Pearson Edexcel

Examiners' Report
June 2022

GCE Physics 9PH0 03

ResultsPlus

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications come from Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk.

Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

ResultsPlus

Giving you insight to inform next steps

ResultsPlus is Pearson's free online service giving instant and detailed analysis of your students' exam results.

- See students' scores for every exam question.
- Understand how your students' performance compares with class and national averages.
- Identify potential topics, skills and types of question where students may need to develop their learning further.

For more information on ResultsPlus, or to log in, visit www.edexcel.com/resultsplus. Your exams officer will be able to set up your ResultsPlus account in minutes via Edexcel Online.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk.

June 2022

Publications Code 9PH0_03_2206_ER

Introduction

This paper comprises short, open-response, calculation and extended writing questions worth a total of 120 marks. The questions draw on a range of the topics in the specification and include synoptic questions drawing on two or more different topics. The paper also includes questions that assess conceptual and theoretical understanding of experimental methods (indirect practical skills), some of which draw on candidates' experiences of the core practicals. The paper gave candidates the opportunity to demonstrate their understanding of a wide range of topics from the specification, with all of the questions eliciting responses across the range of marks.

There was a mixed response to the two linkage questions in this paper. Q05 tended to generate better responses than Q09(a). In particular, the responses to Q05 were an improvement to responses seen for linkage questions in previous series. In this question candidates were able to demonstrate an improved ability to link ideas coherently to the context provided in the question.

There is still evidence that candidates are not paying sufficient attention to the command words used in the question. In a number of cases, questions requiring an explanation were answered with a description by a proportion of candidates. In general, calculation and 'show that' questions gave candidates an opportunity to demonstrate their problem solving skills to good effect. Some very good responses were seen for such questions, with well-crafted solutions which were accurate and clearly set out. In some calculation questions the final mark was not awarded due to a missing unit, although this was rare.

There were instances where candidates disadvantaged themselves by not using suitably precise language. This was particularly the case in some of the questions testing indirect practical skills, where candidates had knowledge of the method, but could not express it accurately and succinctly. Some candidates did not seem to understand the language and processes of quantifying uncertainties in practical work. In particular, candidates struggled to use the terms 'accuracy', 'error', 'precision', 'resolution' and 'uncertainty' correctly.

The space allowed for responses was usually sufficient. However, candidates need to remember that the space provided does not have to be filled. Candidates should be encouraged to consider the number of marks available for a question, and to use this to determine the length of response required. If candidates either need more space or want to replace an answer with a different one, they should indicate clearly where the response they wish to be marked by examiners can be found.

Question 1 (a)

Many candidates were aware that the data was presented to an inconsistent number of significant figures. An inconsistent number of decimal places was also accepted for MP1. However, few candidates seemed to appreciate the importance of recording all the raw data in the table, so MP2 was only occasionally awarded. Many candidates thought that the masses should be increased in equal intervals, although this is not important in this experiment. Many references to experimental technique were seen here, although the question is specific in asking for comments on the recording of the data.

(a) The position of the bottom of the mass holder was recorded. The spring was stretched by adding masses to the mass holder and the new positions were determined. The extension of the spring for each mass was calculated.

The results are shown in the table.

Mass / kg	Extension / m
0.05	0.019
0.10	0.042
0.15	0.058
0.20	0.085
0.25	0.1
0.35	0.14

Criticise the recording of these results.

(2)

a reading for mass of 0.30kg has been forgotten, plus the extension measurement for mass 0.25kg ~~and~~ is not to 2 significant figures like the other measurements.

ResultsPlus
Examiner Comments

This response gains MP1 but makes no mention of the need to include raw data in the data table.

Criticise the recording of these results.

(2)

extension is

They ~~start~~ given to different number of decimal places. Should have included columns for length, then another one for the calculated extension.

ResultsPlus
Examiner Comments

This response is sufficient for both marks to be awarded.

Question 1 (b)

Few candidates seemed to be aware of the technique of recording loading and unloading values when carrying out this experiment. However, it was quite common for a reference to the more generic "repeat readings" and calculating a mean to be seen. Many candidates were aware of the problems associated with parallax in the metre rule readings, and the use of a pointer or a set square was referred to by many. Some responses were quite vague as to where the pointer should be positioned, with many responses simply referring to a fiducial marker. Many candidates thought about ensuring that the metre rule was vertical and fixed in position. Often this was in terms of ensuring that the metre rule was parallel to the spring.

(b) Describe how the student should determine the extension of the spring as accurately as possible.

(3)

The student should clamp the ruler to the stand and observe extentions at eye level to avoid parralax error. they should take multiple readings for each extension and find the average to reduce uncertainty. they should measure the initial length of the spring.

ResultsPlus
Examiner Comments

This response covers all three marking points. Although reasons are given for the method, there are not necessary for full marks to be awarded.

Question 2 (a)

Despite the hint in the question, many candidates described measuring multiple slides individually in different places / orientations. MP2 was rarely awarded, as very few candidates' responses specified that uncertainty would remain the same. Some candidates focussed on the micrometer in their answer rather than experimental technique.

2 A student was given a box of identical glass microscope slides and asked to determine the density of the glass. She used a micrometer to measure the thickness of one of the slides. She repeated this measurement twice in different places and calculated a mean value for the thickness. The thickness of each slide was approximately 1 mm.

(a) Explain how she should have measured the thickness of the slides in order to minimise the percentage uncertainty.

(2)

- Should have taken more than 3 measurements.
- In different positions and orientations
- And found the mean (to help reduce random error).

ResultsPlus
Examiner Comments

This response is an example of a standard method (repeat and calculate a mean value) being given without reference to the context of the question. It is not clear how repeats of the slide thickness could be made at different orientations, but it was commonly seen.

ResultsPlus
Examiner Tip

Always relate your response to the context given in the question.

(a) Explain how she should have measured the thickness of the slides in order to minimise the percentage uncertainty.

(2)

She should measure the thickness of at least 10 slides and divide this thickness by 10, as one slide is very thin and makes the percentage uncertainty very big. Repeat the measurement for at least three times and take the average.

ResultsPlus
Examiner Comments

This response gains MP1 but doesn't quite say enough for MP2.

Question 2 (b)

Some candidates gave clear definitions of the required terms but few specifically mentioned resolution. Not many candidates stated that repeating alone does not reduce random error.

Question 3 (a)

This was a popular question with candidates, and many correct solutions were seen. Responses were usually set out logically and were relatively easy to mark. The final MP was most commonly given for a comparison of energy transferred and energy required.

3 It was suggested on an online forum that it would be possible to cook a chicken by repeatedly slapping the chicken with one hand.

It was claimed that the energy transferred to a chicken in 8000 slaps would be sufficient to raise the temperature of the chicken from 23 °C to 165 °C.

In an investigation to test the claim, the effective mass of the hand was taken as 1.75 kg and the speed of the hand just before impact with the chicken as $6.25\,\mathrm{m\,s^{-1}}$.

(a) Deduce whether the data confirms that 8000 slaps would be sufficient.
Assume that no energy is transferred from the chicken to the surroundings.

mass of chicken = 0.875 kg
specific heat capacity of chicken = $1770\,\mathrm{J\,kg^{-1}\,K^{-1}}$
efficiency of energy transfer from the hand = 65%

(5)

$E_k = \frac{1}{2}mv^2$ (per slap) $\frac{1}{2} \times 1.75 \times 6.25^2 = 34.18\,\mathrm{J}$

$34.18 \times 0.65 = 22.22\,\mathrm{J}$

$E = mc\theta$ $0.875 \times 1770 \times (165 - 23) = 219922.5\,\mathrm{J}$ needed

$\frac{219922.5}{22.22} = 9898$ slaps

$\therefore$ 8000 is insufficient

ResultsPlus
Examiner Comments

This response calculates the number of slaps required to raise the temperature by the required amount and was another way to gain all 5 marks that was seen quite frequently.

(a) Deduce whether the data confirms that 8000 slaps would be sufficient.
Assume that no energy is transferred from the chicken to the surroundings.

mass of chicken = 0.875 kg
specific heat capacity of chicken = 1770 J kg^{-1} K^{-1}
efficiency of energy transfer from the hand = 65%

(5)

E_k of hand in one slap = $\frac{1}{2}mv^2 = \frac{1}{2} \times 1.75 \times 6.25^2$

= 34.18 J
× 0.65
= 22.22 J transferred to chicken per slap
× 8000
= 178 000 J total

$\Delta E = mc\Delta\theta$

$\Delta\theta = \frac{\Delta E}{mc}$

$\Delta\theta = \frac{178000}{0.875 \times 1770}$

$\Delta\theta = 115\,^\circ C$

so final temp = 23 + 115
= 138 °C so 8000 slaps is not sufficient to reach 165 °C

ResultsPlus
Examiner Comments

This response calculates the temperature reached after 8000 slaps. Although seen less frequently, this was another way to score all 5 marks.

(a) Deduce whether the data confirms that 8000 slaps would be sufficient.
Assume that no energy is transferred from the chicken to the surroundings.

mass of chicken = 0.875 kg
specific heat capacity of chicken = 1770 J kg^{-1} K^{-1}
efficiency of energy transfer from the hand = 65%

$\Delta E = mc\Delta\theta$ **(5)**

$\Delta E = 0.875 \times 1770 \times (165-23) = 219923$ J

$E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 1.75 (6.25)^2 = 34.1797$ J

$8000 \times 0.65 \times 34.1797 = 177734$ J

~~219923 J > 177734 J~~ 219923 J > 177734 J

8000 Slaps are not Sufficient

ResultsPlus
Examiner Comments

This response compares the energy gained by 8000 slaps with the energy required to increase the temperature to the value stated in the question. This was a common way for all 5 marks to be gained.

Question 3 (b)

Many candidates referred to energy transfer to the surroundings, but omitted to give qualifying statements such as temperature difference / thermal equilibrium etc. Some responses focused on the efficiency of the process or other aspects which were not related to the assumption that was required to be commented upon.

(b) Explain whether the assumption made in (a) is realistic.

(2)

No, as the efficiency would most likely be less than 65% and no one will stop a chicken 8000 times at the same velocity. (unrealistic). Mass of chicken may change.

ResultsPlus
Examiner Comments

This response follows an approach taken by a number of candidates. The assumption that was stated in (a) has been ignored, and other factors have been considered instead. This approach did not gain any credit.

(b) Explain whether the assumption made in (a) is realistic.

(2)

It is not realistic, as energy ~~##~~ is transferred to the thermal store of the chicken there is a difference in temperature to the surroundings therefore energy would be transferred to the surroundings as heat so energy would be transferred to the surroundings.

(Total for Question 3 = 7 marks)

ResultsPlus
Examiner Comments

This response gains 2 marks, as it identifies that there must be energy transfer to the surroundings if there is a temperature difference. Similar responses sometimes referred to thermal equilibrium between the chicken and its surroundings.

(b) Explain whether the assumption made in (a) is realistic.

(2)

The assumption is not realistic since as the chicken heats up, it is not in an insulated space like an oven and most of the thermal energy the chicken may gain will be lost to the surroundings.

