

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

J259/04 Depth in physics (Higher Tier)

Friday 15 June 2018 – Morning

Time allowed: 1 hour 45 minutes



You must have:

- the Data Sheet (for GCSE Physics B (inserted))
- a ruler (cm/mm)

You may use:

- a scientific or graphical calculator
- an HB pencil



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|---------------|--|--|--|--|--|------------------|--|--|--|--|
| First name | | | | | | | | | | |
| Last name | | | | | | | | | | |
| Centre number | | | | | | Candidate number | | | | |

INSTRUCTIONS

- The Data Sheet will be found inside this document.
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION

- The total mark for this paper is **90**.
- The marks for each question are shown in brackets [].
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **28** pages.

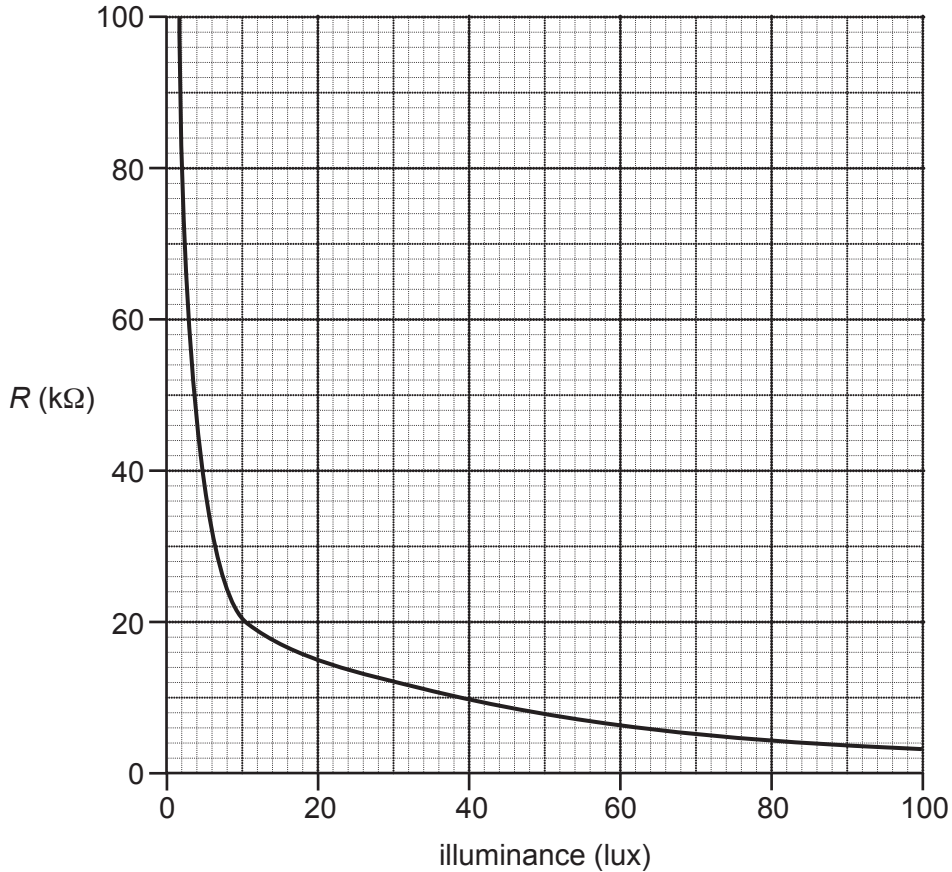
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Answer **all** the questions.

1 This question is about using an LDR (light-dependent resistor) to measure light intensity.

(a) The resistance R of an LDR varies with illuminance (the amount of light energy per unit area hitting a surface) as shown in the graph.



(i) Which of the following statements correctly describes this variation?

Tick (✓) **one** box.

The resistance is directly proportional to the illuminance.

The resistance and the illuminance have a positive correlation.

As the illuminance increases, the change in resistance becomes less and less.

The resistance is greater at 80 lux than at 20 lux.

