Oxford Cambridge and RSA

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# Tuesday 23 November 2021 – Morning

## GCSE (9–1) Physics B
## (Twenty First Century Science)

**J259/01** Breadth in physics (Foundation Tier)

**Time allowed: 1 hour 45 minutes**

**You must have:**
- a ruler (cm/mm)
- the Data Sheet for GCSE (9–1) Physics B (inside this document)

**You can use:**
- a scientific or graphical calculator
- an HB pencil

Please write clearly in black ink. **Do not write in the barcodes.**

| Centre number | | | | | | Candidate number | | | | |
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| | | | | | | | | | | |

First name(s) ______________________________

Last name ______________________________

**INSTRUCTIONS**
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks might be given for using a correct method, even if the answer is wrong.

**INFORMATION**
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **28** pages.

**ADVICE**
- Read each question carefully before you start your answer.

Answer **all** the questions.

**1** Nina is a mountain climber.

**(a)** Calculate the increase in her stored gravitational energy when she climbs a mountain which has a vertical height of 750 m.

Her mass is 70 kg.

Gravitational field strength = 10 N / kg.

Use the equation: gravitational potential energy = mass × gravitational field strength × height

Gravitational potential energy = ......................................................J **[2]**

**(b)** **(i)** What is the useful energy store in Nina's muscles **before** she climbs the mountain?

Tick (✓) **one** box.

Chemical energy store ☐

Elastic energy store ☐

Electromagnetic energy store ☐

Gravitational energy store ☐

**[1]**

**(ii)** Nina returns to her starting point at the bottom of the mountain and stops.

Which **two** energy stores have increased when Nina reaches the bottom of the mountain and stops?

Tick (✓) **two** boxes.

Gravitational energy store in Nina's body ☐

Elastic energy store in the surroundings ☐

Nuclear energy store in the surroundings ☐

Thermal energy stored in Nina's body ☐

Thermal energy stored in the surroundings ☐

**[2]**

**2** Jane investigates a small electrical heater in an electrical circuit.

**(a)** The resistance of the heater when it is first switched on is 1.4 Ω.

The current in the heater is 9.0 A.

Calculate the potential difference across the heater.

Use the equation: potential difference = current × resistance

Potential difference = ...................................................... V **[2]**

**(b)** Jane adjusts the potential difference across the heater to 12 V.

The current in the heater is now 8.6 A.

Calculate the electrical power of the heater.

Use the equation: power = potential difference × current

Power = ...................................................... W **[2]**

**(c)** The temperature of the heater increases.

Predict what happens to the resistance of the heater.

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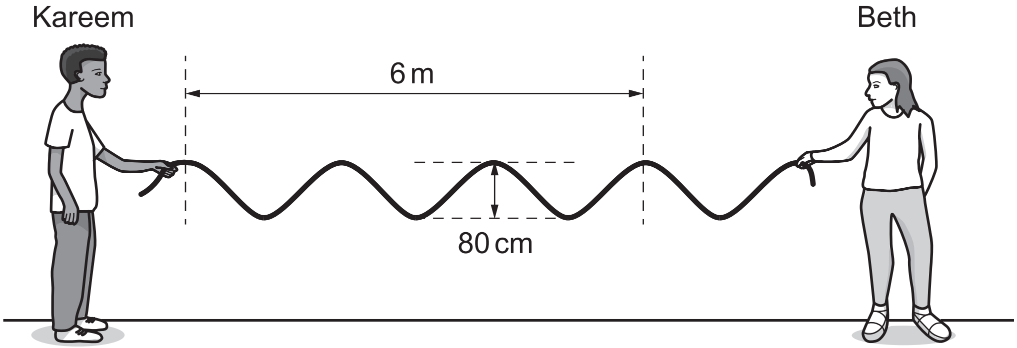
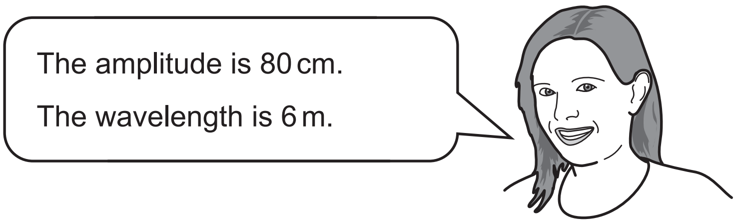
**3** Beth and Kareem make waves on a rope.




