Qualification Accredited

Oxford Cambridge and RSA

GCSE (9–1)

Examiners' report

TWENTY FIRST CENTURY SCIENCE PHYSICS B

J259

For first teaching in 2016

J259/02 Summer 2023 series

Version 1

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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. A selection of candidate answers is also provided. 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 and the mark scheme can be downloaded from OCR.

Paper 2 series overview

J259/02 is the Foundation tier of one of the two examination components for the GCSE (9-1) Physics B specification (Twenty First Century Science). Candidates will have already sat the examination for the Breadth in Physics component, and this is the examination for the Depth in Physics component. Question 12 and Question 13 are also on the Higher tier paper. The same mark scheme is used for these questions for Foundation and Higher tier. These are the most challenging questions on this paper.

This component assesses content from across the whole specification. It allows candidates to demonstrate their depth of understanding of specific aspects of the content. To do well on this component, candidates need to be able to apply their knowledge and understanding to new contexts and to be able to analyse the information and ideas presented by the questions. In calculations, they should write down the equation they are going to use and show their working.

Candidates who did well on this paper generally:	**Candidates who did less well on this paper generally:**
• recalled information they had learned • understood the concepts the questions addressed • performed simple calculations, substituting into equations and calculating the response correctly • interpreted the information given in text, diagrams, and graphs correctly • were able to apply what they had learned to the context of the question.	• could recall some of the information required • were able to substitute values into equations, but were sometimes still unsure whether to divide or multiply • did not understand what they had learned and so could not apply it to the contexts in the questions • were unable to correctly interpret all information given in the questions, especially in the diagrams.

Question 1

1 Draw lines to connect each part of the electromagnetic spectrum to its use.

Electromagnetic spectrum	**Use**
Microwave	Sun beds
Ultraviolet	Cooking food
X-rays	Sterilising surgical instruments
Gamma rays	Looking for broken bones

[3]

Candidates had a good knowledge of the uses of each part of the spectrum, with almost all achieving at least 2 marks and most achieving 3 marks. The usual error was to confuse the use of gamma rays with the use of ultraviolet rays.

Question 2 (a)

2 Sam is making measurements to calculate the density of a rubber bung.

(a) Which piece of apparatus does Sam use to measure the mass of the bung?

Tick (✓) **one** box.

Metre rule ☐

Thermometer ☐

Stopwatch ☐

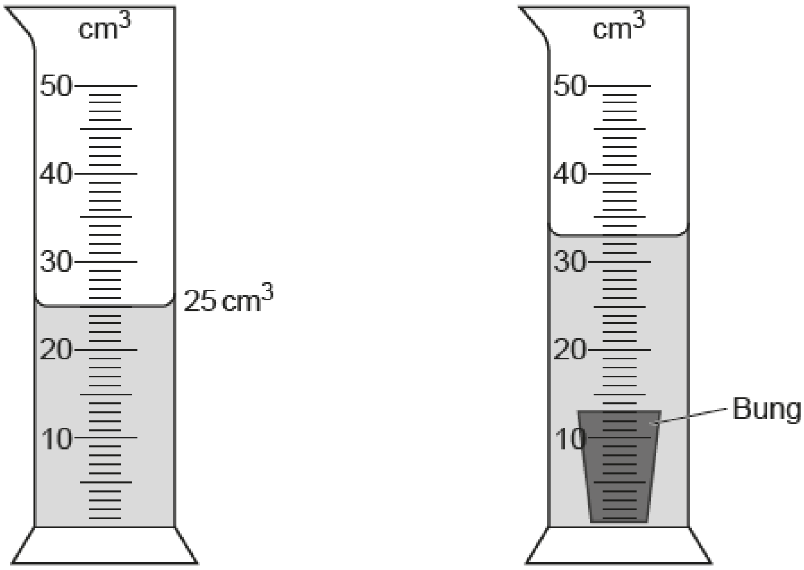
Balance ☐

[1]

Most candidates knew this, but some candidates selected metre rule.

Question 2 (b)

(b) Sam puts 25 cm^3 of water in a measuring cylinder. When the bung is placed into the measuring cylinder, the level of the water rises as shown.



Calculate the volume of the bung.

Volume = ... cm^3 **[2]**

This question was correctly answered by many candidates, but there were a number of common errors: misreading the scale as 32 or 35; leaving the response as 33; and giving the height of the bung (13.

Question 2 (c)

(c) Sam has a second bung which has a mass of 24 g and a volume of 12 cm^3.

Calculate the density of the second bung.

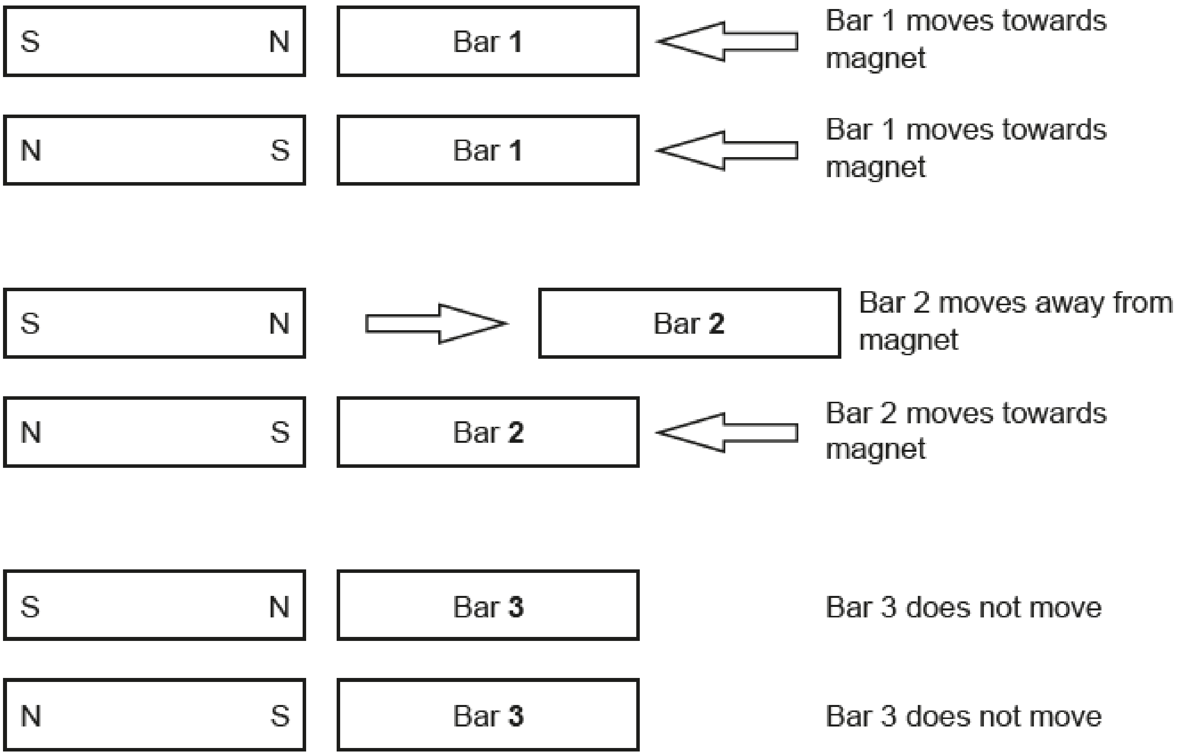
Use the equation: density = $\frac{\text{mass}}{\text{volume}}$

