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OCR
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GCSE (9-1)

Examiners' report

TWENTY FIRST CENTURY SCIENCE PHYSICS B

J259
For first teaching in 2016

J259/04 Summer 2018 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

Paper J259/04 series overview

This is the first of the 'Depth in Physics' papers in this new specification. Even though all papers are now synoptic, covering the whole specification, candidates generally scored well, and the difficult mathematical aspects were well tackled. As this paper consists of long questions structured around specific topics, candidates need to scan each question to discern its structure before diving in to part (a)(i). As an example, Q1 started with a gentle pair of questions, parts (a)(i) & (ii), on interpreting the resistance-illumination graph for the Light-Dependent Resistor, after which candidates were expected to incorporate those ideas into an analysis of a potential divider circuit in (b)(i) to (b)(iii).

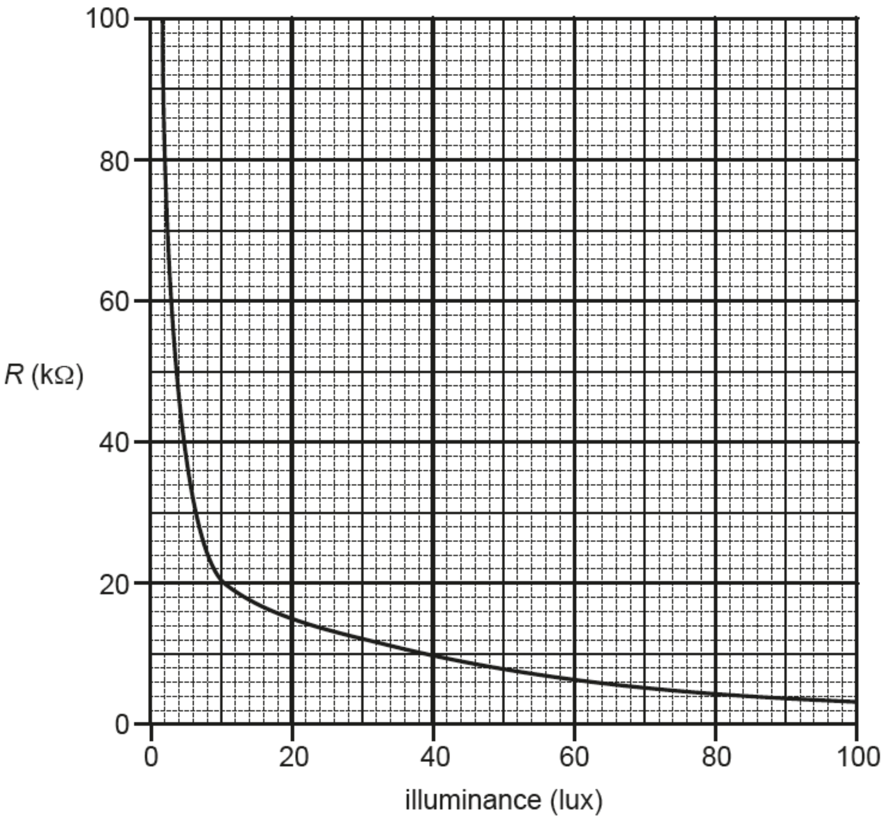
Candidates were generally well prepared for the two extended-response questions in this paper as these had featured extensively in papers for the previous Twenty-First Century Science: Physics specification J245.

A new feature of this paper is the examination of skills related to practical work; in this paper Q2, on specific latent heat, and Q6, on forces and motion, were met with different degrees of success.

Question 1 (a) (i)

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]

Question 1 (a) (ii)

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

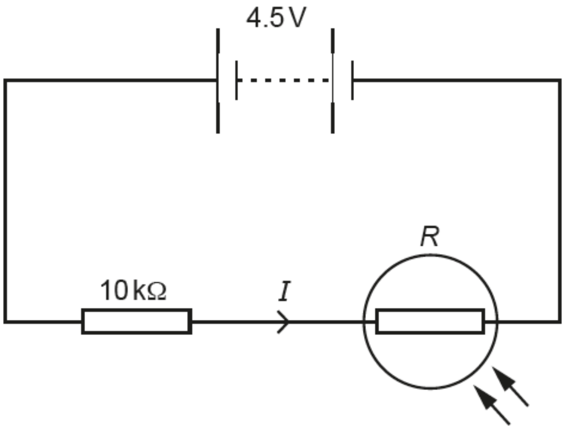
Change in resistance = ... kΩ **[2]**

These introductory questions were answered well by almost all candidates

Question 1 (b) (i)

(b) The LDR is connected in series with a fixed resistor of resistance 10 kΩ and a 4.5 V battery.

The **total** resistance at 30 lux is 22 000 Ω.



(i) Calculate the current in the circuit.

Current = ... A **[3]**

Question 1 (b) (ii)

(ii) Calculate the potential difference across the fixed 10 kΩ resistor when the illuminance is 30 lux.

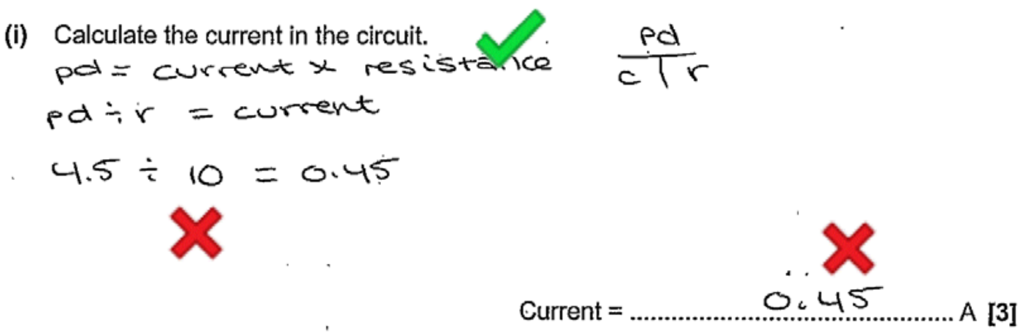
Potential difference = ... V **[3]**

Most candidates found part (b) more challenging. Many ignored the statement in the question stem that the **total** resistance at 30 lux is 22 000 Ω. These candidates used 10 Ω, or 10 000 Ω, or 12 000 Ω, or even 32 000 Ω. About one fifth of candidates gained all three marks.