**(a)**




Beth's description of the wave is **incorrect**.

State the correct amplitude and wavelength.

The amplitude is ........................... cm.

The wavelength is ........................... m. **[2]**

**(b)** Kareem moves his hand up and down to make 2 waves every second.

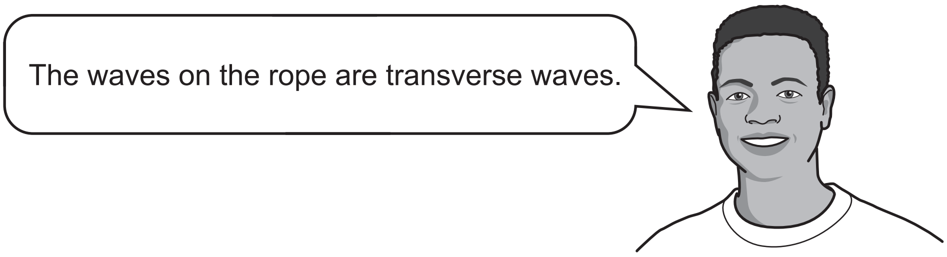
What is the frequency of the wave?

Put a (ring) around the correct answer.

**0.5 Hz** **0.5 s** **2.0 Hz** **2.0 s**

**[1]**

**(c)** Kareem describes the waves another way.




**(i)** Describe how the waves on the rope are an example of transverse waves.

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**(ii)** How are sound waves in air different to the waves on the rope?

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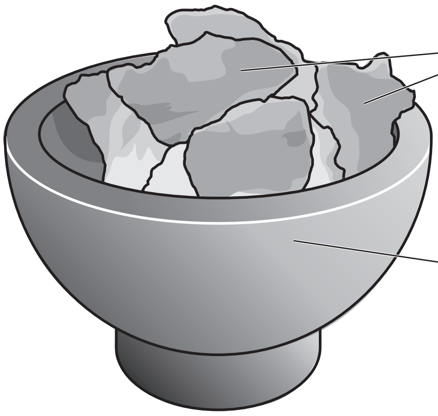
**4** Jamal sees a 'salt lamp' in a shop, as shown in the diagram.




The salt lamp contains a white light bulb covered with blocks of salt.

**(a)** Which **two** statements about visible light waves are correct?

Tick (✓) **two** boxes.

Visible light waves are transverse. ☐

Visible light waves are electromagnetic waves. ☐

Visible light waves have a longer wavelength than radio waves. ☐

Visible light waves travel faster than microwaves through space. ☐

Visible light waves travel slower than sound waves. ☐

**[2]**

**(b)** When the lamp is switched on, visible light passes through the salt as it leaves the lamp. The salt lamp appears yellow.

Complete the sentence to explain why the salt lamp appears yellow.

The salt lamp appears yellow because the salt .................................................... yellow light

and .................................................... all the other colours of white light.

**[2]**

**(c)** Jamal sees this claim on the packaging for the salt lamp.

The lamp emits negative ions that will help you to sleep.

I don't trust this claim.

It has not been peer-reviewed.

Describe the **peer review** process.

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**5** Jack has a wax candle.

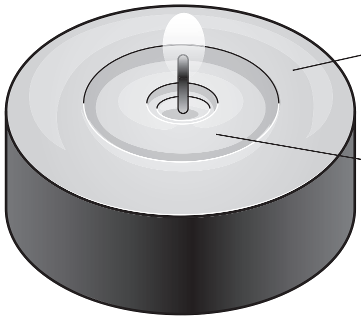
**(a)** The density of the wax in the candle is 0.9 g / $cm^3$.

The total volume of wax in the candle is 11 $cm^3$.

Calculate the mass of wax in the candle.

Mass = ...................................................... g **[3]**

**(b)** Jack lights the candle.




After a few minutes, Jack notices that some of the wax is still solid, and some of it has melted. Approximately 0.6 g of wax has melted.

Calculate the thermal energy needed to melt 0.6 g of wax.