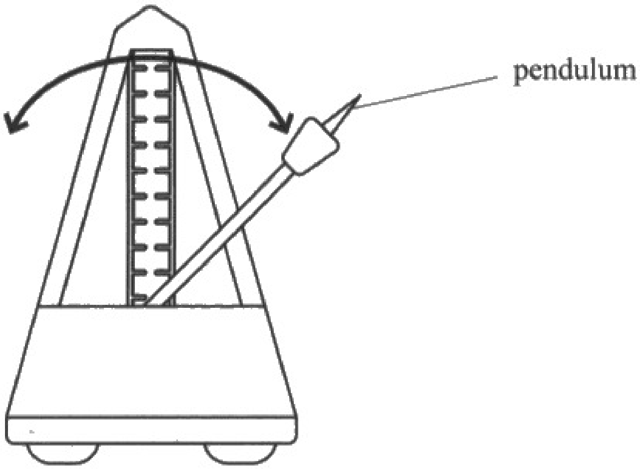
ResultsPlus
Examiner Comments

The idea that it is impossible to insulate the chicken from the surroundings expressed in this response is sufficient for both marks.

Question 4

Some good responses to this question were seen. MP1, MP3, MP4 and MP5 were often given and answers seemed well rehearsed. Many candidates stated light gates but not data logger, although candidates should be aware that light gates need to be connected to something. This may be a data logger, or to a computer or even to digital timers, but some detail is required for this mark to be awarded. In fact, there may be considerable difficulty in the set of light gates and a data logger and so this would not be an ideal improvement to the experimental method anyway.

4 The diagram shows a metronome, which includes an inverted pendulum, used by musicians to set a tempo. The pendulum oscillates with simple harmonic motion and makes a loud click at regular intervals.



(Source: Getty Images)

A faulty metronome stopped making a clicking noise. A student tried to check the accuracy of the period *T* of the metronome, using a stopwatch. The student timed the pendulum as it moved from one extreme of the oscillation to the other.

Explain how the procedure used by the student to determine *T* could have been improved.

A marker can be placed at the equilibrium point to ~~measure~~ see when the pendulum passes it. He should start timing as the pendulum passes the marker (equilibrium position) and record for 20 oscillations, divide this by 20 to get an average of the time period. Multiple oscillations recorded to get a longer recorded time so less % uncertainty. Recorded from the equilibrium position as pendulum is moving fastest so least uncertainty in position.

(Total for Question 4 = 5 marks)

ResultsPlus
Examiner Comments

This response deals with the key aspects of the procedure well and gains all 5 marks.

Explain how the procedure used by the student to determine T could have been improved.

Time the pendulum from the equilibrium position using a fiducial marker. Time for n number of oscillations where n is a large number then divide the time by n to find the period. Repeat the timing at least three times and calculate a mean. This will reduce the percentage uncertainty in the value for T.

ResultsPlus
Examiner Comments

This succinct response is good enough for 4 out of the 5 marks available for the question. MP2 was not awarded, as there is no reference to increasing the total time measured. Nor was there any reference to reaction time.

Question 5

This was a fairly straightforward linkage question. Most candidates were able to score marks by expressing their responses in a logical order and covering all of the key points.

Reference to cutting of flux or changes in flux linkage were often omitted in favour of a reference to the coil cutting magnetic field lines. A number of candidates went into extreme detail about the induction process, so the last 3 IC points were weak in these responses.

The charging process was often described quite poorly. The lack of reference to the capacitor being charged may be a result of the way in which capacitors are currently taught. Many candidates knew that they should not say the capacitor 'stores charge' so maybe they avoided the word charging too. The references to 'one side of the capacitor' may be because they have been told that charge builds up on one plate – and the opposite charge builds up on the other plate, so no net charge is stored. A candidate explaining the process using these concepts correctly would have scored marks. However incorrect references to a build of current were seen quite regularly. Few candidates appreciated that the diode prevented the capacitor from being discharged when the magnet changes direction in the coil.

Explain how the shaker torch is able to light the LED.

as the Magnet moves through the coil there is a change in magnetic flux linkage ~~[illegible]~~. this induces an emf in the coil. which drives a current. the diode stops current flowing Back when the Magnet moves the other direction. ~~when the~~ the current flowing through the circuit when the switch is open charges the ~~[illegible]~~ capasitor. when the switch is closed the capacitor will discharge through the ~~[illegible]~~ LED causing it to emmit light. Barely any current will flow through the coil becuse it has a much higher resistence then the circuit with the LED.

ResultsPlus
Examiner Comments

All the key points are made in this response, and the ideas are sequenced logically. So this response gains 4 marks for indicative content, and 2 marks for linkage, giving it 6 marks in total.

Explain how the shaker torch is able to light the LED.

When the torch is shaken the magnet passes through the coil, hits the rubber stopper, ~~and~~ and passes through the coil again, hits the other stopper and continues passing through the coil. when the magnet passes through the coil, magnetic flux is cut which induces an electromotive force in the coil. This EMF causes current to flow into the ~~in the~~ circuit. It flows through the circuit ~~diode~~, and charge builds up on the capacitor (current is rate of flow of charge). The diode stops current from going back into the electromagnet. Once the switch is closed the capacitor discharges and current flows through the circuit, into the LED and back out the other side. Once the capacitor has discharged and all current ~~has~~ has passed through the LED the light goes out.

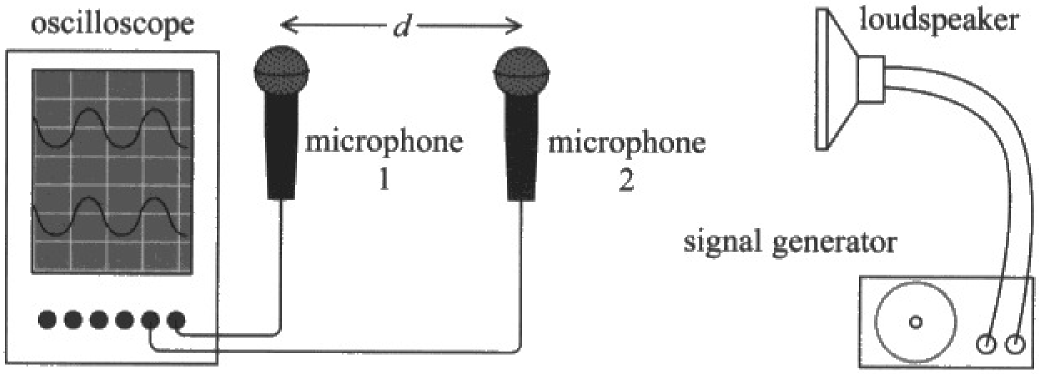
ResultsPlus
Examiner Comments

Once again, this response includes all the key points. Despite some extraneous detail at the beginning of the response relating to how the magnet moves back and forth through the coil, the ideas are sequenced logically. So this response gains 4 marks for indicative content, and 2 marks for linkage, giving it 6 marks in total.

Question 6 (a)

Many candidates didn't understand that they should be saying how to improve the experimental procedure. Most were commenting that it was the correct set up. Most candidates did not realise about finding more in-phase positions. A few candidates sketched waves to illustrate their answer.

6 In an experiment to determine the speed of sound in air a student connected two microphones to an oscilloscope, as shown.



The microphones detect sound from the loudspeaker, converting it to an electrical signal. The signal is displayed on the oscilloscope screen.

Both microphones were initially positioned the same distance from the loudspeaker. The two signals were in phase on the oscilloscope screen. The student slowly moved microphone 2 towards the loudspeaker, until the two signals on the oscilloscope were in phase again. He then measured the distance *d* between the microphones to determine the wavelength λ of the sound waves.

$d = 20.5\text{ cm}$

(a) Comment on the student's experimental technique to determine λ.

(2)

They would have ~~taken multiple readings, each time they became in phase again~~ repeated the experiment more than once so that final answer was more accurate. Also if they had measured the distance of multiple wavelengths rather than just 1, the percentage uncertainty would be smaller.

ResultsPlus
Examiner Comments

This response indicates that multiple wavelengths should have been measured, although doesn't specifically refer to multiple in-phase positions. There is a reference to percentage uncertainty being reduced, which is sufficient for MP2.

(a) Comment on the student's experimental technique to determine λ.

(2)

The student should initially line the traces up in antiphase as this allows easier identification of when they are back in antiphase the second time due to a peak on the bottom trace lining up more closely with a trough on the top trace. Also student should take repeats and take a mean to reduce effect of random error

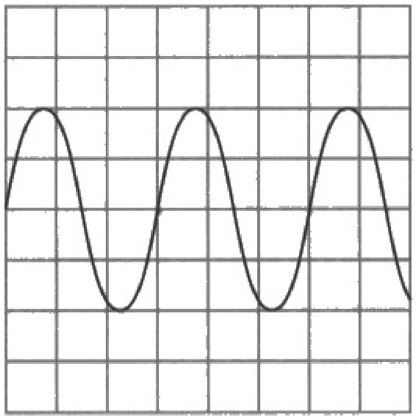
ResultsPlus
Examiner Comments

The reference to repeats doesn't score marks, although it is clear that choosing to measure between out of phase positions leads to an easier judgement of the positions hence this response scores 2 marks.

Question 6 (b)

Most candidates scored full marks on this question, although some were confused by the fact that the trace showed an incomplete number of wavelengths.

(b) The oscilloscope trace for the signal from microphone 1 is shown below.



The time base of the oscilloscope was set to 0.20 ms div^{-1}.

Determine a value for the speed of sound in air.

(5)

$2\lambda = 6$ division

$1\lambda = 3$ divisions $= 0.20 \times 10^{-3} \times 3 = 6 \times 10^{-4}$ s

$\lambda = 20.5$ cm $= 0.205$ m

$V = f\lambda = \frac{1}{T} \times \lambda$

$= \frac{0.205}{6 \times 10^{-4}} = 341.67 \text{ m s}^{-1}$

342 ms^{-1} (3sf)

Speed of sound = 342 ms^{-1}

ResultsPlus
Examiner Comments

The correct answer is obtained, with all the expected elements of the solution included, so this response gains full marks.

ResultsPlus
Examiner Tip

Substitute numerical values before rearranging an equation.

Determine a value for the speed of sound in air.

(5)

$$T = \frac{8\,(0.20 \times 10^{-3})}{2 + \frac{3}{4}}$$

$$= \frac{(8)(4)(0.20 \times 10^{-3})}{11}$$

$$= 5.82 \times 10^{-4}\ \text{s}\ (3\text{s.f.})$$

$$v = f\lambda$$

$$= \frac{1}{T}\lambda$$

$$= \frac{11}{(8)(4)(0.20 \times 10^{-3})}(20.5 \times 10^{-2})$$

$$= 3.5$$

ResultsPlus
Examiner Comments

This response attempts to use the full time displayed on the oscilloscope screen, using 2 complete waves and three quarters of a wave. This is not exact, but acceptable. However, a power of ten error is introduced into the calculation, and the final answer is out by a factor of 100.

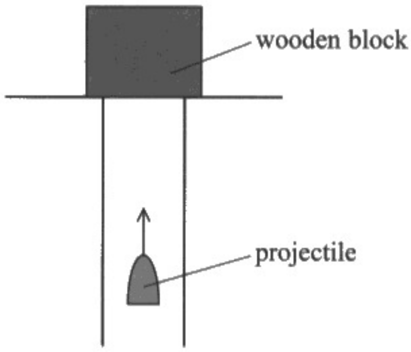
ResultsPlus
Examiner Tip

Take care with powers of 10 when entering data into your calculator.