[1]

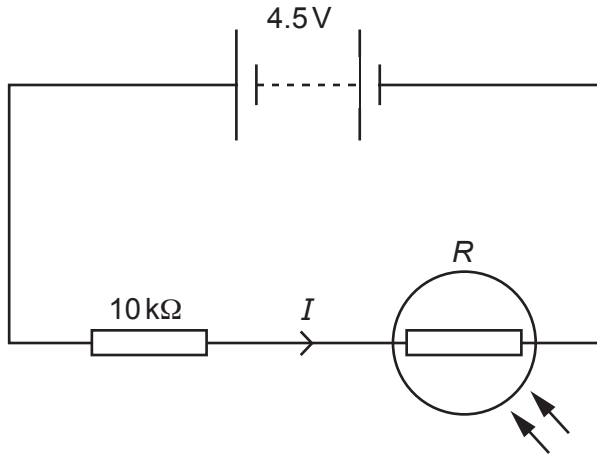
(ii) Use the graph to estimate the change in resistance of the LDR when the illuminance increases from 10 lux to 70 lux.

Change in resistance = $k\Omega$ [2]

Turn over

(b) The LDR is connected in series with a fixed resistor of resistance $10\text{ k}\Omega$ and a 4.5 V battery.

The **total** resistance at 30 lux is 22000Ω .



(i) Calculate the current in the circuit.

Current = A [3]

(ii) Calculate the potential difference across the fixed $10\text{ k}\Omega$ resistor when the illuminance is 30 lux .

Potential difference = V [3]

(iii) Describe, without any calculations, how the potential difference across the fixed resistor will change when the illuminance increases from 30 lux to 100 lux.

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..... [3]

- 2 Sarah carries out an experiment to measure the specific latent heat of vaporisation of water. She does this by finding the energy needed to evaporate a known mass of water.

The apparatus she uses is shown in **Fig. 2.1**.

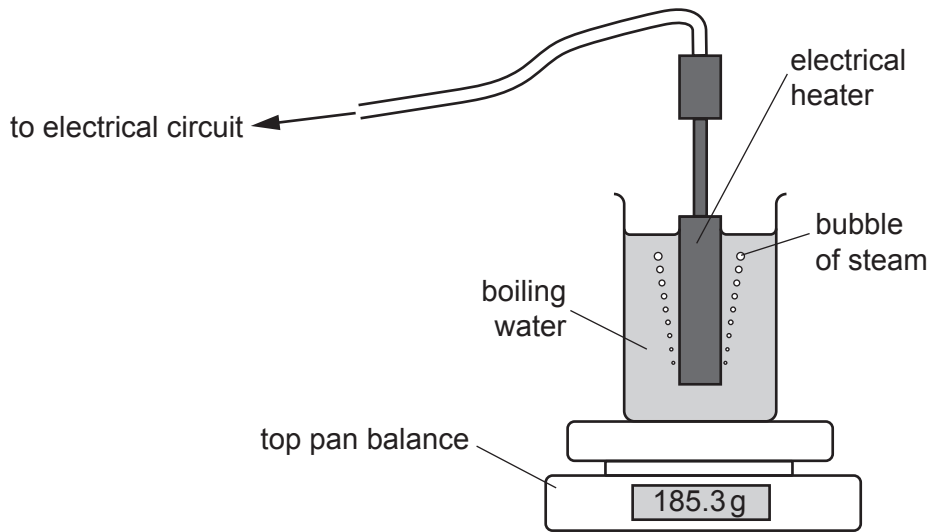


Fig. 2.1

Using this apparatus, Sarah takes these readings.

| | Measured value |
|----------------------------|-----------------------|
| current | 3.0A |
| potential difference | 12V |
| time | 150 s |
| balance reading at start | 185.3g |
| balance reading at the end | 184.3g |

Table 2.1

(b) Sarah's book has this information about vaporisation of two liquids.

| Liquid | Specific latent heat of vaporisation (J per gram) |
|---------------|--|
| water | 2300 |
| alcohol | 950 |

Suggest why it takes more energy to evaporate 1 gram of water than it does to evaporate 1 gram of alcohol.

