life of 10.6 hour

A small sample of lea … has a cou … 000 counts per minute.

How long will it be be … counts …?

3 half lives

3 x 10.6 (half life time)

= 31.8hrs

8000

4000

2000

Irradiation vs Contamination

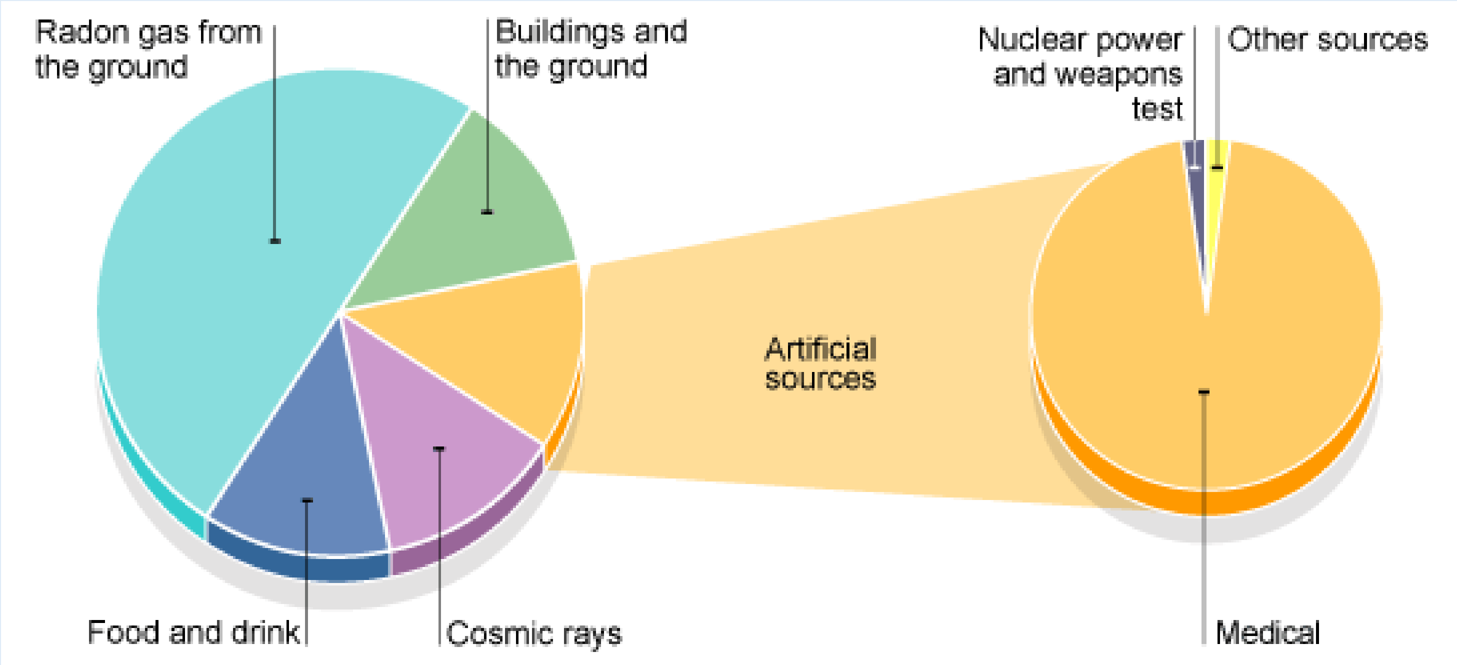
- When an object is exposed to ionising radiation but does not become radioactive it is irradiated.