OCR support The Mathematical Skills handbook provides advice and guidance on the use of units, rounding and conversions.

Exemplar 1

Exemplar 1 is not untypical and shows how many candidates were able to be credited with a compensatory mark for their correct recall of the equation. Although like Exemplar 1, they forgot to convert 10kΩ to 10000Ω.


(i) Calculate the current in the circuit.

pd = current x resistance

pd ÷ r = current

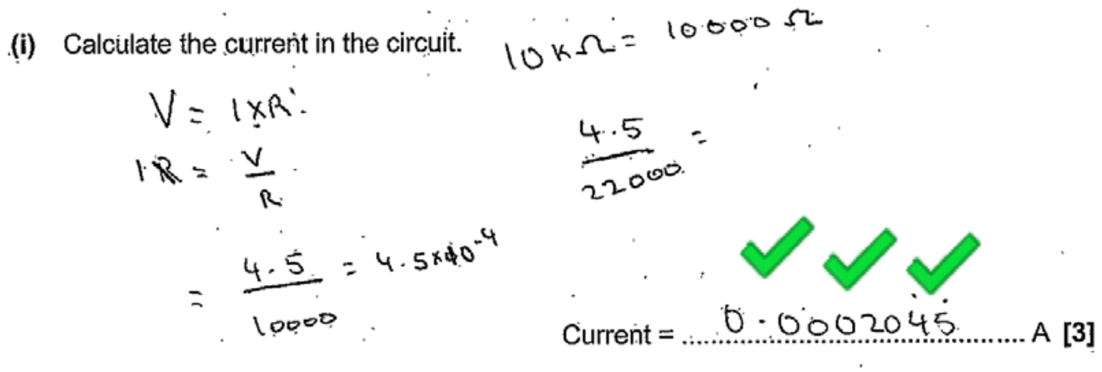
4.5 ÷ 10 = 0.45

pd / c | r

Current = ...0.45...... A [3]

Exemplar 2

In Exemplar 2 the candidate has answered the question correctly but uses the recurring decimal notation. It would have been more appropriate to round the result to 0.00020 Ω or 2.0×10^{-4} Ω.


(i) Calculate the current in the circuit.

10 kΩ = 10000 Ω

V = I×R

I = V/R

= 4.5/10000 = 4.5×10^-4

4.5/22000 =

Current = 0.0002045 A [3]

Question 1 (b) (ii)

(ii) Calculate the potential difference across the fixed 10 kΩ resistor when the illuminance is 30 lux.

Potential difference = ... V **[3]**

Exemplar 3

In Exemplar 3 the candidate has made an error in Q1(b)(i) but fortunately error carried forward (ECF) was applied to Q1(b)(ii) which allowed the candidate to gain full credit for their answer to Q1(b)(i).

(i) Calculate the current in the circuit.

$V = IR$

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

~~22+10 = 32 kΩ~~

10000 + 22000 = 32000 Ω

$\frac{4.5}{32000} = 1.40625 \times 10^{-4}$

0.000141

Current = 0.000141 A **[3]**

(ii) Calculate the potential difference across the fixed 10 kΩ resistor when the illuminance is 30 lux.

$V = IR$

10 000 × 0.000141 = 1.41 ECF

Potential difference = 1.41 V **[3]**

Question 1 (b) (iii)

(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.

....

....

....

....

....

.... **[3]**

Exemplar 4

Exemplar 4 is a rare example here of a candidate who understands what is happening in the circuit; a number of others gained marks for increase in p.d., or decrease in resistance, even if their explanations were not as clearly expressed as they could be.

The potential difference across the fixed resistor will increase. This is because at 100 lux the resistance of the LDR is much lower and because V=IR and potential difference is shared between components in a Series Circuit. Current is the same in all components in a Serions circuit. So the current will increase in the Circuit **[3]** (because of less resistance in the LDR) so the fixed resistor will get more potential difference (V=IR).

Question 2 (a) (part one)

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**.

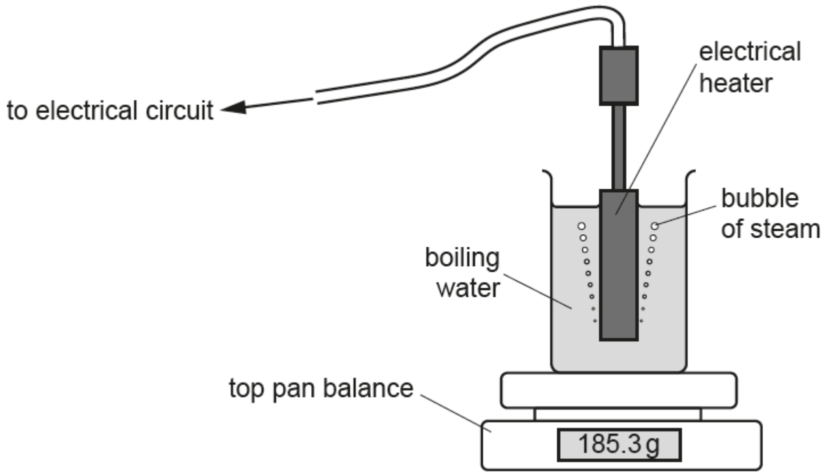


Fig. 2.1

Using this apparatus, Sarah takes these readings.

