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Examiners' report

PHYSICS B (ADVANCING PHYSICS)

H557
For first teaching in 2015

H557/01 Summer 2019 series

Version 1

Contents

Introduction

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

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

Paper 1 series overview

H557/01 'Fundamentals of Physics' component is worth 110 marks and assesses specification content from across all the teaching modules.

Section A consisted of thirty multiple choice questions, each worth one mark.

Section B included five structured short answer questions worth a total of 21 marks. Each question typically examined a single context. To do well on this section candidates needed to be comfortable answering questions that involved problem-solving and practical-based questions as well as performing calculations.

Section C, consisted of six questions worth 59 marks in total. In addition to some short answer questions there were two opportunities for extended writing (Questions 38a and 40b) worth 6 marks each.

Candidate performance overview

Candidates who did well on this paper generally:

- Attempted all the multiple choice questions in Section A.
- Performed the calculations required in Section B well.
- Were able to explain their reasoning, for example when stating the initial horizontal projection velocity in response to Question 32b.
- Applied their knowledge in contexts, for example the image processing techniques in Question 36.
- Used sound physics, covering fully the required strands identified in the question, in a logical structure such as for the extended response questions 38a and 40b.
- Were able to find the radius of orbit of a star, given the information provided in Question 38b, before going on to calculate the mass and the Schwarzschild radius of the object near the galactic centre.

Candidates who did less well on this paper generally:

- Found it difficult to present sound reasoning for questions that required explanation - for example in Question 37bi where they needed to explain the meaning of two sides of an approximation.
- Made errors in Questions 38bi, 39ai 40ai, 41ai, which required them to read information from graphs – for example by reading the current scale in Amps rather than milliAmps when determining the internal resistance of the cell in Question 40.
- Found it hard to manipulate algebraic expressions, for example in Question 38b
- Covered just one of the required strands for the extended response questions 39a and 40b and lacked structure in their reasoning.

There was little evidence that any time constraints had led to a candidate underperforming, with most candidates the final question well.

Note

From this series students have been provided with a fixed number of answer lines and an additional answer space. The additional answer space will be clearly labelled as additional and is only to be used when required. Teachers are encouraged to keep reminding students about the importance of conciseness in their answers. Please follow this link to our SIU:
https://www.ocr.org.uk/administration/support-and-tools/siu/alevel-science-538595/

Section A overview

This section consisted of thirty multiple choice questions, each worth one mark.

Question 2

2 Which quantity is followed by a reasonable estimate of its order of magnitude?

A momentum of a bee in flight $10^{0}\,\text{kg m s}^{-1}$

B speed of an air molecule at room temperature $10^{6}\,\text{m s}^{-1}$

C wavelength of red light $10^{-6}\,\text{m}$

D wavelength of X-rays $10^{-15}\,\text{m}$

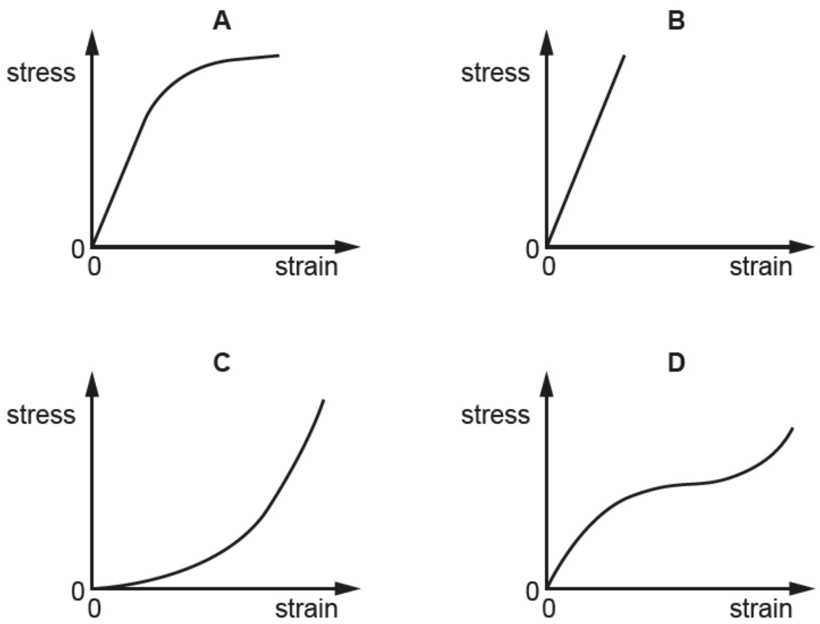
Your answer **[1]**

About half of candidates recognised the correct estimate as that of the wavelength of red light, but the range of other responses selected suggests that many candidates are not familiar with estimated order of magnitudes of everyday quantities as section 2(c)(iii) of the specification requires.