Density = ... g/cm^3 **[2]**

Almost all candidates achieved full marks for this question. Some lower performing candidates substituted correctly and then calculated volume divided by mass. Some higher performing candidates used 12^3 as the volume.

Question 3

3 Anika has a magnet and three bars made of unknown metals. She places the same end of each bar next to each pole of the magnet as shown.



Complete the table by identifying if bars **1**, **2** and **3** are magnets or not magnets.

Tick (✓) **one** box in each row.

Bar	A magnet	Not a magnet
1		
2		
3		

[2]

The majority of candidates deduced that Bar 2 was a magnet and that Bar 3 was not, but thought that Bar 1 was a magnet.

Question 4 (a)

4 A group of scientists investigate four different materials **A**, **B**, **C** and **D**. They measure the density of each material. They also measure the electrical resistance using pieces of a similar size.

The table gives the results.

Material	Density (g/cm^3)	Resistance (Ω)
A	3.0	0.070
B	2.7	0.003
C	2.5	0.023
D	6.7	0.007

(a) State which material **A**, **B**, **C** or **D**, could be used to make the lightest bicycle frame.

Material = ... **[1]**

The majority of candidates correctly selected C

Question 4 (b)

(b) Suggest **one** reason why material **B** is chosen to make an electrical circuit in a mobile phone.

....

.... **[1]**

The majority of candidates said that it had a low or the lowest resistance. Some also made a comment about the low density.

Question 4 (c)

(c) Scientists are developing new materials containing the substance graphene.

Why should scientists communicate new scientific data to a range of audiences?

Tick (✓) **one** box.

They can build a reputation and show everybody how clever they are. ☐

They can sell their work and make money. ☐

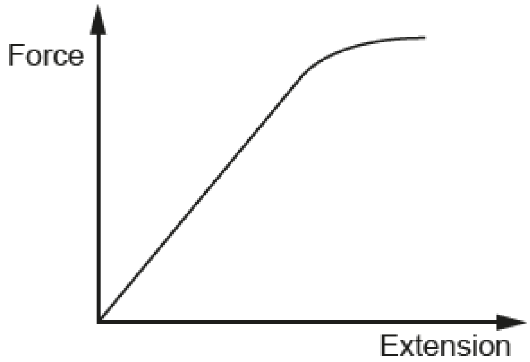
The data can be shared, used and discussed. ☐

[1]

Almost all candidates answered this correctly

Question 4 (d)

(d) The graph shows the force-extension sketch graph for graphene.



Describe the relationship between force and extension for graphene.

....

....

....

....

....

.... **[3]**

Most candidates identified that as force increases extension increases (or that as extension increases force increases) and the more successful candidates identified the relationship as proportional. In the descriptions of the curved part of the graph, some responses confused extension and force, for example stating that the extension stopped increasing.

Exemplar 1

The graph shows that the force and extension ~~are~~ graphene ~~are~~ are directly proportional until the point of elasticity ~~[illegible]~~ when the extension has gone beyond the point where it ~~[illegible]~~ can revert back to its normal shape. we see can see this as the graph shows a straight line equally increasing at the same rate for both sides until it reaches a certain point where it can no longer change back ~~which is the point~~ **[3]**

In this response the candidate has described the proportional relationship between force and extension for 2 marks and then goes on to say that this is only up to a certain point, after which plastic deformation occurs; 'it can no longer revert to its 'normal' shape'. This achieves the third mark.

Question 4 (e)

(e) When graphene is stretched, it can deform elastically or plastically depending on the size of the force.

Describe the difference between elastic and plastic deformation of graphene.

....

....

....

.... **[2]**

Candidates who knew the definitions of plastic and elastic deformation had no problems with this question. The majority of candidates did not know the scientific meaning and wrote descriptions based on their personal experience of elastic bands and hard pieces of plastic.

Question 5*

5* In an emergency the total distance required for a car to come to a stop depends on the thinking distance and the braking distance.

The data in the table shows the thinking distance and braking distance for a car travelling at different speeds.

Speed (miles per hour)	Thinking distance (m)	Braking distance (m)	Stopping distance (m)
20	6	6	12
30	9	14	23
40	12	24	36
50	15	38	53
60	18	56	74
70	21	75	96

Describe the trends in the thinking distance and braking distance when the speed increases, **and** describe other factors that affect the thinking distance and the braking distance.

....

....

....

....

....

.... **[6]**

Strong responses generally gave some details of the trends shown by the data, such as 'the thinking and braking distance increase with speed' and 'the braking distance is greater'. A few candidates explained that the thinking distance increased because at a faster speed you travelled further. Some gave very detailed descriptions of factors that affect the stopping distance, in which mobile phones and distractions featured highly, but all the major factors were often seen. In general, candidates had a good knowledge of these, and many could describe the factors and explain why they increase stopping distance. Few illustrated their response with data from the table, which limited their response to Level 2.