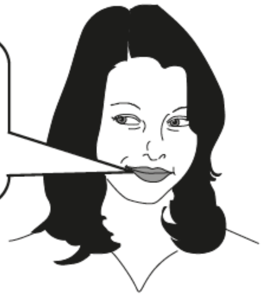
	Measured value
current	3.0 A
potential difference	12 V
time	150 s
balance reading at start	185.3 g
balance reading at the end	184.3 g

Table 2.1

Question 2 (a) (part two)

(a)* Sarah is not happy with her results.

Sarah
The book says the specific latent heat of vaporisation of water should be 2300 J for every gram evaporated. The readings in **Table 2.1** give an answer that's far too big.



Is Sarah right?

What could Sarah do to get an accurate value of the specific latent heat of vaporisation of water from her experiment?

.... **[6]**

Exemplar 5

Like many more able candidates, Exemplar 5 follows the hint in the speech bubble and uses the data to calculate a specific latent heat of 5400 J/g. They also evaluated Sarah's experimental procedure for full marks.

L3

What could Sarah do to get an accurate value of the specific latent heat of vaporisation of water from her experiment?

Firstly, Sarah could use insulating foam to insulate the heat in order to reduce ~~heat~~ the heat loss. Insulating will give a more accurate value. ~~Power = I² × R. 3² × 12 = 9 × 12 = 36 J~~. Charge = I × T. 3 × 150 = ~~48~~ 450 Coloumbs. Then power = Q × V 450 × 12 = ~~12~~ ~~2300~~ ~~so~~ 5400 J. So Sarah is correct as the readings are almost double the textbook. It could be possible that Sarah has misread the readings for one of the values therefore she should always double check or ask a partner.

5400 > 2300.

(Page to the left has clearer calculations) **[6]**

Table 2.1

Change in state energy = mass × SLH

36

= 184.3×

Charge = I × t

= 3 × 150

= 450

Work done = Q × V

= 450 × 12

= 5400 J

to raise 1g to evaporate.

SEEN

Exemplar 6

Level 2 candidates either had a good evaluation of the procedure (Exemplar 6, 4 marks) or else correct calculation with limited evaluation, probably overlooking the heat losses (Exemplar 7, also 4 marks).

L2

Is Sarah right?

What could Sarah do to get an accurate value of the specific latent heat of vaporisation of water from her experiment?

- In order to make the test more acurate, Sarah should insulate the beaker in order to stop any energy from escaping.
- Sarah should also do the test multiple tires and then calculate the avervage.
- Also, Sarah should do the test for longer periods of time such as 30 minutes and then look at the result.

Exemplar 7

Is Sarah right?

L2

What could Sarah do to get an accurate value of the specific latent heat of vaporisation of water from her experiment?

~~Sarah can firstly find out the total energy used by doing P.D x I x time. Once she has this she can~~

The energy used = 3x12x150 = 5400

$\frac{5400}{1}$ = 5400 J per gram.

Sarah is correct because her readings suggest that the water requires much more energy per gram evapourated. Sarah could increase the voltage or decrease the weight of the water by using a smaller amount.

Exemplar 8

This is a Level 1, 2 mark answer. This candidate has made generic comments about improvement that could apply to any investigation. Another typical Level 1 approach was to make limited and faulty attempt at the carrying out the specific latent heat calculation.

Is Sarah right?

L1 What could Sarah do to get an accurate value of the specific latent heat of vaporisation of water from her experiment?

Sarah can measure the change in temperature to see which stage the water is fully vaporising and ~~use a stopwatch~~ ensure she is not losing ~~excessive~~ excess vapour in her experiment. Sarah can also test the experiment ~~t~~ again to see if any results are anomalies or whether the larger reading is due to human error.

Question 2 (b)

(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.

....

....

....

....

.... **[3]**

Exemplar 9

Very few candidates had the clear understanding about bonds/attractive forces between particles shown by Exemplar 9, which scored 3 marks.

~~Vapourisation~~ Evaporating water may require more energy because the bonds between the water molecules are stronger and therefore have a higher boiling point. In contrast, alcohol has a lower density so is easier to break apart. Alcohol may also have a **[3]** ~~larger~~ smaller mass and be lighter than water, with particles already spread out more.

Exemplar 10

There are a number of alternative marking points in the mark scheme and many managed to gain a mark for a general statement such as in this exemplar.

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

Water is more denser than alcohol so more energy is needed for water to evapourate.

Question 3 (a) (i)

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.

$$^{238}_{94}\mathrm{Pu} \longrightarrow {}^{\dots\dots}_{\dots\dots}\mathrm{U} + {}^{\dots\dots}_{\dots\dots}\alpha$$

[3]

Most knew how to calculate the nucleon and proton numbers of the uranium nuclide. About one third of all candidates did not know the values for an alpha particle.

Exemplar 11

Although this candidate has mistaken an alpha particle for a neutron, the application of error carried forward (ECF) allowed them to be credited with two compensatory marks for demonstrating a correct understanding of .standard nuclear notation.

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

Question 3 (a) (ii)

(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]

This question was done well done by most candidates, who gained full marks for calculating 1440 W.

Question 3 (a) (iii)

(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 J/kg °C

[5]

The calculations here were done well by most. Weaker candidates calculated the internal energy gain of 7140 000 J and went no further. About two-third of all candidates then used this energy with the 1500 W (or 1440 W) to calculate a time longer than an hour, or calculated the power required to transfer that energy in one hour and stating that it was more than that available.