- Contamination is when a radioactive substance is present on a surface, substance or within solids, liquids or gases (including the human body), where their presence is unintended

Background Radiation

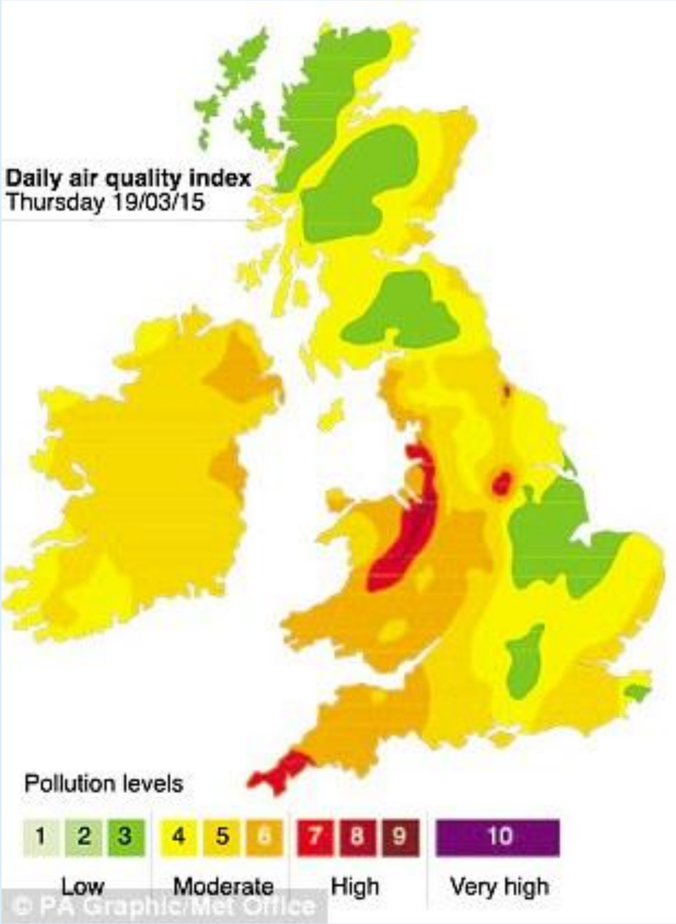
- natural sources such:
  - as rocks and cosmic rays from space.

- man-made sources such as:
  - the fallout from nuclear weapons testing and nuclear accidents.
  -



Background Radiation changes on where you live

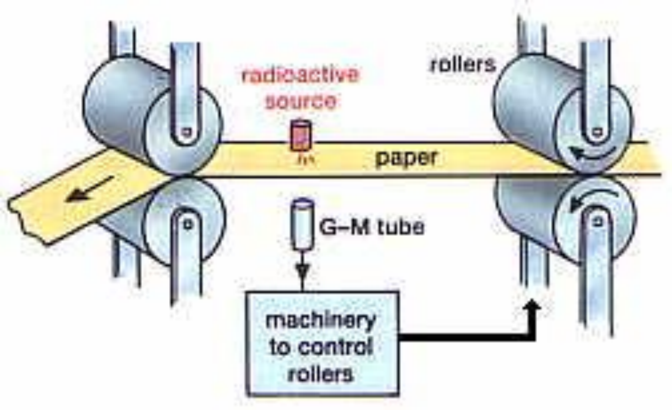
- Radiation dose in measured in Sieverts (Sv) or milli Sieverts (mSv)



Uses of radiation

Checking thickness

- Use a **detector** to measure the rate Beta passes through paper
- **Thinner paper = higher beta count.**



Smoke Alarms

- Contains a source of **alpha particles**
- There is an electrical circuit with a gap between 2 charged plates.
- **Air** in gap is **constantly ionised** therefore **constant electric current**.
- When smoke get in the alpha particles are absorbed and stops the **current drops = alarm sounds**