Exemplar 2

well with the Brakinng distance the car is travelling at a faster speed and it will take longer to ~~sl~~ slow the car down so at 20mph when you have already reacted it need 6meters to stop and at 70mph 75meters to stop however if you have some used brakepads or on a wet or ~~fog~~ icy road it may take a longer distance. But to help this make sure to have good tread on your tires and make sure to change your break pads every so often. And for thinking distance it may take you the same amount of time but Because you are going faster you will travel further. so at 20 mph The Thinking distance is 6 meters but that same amount of time **[6]** at 70mph is 20 meters. But if you are tired your reaction time could Be slower and if you ~~are~~ have had any caffine you could Have a faster reaction time. ~~[illegible]~~ yes that would be a good thing But you don't want to drink an energy drink just before you drive But also don't drive when you are tired.

This response starts with a clear explanation of why braking distance increases and illustrates the increase with an example from the table. The candidate then continues with other factors that affect braking distance. This is followed by the same structure for thinking distance. The response was given Level 3, 6 marks.

Misconception

Some candidates simply confuse braking and thinking distance.

Some candidates think that thinking distance increases with speed, as it takes longer to think/react at higher speeds. They do not seem to understand that the time is the same, but (at higher speeds) the distance travelled in that time is further (distance = speed × time).

Thinking distance is the distance travelled before the driver has pressed the brake and thinking distance is proportional to speed, as the typical thinking distances given in the Highway Code correspond to the distance travelled in a reasonable reaction time.

Question 6 (a) (i)

6 Radon-222 is radioactive. Radon-222 decays to polonium-218 as shown by the decay equation.

$$^{222}_{86}\text{Rn} \longrightarrow \, ^{218}_{84}\text{Po} + \mathbf{X}$$

(a) **(i)** What is particle **X**?

Put a ring around the correct option.

$^{0}_{-1}\text{e}$ $\quad$ $^{4}_{2}\text{He}$ $\quad$ $^{1}_{0}\text{n}$

[1]

The majority of candidates correctly ringed the alpha particle (helium nucleus).

Question 6 (a) (ii)

(ii) Complete the sentences about the decay equation.

Put a ring around the correct options.

1. When a nucleus of radon-222 decays the mass number reduces by **4 / 2 / 0**
2. When a nucleus of radon-222 decays the atomic number reduces by **4 / 2 / 0**

[2]

About half of the candidates thought the mass number reduced by 4 and the atomic number by 2; many thought it was 2, 4.

Question 6 (b)

(b) Half-life is used to measure the length of time of decay.

Define the term half-life.

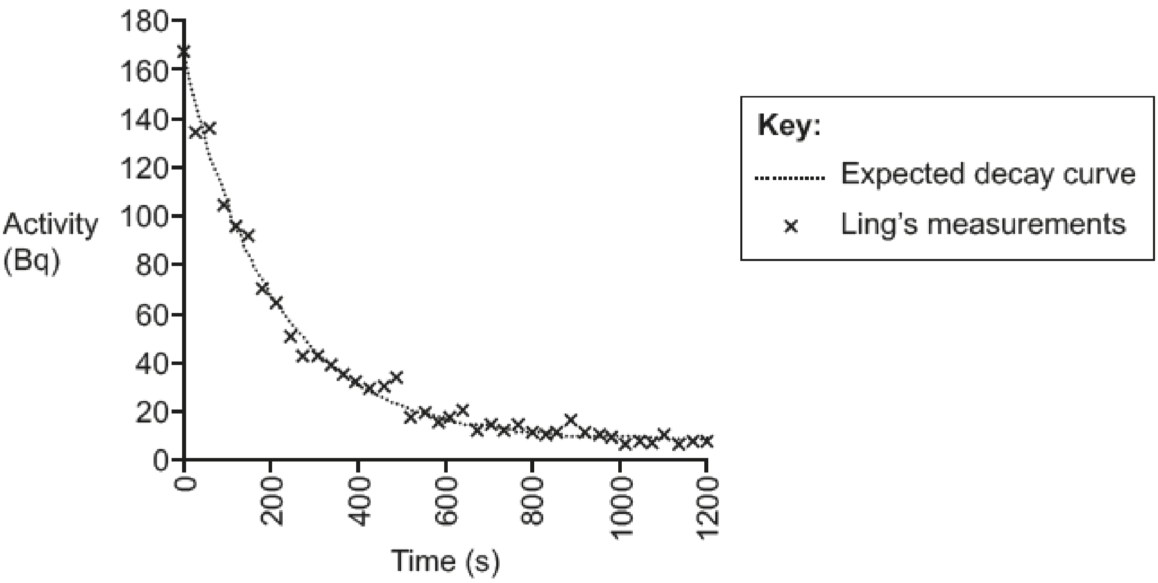
....

.... **[1]**

The majority of candidates did not know the definition.

Question 6 (c) (i)

(c) Ling takes measurements of the decay of a piece of radioactive radium. The results are shown in the graph.



(i) Ling says that some of the measurements do not lie exactly on the expected decay curve because of experimental errors.

Give **one** other reason why some readings do **not** lie on the expected decay curve.

....

.... **[1]**

Very few candidates made the connection between the data on the graph and the random nature of radioactive decay. Most candidates were thinking of inaccurate readings, outliers, and the variability of experimental results, despite the statement about experimental errors in the question.

Misconception

It is correct that an outlier is a value that does not lie on the curve, but this is not the reason why it is not on the curve. There will be a reason why it is an outlier.

Question 6 (c) (ii)

(ii) Suggest **two** precautions Ling should take while doing experiments with radioactive materials.

1. ....

....

2. ....

....