Question 3 (b) (i)

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

Watney knows that the vehicle can travel at 25 km/hour using 5 kW 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]**

Most made good effort in this question which involves a number of calculation stages, with some estimating extra time needed between runs to allow the batteries to regain full charge.

Question 3 (b) (ii)

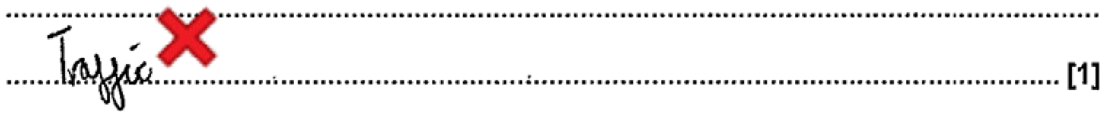
(ii) Give **one** reason why it would actually take longer than the time calculated in **(b)(i)**.

....

.... **[1]**

Some answer here lacked enough detail, e.g. 'not enough Sun' rather than 'Sun obscured by dust clouds' but many answers showed they had forgotten the context of the whole question (Exemplar 12).

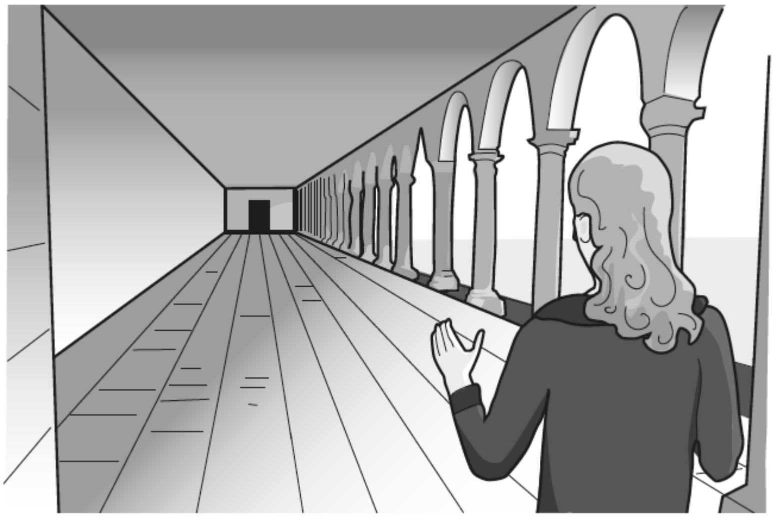
Exemplar 12



Question 4 (a) (i)

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
$k = 4.02\,s^2/m$.

Calculate the swing time T of his 0.046 m pendulum.

T = ... s **[3]**

Question 4 (a) (ii)

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

Speed of sound = ... m/s **[3]**

Most correctly calculated the pendulum period as 0.43 s in (a)(i), but a number then forgot to double the distance in (a)(ii), losing a mark.

Exemplar 13

This candidate successfully calculates the swing time (i) gaining 3/3 but then forgets to double the distance (ii). However, the application of ECF allowed them to be credited with 2/3 because they had shown their workings.

Calculate the swing time T of his 0.046 m pendulum.

$T^2 = 4kL$

$T^2 = 4.02 \times 0.046$

$T^2 = 0.18492$

$T = 0.4300232552\ s$

$T = 0.43\ s$

T = ...0.43.......... s **[3]**

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

$S = \frac{d}{t}$ $S = \frac{64}{0.43....}$

ECF

$S = 148.8791603\ m/s$

$S = 149\ m/s$

Speed of sound = ...149.......... m/s **[3]**

Question 4 (b) (i)

(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.

....

.... **[1]**

Few candidates were specific enough to suggest why the time measurement was Newton's poorer observation. This was probably because they had not considered the effect of judging the synchronicity of the pendulum swing and the echo for such a small intervals would have on the observation error. While Newton would be able to measure the distance accurately even with the instruments available to him in the 1680s.

Question 4 (b) (ii)

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

....

....

....

.... **[2]**

Only a few candidates were specific enough to suggest in (b)(i) why the time measurement was the poorer one. However, many realised that the over-large value for time would result in a too low a value for the speed of sound. A few candidates suggested that Newton's value was too low because he had not doubled the 64 m in his calculations.

Question 5 (a) (i)

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.

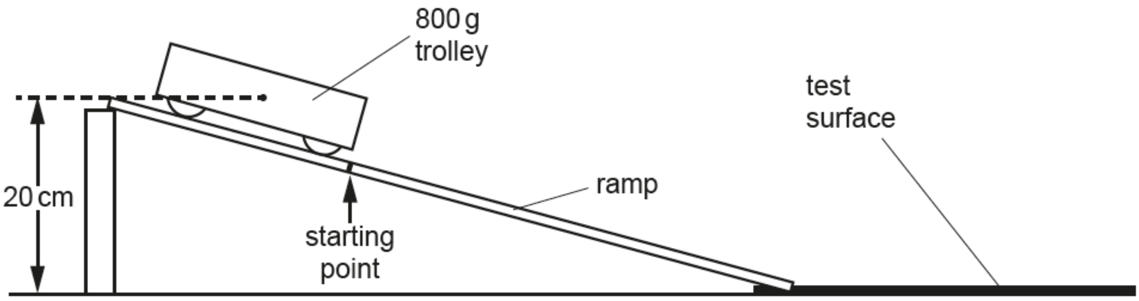


Fig. 5.1

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

Kinetic energy gained by the trolley = gravitational potential energy store it had at the top of the slope.
= mass × g × height = 800 g × 10 N/kg × 20 cm = 160 J

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.

....

....

....