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..... [3]

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3 There is a film about an astronaut named Mark Watney. He is left alone on the planet Mars. He has to use science to stay alive until he can be rescued.

(a) Mars is a cold planet, and Watney has a radioactive thermal generator. This contains radioactive plutonium-238 which emits alpha-particles, giving an isotope of uranium.

(i) Complete the radioactive decay equation for plutonium-238.



[3]

(ii) The plutonium emits 1.6×10^{15} alpha particles every second, each with an energy of 9.0×10^{-13} J.

The energy released is all transferred to the internal energy of the generator.

Show that the input power of the generator is about 1500 W.

[3]

(iii) Watney uses the generator to heat up water for a bath. He heats 100 kg of water from 20°C to 37°C .

Show that it takes more than an hour (3600 s) for his bath to warm up using his 1500 W generator.

You can assume that all the input energy to the generator is transferred to the internal energy of the water.

specific heat capacity of water = $4200 \text{ J/kg}^\circ\text{C}$

[5]

- (b) To be rescued, Watney needs to drive a vehicle to a site 3200km away. The vehicle is powered by batteries of capacity 18kWh.

Watney knows that the vehicle can travel at 25km/hour using 5kW of power from the batteries to do this. When the batteries are discharged Watney has to wait until the next day to continue. He has solar panels to recharge the batteries after a day's travel.

- (i) Use these data to calculate the smallest number of days it would take to drive to his destination.

Number of days = days [4]

- (ii) Give **one** reason why it would actually take longer than the time calculated in (b)(i).

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..... [1]

- 4 This question is about a measurement of the speed of sound in air that Isaac Newton made over 300 years ago.

At Newton's college in Cambridge there was a long outdoor corridor where clapping his hands would give a loud echo a fraction of a second later.



- (a) Newton measured the distance from where he stood to the reflecting wall as 64 m.

To measure the time, he made a very tiny pendulum – a weight swinging on a thin cotton thread – and adjusted the length until one to-and-fro swing of this pendulum matched the time between the clap and the echo.

This happened when the length L of the pendulum was 4.6 cm (0.046 m).

- (i) Newton showed that the time of one swing, T , was given by the equation:

$$T^2 = kL$$

L = the length of the pendulum

$$k = 4.02 \text{ s}^2/\text{m}.$$

Calculate the swing time T of his 0.046 m pendulum.

$$T = \dots\dots\dots \text{ s [3]}$$

- (ii) Use Newton's data to calculate the speed of sound.
Distance to wall = 64 m

Speed of sound = m/s [3]

- (b) Newton's calculated value for the speed of sound was low when compared with the speed found by modern measurements.

- (i) Explain which of Newton's measurements (distance or time) was likely to be the least accurate.

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..... [1]

- (ii) Explain why Newton's value for the speed was too low.

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..... [2]

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- 5 Alex is investigating how the initial kinetic energy of a trolley will affect the distance it travels before it stops.

Fig. 5.1 shows his apparatus.

Each time, the trolley starts at the same marked point and Alex measures how far it goes along the test surface before it stops. The centre of the trolley is marked with a dot.