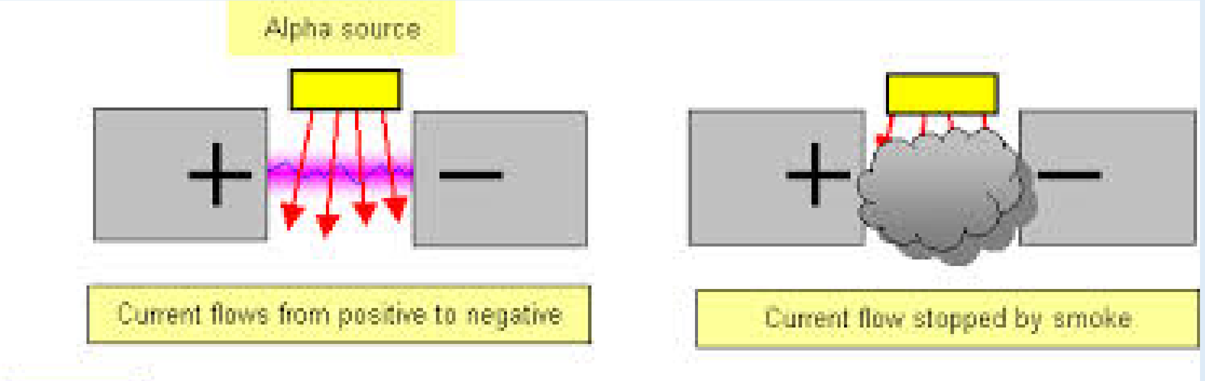


Figure 3

Uses of radiation

Irradiating food

- Bacteria will cause food to decay or make us ill
- Gamma rays **kill bacteria**
- Makes food safer and longer lasting
- Does not make food radioactive
- Foods like Fruit, cereals and shellfish are irradiated.

Sterilisation of equipment

- To **kill microorganisms** surgical instruments need to be sterilised
- Heat usually used but cannot be used on some things e.g. plastics
- They are **irradiated** with Gamma rays instead.

Diagnosis of Cancer

- Gamma rays used
- A **tracer** solution **injected** into body that collects in cancers
- **Gamma camera** used to detect rays
- Pass through the body so easily detected

Advantages of nuclear power	Disadvantages of nuclear power
• Station does not produce CO_2 • Less impact on global warming	• Making the fuel rods requires energy (CO_2 released) • Waste has to be stored for tens of thousands of years without leaks • People perceive it as unsafe after the Chernobyl accident

Low level Waste -

- Only **slightly** radioactive
- Remains so for tens of thousands of years
- Clothing and cleaning materials from nuclear power stations
- Hospitals also a source of LLW from radiotherapy cancer treatments
- Compacted and buried in special landfill

Intermediate level waste

- Remains **moderately radioactive** for thousands of years
- Includes the metal cylinders that contained uranium fuel which become radioactive
- Stored in **concrete** and **steel** containers
- None disposed of yet

High level waste

- The fission products from Uranium fuel are **very radioactive**
- Produces **large** amounts of **ionising radiation** for about **50 years**
- Remains moderately radioactive for thousands of years as intermediate level waste
- Transported in **thick concrete** and **steel** containers
- **Sealed in glass** to prevent escape
- Stored in **canisters** until it becomes ILW

Disposal methods

1. **Firing into space**
   - Risk of it falling back
2. **Dumping in barrels at sea**
   - Barrels can corrode
   - Enters food chain
3. **Storage underground**
   - Need geologically stable site
   - Low earthquake risk