Specific latent heat of melting of wax = 210 000 J / kg

Use the equation: energy to cause a change of state = mass × specific latent heat

Thermal energy = .......................................................J **[3]**

**(c)** Jack blows out the candle.

The liquid wax turns back into a solid.

Describe what happens to the particles in the wax as it changes from a liquid into a solid.

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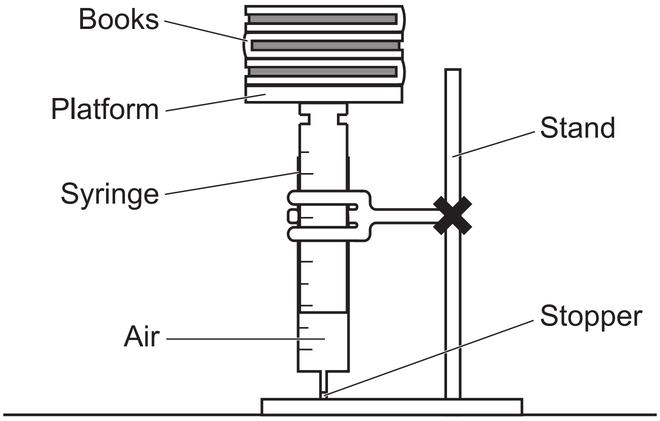
6 Eve does an experiment to investigate the relationship between pressure and volume of a gas.

She uses a syringe containing air. She compresses the air by placing some books on top of the syringe.




**(a)** The mass of one book is 0.85 kg.

Calculate the weight of this book.

Use the equation: weight = mass × gravitational field strength

Gravitational field strength = 10 N / kg.

Weight = ...................................................... N **[2]**

**(b)** The total weight of the books on top of the syringe is 24 N.
The surface area of the syringe in contact with the books is 0.0028 $m^2$.

Calculate the pressure on the air in the syringe due to the weight of the books.

Use the equation: pressure = force normal to a surface ÷ area of that surface

Give your answer to **2** significant figures.

Pressure = .................................................... Pa **[3]**

**(c)** Eve observes that as the pressure increases, the volume of the air in the syringe decreases.

Explain this observation using ideas about particles.

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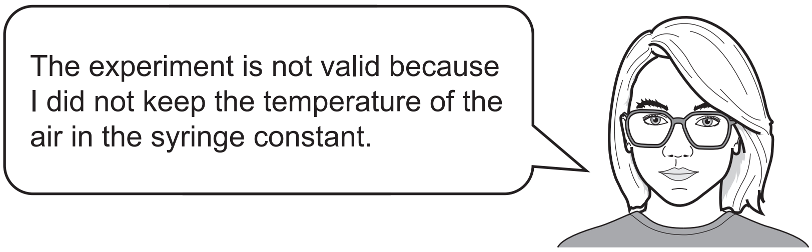
**(d)** Eve talks about the experiment.




How could Eve keep the temperature of the air in the syringe constant?

Tick (✓) **one** box.

Check the temperature of the room. ☐

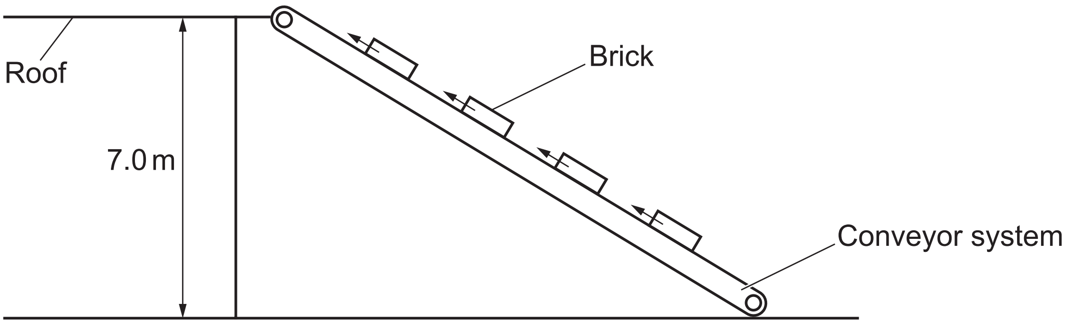
Put the syringe in a water bath. ☐

Put a thermometer inside the syringe. ☐

Put insulation around the syringe. ☐

**[1]**

**7** Kai is a builder. He uses a conveyor system to lift bricks up to the roof of a house, as shown in the diagram.




**(a)** The conveyor system is powered by an electric motor, which is connected to a petrol generator.

The petrol used by the generator is a store of chemical energy.