Question 3

The following information is for use in questions **3** and **4**.

The stress–strain graphs for four different materials are shown.



3 Which diagram shows the stress–strain graph for a ductile metal?

Your answer **[1]**

Question 4

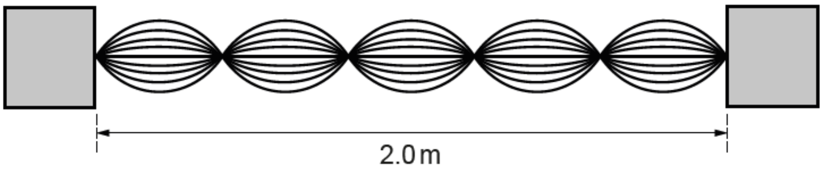
4 Which diagram shows the stress–strain graph for a rubber polymer?

Your answer ☐ **[1]**

Almost half of candidates could correctly identify A as the stress-strain graph for a ductile metal and, likewise, select graph D as being that of a rubber polymer.

Question 6

The diagram is for use in questions **6** and **7**.
The diagram shows a sketch of a wave pattern on a vibrating string.



6 Which description of this wave is correct?

A The wave is longitudinal, has a wavelength of 40 cm and is stationary.

B The wave is transverse, has a wavelength of 40 cm and is stationary.

C The wave is transverse, has a wavelength of 80 cm and is progressive.

D The wave is transverse, has a wavelength of 80 cm and is stationary.

Your answer ☐ **[1]**

A common error was to correctly identify that the wave is transverse and stationary but incorrectly calculate the wavelength as 40cm instead of 80cm.

Question 7

7 The frequency of the wave shown in the diagram is 3.0 Hz.

What is the wave speed on the string?

A 1.2 m s^{-1}

B 2.4 m s^{-1}

C 3.8 m s^{-1}

D 7.5 m s^{-1}

Your answer **[1]**

Exemplar 1

The frequency of the wave shown in the diagram is 3.0 Hz.

What is the wave speed on the string?

$v = f\lambda$

$= 3 \times$ ~~[illegible]~~ $0.8 = 2.4$

A 1.2 m s^{-1}

B 2.4 m s^{-1}

C 3.8 m s^{-1}

D 7.5 m s^{-1}

Your answer B

Whilst working is not required or credited, successful candidates, as in this exemplar, often showed their working for multiple-choice questions that involved calculations.

Question 8

8 A signal is digitised by sampling at 22 kHz.
The total voltage variation is 2.0 V and the noise voltage variation is 1.0 mV.

Which statement is correct?

A The highest frequency accurately sampled will be 11 kHz.

B The recommended number of bits per sample is 8.

C The voltage resolution of the sampling should be about 0.1 mV.

D $\frac{V_{total}}{V_{noise}} \approx 11 \times 10^3$

Your answer ☐ **[1]**

Most candidates were able to select the correct response, A, based on their understanding that the minimum rate of sampling should be at least 2 × maximum frequency of the signal.

Question 11

11 A nickel wire has conductance of 0.43 S, a length of 2.0 m and a cross-sectional area of 5.0×10^{-7} m^2.

What is the conductivity of nickel in S m^{-1}?

A 1.1×10^{-7}

B 5.9×10^{-7}

C 1.7×10^{6}

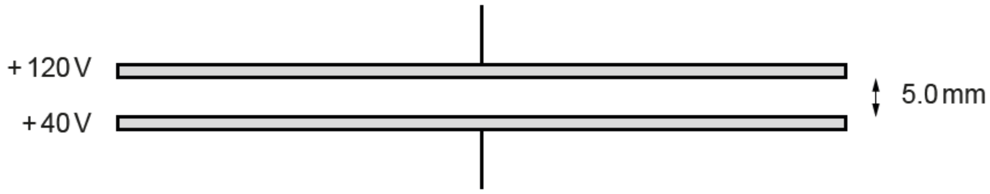
D 9.3×10^{6}

Your answer ☐ **[1]**

A common error was to incorrectly substitute the conductance value of 0.43 as conductivity into the formulae G = σA/l, leading to an answer of 1.1×10^{-7}.

Question 13

13 Two horizontal metal plates are 5.0 mm apart.
The plates are at potentials of +120 V and +40 V.



What is the force experienced by an electron in the electric field between the plates?