.... **[2]**

This was a new style of question that assesses the candidates' ability to design a valid experiment. Lower ability candidates found this question challenging and a third of all candidates gave no creditable response. The majority of answers identified at least one of the unit errors in the data and the calculation. However, most candidates could not identify the error in the vertical drop (i.e. centre of mass to the test surface) and suggested that it should have been measured from the test surface to the lower tip of the trolley. Very few candidates annotated the diagram which would have been the simplest way to identify the errors.

Question 5 (a) (ii)

(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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....

....

.... **[3]**

In this question many candidates described how they would have done the experiment rather than suggesting how Alex should modify how he does the experiment to increase the validity of his data and hence the accuracy of his final value. Many candidates wanted Alex to use light gates, and very few suggested that he correct the errors identified in Q5(a)(ii).

Question 5 (b) (i)

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

Table 5.1 shows his results.

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).

....

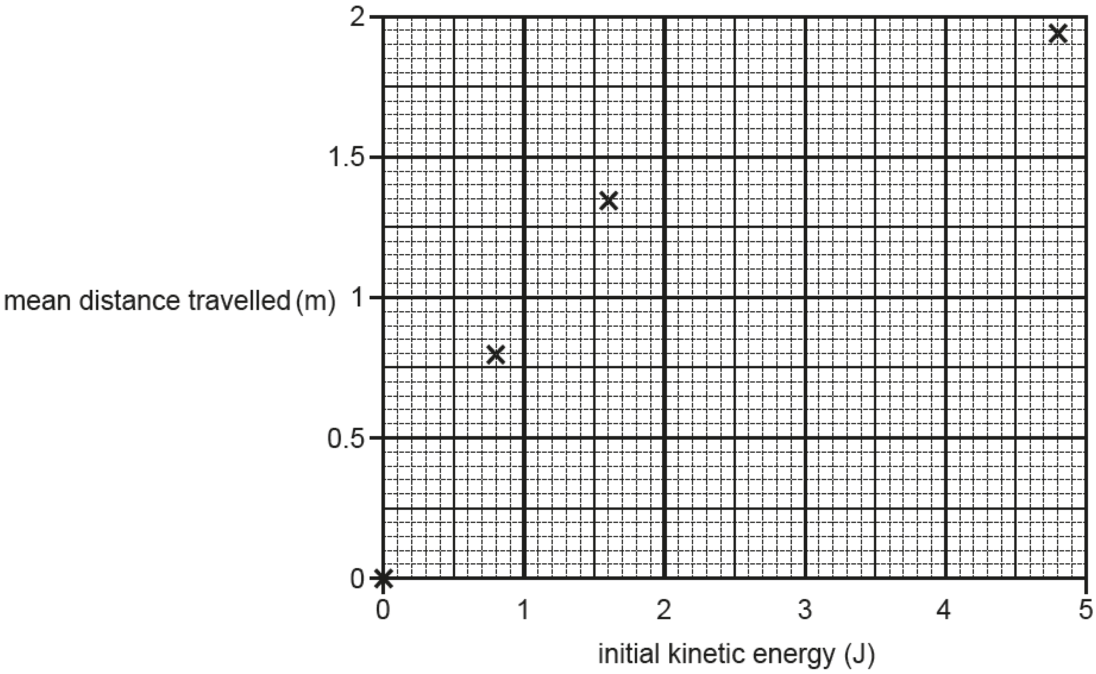
....

.... **[1]**

Almost all higher ability candidates indicated that, if the trolley has no kinetic energy, it is not going to go any distance. However many lower ability candidates stated that you need to plot (0,0) because 'it's what you always do'.

Question 5 (b) (ii)

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



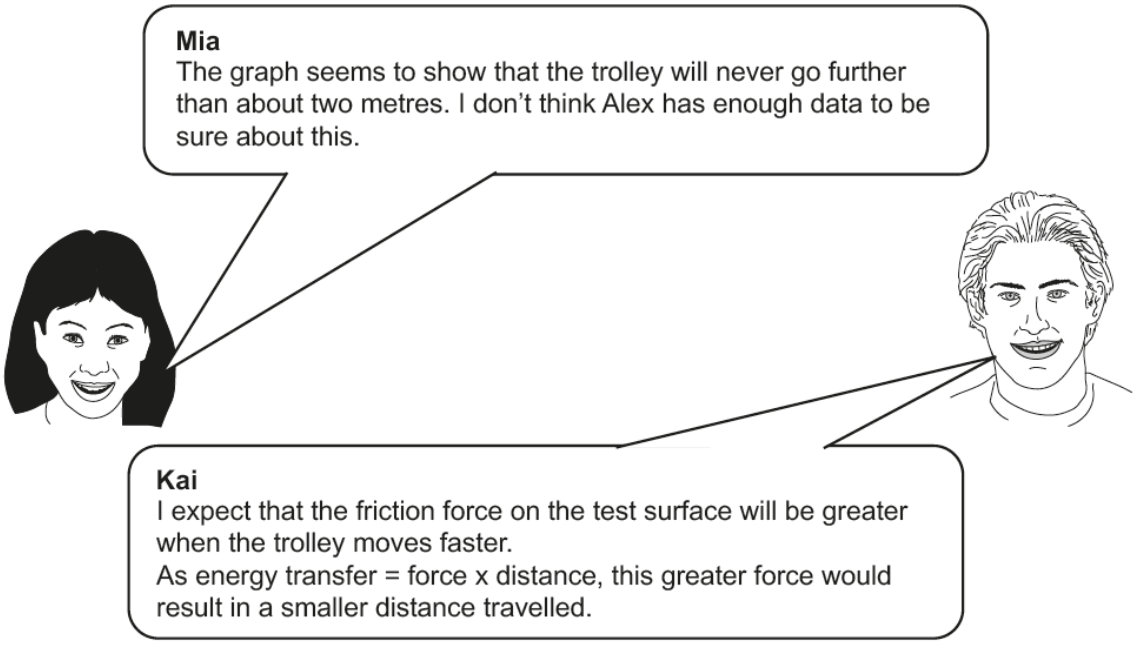
[2]

Fig. 5.2

Most candidates were able to plot the data points accurately and drew a smooth curve through the data. Around a quarter of the candidates were less precise in their plotting (the allowed a tolerance was ±1 small square) or did not draw their line of best fit as a clear single smooth curve. Some candidates sketched a feathery rough curve using multiple short strokes.