Describe **two** changes in stored energy as the bricks are lifted to the roof of the house.

1. ..........................................................................................................................

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2. ..........................................................................................................................

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**(b)** Calculate the work done by the electric motor to lift a brick with a weight of 35 N to the roof.

Use the equation: work done = force × distance

Give the correct **unit** for your answer.

Work done = ................................ **Unit** = ............ **[3]**

**(c)** Kai considers using a conveyor system with a higher power rating.

**(i)** Explain what is meant by the **power** of the conveyor system.

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**(ii)** Suggest how a **higher power** conveyor system could help Kai lift bricks up to the roof of a house.

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**8** Sarah investigates the effect of frictional forces on a sliding object. She uses a block of wood which is on a table, as shown in **Fig. 8.1**.

She pushes the block with her hand to start it moving. She then releases it and waits for it to come to rest.

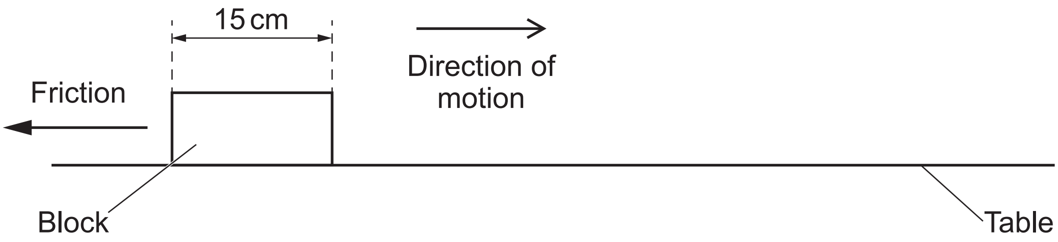


**Fig. 8.1**

**(a) (i)** One of the forces acting on the block is friction. This friction force acts to the left, as shown in **Fig. 8.1**.

Describe one **other** force acting on the block **after** Sarah has released it.

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**(ii)** Why does the block slow down when it is released?

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**(b)** To measure the speed of the block, Sarah uses a light gate, as shown in **Fig. 8.2**.

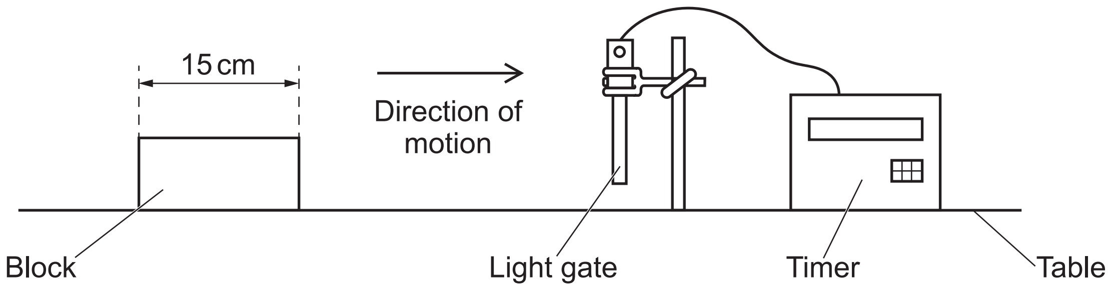


**Fig. 8.2**

The light gate measures the time that the block takes to pass through it.
In one test, the block takes 0.60 seconds to pass through the light gate.

The length of the block is 15 cm.

Calculate the average speed of the block as it passes through the light gate.

Use the equation: average speed = distance ÷ time

Average speed = .................................................. m/s **[3]**

**(c)** Sarah wants to do an experiment to investigate how the initial speed of the block affects the distance the block travels before stopping.

Suggest how Sarah could do this experiment.

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**9** The UK government plans to build more nuclear power stations in the future.

**(a)** Why is nuclear fuel a **non-renewable** energy source?

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**(b)** Nuclear power stations use uranium as a fuel. Energy is released from the uranium nuclei by nuclear fission.