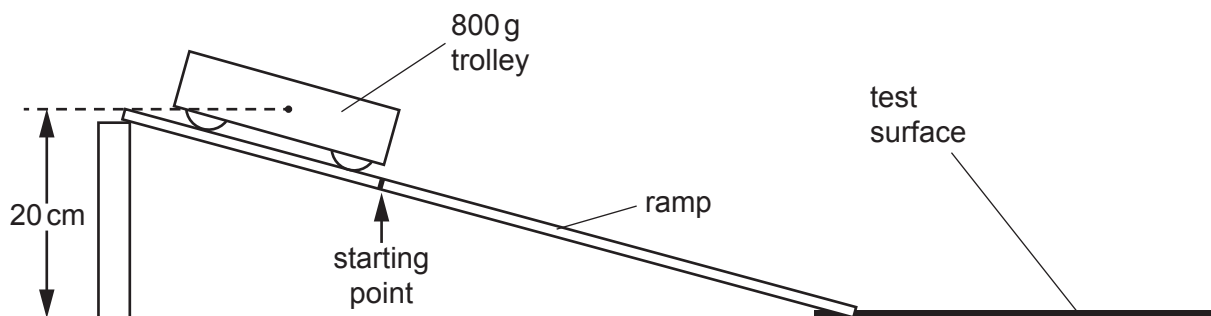


Fig. 5.1

- (a) Alex makes this calculation to find the energy.

$$\begin{aligned} \text{Kinetic energy gained by the trolley} &= \text{gravitational potential energy store it had at the top of the slope.} \\ &= \text{mass} \times g \times \text{height} = 800 \text{ g} \times 10 \text{ N/kg} \times 20 \text{ cm} = 160 \text{ J} \end{aligned}$$

The value for the energy calculated by Alex is too large.

- (i) Identify mistakes that Alex has made in his measurements and in his calculation.

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..... [2]

- (ii) Describe how Alex should have done this experiment to get a more accurate value for the kinetic energy of the trolley.

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(b) Alex carries out this experiment for a range of kinetic energy values.

Table 5.1 shows his results.

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|------------------------------------|------|------|------|------|------|------|
| Initial kinetic energy (J) | 0.8 | 1.6 | 2.4 | 3.2 | 3.9 | 4.8 |
| Mean distance travelled (m) | 0.80 | 1.35 | 1.60 | 1.85 | 1.90 | 1.95 |

Table 5.1

Some of these data are plotted on the graph in Fig. 5.2.

(i) State the reason why Alex was right to plot a point at the origin, (0,0).

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 [1]

(ii) Plot the three remaining points on the graph in Fig. 5.2 and draw an appropriate best fit curve.

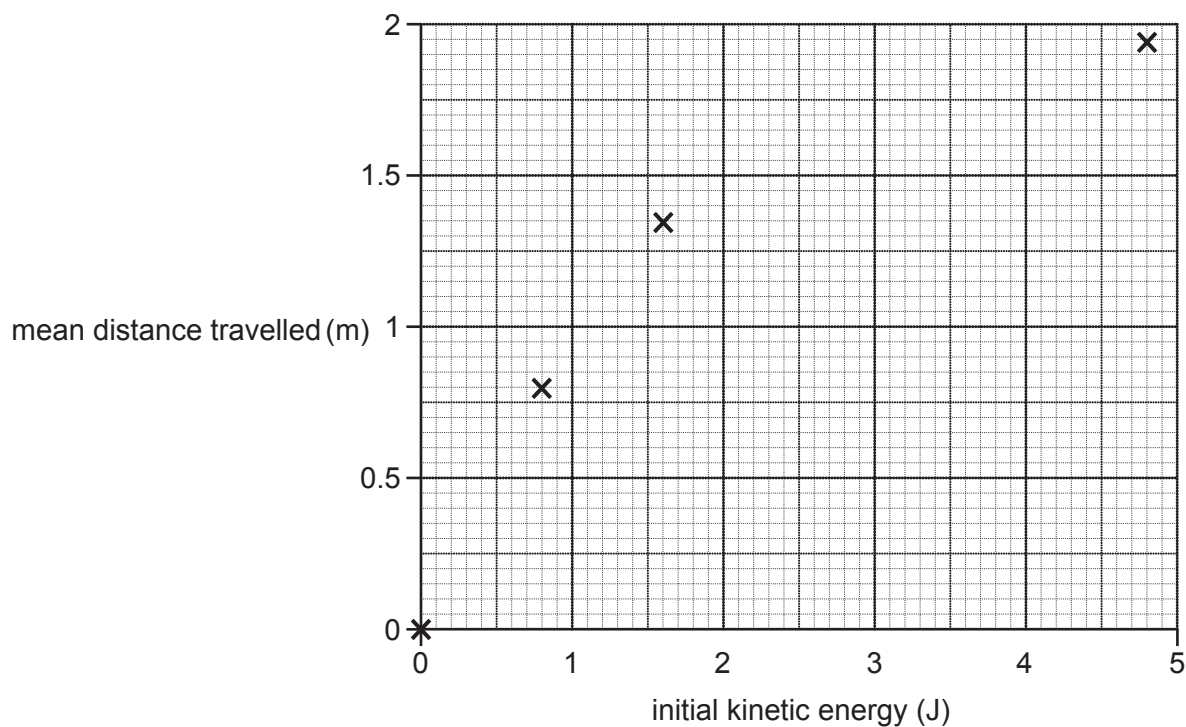
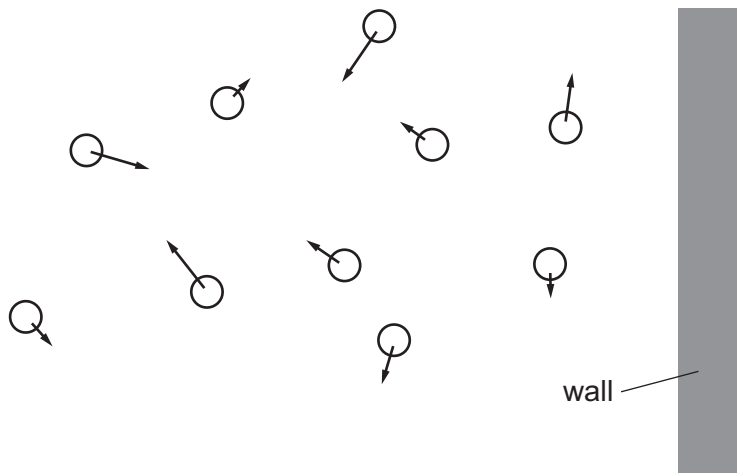