A 2.6×10^{-18} N

B 5.1×10^{-18} N

C 2.6×10^{-15} N

D 5.1×10^{-15} N

Your answer **[1]**

Successful candidates used the information provided in the formulae and data booklet (E = F/q = V/d and e = -1.6×10^{-19} C) to answer this question correctly.

Question 14

14 The resistance R of an unknown resistor is found by measuring the potential difference V across the resistor and the current I through it, using the equation

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

The voltmeter reading has a 2% uncertainty and the ammeter reading has a 3% uncertainty.
What is the best estimate of the uncertainty in the calculated resistance?

A 0.7%

B 3%

C 5%

D 6%

Your answer **[1]**

The majority of candidates were able to recognise that they should add the uncertainties to give 5% in this arrangement of a formulae where data is combined by division.

Question 19

19 Protons consist of quarks.

The 'up' anti-quark has a charge of $-\frac{2e}{3}$ and the 'down' anti-quark has a charge of $+\frac{1e}{3}$, where e is the charge on an electron.

What does an **anti-proton** contain?

	Up anti-quarks	Down anti-quarks
A	0	3
B	1	1
C	1	2
D	2	1

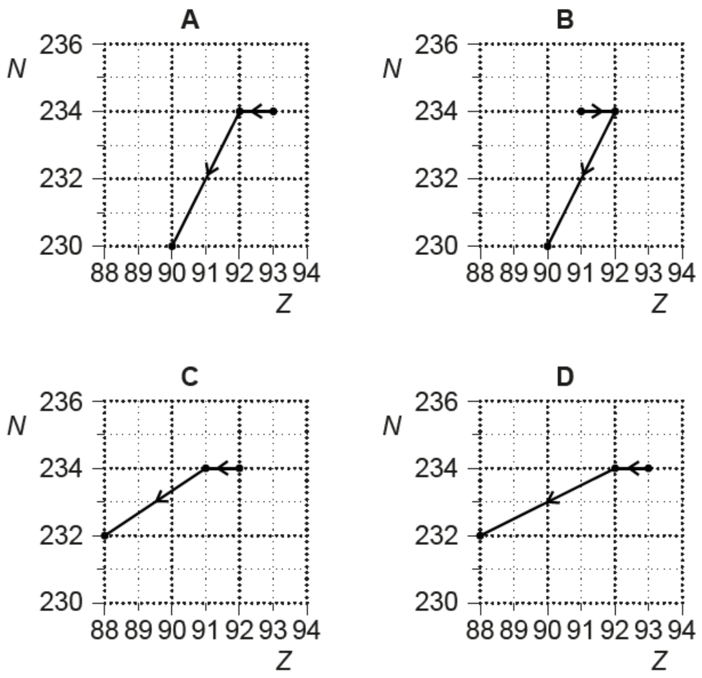
Your answer ☐ **[1]**

This question required candidates to infer that, as the anti-particle to a proton, the charge on an anti-proton is -1 electric charge and then to deduce the correct quark composition to give that overall charge is 2 up and 1 down anti-quarks.

Question 20

20 A radioactive nucleus is formed by β-decay. This nucleus then decays by α-emission.

Which graph of nucleon number *N* plotted against proton number *Z* shows the β-decay followed by the α-emission?



Your answer [1]

The key to answering this question was for candidates to recognise that only one graph has β decay represented as indicated by the "horizontal" arrow which shows an increase in Z of 1, with no change in N. Graph B is, therefore, the only alternative that includes both β and α decay as required.

Question 21

The following information is for use in questions **21** and **22**.

Two radioactive sources of equal mass are freshly prepared.
One is ^{225}Ra, which has a half-life of 15 days.
The other is ^{225}Ac, which has a half-life of 10 days.

21 After 30 days which ratio gives $\dfrac{\text{number of } ^{225}\text{Ra atoms remaining}}{\text{number of } ^{225}\text{Ac atoms remaining}}$?

A $\frac{1}{2}$

B $\frac{3}{4}$

C $\frac{4}{3}$

D 2

Your answer ☐ **[1]**

Question 22

22 After 30 days which ratio gives $\dfrac{\text{activity of the } ^{225}\text{Ra source}}{\text{activity of the } ^{225}\text{Ac source}}$?

A $\frac{1}{2}$

B $\frac{3}{4}$

C $\frac{4}{3}$

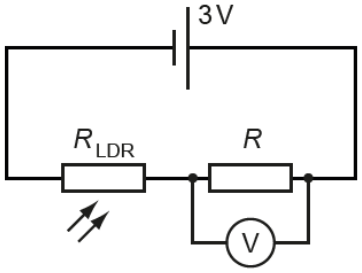
D 2

Your answer ☐ **[1]**

This pair of questions about radioactive sources required candidates to calculate ratios. Most candidates correctly identified the relevant number of half-lives for each source after 30 days and select D as the correct answer to Question 21. A common mistake in Question 22 was to neglect the decay constant, λ, and make the assumption that activity is proportional to the number of atoms, and therefore that the ratio is also 2 for this question, rather than 4/3 (response C).