Question 7 (a)

Most candidates managed to find the speed of block after collision and the energy of block. However, many candidates missed the point that they had to use conservation of momentum to complete the question.

7 A projectile of mass 65 g is fired vertically upwards into a stationary wooden block of mass 2.400 kg, as shown.



(a) The projectile becomes embedded in the block. They both move vertically upwards through a vertical displacement of 55 cm before momentarily coming to rest.

Calculate the energy dissipated as the projectile hits the block.

(6)

$p = mv$

$(0.065 \times v) = (0.065 + 2.4 \times v)$

$E_h = mgh$

$= 2.465 \times 9.81 \times 0.55$

$= 13.3\text{ J}$

$\rightarrow E_K = \frac{1}{2} m v^2$

$13.3\text{ J} = \frac{1}{2} \times 2.465 \times v^2$

$v = 3.2849\text{ ms}^{-1}$

$(0.065 \times v) = 8.097$

$v = 124.576\text{ ms}^{-1}$

$E_{K\,before} = \frac{1}{2} 0.065 \times 124.576^2$

$= 504.3769$

$E_K\text{ before} - E_K\text{ after} = 491.1$

Energy dissipated = 491.1 J

ResultsPlus
Examiner Comments

This response uses energy conservation to calculate the velocity of the block and projectile just after the impact. Conservation of momentum and kinetic energy calculations are carried out to give a correct final answer.

ResultsPlus
Examiner Tip

Show your working clearly in all calculations.

(a) The projectile becomes embedded in the block. They both move vertically upwards through a vertical displacement of 55 cm before momentarily coming to rest.

Calculate the energy dissipated as the projectile hits the block.

(6)

$E = \frac{1}{2}mv^2$ mv before $= mv$ after

$v^2 = u^2 + 2as$ $v = 0$ $u = ?$ $a = -9.8$ $s = 0.55$

$0 = u^2 + 2 \times -9.8 \times 0.55$ $0.065 + 2.4 = 2.465\,kg$

$10.78 = u^2$ mv after $= 2.465 \times \frac{7\sqrt{22}}{10}$

$\sqrt{10.78} = u$ $= 8.093312394$

$u = 7\sqrt{22}/10 = 3.283291032$ mv befor $= 8.093312394$

E_k after $= \frac{1}{2} \times 2.465 \times \left(\frac{7\sqrt{22}}{10}\right)^2$ $\Rightarrow v$ before $= \frac{8.093312394}{0.065}$

$= 13.28635$ $= 124.5124984\ ms^{-1}$

E_k before $= \frac{1}{2} \times 0.065 \times 124.5124984^2$

$= 503.8592731$

$503.8592731 - 13.28635 =$ ~~40~~ $490.5729231 = 490.57J$

Energy dissipated = 490.57J

ResultsPlus Examiner Comments

This response uses an equation of motion to calculate the velocity of the block and projectile just after the impact. Again, conservation of momentum and kinetic energy calculations are carried out to give a correct final answer.

Question 7 (b)

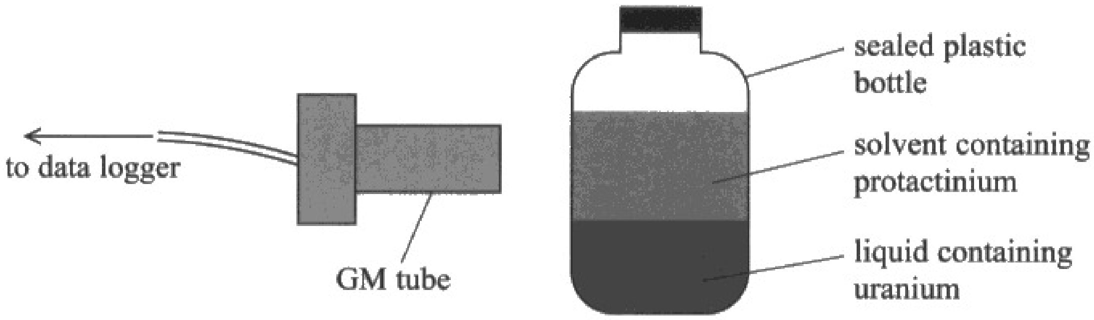
A few candidates referred to an inelastic collision, but most did not. Many candidates quoted conservation of energy but did not relate this to decreasing KE or an inelastic collision.

Question 8 (a)

Many candidates could recall that alpha radiation was stopped by paper, whereas beta radiation is stopped by a few mm of aluminium. However, the link with radiation escaping the plastic bottle was often not made. Some candidates said that alpha radiation would be stopped by the plastic bottle but did not explicitly state that the beta radiation would penetrate the plastic bottle.

8 A teacher demonstrated the decay of protactinium using a Geiger-Müller (GM) tube connected to a data logger.

A sealed plastic bottle contains a solvent floating above a liquid containing a uranium salt. Protactinium is produced from the decay of uranium and is present in the solvent as shown.



(a) Deduce whether alpha radiation or beta radiation from the inside of the bottle is detected by the GM tube.

(2)

Alpha is not detected as it can only penetrate through a couple of cm of air, and not through plastic
Beta can be detected as it can penetrate through plastic.

ResultsPlus
Examiner Comments

Many candidates made reference to the alpha radiation only being able to pass through a few cm of air. On its own, this isn't enough for MP1, as a specific reference to the alpha radiation being absorbed by the plastic bottle is required. In this response this extra information is added, and there is a clear statement that beta radiation can penetrate the plastic bottle and so this response scored both marks.

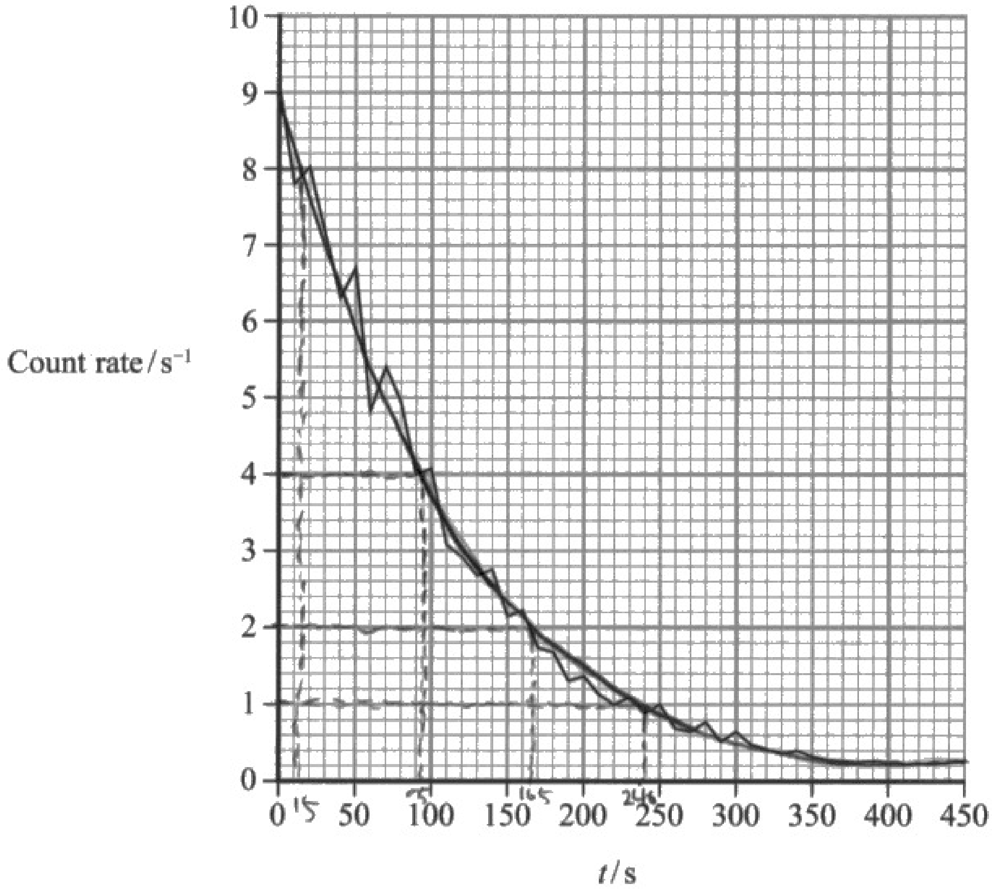
ResultsPlus
Examiner Tip

Always give as much detail as you can that relates to the context given in the question.

Question 8 (b)(i)

Very few candidates drew a line of best fit. The candidates who only found one half-life from the graph without drawing a line of best fit had a tendency to be out of range as the change from 9 to 4.5 gives 85 s. Readings taken from the graph with calculations of mean often scored full marks.

(b) The data logger output is shown below.



(i) Determine the half-life of the protactinium.

(4)

8 → 4 time = (95 − 15) = 80

4 → 2 time = (165 − 95) = 70

2 → 1 time = (240 − 165) = 75

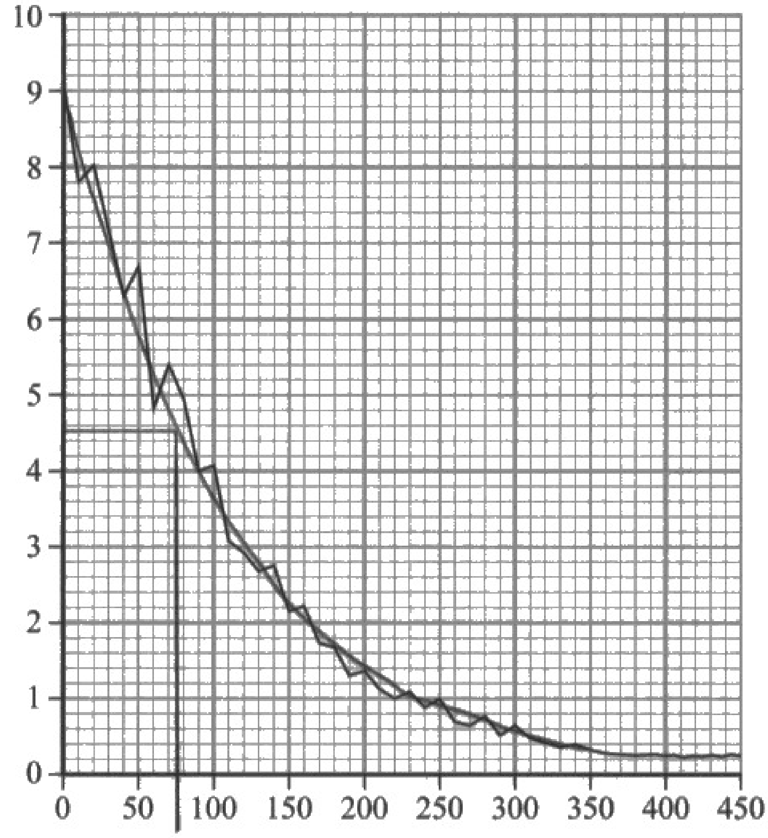
$\frac{80 + 70 + 75}{3} = 75\text{ s}$

Half-life of protactinium = 75 s

ResultsPlus
Examiner Comments

A mean line has been drawn, and the time taken for the count rate to fall to half has been carried out 3 times. A mean half-life is calculated, and the final value is within the range specified and so this response scores all 4 marks.