Fig. 5.2

[2]

- 6 This diagram shows air molecules in a small volume of the atmosphere near to a wall. The arrows show the velocity of each molecule.



- (a) Explain, using ideas of momentum and force, how air molecules exert pressure on the wall.

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- (b) As you go further from the Earth's surface, the atmospheric pressure gets smaller.

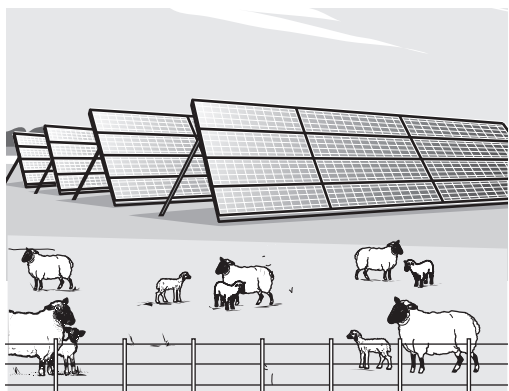
Explain this in terms of the movement of the molecules at different heights.

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..... [3]

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- 7 Solar farms are large power stations made up from many photovoltaic (PV) panels. They have become very common in Britain.



- (a) A large solar farm in England has a total area of $216\,000\text{m}^2$ covered by PV panels. Every square metre of the solar panels receives about 1000W of power from the Sun during each day.

The panels have an efficiency of energy transfer of 15%.