Describe the process of nuclear fission.

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**(c)** A typical nuclear power station has a useful power output of 1600 MW.

The total power input is 4000 MW.

Calculate the efficiency of a typical nuclear power station.

Use the equation: $\text{efficiency} = \dfrac{\text{useful power output}}{\text{total power input}}$

Give your answer as a **percentage**.

Efficiency = ...................................................... % **[3]**

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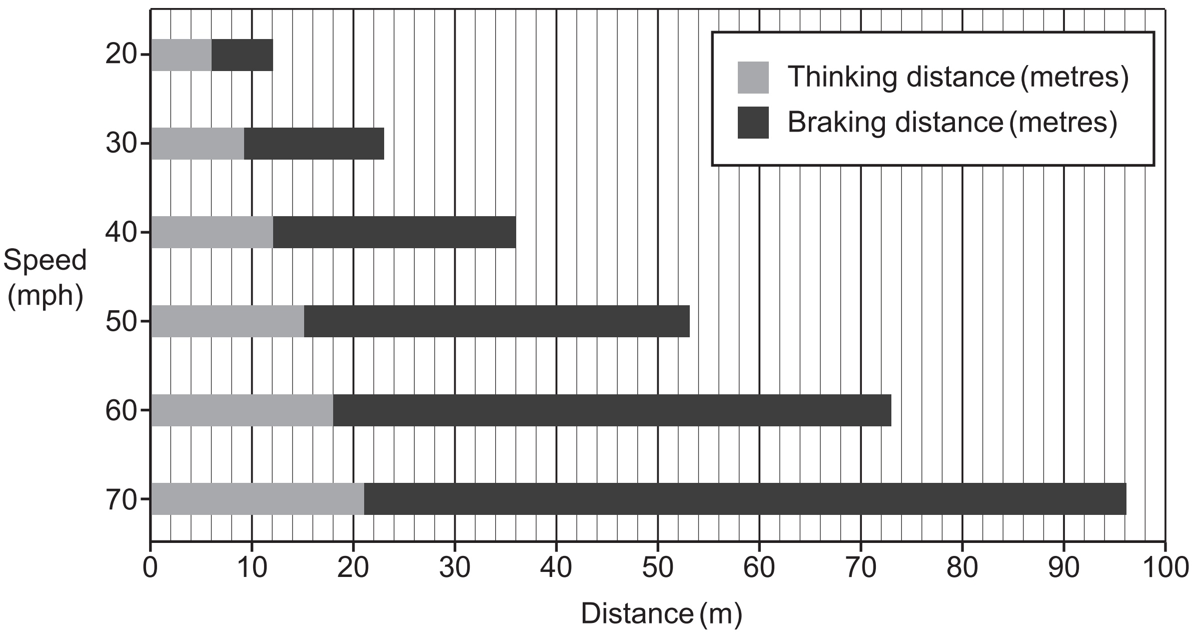
**10** The chart shows typical thinking distances and braking distances for a car in normal driving conditions.




**(a)** Estimate the total stopping distance of a car travelling at a speed of **45 mph**, using the chart.

Total stopping distance = thinking distance + braking distance

Total stopping distance = ...................................................... m **[1]**

**(b)** Some residential areas are reducing their speed limits from 30 mph to 20 mph.

Explain why reducing the speed limit improves road safety.

Use data from the chart in your answer.

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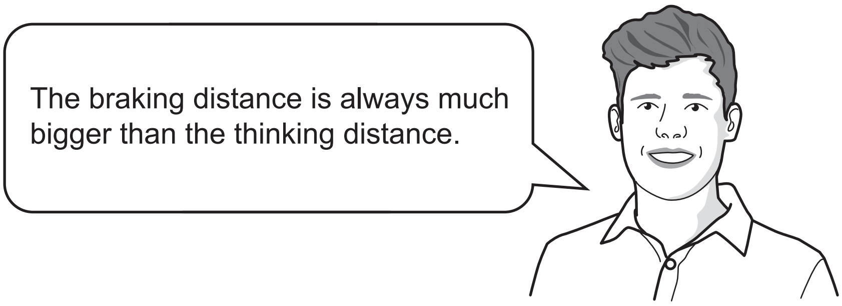
**(c)** Ben looks at the chart.