Question 5 (c)

(c) Two of Alex's friends make comments about the graph in **Fig. 5.2**.



Discuss the statements made by Mia and Kai.

....

....

....

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....

....

....

.... **[4]**

Exemplar 14

This is a good response which was credited with 3 marks. It is typical of many better answers and describes what the data shows and then evaluates the comments given based on that.

Mia is correct. The graph seems to plateau however Alex could increase the initial kinetic energy of the trolley to find out if the trolley will ~~[illegible]~~ or will not travel further than two metres. Alex is wrong, the greater the force, the further it travels due to the higher ~~initial~~ initial kinetic energy. [4]

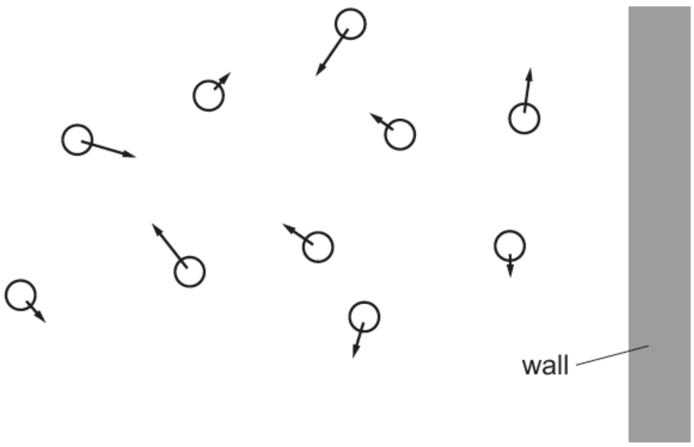
Exemplar 15

This response offers the candidates opinions but does not attempt to answer the question. The candidate has quoted from statements given by Mia and Kai without any reference to what the data shows or linking the statements to whether they were true or not. The red up-arrow symbol indicates that the candidate almost made a valid point about Alex's data.

I think that Mia is correct, because the more data that Alex collects, the higher the likelihood that his conclusion will be correct. However, I disagree with what Kai says, as the energy transfer equation would imply that the ^ force would result in a larger distance travelled by the trolly. [4]

Question 6 (a)

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.

....

....

....

....

.... **[3]**

Question 6 (b)

(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.

....

....

....

....

.... **[3]**

It was rare in (a) to see a clear explanation of momentum change leading to force. In (b) many candidates wrote about the idea of slower molecular or greater separations. However candidate responses answers were often ambiguous or confused.

Exemplar 16

Exemplar 16, was credited with 3/3 and 3/3 on these two parts. The candidate clearly explained the collisions of particles with the wall clearly in (a) and in (b) kept to a particle model in their explanation.

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

The air molecules will hit the wall. Even though they have a small mass, there will be momentum (mass x velocity) and as there's a change in direction, there will be a change in momentum (force x ~~distance~~ time), resulting in a force acting on the wall! **[3]**

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

There are more particles above you if you are closer ~~from~~ to the Earth's surface, this means that the density lower down is higher. There's also a larger pressure because more force is given in a certain area. The molecules high up will be more spread **[3]** out and move slower, and as there's a larger area and a smaller force, the pressure will decrease, as ~~less~~ fewer molecules interact with each other.

Exemplar 17

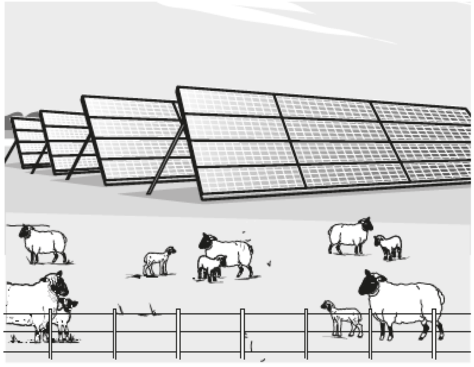
This response was credited with just one mark in (a) for stating that particles colliding with the wall create the pressure. For part (b), although they state that the number of "air molecules" reduces with height they do not go one to explain why the movement of these molecules results in a reduction in air pressure. This was typical of many candidate responses to Q6.

Air molecules move freely so may collide with the Surface of the wall, pushing ~~a~~ against it to create pressure.

Pressure is reduced higher up as there are less ~~a~~ air molecules above you meaning there are less to create a pressure.

Question 7 (a)

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 m^2 covered by PV panels. Every square metre of the solar panels receives about 1000 W 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 MW = 1 000 000 W).

Average electrical power = ... MW **[3]**

All candidates responded well to this question with two-thirds of responses gaining all three marks. Conversion to MW was completed by all candidates, but a few did have difficulty calculating the percentage efficiency. Some ignored the effect of efficiency totally or else multiplying (or dividing) by 0.85 instead of 0.15.

Question 7 (b)

(b)* Many people are not in favour of solar farms.

Jane
Solar farms are ugly and take up such a lot of space. Their output power is very small. A gas-burning power station can provide 1000 MW all day and night, the whole year long, and in any weather.

I'm told that extracting and purifying the material for the PV panels is very polluting, so it's not as green as people say.

Discuss what Jane has said about solar farms and gas-burning power stations.