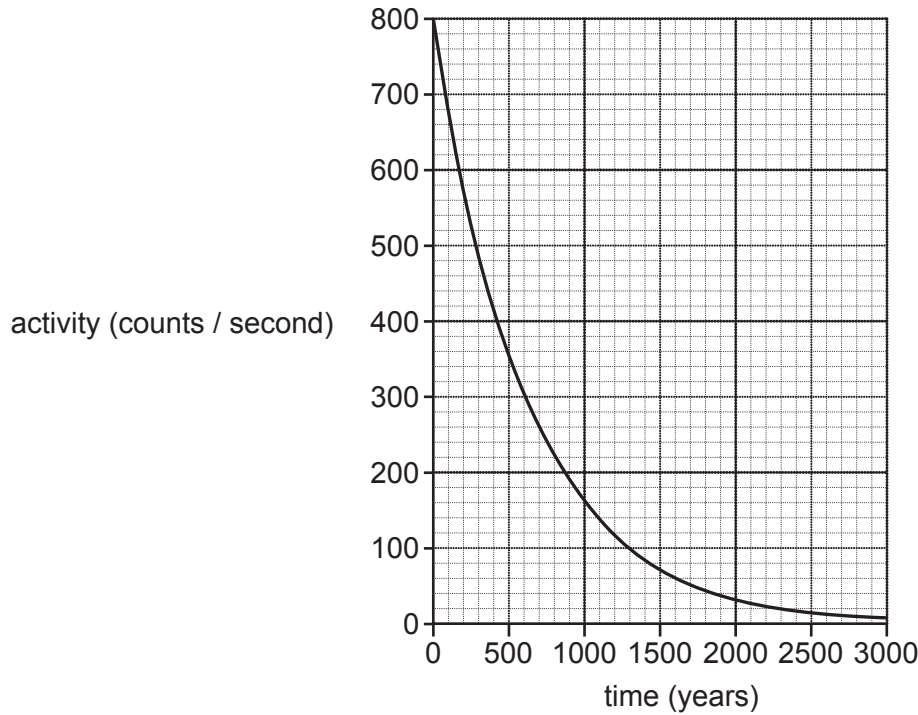
Calculate the daily average electrical power produced by the solar farm.

Give your answer in MW ($1\text{MW} = 1\,000\,000\text{W}$).

Average electrical power = MW [3]

8 This question is about the radioactive isotope americium-241, which is found in smoke detectors.

The graph shows how the activity of a sample of americium-241, with an initial activity of 800 counts per second, would change with time.



(a) Use the graph to obtain an estimate of the half-life of americium-241. Show your working on the graph.

Half-life = years [2]

(b) Americium-241 decays by emitting alpha-particles.

A smoke detector is not a hazard in your house. They usually last 10 years.

Explain why a smoke detector should be disposed of carefully when it no longer works.

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[4]

- (c) In schools, the decay of radioactive isotopes such as americium-241 can be modelled by a game rolling many dice. Each dice has 1 chance in 6 of showing a 'six' each time.

In a typical game, **100** dice are rolled onto a table.

The number showing six spots on the top are removed and counted.

The remaining dice are rolled again, and the process continued.

The results are put into a table. The following is an example for one game.

| | | | | | | | |
|---------------------------------|----|----|----|----|----|----|----|
| Roll number | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Number of sixes | 18 | 13 | 12 | 9 | 6 | 7 | 5 |
| Number of dice remaining | 82 | 69 | 57 | 48 | 42 | 35 | 30 |

Each 'roll number' stands for an equal interval of time.

- (i) What does the number of dice remaining at any roll stand for?

..... [1]

- (ii) What does the number of sixes taken out in any roll stand for?

..... [1]

- (iii) Explain why the data in this table suggest that the half-life is about 4 'rolls' but that it's not possible to be exact.