Discuss Ben's statement.

Use data from the chart in your answer.

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**(d)** Speed is a factor which affects the total stopping distance of a car in an emergency.

State **one other** factor, and explain why it affects the total stopping distance.

Factor .............................................................................................................................

Explanation .....................................................................................................................

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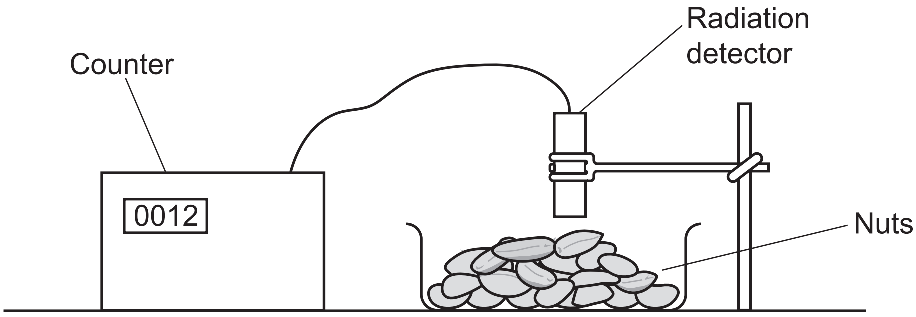
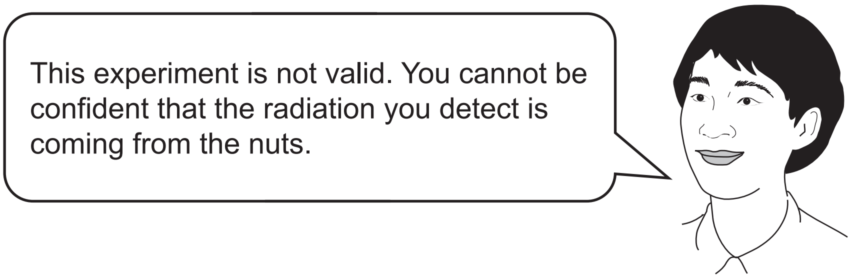
**[2]**

**11** Some types of nut are slightly radioactive. They emit alpha radiation.

Amaya uses a radiation detector to measure the radiation given out by some nuts.




**(a)** Li comments that there is a problem with Amaya's experiment.




Suggest how to solve this problem.

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**(b)** Explain how Amaya could find out if the radiation that she detects is alpha radiation.

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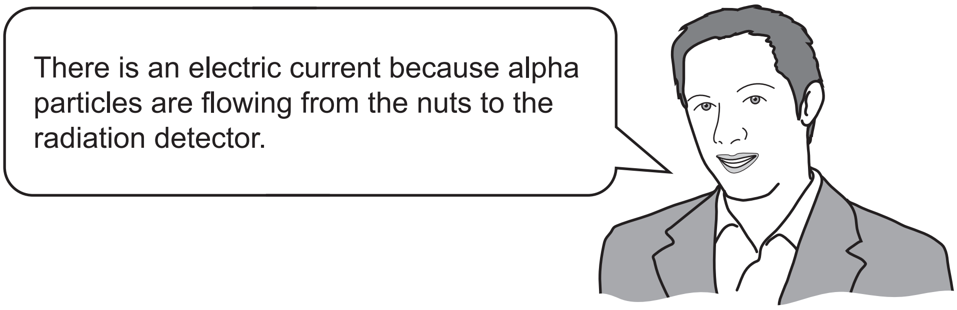
**(c)** Amaya's teacher says that there is an electric current flowing between the nuts and the radiation detector.




Explain why Amaya's teacher is correct.

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**(d)** Suggest why people still eat nuts, even though they know that some types are slightly radioactive.

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**12** Sundip wants to measure Alex's reaction time.

Their teacher gives them a 30 cm ruler, and the table shown.

| **Reading on ruler (cm)** | **Reaction time (s)** |
|---|---|
| 12 | 0.15 |
| 15 | 0.17 |
| 18 | 0.19 |
| 21 | 0.20 |
| 24 | 0.22 |
| 27 | 0.23 |
| 30 | 0.24 |

**(a)** Explain how to use the ruler and the table to measure Alex's reaction time.

You can draw a diagram to support your answer.