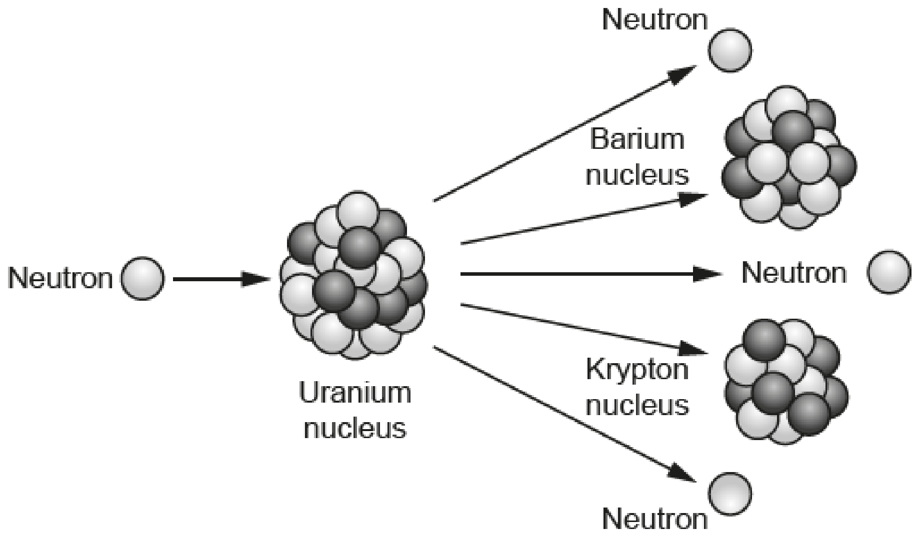
[2]

Examiners saw some very good responses from candidates, covering all of the marking points given on the mark scheme. There was a good understanding of radioactive contamination and irradiation, and the majority of candidates achieved at least one mark here. A common suggestion was that Ling should wear goggles, but this was only accepted if it was made clear that these were to stop radiation or radioactive material entering the eye. It was clear that some candidates did not understand the dangers of radioactive materials and were giving examples of protective equipment and safety precautions suitable for handling chemicals or for experimental work in general. For example, a few suggested lab coats and tying hair back.

Question 7 (a)

7 In a fission reaction a uranium nucleus absorbs a neutron.

The diagram shows a model of this fission reaction.



(a) State **two** ways that energy is released during this fission reaction.

1. ....

2. ....

[2]

Most candidates did not apply their knowledge of nuclear fission to suggest gamma rays or radiation. Many candidates selected one or more of the products shown in the diagram as their response, but did not say enough to indicate that these particles had gained kinetic energy, or thermal energy, or were moving faster.

Question 7 (b)

(b) Neutrons are emitted during a fission reaction. These neutrons may collide with other uranium nuclei.

Explain how this can lead to a chain reaction.

....

....

....

.... **[2]**

A lot of the less successful candidates did not understand this at all. A lot of the higher achieving candidates struggled to explain it, and often did not give the essential points that more neutrons were being emitted resulting in more collisions between nuclei and neutrons. Some candidates wrote a response suggesting the same neutron was colliding with one nucleus and then another and so on, or that the krypton and barium nuclei then collided.

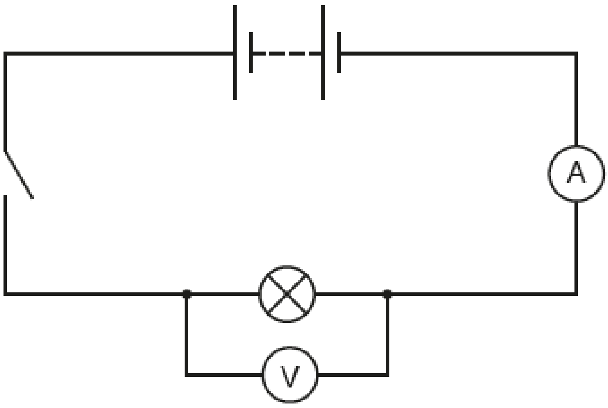
Assessment for learning

A ball game played with students may help here. Each student (uranium nucleus) has three balls (neutrons) which they can only throw to other students if they first catch one that is thrown to them. After they have thrown their three balls they have no more to throw even if they catch one. Discuss both similarities and differences (the candidate has not split into two parts – a barium and a krypton nucleus.)

Question 8 (a) (i)

8 Taylor builds an electrical circuit as shown in **Fig. 8.1**.

Fig. 8.1



(a) Taylor closes the switch. The ammeter records a current.

(i) Give **two** reasons why there is a current.

1. ....

....

2. ....

.... **[2]**

Closed and open switches continue to confuse some candidates. Less successful candidates tried to explain why current was still passing even though the switch had been closed. Many candidates recognised that the battery or cell was required, but often focused on the power or energy required rather than the voltage or potential difference. Some less successful candidates thought the ammeter and/or the voltmeter supplied the current to the circuit.

Assessment for learning

Understanding that a closed switch is 'on' is linked to the idea that a complete circuit is required, because closing the gap in the loop or circuit allows the current to pass all the way round. Examples of racing circuits for vehicles, people or animals, can be used to illustrate this and demonstrating a model or toy track, for example a circular railway track, may help candidates to remember it.

To focus minds on voltage rather than energy, connect two of the same batteries in a circuit, one on each side of a lamp with their potential difference in opposite directions. With twice as much energy from two batteries, that fact that the lamp won't light or is very dim shows that energy or power is not enough – something more is required, reversing one of the batteries, shows that a (net) potential difference is what is needed.

Question 8 (a) (ii)

(ii) Taylor records a current of 2 A flowing for a time of 120 s.

Calculate the charge that passes through the lamp in this time.

Use the equation: charge = current × time

Charge = ... C **[2]**

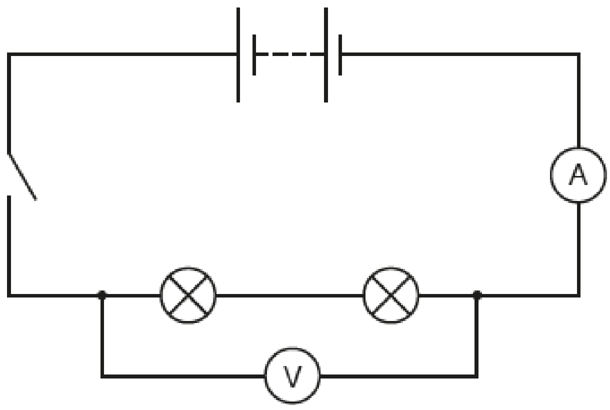
Almost all candidates achieved full marks for this calculation.