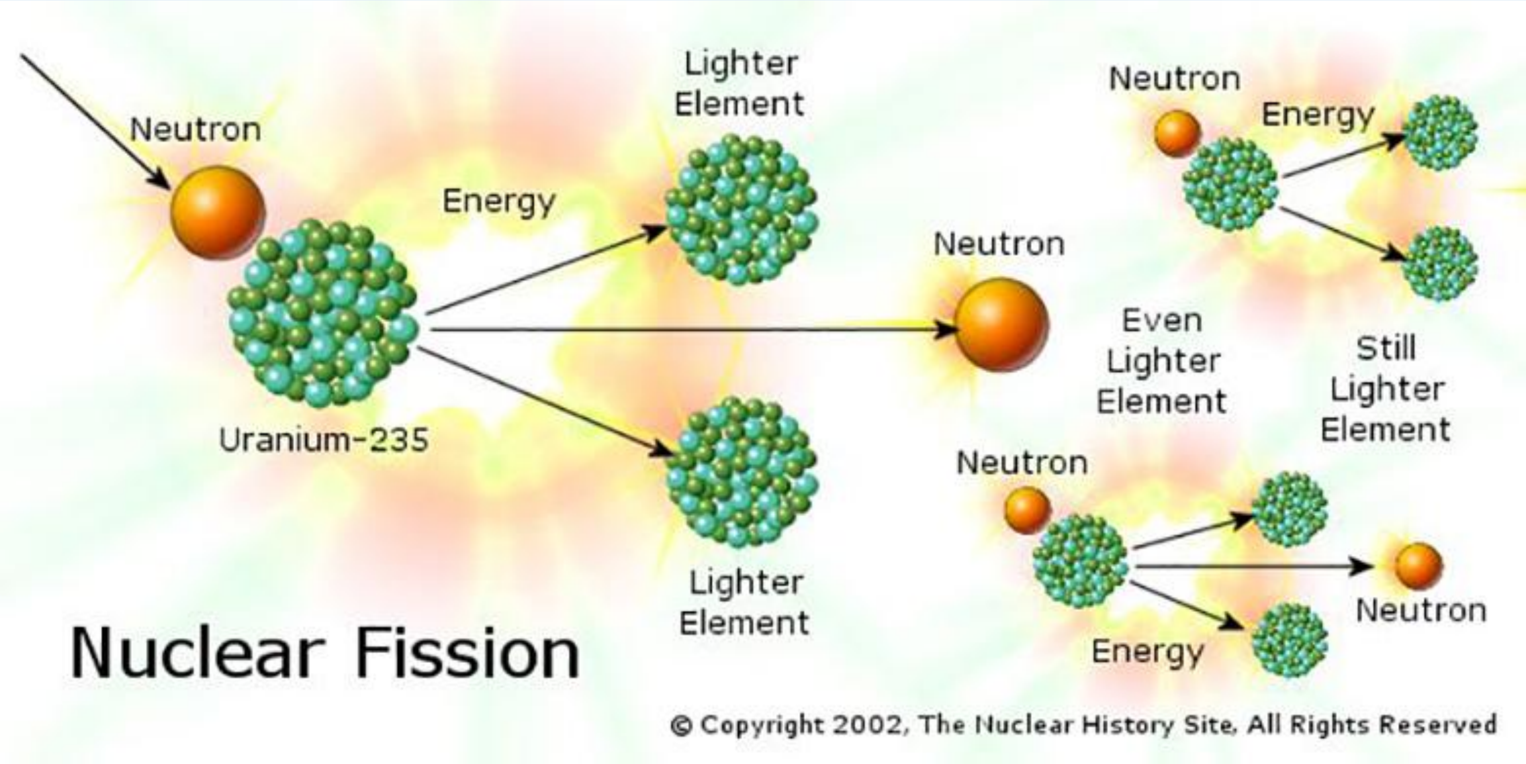
TRIPLE ONLY: Fission and Fusion

- Nuclear fission is the splitting of a large (Uranium or Polonium) unstable nuclei into two smaller nuclei.

- Nuclear fusion is the joining of two light nuclei to form a heavier nucleus.
- In this process some of the mass of the smaller nuclei is converted into energy