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**(b)** Suggest why the table does **not** include values below 12 cm.

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**(c)** Sundip wants to use the 30 cm ruler to measure the reaction times of her class.

**Sundip**

The 30 cm ruler will not be suitable to measure some students' reaction time in my class.

Explain why Sundip is correct and suggest **one** solution to this problem.

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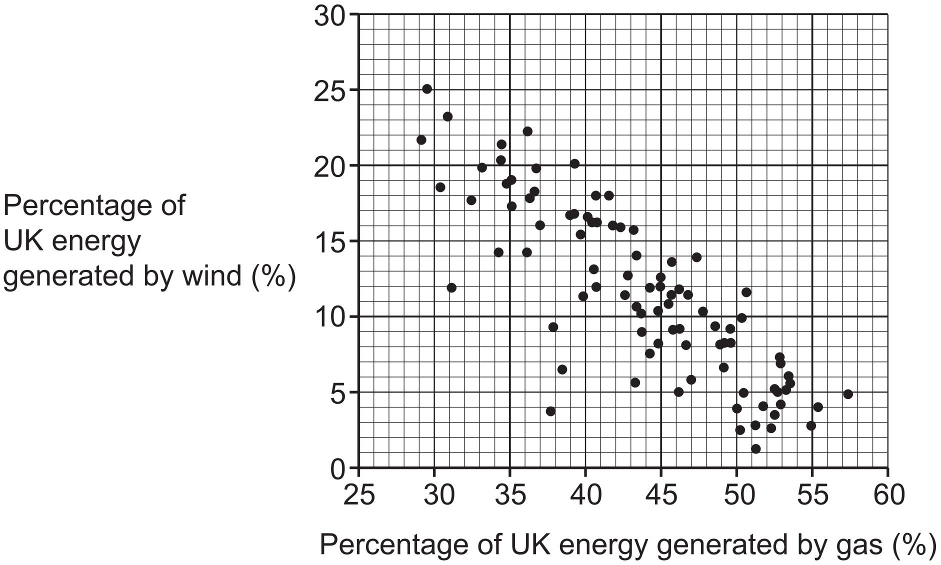
**13** A large percentage of electricity in the UK is generated using wind turbines and gas-fired power stations.

The graph compares the percentage of UK energy generated by wind and gas from January to March 2017.

Each plot point shows the energy generated in one day.




**(a)** Describe and explain the relationship shown in the graph.

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**(b)** Mia and James discuss the data.


**(i)** Give **one** reason why Mia is correct.

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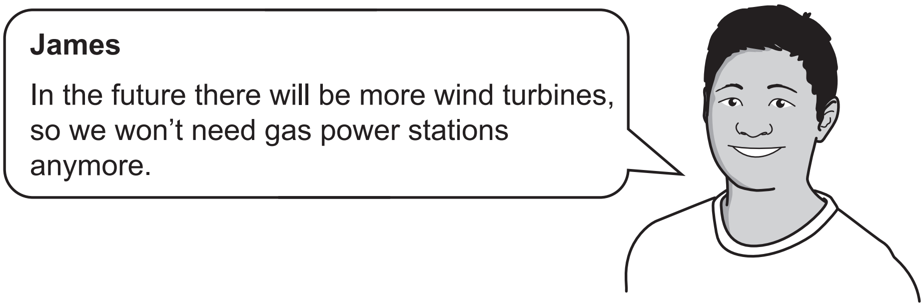


**(ii)** Discuss James' comment.

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**14** An atomic clock is a very accurate way of measuring time.

Many atomic clocks use electromagnetic radiation emitted from caesium atoms.

**(a)** Explain how an atom can emit electromagnetic radiation.

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**(b)** The frequency of electromagnetic radiation emitted from caesium atoms is $9.19 \times 10^9$ Hz.

Calculate the wavelength of this radiation.

Speed of light = $3.0 \times 10^8$ m/s.

Wavelength = ...................................................... m **[3]**

**(c)** Satellite navigation systems rely on atomic clocks for their accuracy.

Suggest **one** way that society has benefited from the invention of accurate satellite navigation systems.

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.................................................................................................................................... **[1]**

**END OF QUESTION PAPER**

## ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).