.... **[6]**

Most candidates demonstrated Level 2 performance in their responses to this question, often at the top of the band.

Exemplar 18

This Level 1 response largely restricts itself to paraphrasing Jane's speech bubble and was credited with two marks.

L1

Discuss what Jane has said about solar farms and gas-burning power stations.

Solar Farms are very big and do take up space which could block the view for people living in that area. Solar farms get their energy from the sun so if theres no sun, theres no energy. However Gas burning power stations, although they can provide a lot of power whenever, burning those gases causes the air to be polluted.

Exemplar 19

This Level 2 response was credited with four marks and gives a more balanced comparison of the two types of power stations.

Jane is correct in that ~~a~~ gas-burning power stations are much more reliable than solar farms. Solar farms are only effective when there is sunshine which does not always occur. Gas-burning stations are able to provide more power because they do not depend on a natural resource that is inconsistent in its occurance. However ~~gas but~~ a disadvantage of gas-burning stations is that the natural gas from fossil fuels, ~~are~~ is non-renewable. Therefore, one day it will run out as there is a finite amount and we will have to be able to use renewable sources such as solar panels efficiently before that happens. [6]

L2

Exemplar 20

This Level 3 answer was credited with all six marks. The candidate has written a full and coherent evaluation of the merits and disadvantages of the two systems.

L3

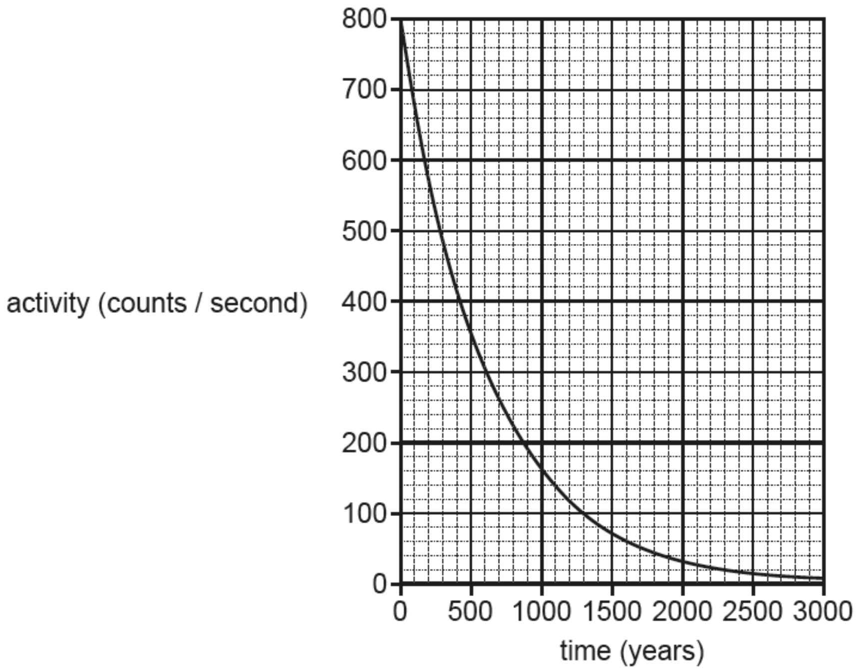
Discuss what Jane has said about solar farms and gas-burning power stations.

Jane is incorrect because although power stations can produce more power, solar farms can still produce enough power, especially if more were installed. In addition, gas-burning power stations are extremely polluting, as they emit dangerous levels of greenhouse gases. By comparison, any pollution from solar panels would be insignificant. Furthermore, power stations are just as unsightly as solar farms, if not more, and also take up a lot of space. While there are drawbacks to using solar farms, they are more sustainable and therefore more reliable in the long run, which makes them better to use than gas-burning power stations. **[6]**

Question 8 (a)

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]**

The majority of candidates successfully calculated the correct half-life of ^{241}Am., someone in ten candidates did not show any working on the graph, or quote any data taken from the graph and so could not be credited with both marks.

AfL It is important to answer the question that has been asked. Underlining key terms such as use the graph and show your working on the graph can help candidates to check that they are answering the question asked.

Key:

AfL Guidance to offer for future teaching and learning practice.

Question 8 (b)

(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.

....

....

....

....

....

.... **[4]**

Many candidates gained a couple of marks for stating that alpha radiation is ionising, and that it can damage cells. Some also stated that after 10 years the radioactive material is still emitting alpha particles. There were a number of familiar and persistent misconceptions such as radiation/the alpha particles could escape from the smoke detector and contaminate the environment. Better candidates did recognise that a smoke detector crushed in landfill could release radioactive material which could then enter the food chain.

Question 8 (c) (i)

(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]**

Question 8 (c) (ii)

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

.... **[1]**

This was a very challenging question for the majority of candidates. Many candidates used technical terms such as 'isotope' 'half-life' and 'amount of radiation' in their responses to parts (i) or (ii) but in an arbitrary way that showed poor understanding.

Exemplar 21

This straightforward response to Q8(c)(ii) was one of the few which showed a good understanding of the dice rolling simulation.

The number of alpha particles emitted. **[1]**

Question 8 (c) (iii)

(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.

....

....

....

.... **[3]**

Many candidates were able to analyse the table and identified that the 'number of remaining nuclei' roughly halved from 100 to 48 in this time, or that the 'activity' dropped from 18 to 9 in about 4 throws (actually 3). Some gained credit for identifying the random nature of rolling dice to explain why the figures were not exact. Interestingly, a number of candidates were able to express very clearly their feeling that the dice model was only a game and not real physics such as measuring radioactive decay using a radioactive source.