(b) The data logger output is shown below.



(i) Determine the half-life of the protactinium.

(4)

LoBF. Time when count-rate halves. using graph.

9 → 4.5.

=> 75s

($A = A_0 e^{-\lambda t}$

$e^{-\lambda t} = 1/2$

$-\lambda t = \ln(\frac{1}{2}) = -\ln(2)$ 4 $\frac{t}{t_{1/2}} = 1.$ $t = t_{1/2}$.)

$-\frac{\ln 2}{t_{1/2}} \times t = -\ln 2.$

Half-life of protactinium = 75s

ResultsPlus
Examiner Comments

Again, a mean line is drawn and MP1 awarded. However, in this response only one half-life is determined, so MP2 is given, but not MP3. The value obtained is within range, and so MP4 is met, giving a total of 3 marks for this response. The theory included that relates to the exponential decay equation is mostly correct but doesn't add to the number of marks gained by this response.

Question 8 (b)(ii)

Most responses mentioned background count or the idea of exponential decreasing never reaching zero. Only some candidates mentioned that it would be detected by the data logger or GM-tube to gain MP2.

(ii) Explain why the count rate doesn't reach zero.

(2)

The teacher did not take into account background radiation, which will cause the geiger-müller tube to continuously ~~obtain~~ obtain values of activity above zero.

ResultsPlus
Examiner Comments

This response says enough for both marks to be awarded.

(ii) Explain why the count rate doesn't reach zero.

(2)

~~Count rate~~ The GM counter counts all radiation, including background radiation, so ~~this~~ the count rate is never 0 as there's always background radiation e.g from cosmic rays Protactinium is also radioactive so it could include counts from this too

(Total for Question 8 = 8 marks)

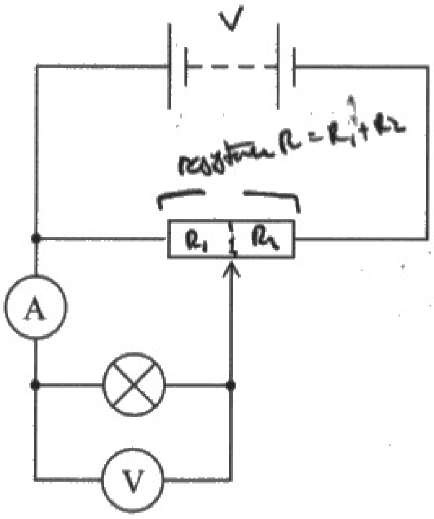
ResultsPlus
Examiner Comments

This response says enough for full marks. The reference to protactinium at the end of the response is treated as neutral.

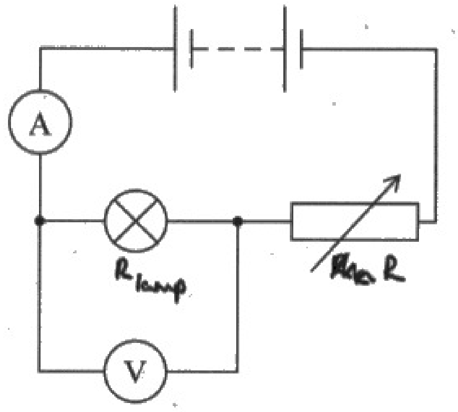
Question 9 (a)

This linkage question was poorly answered. Answers often lacked structure. Without a logical flow it was often hard to identify the comparison being made. IC2 and IC3 were often described together. IC4 and IC5 were the most commonly omitted.

9 A student is planning to collect data to produce a current-potential difference graph for a filament lamp. Her teacher suggests two circuits that she could use.



Circuit 1



Circuit 2

Circuit 1 uses a potential divider and circuit 2 uses a variable resistor to vary the potential difference across the filament lamp.

*(a) Discuss the suitability of each circuit to collect the data.

(6)

In circuit 1, the slider on the potential divider can be varied to vary the 'share' of the resistance of the fixed resistor that is in parallel with the filament lamp – as this is a parallel circuit, the p.d. dropped across the left hand side of the fixed resistor ("R_1") is equal to the p.d. dropped across the filament lamp, so $V_{lamp} = V_{terminal} \times \frac{R_1}{R_1 + R_2}$ (where R_1 varies from 0 to R). This allows the potential difference across the filament lamp to be varied from 0 V right up to the terminal p.d., V, allowing data to be collected across a large range.

However in circuit 2, the filament lamp is in series with the variable resistor, so p.d. is 'shared' between the lamp and resistor according to $V_{lamp} = V_{terminal} \times \frac{R_{lamp}}{R + R_{lamp}}$, where R_{lamp} is fixed. This gives a maximum p.d. across the lamp when R (variable resistor's resistance) is at a minimum, which should be approximately equal to the terminal p.d. However, the minimum p.d. across the lamp, when R is at a maximum, is much greater than 0 – so circuit 2 can only collect data over a more limited range of p.ds than circuit 1, so circuit 1 is therefore much more suitable.

ResultsPlus
Examiner Comments

In this response the key features of each circuit (IC2 – IC4) are made, and there is an understanding that, although both circuits are suitable, circuit 1 is better. Therefore 4 marks for indicative content can be awarded. The ideas are logically sequenced, and so 2 linkage marks are merited, giving a total of 6 marks for the response.

ResultsPlus
Examiner Tip

Plan your response to an extended open response question so that you are clear which points you are going to make before you start writing your response.

*(a) Discuss the suitability of each circuit to collect the data.

(6)

Circuit 2 and circuit 1 both allow the student to vary the potential difference across the filament lamp ~~and get a~~ to allow the student to plot a graph of voltage against current and identify a trend or anomalies or systematic error. In circuit 2 the potential difference is shared between the lamp and the variable resistor. It is difficult to make the resistance of the variable resistor very high so that you get low values of potential difference across the lamp as it is connected in series so the current would be reduced to zero and the student won't get many results for low voltages of the filament lamp. Circuit 1 is more suitable as you can vary the potential difference of the lamp from 0 V to the voltage of the supply therefore the student will be able to identify how the current varies for small voltages in a filament lamp and will get a more accurate trend than using Circuit 2.

ResultsPlus
Examiner Comments

In this response the key features of each circuit (IC2 – IC4) are made, and there is a clear statement of the pros and cons of each circuit in the practical context given in the question. For this reason all 4 marks for indicative content can be awarded. The ideas are logically sequenced, and so 2 linkage marks are also merited, giving a total of 6 marks for the response.

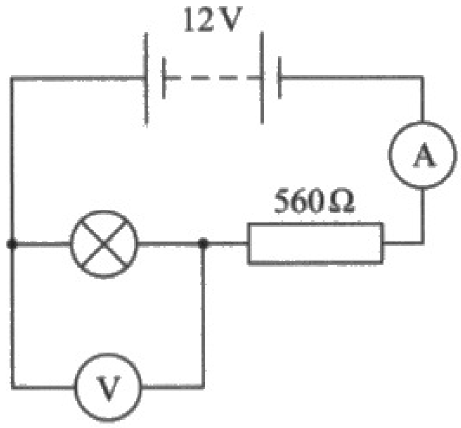
Question 9 (b)(i)

This was well answered by most candidates. Some responses stopped after a calculation of the potential difference across the 560 W resistor, so missed out on MP2.

Question 9 (b)(ii)

Most candidates struggled with this question and only very few could follow through with a full explanation. Often candidates said one mark from one set of MPs and another from a different set. The idea of reduced resistance in the voltmeter circuit was seen often, however the result of this on the rest of the circuit was poorly explained. It was often said that current decreases in the whole circuit, but many candidates thought that the current was constant. Basic errors in the use of terminology such as “current across” and “voltage through” indicated that many candidates had only a weak grasp of basic circuit principles.

(ii) When a voltmeter with a resistance of 1.5 kΩ is connected as shown, the p.d. across the filament lamp decreases.



Explain why the p.d. across the filament lamp decreases.

(3)

The voltmeter is connected in parallel, so total resistance of the circuit decreases, V=IR so current in the circuit increases. This means that there is an increase in current for the resistor, so p.d across the lamp decreases.

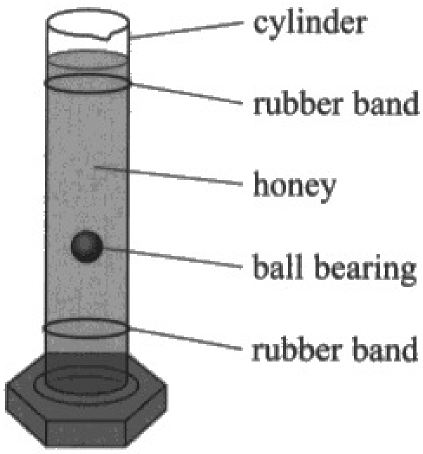
ResultsPlus Examiner Comments

The response clearly states that the circuit resistance decreases and so the circuit current increases. However, there is no justification given for the decrease in circuit resistance, so MP1 is not awarded. The response needed to state that the resistance of the parallel combination decreases when the voltmeter is connected.

Question 10 (a)

This question was poorly answered, with most candidates producing rote-learned answers about repeats and uncertainties, without addressing the specific situation. Many candidates did score MP1 and mentioned terminal velocity, but almost none then went on to explain this further so did not score MP2.

10 A student carried out an experiment to determine the viscosity of some honey. He filled a tall glass cylinder with honey as shown, and timed a ball bearing as it fell through the honey.



(a) The student placed rubber bands near the top and bottom of the cylinder. He started a stopwatch when the ball bearing passed the first band and stopped the stopwatch when the ball bearing passed the second band. He repeated this several times to determine a mean time.

Criticise the student's method.

(2)

Ball mightn't have reached terminal velocity by the first band - it should be placed much lower. There should be more rubber bands at fixed intervals so multiple times can be measured per go & it can be verified the sphere is travelling at terminal velocity

ResultsPlus
Examiner Comments

Both marking points are clearly stated, and so this response gains full marks.

Question 10 (b)(i)-(ii)

(b)(i)

This question was answered very well, although some candidates seemed to think that there was an anomalous value included in the data. None of the values given in the table were far enough away from the mean to be considered anomalous.

(b)(ii)

This question was also answered very well, although a minority of candidates did not give a conclusion, having calculated a correct value for the viscosity.

(b) The time t for the sphere to fall through a distance of 25.0 cm is shown in the table.

t / s			
6.40	6.35	6.36	6.38

(i) Show that the mean velocity v of the ball bearing is about $0.04\,\mathrm{m\,s^{-1}}$.

(3)

$$t_{mean} = \frac{6.4 + 6.35 + 6.36 + 6.38}{4} = 6.37\ \mathrm{s}$$

$$V = \frac{25 \times 10^{-2}}{6.37} = 0.039\ \mathrm{ms^{-1}}$$

$$\approx 0.04\ \mathrm{ms^{-1}}$$

(ii) The student had three different types of honey available.