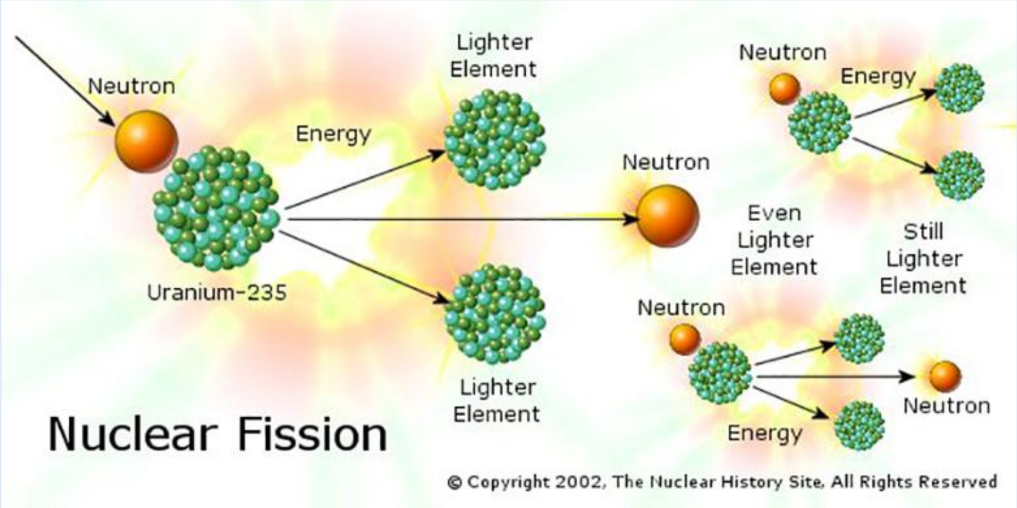
TRIPLE ONLY: Fission

- Spontaneous fission is rare. Usually for fission to occur the unstable nucleus must first absorb a neutron.



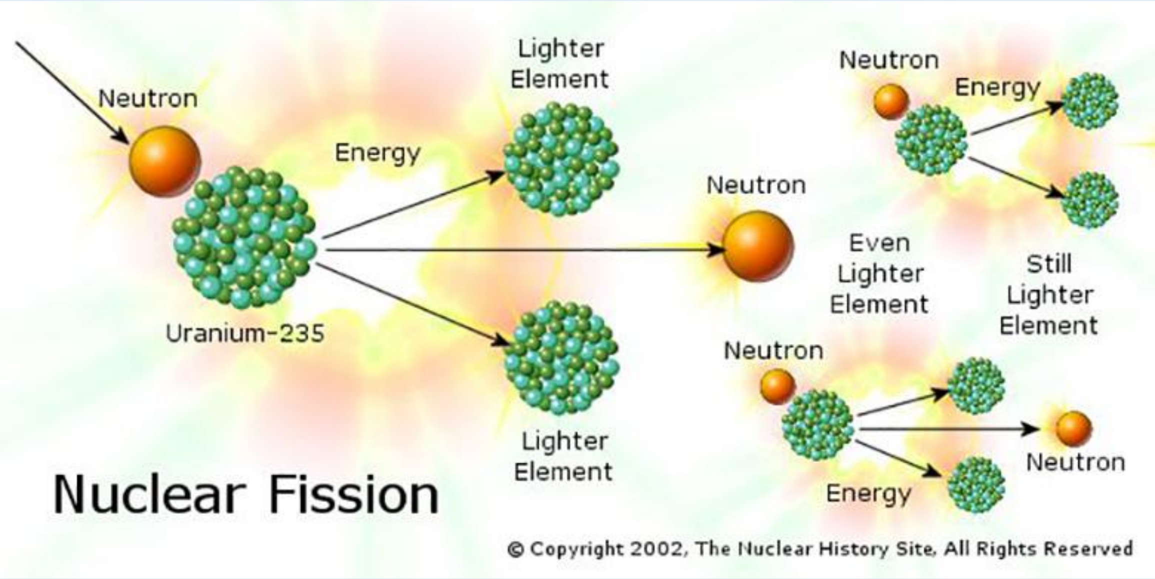
TRIPLE ONLY: Fission

- Total mass after splitting is less than what you started with.
- Matter is converted to energy.
- $E=mc^2$



TRIPLE: Fission Chain Reaction

- Uranium nuclei absorbs neutron
- Forms a larger more unstable nuclei
- Larger nucleus splits into two smaller nuclei
- releasing two - three neutrons and energy.
- All of the fission products have kinetic energy.



TRIPLE ONLY: Fission

- Controlled Chain Reaction: occurs in nuclear reactors or power plants.
  - Some of the free neutrons are removed

- Uncontrolled Chain Reaction: occurs in nuclear bombs or “atomic bombs”.

Major Parts of a Nuclear Reactor

- **Fuel Rods:**
  - Contain a fissionable isotope
  - Surrounded by coolant in the reactor core
    - Enriched U-235, Pu-239

- **Moderator:**
  - **Slows down** neutrons to increase chances for fission.
    - Graphite, water, or heavy water

- **Control Rods:**
  - **Absorb excess** neutrons
  - Control rate of chain reaction (can be raised and lowered)
    - Boron or Cadmium