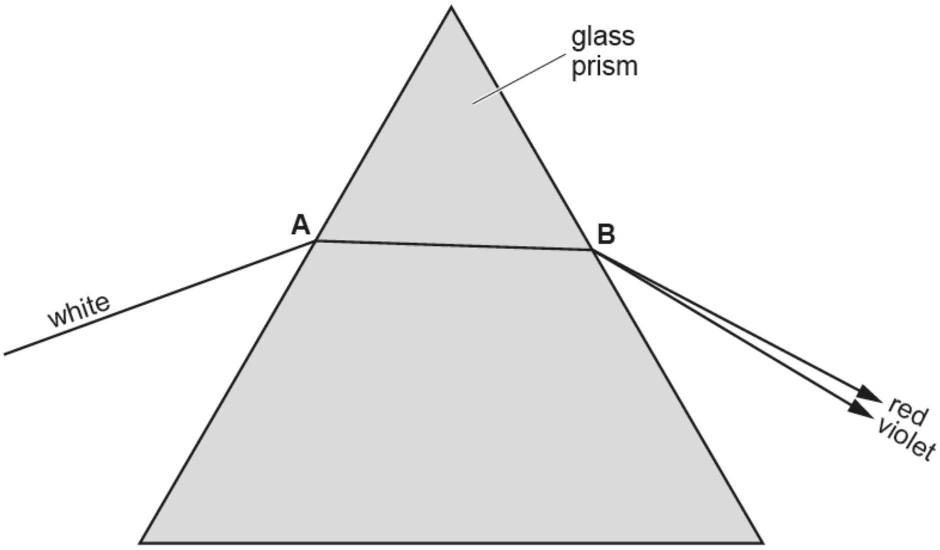
Question 9 (a)

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.

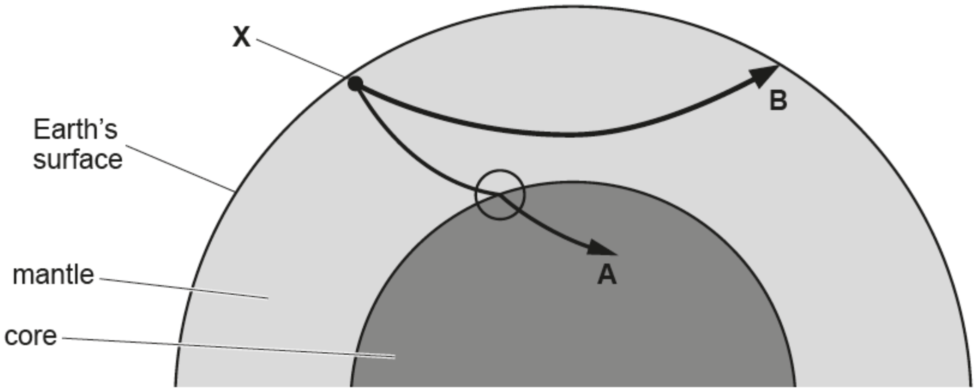
Red light and violet light both slow down when going from air into glass.	☐
Red light travels slower than violet light in air.	☐
Violet light travels faster than red light in glass.	☐
When they go from glass into air, both red light and violet light decrease in wavelength.	☐
When they go from glass into air, violet light speeds up more than red light.	☐

[2]

Question 9 (b) (i)

(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.

....

....

....

.... **[2]**

Question 9 (b) (ii)

(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.

....

....

....

.... **[2]**

This question was an example where many candidates did not see the linking 'story' in the question and treated each item as a standalone question. Part (a) was well done, but fewer candidates gained any credit for part (b). Only a handful of candidates were credited with all six marks for Q9.

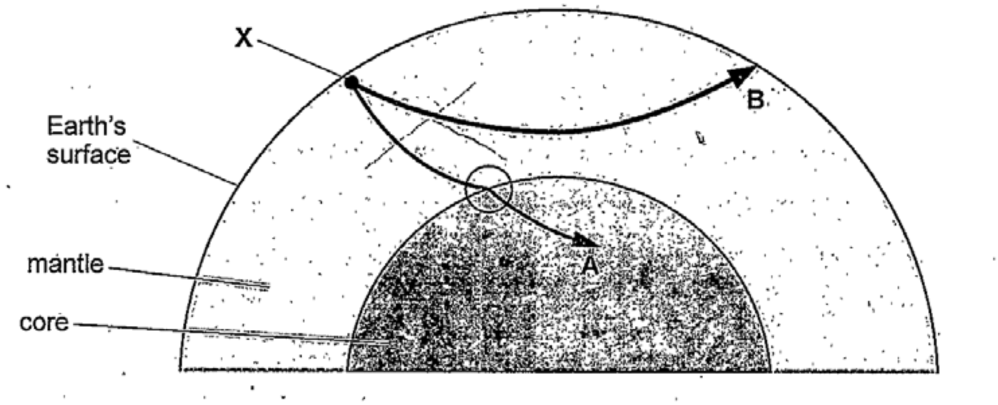
Exemplar 22

In this exemplar the candidate has clearly understood that the diagrams in parts (a) and (b) are meant to be compared. The candidate explains in a clear and precise way that the seismic wave is refracted as it goes from mantle to core in (b), just like the light in (a), and so it must be slowing down. They note that wave in the mantle is refracting in the opposite direction, and so this must indicate that the wave speed is greater the deeper you go into the mantle. This candidate is able to express themselves using appropriate scientific language such as 'normal' and the 'speed must be changing continuously'.

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]



(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.

As the wave bends towards the normal as it enters the core, this shows that the wave is slowing down / the speed of the wave ~~has~~ has decreased. **[2]**

The changing direction of the wave shows that its speed must be changing continuously too. The curve shows that as the wave travels deeper, it must increase in speed as it bends away from the normal(s) and then back up to the surface. [2]

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