Viscosity η is given by the following expression

$$\eta = \frac{2r^2 g(\rho_B - \rho_H)}{9v}$$

radius r of ball bearing = 5.50×10^{-3} m
density of ball bearing ρ_B = 7750 kg m^{-3}
density of honey ρ_H = 1360 kg m^{-3}

Viscosity (at 20 °C) / Pa s		
Honey A	Honey B	Honey C
10.6	12.5	13.6

Deduce which honey the student used.

(2)

$$\eta = \frac{2 \cdot (5.5 \times 10^{-3})^2 \cdot 9.81 \cdot (7750 - 1360)}{9 \cdot 0.039}$$

η = 10.8 Pas

∴ Honey A was used

ResultsPlus
Examiner Comments

The response shows a correct method for the velocity calculation, and the answer is given to 2 sf (one more than the "show that" value). The calculated value of velocity is used in the viscosity equation, and honey A is correctly selected on the basis of the viscosity value.

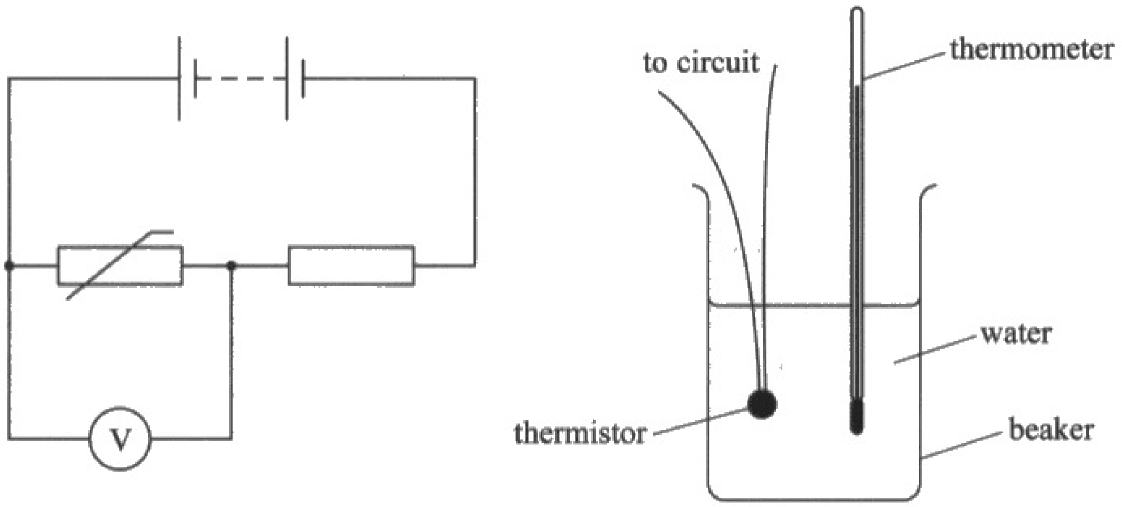
ResultsPlus
Examiner Tip

In a "show that" question you must give your final answer to at least one more significant figure than the value quoted in the question.

Question 11 (a)

Most candidates scored MP1 with most of these going on to score MP2. However, a significant proportion of responses seen demonstrated a clear lack of understanding of potential divider circuits. A common misconception was to attempt to apply V=IR, with an erroneous statement that the current would remain constant.

11 A student carried out an experiment to calibrate a thermistor. She connected the thermistor in series with a resistor and a power supply as shown. Then she placed the thermistor in a beaker of hot water and used a thermometer to record the temperature θ of the water.



The student recorded θ and corresponding values of the reading V on the voltmeter as the water cooled.

(a) Explain, making reference to charge carriers, why V increased as the water cooled.

(3)

As the water cools, the thermistor cools so its charge carrier density decreases. Since $I = nAqv$, this causes a decrease in current which corresponds to an increase in the resistance of the thermistor. The thermistor now has a greater proportion of the circuit's total resistance so it takes a greater share of the terminal pd. This means that the pd across the thermistor and therefore across the voltmeter increases.

ResultsPlus
Examiner Comments

This response includes the key points required in the explanation, and so all 3 marks are awarded.

(a) Explain, making reference to charge carriers, why V increased as the water cooled.

(3)

As the water cooled, more charge carriers would move from the conduction band to the valence band as they had less energy. This would increase the resistance of the thermistor so that it allows for a greater share of the total resistance. This means it would receive a greater share of the emf so V increases.

ResultsPlus
Examiner Comments

This response refers to charge carriers moving from the conduction band to the valence band, as did many of the responses seen. This was taken as being equivalent to MP1. The other two points are included and so this response scores full marks.

Question 11 (b)(i)

Most, but by no means all, candidates were able to score MP1, but a significant minority did not score MP2, either omitting to use the equation $y = mx + c$ or by not explaining the link between this and their answer to MP1.

(b) Over a limited temperature range V varies with θ according to the expression

$$V = V_0 e^{-b\theta}$$

where b and V_0 are constants.

(i) Explain why a graph of $\ln V$ against θ would give a straight line.

(2)

$$\ln V = \ln(V_0 e^{-b\theta})$$

$$\ln V = \ln V_0 + \ln e^{-b\theta}$$

$$\ln V = -b\theta + \ln V_0$$

$$y = mx + c$$

ResultsPlus
Examiner Comments

There is a correct log expansion and a clear link to the equation of a straight line.

Question 11 (b)(ii-iii)

(b)(ii)

Despite the same mark scheme having been applied to the graph plotting question since the beginning of this specification, many candidates did not pick up marks. This may be as a result of the reduced classroom practice time for graph plotting as a result of the lockdowns during the pandemic.

Most candidates were able to score MP1, but many did not record ln(*V*/V) for MP2. Many candidates used highly inappropriate scales, with examples of 4s, 6s or even 7.5 being used, so did not score MP3 or MP4. There were a few candidates with plotting errors but most scored MP4. Many candidates did not appreciate how to draw a line of best fit, with some lines rotated, and many with three points either above or below the line.

(b)(iii)

Again, this question was quite poorly answered. Many candidates attempted to find a gradient for MP1, although a significant minority did not recognise this, however almost no candidates gave units to their answer for MP2. Most candidates scored MP3, but a significant minority missed out on MP4 by omitting the units.

(ii) The student's data is shown in the table below.

θ/°C	V/V	ln(V/V)
89.0	1.9	0.64
74.0	2.9	1.06
53.5	4.9	1.59
32.5	9.1	2.21
18.5	12.6	2.53
3.5	18.7	2.93

0.60

3.00

Plot a graph of ln V against θ on the grid opposite. Use the column provided to show any processed data.

(5)

(iii) Determine values for b and V_0.

(4)

$\ln V = -b\theta + \ln V_0$

so, gradient $= -b \therefore b = -$gradient

so, $b = -\left(\frac{2.88 - 0.88}{(6.0 - 80.0)\,°C}\right) = 0.027027\ldots\,°C^{-1}$

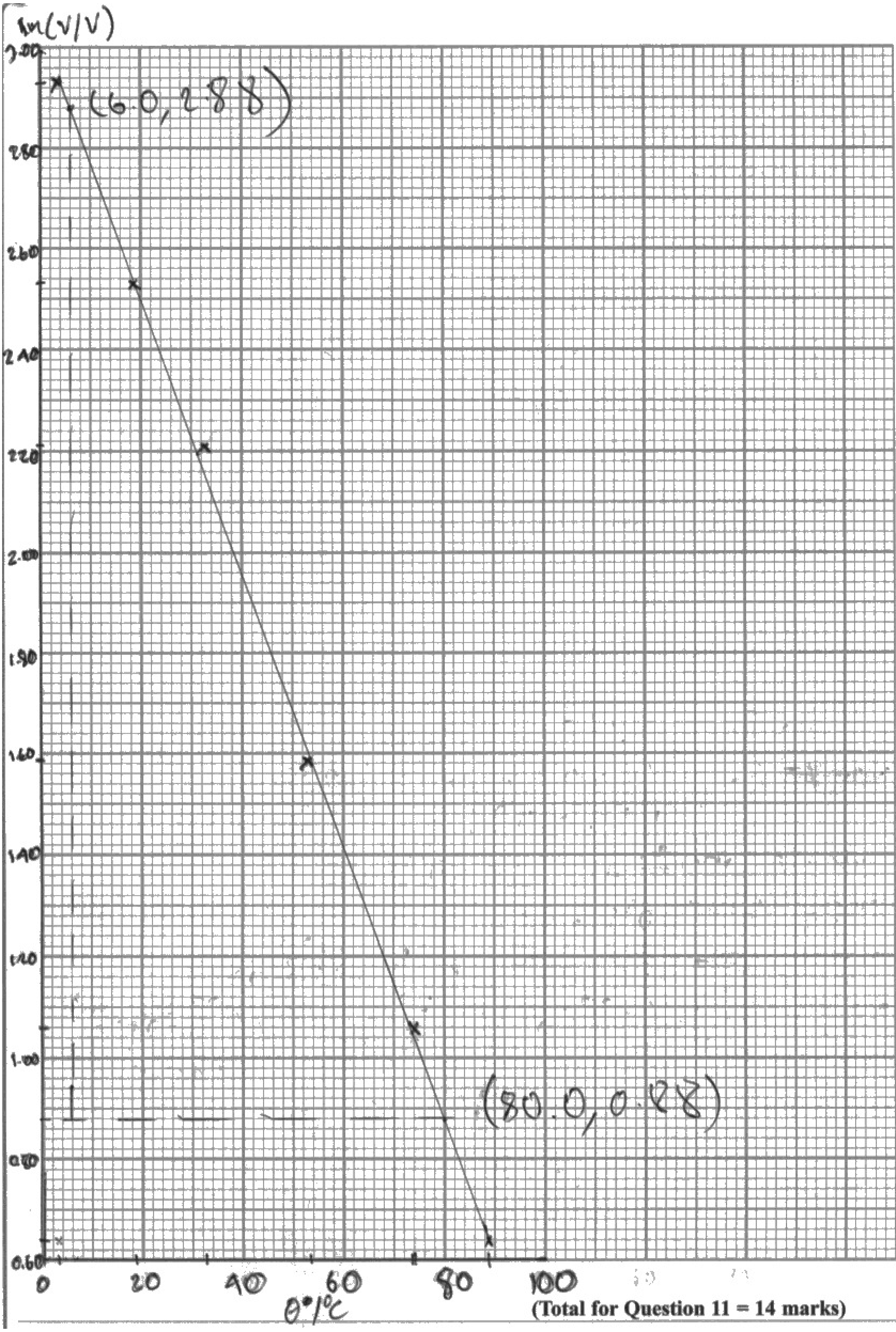
so, $V = V_0 e^{-0.027\ldots°C^{-1}(\theta)}$

when $\theta = 89.0\,°C$ and $V = 1.9$, $V_0 e^{-0.027\ldots°C^{-1} \times 89.0°C} = 1.9V$

so, $V_0 = \frac{1.9\,V}{e^{-0.027\ldots°C^{-1}(89.0°C)}} = 21.0585\ldots$

$b =$ 0.027 °C^{-1}

$V_0 =$ 21.1 V



(Total for Question 11 = 14 marks)

ResultsPlus
Examiner Comments

The ln*V* values are correctly calculated to 2 decimal places, and the axis labels follow correct connections for units. The graph scales enable just a little more than half the available space to be used which is fine. The plots and line of best fit are accurate.