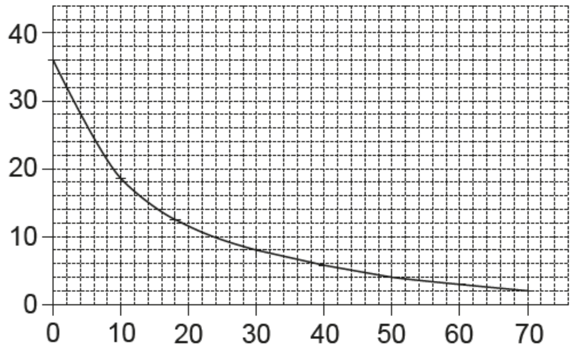
Question 23

23 An LDR is used in a potential divider circuit.



The graph shows the LDR resistance against light intensity.

LDR resistance R_{LDR} / kΩ



light intensity / × 10^3 lux

When the light intensity on the LDR is 30 × 10^3 lux, the reading on the voltmeter is 2.0 V.
What is the resistance R of the resistor?

A 4.0 kΩ

B 8.0 kΩ

C 12 kΩ

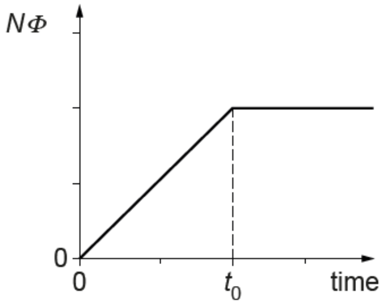
D 16 kΩ

Your answer [ ] **[1]**

To successfully select response D, candidates needed to read the value of LDR resistance as 8kΩ from the graph, and then recognise that the potential divider voltage ratio requires the value of R to be twice that of the LDR.

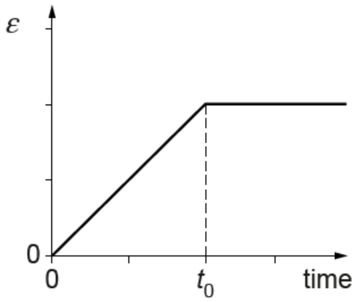
Question 24

24 The graph shows how the flux linkage $N\Phi$ through a coil changes with time when the coil is moved into a magnetic field.

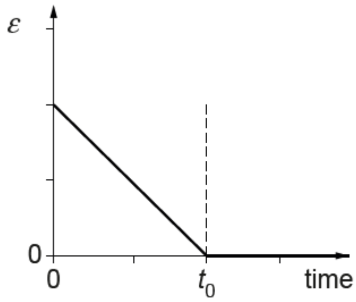


Which of the following graphs shows the magnitude of the induced e.m.f. ε in the coil over the same time period?