Question 8 (b) (i) and (ii)

(b) Taylor adds a second, identical lamp to the circuit as shown in **Fig. 8.2**. He does not change the cells.

The two lamps in **Fig. 8.2** are dimmer compared to the single lamp in **Fig. 8.1**.

Fig. 8.2



(i) How do the readings on the ammeter and voltmeter change when the second lamp is added?

Put a ring around the correct options.

The reading on the ammeter **increases / decreases / stays the same**.

The reading on the voltmeter **increases / decreases / stays the same**.

[2]

(ii) Explain why the lamps are dimmer in **Fig. 8.2** compared to the single lamp in **Fig. 8.1**.

....

....

....

....

....

.... **[3]**

Many candidates achieved no marks for part (b) (i) or part (b) (ii).

The common response for (b) (i) was that the reading on the ammeter stays the same and the reading on the voltmeter decreases.

For part (b) (ii) the overwhelming majority of candidates said that the current was shared. Examiners did not see any candidate mention the resistance of the lamps.

Misconception

The role of resistance in an electrical circuit is not taken into account, as candidates consider the battery as a source of energy or power and assume that batteries supply a constant amount of power (or energy in a certain time) to the circuit. They need to understand that current is a flow of charge and this flow is impeded by resistance in the circuit, so changing the resistance in the circuit will change the current (the flow of charge).

Assessment for learning

Candidates may have done some circuit works with lamps at KS3, so starting with resistors at KS4, before going back to revise lamps, has many advantages. They are more reliable and don't change in resistance when the voltage or current changes. Resistance – which is so important when studying current electricity – is emphasised by this approach. There are also many analogies which are useful here. For example, candidates may have experienced the slowing of traffic that occurs as a road changes from dual to single carriageway. A demonstration of a water tank emptying with a wide or narrow pipe will show that the same head of water does not result in the same flow of water if the pipe is narrower.. The ASE's Teaching Secondary Physics recommends demonstrations of models combined with hands on circuit experience as important in developing understanding and challenging misconceptions. Use of the rope loop model (from IOP Spark), or demonstration of a water, or other, analogy and of the circuit, pointing out the similarities may help make this clear.

Question 8 (c) (i)

(c) Taylor investigates how the brightness of lamps change when they are connected in parallel.

(i) Draw a circuit diagram of two lamps in parallel that Taylor can use in his investigation.

[1]

Higher performing candidates drew acceptable circuits here. Many candidates drew series circuits. Some candidates added short circuits to their diagram.

Question 8 (c) (ii)

(ii) What happens to the brightness of each lamp when a third lamp is added in parallel?

Put a ring around the correct option.

The brightness of each lamp **increases / decreases / stays the same**.

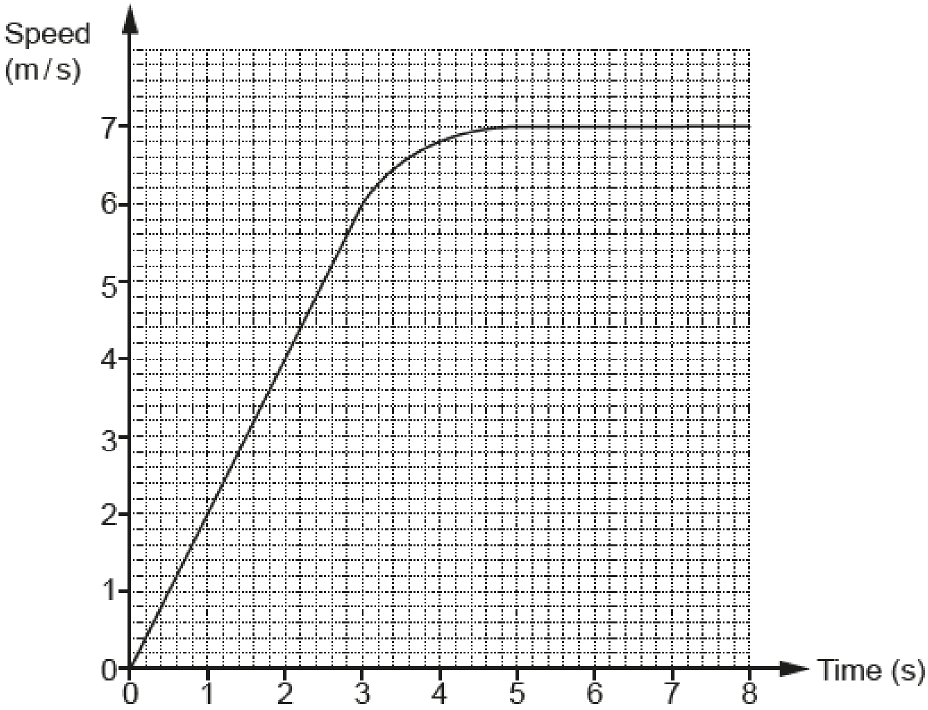
[1]

The majority of candidates thought the brightness would decrease.

Question 9 (a), (b) and (c)

9 Charlie is competing in a cycling race.

The speed–time graph shows Charlie's speed during the race.



(a) State Charlie's maximum speed.

Maximum speed = ... m/s **[1]**

(b) State the time into the race that Charlie reaches a speed of 2 m/s.

Time = ... s **[1]**

(c) Calculate Charlie's acceleration in the first 3 s.

Acceleration = ... m/s^2 **[2]**

Almost all candidates achieved the marks for parts (a) and (b). For part (c) the majority gained 2 marks, but less successful candidates were unable to calculate acceleration and examiners saw a variety of responses. 6 and 1.5 were often seen.

Question 9 (d)

(d) In another race, Charlie starts with a greater acceleration and reaches the same maximum speed.

Sketch a line on the speed–time graph to show how Charlie's speed changes for this race. **[2]**

Many candidates drew a line that started with a steeper gradient and finished at a maximum speed of 7 m/s. There were some who continued the steeper gradient to a higher maximum speed. A few of the least successful candidates drew lines that were not as steep and finished at a lower maximum speed.