A large triangle (at least half of the drawn line) is used to calculate the gradient, and the intercept is read from the y-axis accurately. The value for *b* is within range and correct units are included. V_0 is also in range with correct units.

(ii) The student's data is shown in the table below.

θ/°C	V/V	ln (V/V)
89.0	1.9	0.642
74.0	2.9	1.065
53.5	4.9	1.589
32.5	9.1	2.208
18.5	12.6	2.534
3.5	18.7	2.929

Plot a graph of ln V against θ on the grid opposite. Use the column provided to show any processed data.

(5)

(iii) Determine values for b and V_0.

(4)

$b = \frac{3-0.6}{90-0} = \frac{2}{75} = 0.027$ large triangle

$\ln(V_0)$ = y intercept ∴ $\ln(V_0) = 3$

$0.642 + 0.027(89) = 3.045$

$\ln(V_0) = 3.045$

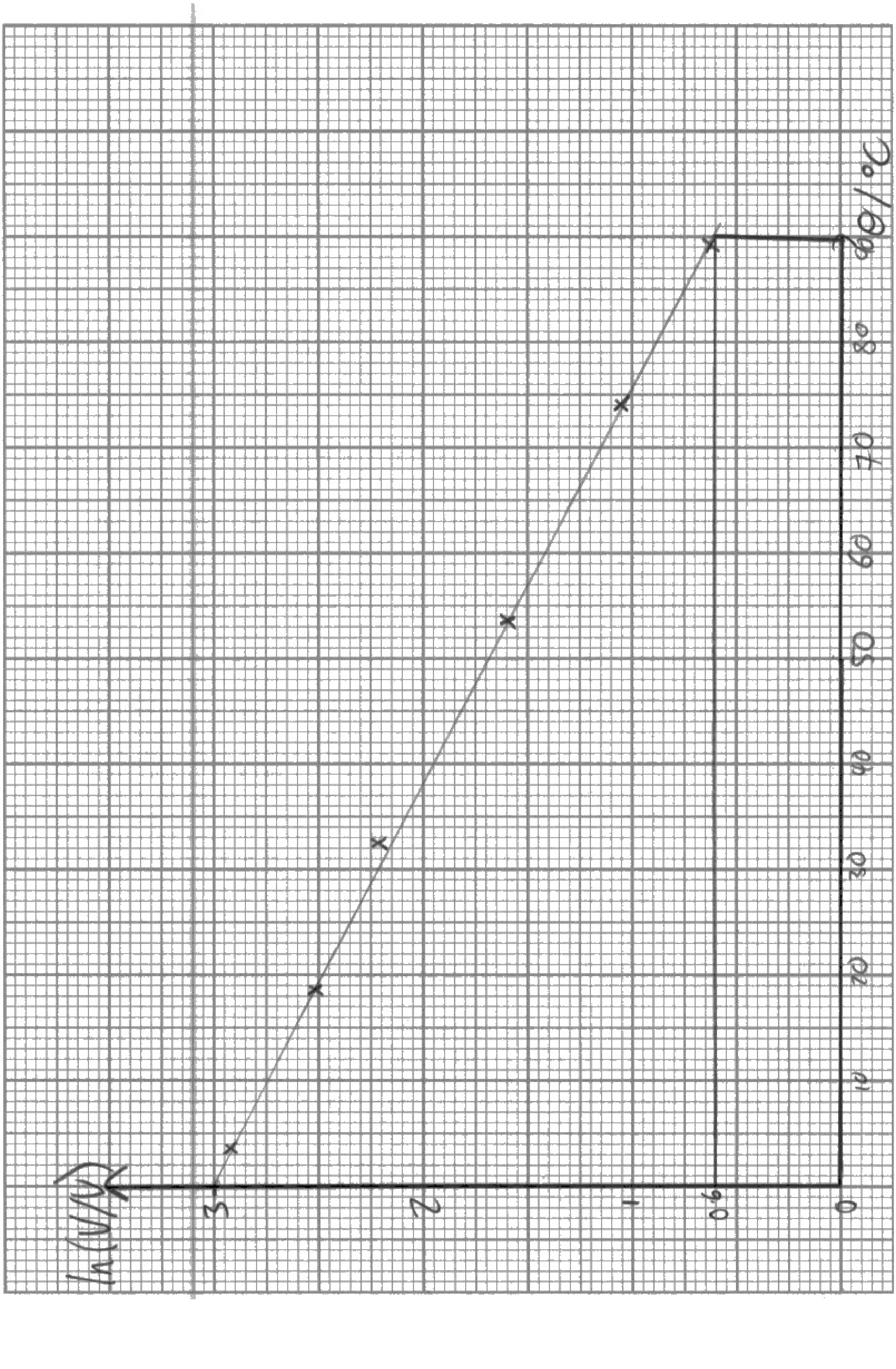
$V_0 = e^{3.045} = 21.01$

$\ln V = \ln V_0 - b\theta$

$V = V - (b)$ °C

$b =$ 0.027 °C^{-1}

$V_0 =$ 21 V


θ/°C
0
10
20
30
40
50
60
70
80
90
3
2
1
0.6

ResultsPlus
Examiner Comments

The ln$V$ values are correctly calculated to 3 decimal places, and the axis labels follow correct connections for units. The graph grid has been rotated to make better use of the space available, and the plots and line of best fit are accurate.

A large triangle (at least half of the drawn line) is used to calculate the gradient, and the intercept is read from the y-axis accurately. The value for b is within range and correct units are included. V_0 is also in range with correct units.

ResultsPlus
Examiner Tip

Rotate the graph grid as it enables a more efficient use of the available space.

Question 12 (a)(i)

This was well answered, although a worrying minority of candidates either did not know the numbers for a beta particle or struggled with applying the minus sign in the bottom line.

Question 12 (a)(ii)

Most candidates scored full marks here with a good understanding of lambda, and the decay equation. Many candidates insisted on using seconds instead of years so gave themselves extra work, but still were able to find the right answer. A few candidates missed out the factor of 5000.

(ii) An activity of 2.35×10^{12} Bq per m^3 of water in the reservoir was measured. It is suggested that a safe level for the activity of all water in the reservoir would be 100 Bq.

Calculate the time in years for the caesium-137 to decay to a safe level.

volume of water in reservoir = 5000 m^3
half-life of caesium-137 = 30 years

(4)

$2.35 \times 10^{12} \times 5000 = 1.175 \times 10^{16}$ Bq.

$\lambda = \frac{\ln 2}{30}$

$A = A_0 e^{-\lambda t}$

$100 = (1.175 \times 10^{16}) e^{-\frac{\ln 2}{30} t}$

$-\ln\left(\frac{100}{1.175 \times 10^{16}}\right) = \frac{\ln 2}{30} t$

$\Rightarrow t = 1402.18...$

Time = 1400 years

ResultsPlus Examiner Comments

The decay constant is calculated in $year^{-1}$, which is fine as the final answer is required in years. The 5000 m^3 is used, and the final answer is correct.

(ii) An activity of 2.35×10^{12} Bq per m^3 of water in the reservoir was measured. It is suggested that a safe level for the activity of all water in the reservoir would be 100 Bq.

Calculate the time in years for the caesium-137 to decay to a safe level.

volume of water in reservoir = 5000 m^3
half-life of caesium-137 = 30 years

(4)

$A = A_0 e^{-\lambda t}$. $\lambda = \frac{\ln 2}{t_{1/2}} = \frac{\ln 2}{30 \times 365 \times 24 \times 3600} = 7.33 \times 10^{-10}$

~~2.235 × 10^12 Bq per m^3.~~

~~2.235 × 10^12 × 5000~~

$2.35 \times 10^{12} \times 5000 = 1.175 \times 10^{16}$ Bq for all the reservoir.

$100 = 1.175 \times 10^{16} e^{-7.33 \times 10^{-10} t}$

$\ln\left(\frac{100}{1.175 \times 10^{16}}\right) \div (-7.33 \times 10^{-10}) = t$ $t = 4.42 \times 10^{10}$ seconds

$\frac{4.42 \times 10^{10}}{3600 \times 24 \times 365} =$ ~~1401 years.~~

Time = 1402 years

$= 1401.5$
=> 1402 years

ResultsPlus
Examiner Comments

The decay constant is calculated in s^{-1}. Although correct, this was not absolutely necessary. As the time elapsed is required in years, a conversion from s to year is required at the end of the calculation. This is done correctly here, although some candidates who did this made arithmetic errors in their unit conversions.

ResultsPlus
Examiner Tip

If the equation $A = \lambda N$ is used, λ must be in s^{-1}. Otherwise, λ and t just need to be in complementary units.

Question 12 (b)

Most candidates did well here but many were tripped up at one stage or another. Surprisingly few candidates used the concept of half-life, with most using the decay equations. Many candidates missed MP3. MP4 was well understood. Some candidates tried to work backwards to find *N*, or even *T* and these were, in general, less successful.

(b) The most common radionuclide amongst the fission products in the fuel was iodine-131, which decays with a half-life of 8.0 days to form a stable isotope of the gas xenon.

Deduce whether enough xenon would have collected in 32 days to exert a pressure of 1.0×10^5 Pa in a volume of 450 m^3. Assume that no gas escapes.

temperature = 20 °C
initial number of iodine nuclei = 1.25×10^{28}

(6)

pV = nKT $\lambda = \frac{\ln 2}{8} = 0.0866$

~~0.0866 x 1.25x10^28 = 1.083 x10^27 = N after 1 day~~

$N = N_0 e^{-0.866 \times 32}$ $1.25 \times 10^{28} \times e^{-2.772588...}$

$N = 7.8 \times 10^{26}$ change = $1.178.1875 \times 10^{28}$ N collected

$\frac{1 \times 10^5 \times 450}{k \times 293} = 1.1129 \times 10^{28}$ required

$1.178 \times 10^{28} > 1.1129 \times 10^{28}$

so sufficient amount of xenon is produced in 32 days.

ResultsPlus
Examiner Comments

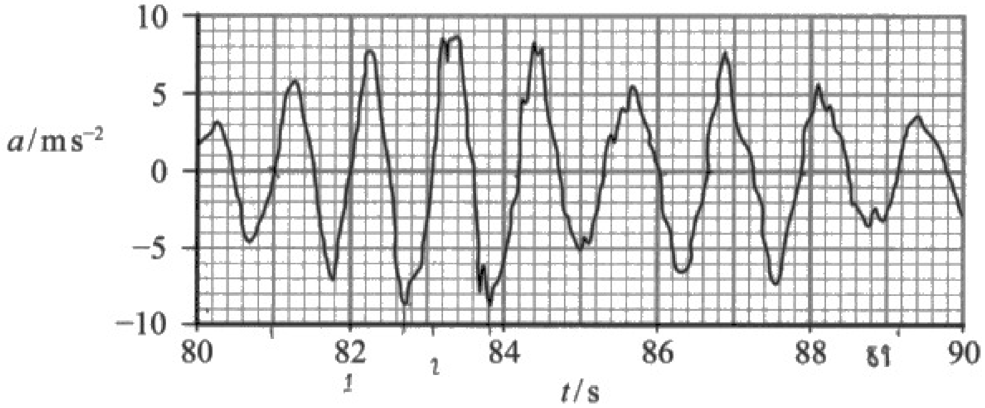
This response scores all 6 marks. The number of molecules required to give the required pressure is compared with the actual number of molecules in the gas. The number of unstable nuclei remaining has been subtracted from the initial number of unstable nuclei to give a correct value for the number of molecules in the gas.