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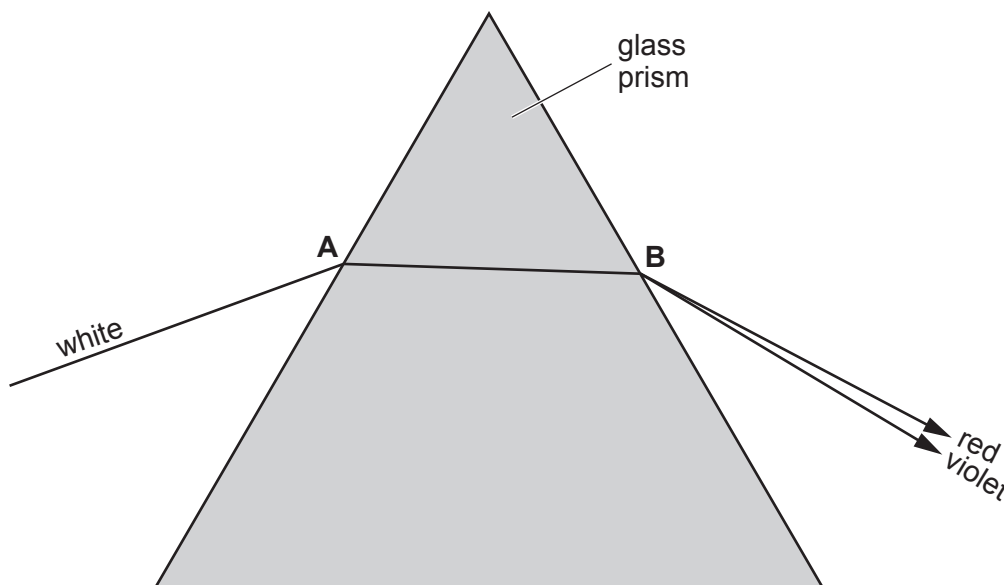
 [3]

9 This question is about the refraction of waves.

(a) Layla uses a ray-box to send a ray of white light into a triangular glass prism at point **A**.

She cannot see clearly what happens inside the prism, but she sees a spectrum of colours coming out at point **B**.

The diagram shows the paths taken by the colours at the two ends of the spectrum.



(diagram to scale)

Which statements about the physics of this refraction are correct?

Tick (✓) **two** boxes.

Red light and violet light both slow down when going from air into glass.

Red light travels slower than violet light in air.

Violet light travels faster than red light in glass.

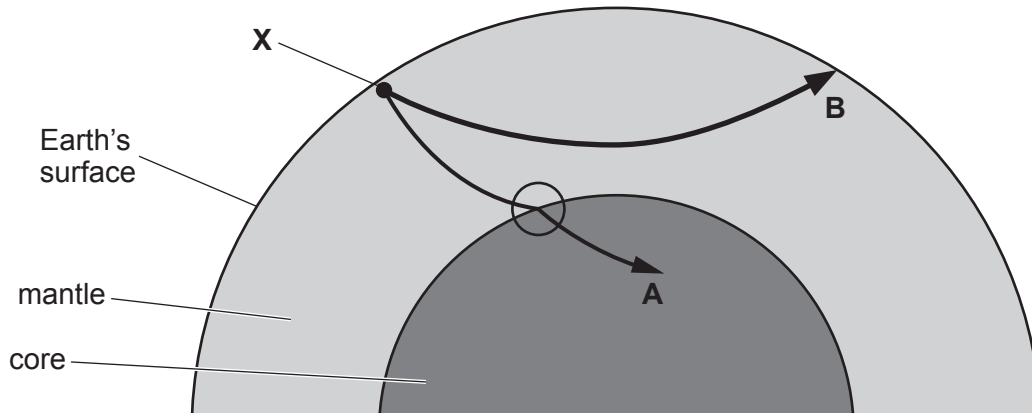
When they go from glass into air, both red light and violet light decrease in wavelength.

When they go from glass into air, violet light speeds up more than red light.

[2]

(b) The diagram below is a section through part of the Earth.

Following an earthquake at **X**, earthquake waves travel through the Earth. Two wave paths, **A** and **B**, are shown on the diagram.



(i) Look at path **A**.

The wave direction changes suddenly at the place ringed.

Explain what this shows about the speed of the earthquake wave as it moves from the mantle into the core.

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..... [2]

(ii) Look at path **B**.

The wave direction changes continuously.

Explain what this shows about the speed of the earthquake waves in the mantle at different depths below the Earth's surface.

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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).

A large area of lined paper for writing. It features a vertical solid line on the left side, creating a margin. The rest of the page is filled with horizontal dotted lines, providing space for writing answers.