Question 10 (a) and (b)

10 The New Car Assessment Program (NCAP) tests how cars perform in crashes.

(a) NCAP tests a car travelling at 25 m/s in a head-on crash. The car comes to a stop in 0.1 s.

Calculate the deceleration of the car.

Use the equation: acceleration = $\frac{\text{change in speed}}{\text{time}}$

Deceleration = ... m/s^2 **[2]**

(b) In another head-on crash test, a car with a mass of 1000 kg decelerates at 150 m/s^2.

Calculate the force needed to produce this deceleration.

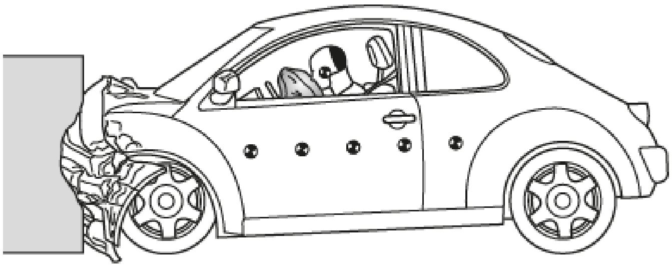
Use the equation: force = mass × acceleration

Force = ...N **[2]**

Most candidates did the calculations correctly. In (a) a few candidates multiplied the two values. In (b) a few candidates confused the powers of 10.

Question 10 (c)

(c) The picture shows what happens to the crumple zone of a car in a controlled head-on crash.



Explain how the crumple zone of a car improves safety for the driver in a head-on crash.

Use ideas about acceleration and force in your answer.

....

....

....

....

....

.... **[3]**

The majority of candidates talked about the crumple zone absorbing the force or acting as a barrier. A few compared it to an airbag, or thought it was the airbag shown in the diagram. There were a few candidates who clearly understood how it worked, but they generally gave responses that gained two marks, not three. They either said the time increased reducing the deceleration or that the deceleration reduced reducing the force.

Misconception

?

Very few candidates understood that the crumple zone reduces the deceleration. They thought that the increased distance between the front of the car and the driver allowed deceleration to occur before the driver reached the point where damage was occurring, or in other words the crumple zone distanced the driver from danger.

Exemplar 3

because it would take longer for the force to act really hit the driver meaning there is a decrease of force

This candidate has understood that the crumple zone works by increasing the time over which the crash occurs. They have explained that this reduces the force on the driver, and the response was given 2 marks. For the third mark we needed to see that the deceleration was reduced.

Question 11 (a)

11 Li does an experiment to find the specific heat capacity of aluminium.

(a) Define the term specific heat capacity.

....

.... **[1]**

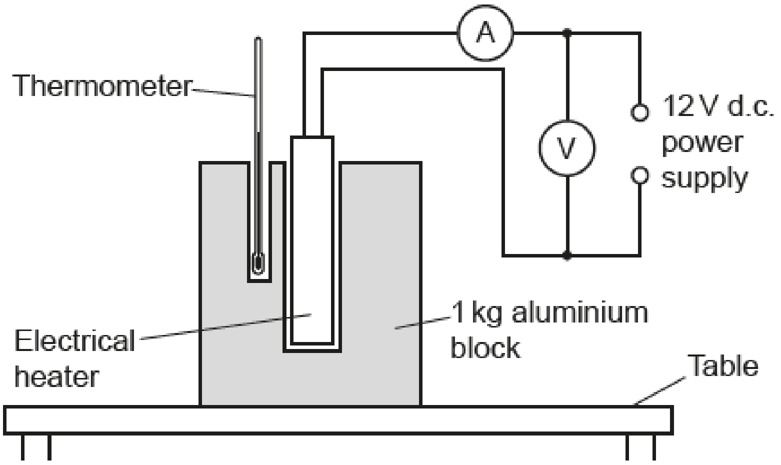
Candidates did not know this definition. They did not omit the question, but attempted to define it from what they knew. Those candidates who worked from the equation given on the data sheet were often successful. Examiners recognised that any candidates using the form of the equation given in part (d) may have been misled by the use of 'temperature' instead of 'temperature change,' so the mark was also given to candidates who defined specific heat capacity in terms of temperature instead of temperature change.

Assessment for learning

When asked for a definition, if there is an equation on the data sheet or the paper, candidates can use this to help write it, or check that they have written it correctly.

Question 11 (b) (i)

(b) Li uses this equipment:



This is the method:

- Connect an ammeter and a voltmeter in a circuit with a 12 V power supply and an electrical heater.
- Place the heater into a hole in the aluminium block.
- Place a thermometer into the other hole and record the temperature.
- Switch on the power supply.
- After 5 minutes take a reading from the thermometer, the ammeter, and the voltmeter.

(i) Describe **one** energy transfer taking place during this experiment.

....

.... **[1]**

Candidates usually stated an energy store, or a type of transfer. The question asks for a description so this was not enough to for the mark. An example which was given the mark was 'thermal – heat leaving the heater into aluminium block' This transfer was described more often than any other.

Question 11 (b) (ii)

(ii) Describe how the motion of the aluminium particles changes as the block is heated.

....

.... **[1]**

Candidates who were successful on the whole paper did well here. They understood that the particles vibrated more or said that their motion increased. A lot of the candidates said that the particles started to vibrate or that they moved around more or collided more often. It is not quite clear whether they thought that particles in a solid don't vibrate or that they only vibrate above a certain temperature. It was clear that some candidates thought that the block was melting: a lot stated 'as it melts' and this comment was also seen in responses to 11 (c). A lot of candidates with a low performance wrote responses that did not relate to particles but to the block as a whole.

Question 11 (c) (i)

(c) **(i)** Explain improvements that can be made to the **equipment**.

....

....

....

....

....

.... **[4]**

The most common acceptable response here was to say that the block should be placed on a heat proof mat or other insulator. This was usually to protect the table. Many candidates stated that a table was an unsuitable surface on which to be doing such an experiment. A few candidates said the block should be insulated to reduce heat loss. Candidates often said that a stop-clock or stopwatch was needed to measure the time.