Question 12 (c)

Candidates found it hard to recognise SHM here, with many attempting to use $s = v\,t$. Those that did attempt the question normally scored marks, with MP1, MP3, MP4, and MP5 being awarded regularly. MP2 was poorly completed with most candidates not recognising the need for multiple cycles when using real world data. Most candidates wrote good conclusions as part of MP5.

(c) Buildings in nearby Tohoku University suffered structural damage during the 2011 earthquake.

The graph shows how the acceleration of one of the buildings, measured on the 9th floor, varied with time during the earthquake.



(Source: https://www.sciencedirect.com/science/article/pii/S0038080612001035)

At the time it was reported that during the earthquake the 9th floor of the building displaced by more than 30 cm from its normal position.

Assess the accuracy of this report.

(5)

max $a = -8.9\,ms^{-2}$ $a = -A\omega^2 \cos \omega t$

$\omega = 2\pi/T$ $= -A\omega^2$

$7T = 89.19 - 81$ $\omega = 5.37\ rad\,s^{-1}$ $\omega^2 = 28.84$

$= 8.19$ $8.9 = 28.84(A)$

$T = 1.17s$ $= 0.3086\,m \approx 31cm$

max amplitude was recorded to be ~~30~~ over 30cm so report is accurate, but most of the time it was much less than 30cm. this only ~~occure~~ occured in a 1s interval Also likely for energy to be lost through building so may not be 30cm in actual fact, this ~~is~~ from raw data, may not have displaced so far.

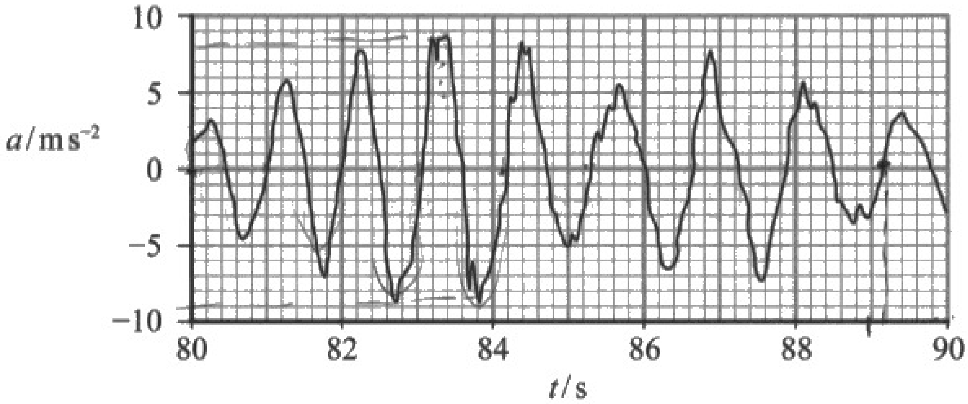
(Total for Question 12 = 17 marks)

ResultsPlus
Examiner Comments

This response works through all the steps correctly to arrive at a correct conclusion. Since the value calculated for the amplitude is close to 30 cm, the conclusion is cautious, but it is clear that a valid conclusion based on the data has been drawn.

(c) Buildings in nearby Tohoku University suffered structural damage during the 2011 earthquake.

The graph shows how the acceleration of one of the buildings, measured on the 9th floor, varied with time during the earthquake.



(Source: https://www.sciencedirect.com/science/article/pii/S0038080612001035)

At the time it was reported that during the earthquake the 9th floor of the building displaced by more than 30 cm from its normal position.

Assess the accuracy of this report.

(5)

$x = A\cos\omega t$. $a = -A\omega^2 \cos\omega t$

~~time for 8 waves = 89.2 s − 80 ... $T = \frac{89.2}{8} = 11.15$~~

~~$\omega = \frac{2\pi}{T} = \frac{2\pi}{11.15} = 0.564$~~. time for 8 waves = 89.2 − 80 = 9.2 s

$\frac{9.2}{8} = 1.15$ s.

maximum magnitude of acceleration from graph ≈ 8.9 ms^{-2}

maximum $|a| = A\omega^2$ $T = \frac{2\pi}{\omega}$ ∴ $\omega = \frac{2\pi}{1.15} = 5.46$ rads^{-1}

~~$8.9 = A \times 5.64^2$~~   ~~A = 28.0 cm~~

$8.9 = A \times 5.46^2$ A = 0.298 m ≈ 29.8 cm

~~28.0 < 30 so the result is not accurate as it has not been displaced by more than 30cm~~

29.8 < 30 so not displaced by more than 30cm

but the value is very close to 30cm.

(Total for Question 12 = 17 marks)

ResultsPlus
Examiner Comments

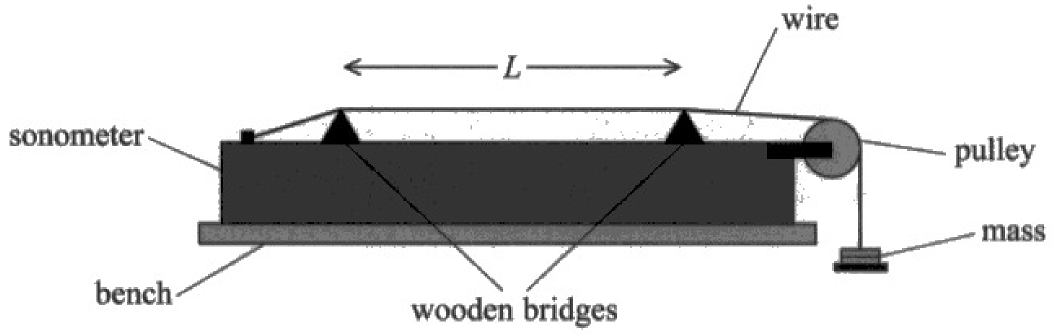
In this response the calculated value of the amplitude is less than 30 cm. This is not a problem, as the correct conclusion is drawn, based on the calculated data.

Question 13 (a)

Most candidates correctly applied ideas of standing waves here but there was too much reliance on rote learning and not enough application to the question. MP1 was often not awarded. Many candidates did not use the word "superpose" and so missed MP2. Most candidates scored MP3, but a significant minority did not describe a maximum amplitude/displacement.

13 A student used a sonometer to investigate the properties of a stretched wire. The sonometer is a long hollow wooden box.

A steel wire is attached to one end of the box and rests on two wooden bridges. The wire is placed under tension *T* by hanging a mass from the end of the wire, as shown.



The student placed the base of a vibrating tuning fork in contact with the wire, at one of the bridges. This set the wire into oscillation. He adjusted the position of the other bridge until a single-loop standing wave was produced on the wire between the bridges.

(a) Explain how an antinode is produced at the mid-point of the wire between the bridges.

(3)

When the standing wave is formed, there is a node at both bridges. The wave is fixed at the end, so the wave is reflected. When it is reflected, the peaks and troughs meet in phase and superimpose to form the standing wave. The point at the anti-node is where they superimpose to form a wave 2x amplitude of a normal one, and constructive interference also takes place.

ResultsPlus
Examiner Comments

The key features of the explanation are included. The references to nodes and antinodes are correct, but not necessary for marks to be awarded.

(a) Explain how an antinode is produced at the mid-point of the wire between the bridges.

(3)

Waves are reflected from the other bridge and interfere with emitted waves. The two waves constructively superpose because they are in phase. This means there is a vector addition of their displacements and maximum amplitude is produced.

ResultsPlus
Examiner Comments

This response includes the key elements of the explanation. There is no specific reference to the mid-point of the wire, but since this is specified in the question this detail can be assumed.

Question 13 (b)(i)

Most candidates scored a mark here. Those that did not typically described keeping feet safe without giving an example of how to do it e.g. no mention of a landing pad.

Question 13 (b)(ii)

Most candidates scored well here, however a significant minority did not use that $\lambda = 2L$. Some tried to work backwards but this was generally less successful.

(ii) The student plotted a graph of L^2 against $1/f^2$.

Show that the gradient of this graph is equal to $\frac{T}{4\mu}$

(3)

$v = \sqrt{\frac{T}{\mu}}$ $\quad\quad$ $v = f\lambda$

$2fL = \sqrt{\frac{T}{\mu}}$ $\quad\quad$ $v = f(2L)$

$4f^2L^2 = \frac{T}{\mu}$

$L^2 = \frac{T}{4\mu} \times \frac{1}{f^2}$

when relating to $y = mx + c$ the equation of a straight line the gradient is $\frac{T}{4\mu}$

ResultsPlus
Examiner Comments

This response sets out the algebra clearly so that the progression is clear.

ResultsPlus
Examiner Tip

Set your work out clearly when problem solving and re-arranging equations.

(ii) The student plotted a graph of L^2 against $1/f^2$. against snapping wire

Show that the gradient of this graph is equal to $\frac{T}{4\mu}$

(3)