Common responses that were not worthy of credit were, use a digital thermometer, a more powerful heater, a bigger block, add a voltmeter and ammeter and other similar changes.

Question 11 (c) (ii)

(ii) Suggest **one** improvement to the **method**.

....

.... **[1]**

Common acceptable responses included increase the time from five minutes, take more readings, measure the temperature every minute. Candidates suggested repeating the experiment to exclude outliers or to calculate a mean. Three common responses not worthy of credit were repeat the experiment (a) with no further detail, (b) to make it reliable, (c) to make it a fair test.

Question 11 (d)

(d) Li records the results from the experiment in a table:

Current (A)	4.62
Final Temperature (°C)	32
Initial Temperature (°C)	18
Mass of aluminium block (kg)	1
Potential difference (V)	10.80
Time (s)	300

Calculate the specific heat capacity of aluminium using Li's results.

Use the equations:

- specific heat capacity = $\frac{\text{change in internal energy}}{\text{mass} \times \text{temperature}}$
- power = potential difference × current
- energy transferred = power × time

Specific heat capacity = ... J / kg °C
[5]

This calculation was a challenge, and lower achieving candidates often omitted the question. Some wrote numbers or calculations that made little sense, but some achieved 1 mark for substituting for power. Among the more successful responses, many achieved 3 marks for calculating the correct value for the change in internal energy. Often candidates did not realise that the energy transferred was equal to the change in internal energy. Examiners recognised that candidates may have been misled by the wording of the equation for specific heat capacity, and marks were given for the use of temperatures of 32 °C and 18 °C instead of the temperature difference of 14 °C, and responses of 467.775 (J / kg °C) or 831.6 (J / kg °C) in addition to the correct response of 1069.2 (J / kg °C.) All of these responses were acceptable to two or more significant figures.

Question 12 (a)

12 A student investigates the path of light passing through a triangular glass prism.

A narrow beam of white light is directed at the prism with an angle of incidence equal to 40°. The student observes a spectrum of different coloured light.

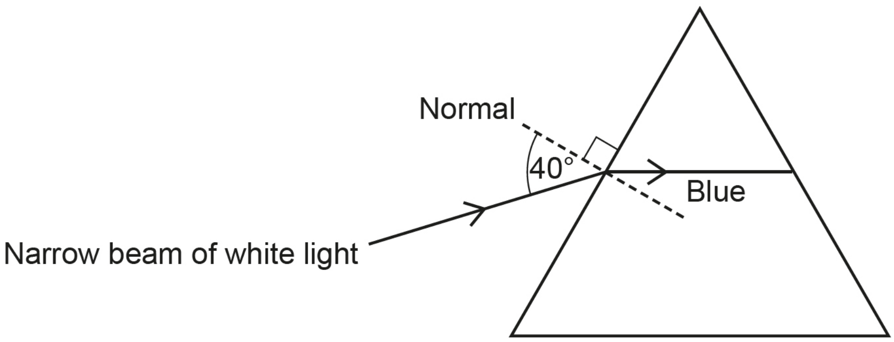
Narrow beam of white light

Item removed due to third party copyright restrictions

Spectrum of coloured light

The two-dimensional diagram shows a narrow beam of white light directed at the side of a prism.

A line showing the path of a ray of blue light passing through the prism is partially drawn.



(a) Complete the line to show the path of blue light as it passes out the other side. **[1]**

The more successful candidates drew the blue ray correctly.

Question 12 (b)

(b) Estimate the size of the angle of refraction of the ray of blue light as it enters the prism.

Angle of refraction = ...° **[1]**

Most candidates did not estimate a value within the acceptable range. Many thought that the response was 40°, but responses ranging from 0° to 360° were seen.

Question 12 (c)

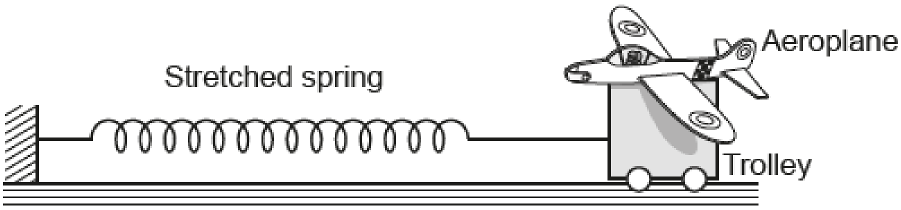
(c) Add another line to the diagram to show the path of a ray of red light as it passes through the prism and out the other side. **[2]**

Candidates found this difficult and most did not achieve any marks. Many drew another ray incident on the side of the prism. Those that used the beam of white light often drew a path that was the same as the blue light while inside the prism, or that was not refracted at all, or that was refracted away from the normal. As a result, rays leaving the prism were often in odd directions. Examiners gave credit to rays that were refracted less than the blue ray on leaving the prism, if this could be determined. For example, if the rays inside the prism were parallel it was possible to see whether the red ray was refracted less than the blue ray.

Question 13 (a)

13 Jamal is making a model aeroplane that can be launched from a moving trolley.

One end of a spring is connected to the trolley. The other end of the spring is held stationary.



The aeroplane is placed on the trolley. Jamal pulls the trolley and the aeroplane to the right so that the spring stretches. When Jamal lets go, the trolley and the aeroplane accelerate to the left.

(a) Explain how Jamal can make the trolley and aeroplane accelerate more quickly using the same apparatus.

....

....

....

....

....

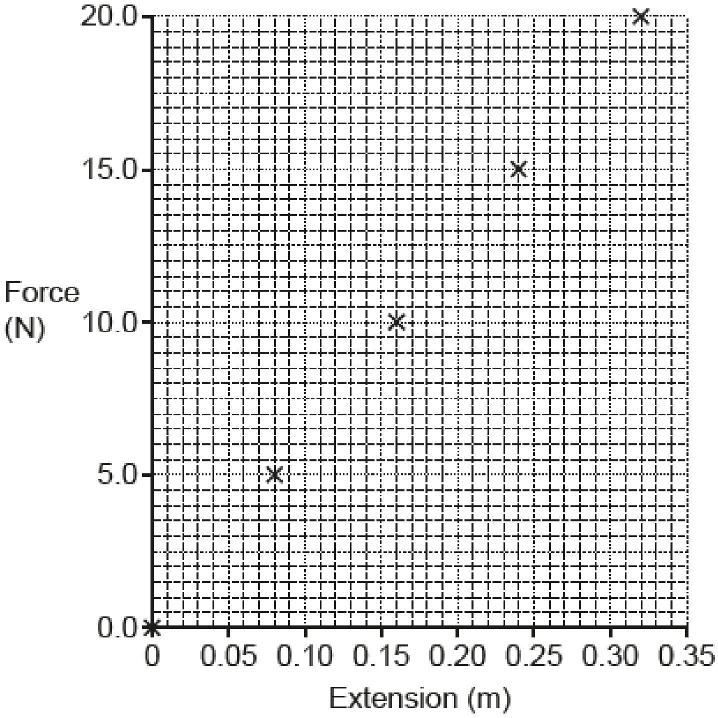
.... **[3]**

Many candidates correctly said that Jamal should pull the aeroplane back further, or stretch the spring 'as far as he could' and achieved the first mark. Other candidates interpreted the question to mean that Jamal pulled the aeroplane to its right, or to his right. They said that he should pull it straight back. These candidates could still go on to be given a mark for saying that this increased the force. No candidates linked this to acceleration by saying that force was proportional to acceleration or force equals mass times acceleration. The energy alternative for the first 2 marks was seen a few times.

Question 13 (b) (i)*

(b) Jamal investigates the relationship between force and extension for the spring. The results of the investigation are shown in the table and the graph.

Force (N)	Extension (m)
0.0	0
5.0	0.08
10.0	0.16
15.0	0.24
20.0	0.32



(i)* Describe how Jamal gets these results safely **and** how he uses the results to calculate the work done in stretching the spring.

....

....

....

....

....

.... **[6]**

It was rare to see responses that suggested removing the spring and clamping it vertically so that weights could be hung from it. Candidates did not make a connection between Jamal's investigation and any investigation they may have done. They focused on the word 'safely' and many suggested wearing goggles and other safety precautions. Credit was given for this, as long as they gave some indication of why goggles were needed. The majority of candidates quoted work done = force × distance, and some credit was given if they used this equation instead of $E = \frac{1}{2} F x$. It was very rare to see candidates refer to using $F = k x$, $E = \frac{1}{2} F x$ or $E = \frac{1}{2} k x^2$.

Assessment for learning

The examination always includes questions based on practical skills. Candidates may have had the opportunity to use all the required apparatus and techniques in the investigations suggested in the practical activity groups (PAG 1 – 8), but applying them to exam questions is a different skill. To improve their exam technique, it may help to look at some questions like this one, where a context links to one of the PAG investigations. For questions like this one, students could be asked to consider whether they have done a similar investigation and how it applies; without **completing** the question, this may better prepare them to spot links in the examination questions. Higher tier candidates are more likely to see these links, but Foundation tier candidates need some assistance with this exam technique.

Question 13 (b) (ii)

(ii) The kinetic energy of the trolley must be at least 1 J for the aeroplane to launch from the trolley.

Jamal concludes that the aeroplane can launch from the trolley when the spring has an extension of 0.16 m.

Use the graph to explain why Jamal's conclusion is **wrong**.

....

....

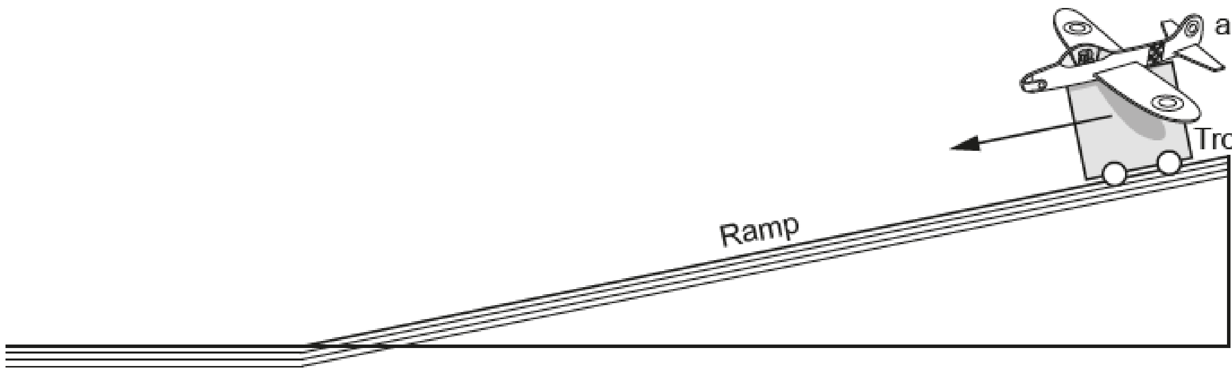
....

.... **[2]**

Many candidates used the extension of 0.16 m and deduced that the force was 10.0 N, but were unable to progress any further.

Question 13 (c)

(c) Jamal investigates using a ramp instead of a spring to launch the aeroplane.



Jamal releases the trolley and the trolley accelerates down the ramp. The aeroplane is launched when the trolley reaches the bottom of the ramp.

Describe how Jamal can accurately measure the speed of the trolley at the bottom of the ramp.

You should include the equipment Jamal uses.

....

....

....

....

....

.... **[3]**

Very few candidates suggested that Jamal should use a light gate for this. Although the calculation of speed is more difficult using the time and distance to travel the whole of the ramp, and we did not see candidates achieving the third mark, this method allowed many candidates to access the first two marks. In general, candidates did describe measuring the ramp and timing the trolley descending the ramp. The question asks for the equipment, so examiners were looking for both the measuring instrument and the quantity being measured. Many candidates did not achieve the marks because they did not say what they were measuring, or they did not say what equipment they were using. Some candidates said that they were measuring the speed with a stopwatch.

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