$v = f\lambda = 2Lf$

$2Lf = \sqrt{\frac{T}{\mu}}$

$4L^2f^2 = \frac{T}{\mu}$

$L^2 = \frac{1}{f^2} \times \frac{T}{4\mu}$

y ↑ x ↑ m ↑

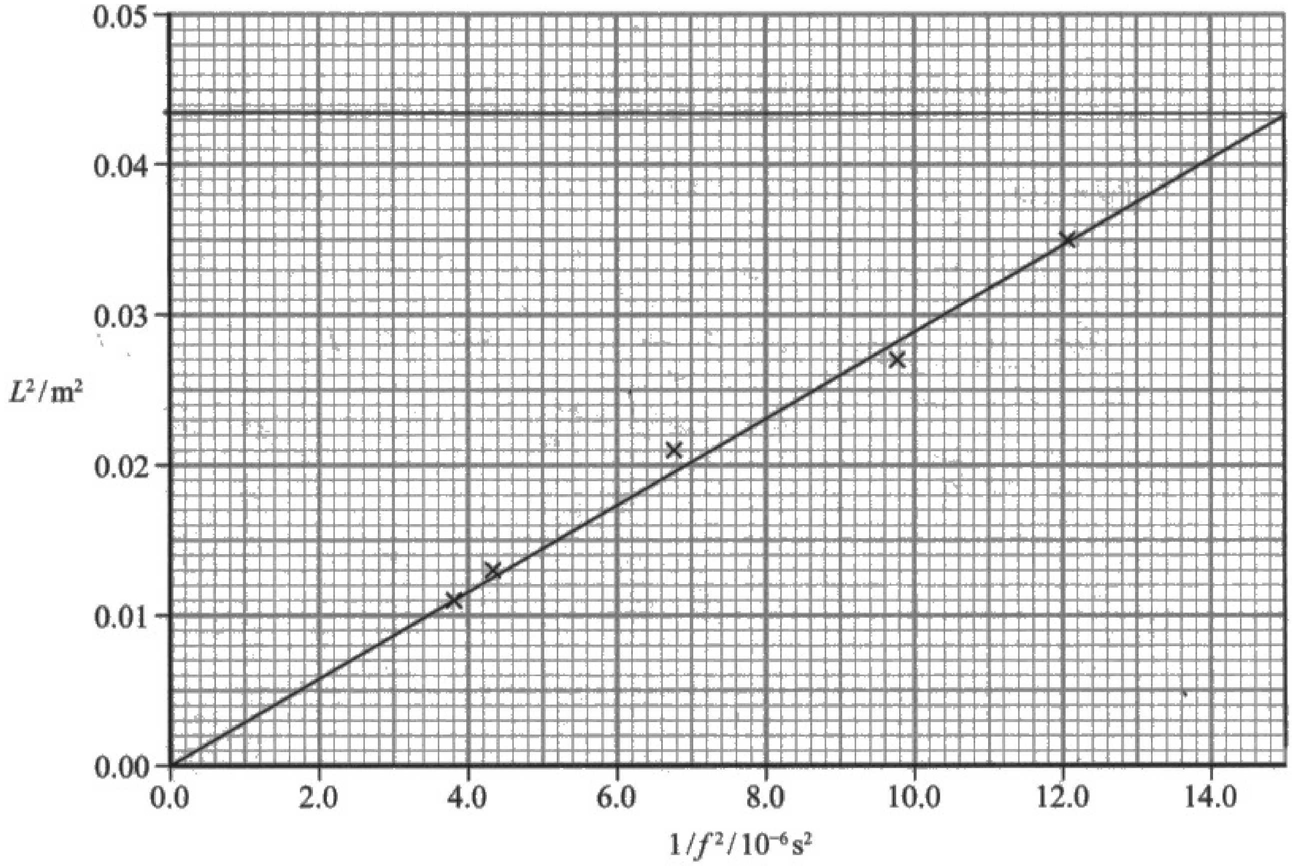
ResultsPlus
Examiner Comments

In this response specific reference to the equation of a straight line is made, although this was not strictly required here.

Question 13 (b)(iii)

Most candidates scored well here. MP1 was largely good, although a significant minority did not read the scales correctly when calculating the gradient. Some candidates omitted to calculate tension for MP2, and a few candidates forgot to say "SWG 24" for MP4.

(iii) The student's graph is shown below.



The value of μ for different standard wire gauge (SWG) steel wire is shown in the table.

SWG	μ / g m^{-1}
22	3.15
24	1.95
26	1.31

Deduce which wire the student used in the investigation.

(4)

$\frac{0.0435}{15\times10^{-6}} = \frac{T}{4\mu}$

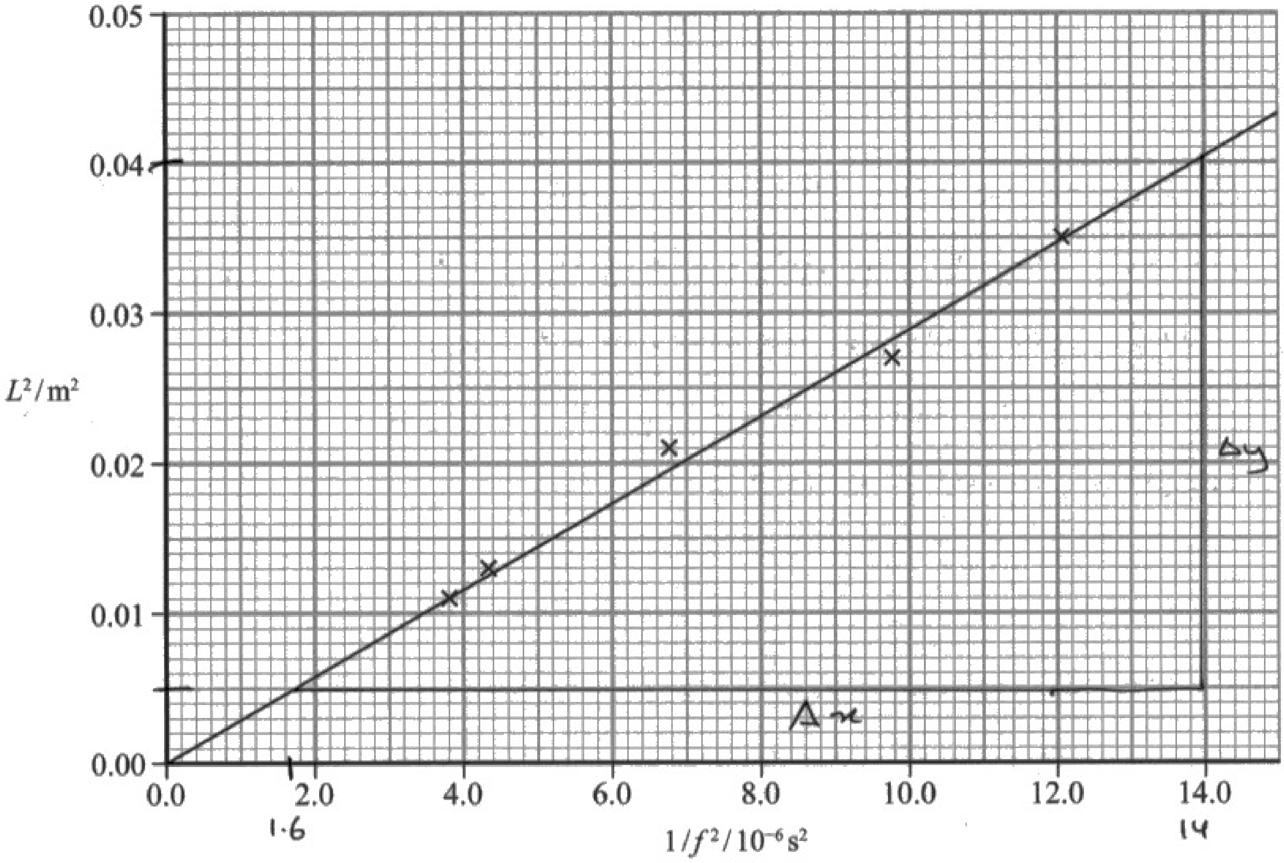
$\frac{2.1\times10^{3}\times 9.81}{4\left(\frac{0.0435}{15\times10^{-6}}\right)} = 1.78$ g m^{-1}

1.78 closest to 1.95 so 24 SWG wire

ResultsPlus
Examiner Comments

This response is typical of many that were seen. There is a determination of the gradient and a calculation of the mass per unit length together with a correct selection of the likely swg so full marks gained.

(iii) The student's graph is shown below.



The value of μ for different standard wire gauge (SWG) steel wire is shown in the table.

SWG	$\mu/\text{g m}^{-1}$
22	3.15
24	1.95
26	1.31

Deduce which wire the student used in the investigation.

(4)

$m = \frac{T}{4\mu}$ → gradient $= \frac{mg}{4\mu}$ → $2823 = \frac{2.1 \times 9.81}{4\mu}$

→ $\mu = 1.82$

$\frac{\Delta y}{\Delta x} = \frac{0.04 - 5\times10^{-3}}{(14-1.6)} = \frac{0.035}{1.24\times10^{-5}} = 2823$

wire closest to 1.95, so the SWG 24 was used

$\%\text{diff} = \frac{1.95 - 1.82}{1.95} \times 100$

$\%\text{diff} = 7\%$

ResultsPlus
Examiner Comments

This response shows a correct gradient determination and a calculated value of the mass per unit length of the wire that is correct. The difference between this calculated value and the nearest value in the data table is calculated, although this wasn't necessary to make a correct conclusion. The response scores full marks.

Question 13 (c)(i)

Most candidates scored MP1 here, but few managed to address the "explain" in the question for MP2.

(c) The student then found a value of μ for a brass wire, using a different method.

(i) He measured the diameter d of the wire using a micrometer.

Explain one technique the student should use when measuring d.

(2)

measure from multiple different orientations and positions along the wire and find average. (at least 6). reduces effect of random error and gets more accurate result because of any inconsistencies in diameter. reduces uncertainty.

ResultsPlus Examiner Comments

The standard response of taking multiple readings in different positions / orientations along the wire scores MP1 here. The reference to inconsistencies in the diameter is accepted as being equivalent to the statement that the wire diameter may not be uniform.

(c) The student then found a value of μ for a brass wire, using a different method.

(i) He measured the diameter d of the wire using a micrometer.

Explain one technique the student should use when measuring d.

(2)

- measure the brass from different angles and at different points of the wire to calculate the mean diameter of wire as wire may be uneven at some points along wire.

ResultsPlus Examiner Comments

MP1 is clearly met. The reference to the wire being uneven at some points along the wire is just enough for MP2.

Question 13 (c)(ii)

This was well answered by some candidates, who used % uncertainties well. These candidates tended to score full marks. However, several candidates did not use the mean to find the % uncertainty in *d*. MP2 was very well answered, and most candidates scoring MP2 also scored MP3 and MP4. Some candidates attempted to work backwards from the stated value of *m* to find density. This method often missed out on a number of marks, as candidates only used the uncertainty in density. A significant minority did not score MP5. A minority of candidates attempted no error analysis although a worrying few tried to use the volume of a sphere.

(ii) The student obtained the following data.

d / mm			
0.55	0.59	0.57	0.58

The stated value of μ for the brass wire used by the student was $2.14 \times 10^{-3}\,\text{kg m}^{-1}$.

Deduce whether the student's data supports this value for μ.

density of brass = $8700\,\text{kg m}^{-3} \pm 200\,\text{kg m}^{-3}$

(6)

Uncert in $d = \frac{1}{2}$ range $= \frac{1}{2}(0.59\times10^{-3} - 0.55\times10^{-3})$
$= 2\times10^{-5}$

Mean $= 5.725\times10^{-4}$ m

percentage uncertainty $= \frac{2\times10^{-5}}{5.725\times10^{-4}} \times 100 = 3.49\%$

~~the~~ crosssectional area:

$\pi r^2 = \pi\left(\frac{5.725\times10^{-4}}{2}\right)^2 = 2.574\times10^{-7}$

Percentage uncertainty $= 3.49 + 3.49 = 6.98\%$

Density $= \frac{M}{V}$ ~~percentage uncertainty of density~~

μ = Dens × Area   Percentage uncertainty in density
$= \frac{200}{8700} \times 100 = 2.30\%$

$\mu = 8700 \times 2.574\times10^{-7} = 2.239\times10^{-3}$

percentage uncert $= 2.30 + 6.98 = 9.28\%$

9.28% of $2.239\times10^{-3} = 2.078\times10^{-4}$ $2.03\times10^{-3} \leq \mu \leq 2.45\times10^{-3}$

so data supports $\mu = 2.14\times10^{-3}$

(Total for Question 13 = 19 marks)

ResultsPlus
Examiner Comments

This response shows good understanding of uncertainties and how they combine when multiple quantities are used to calculate a final value. The response scores full marks.

Paper Summary

Based on their performance on this paper, candidates should:

- ensure they have a thorough knowledge of the physics content of the whole specification.
- be ready to apply their knowledge of core practicals and general techniques to questions testing their indirect practical skills.
- read each question carefully, and answer what is asked. Show all workings in calculations.

For extended writing questions:

- make a note of the marks available and include that number of different physics points in their response.
- try to base the answer around a specific equation or principle.
- formulate a response that is consistent with the command word used in the question.

Grade boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

https://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London WC2R 0RL.