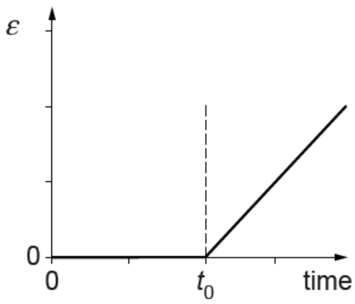
A



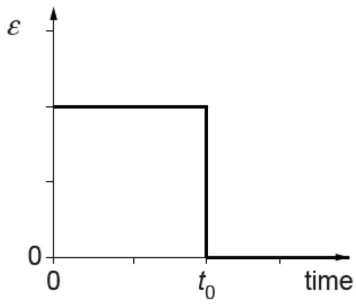
B



C



D

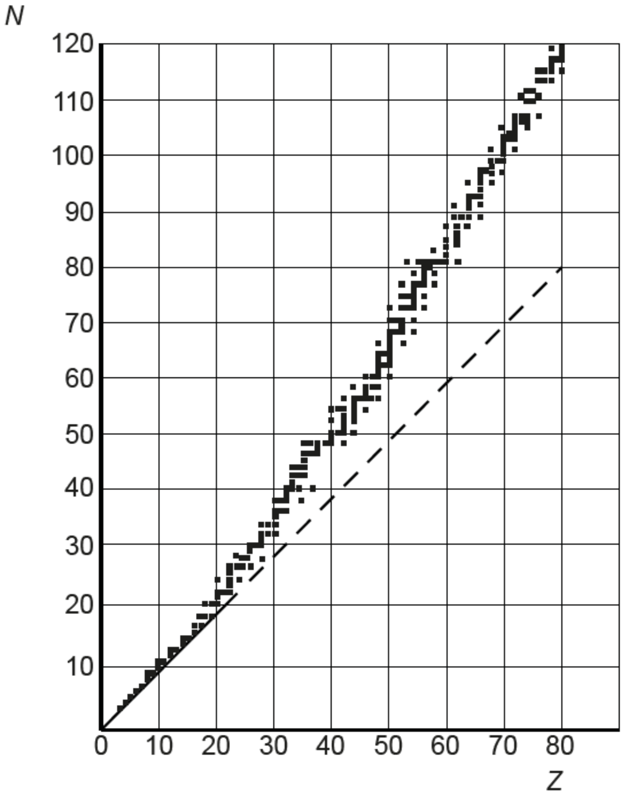


Your answer [ ] **[1]**

Candidates who recognised that induced e.m.f. is proportional to the rate of change of flux linkage were able to correctly identify that alternative D is the only graph that shows a constant non-zero magnitude of induced e.m.f. until $t_{0.}$

Question 29

29 The graph shows neutron number *N* plotted against proton number *Z* for stable nuclei.



Which statements about stable nuclei are correct?

1 Nuclei of elements with $Z > 20$ have more protons than neutrons.

2 For the nuclei of lighter elements $N \approx Z$.

3 Greater $\frac{N}{Z}$ ratio is needed to hold larger nuclei together, because only nearest neighbour nucleons take part in the strong nuclear force of attraction to balance electrostatic repulsion.

A 1, 2 and 3 are correct

B only 1 and 2 are correct

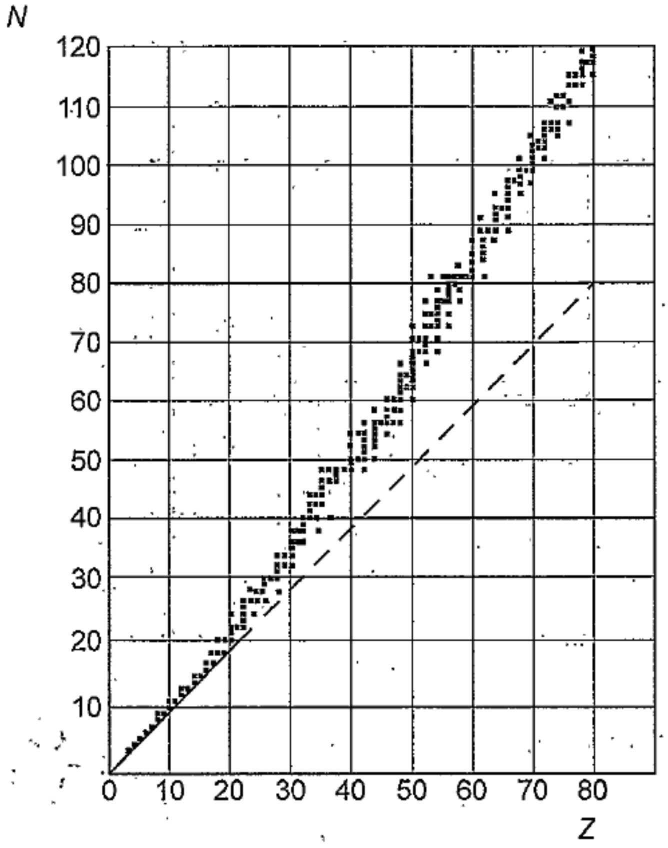
C only 2 and 3 are correct

D only 1 is correct

Your answer ☐ **[1]**

Exemplar 2

The graph shows neutron number N plotted against proton number Z for stable nuclei.



Which statements about stable nuclei are correct?

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3 Greater $\frac{N}{Z}$ ratio is needed to hold larger nuclei together, because only nearest neighbour nucleons take part in the strong nuclear force of attraction to balance electrostatic repulsion.

A 1, 2 and 3 are correct

B only 1 and 2 are correct

C only 2 and 3 are correct

D only 1 is correct

Your answer C **[1]**

This exemplar shows how candidates could successfully eliminate incorrect statements in response to this question. The candidate here has correctly eliminated statement 1 as it contradicts the information presented in the graph. Since the only response that does not include statement 1 is C, this must be the correct response. The candidate in this exemplar has also ticked to confirm statements 2 and 3 as correct.

Section B overview

This section included five structured short answer questions worth a total of 21 marks.

Question 32 (a) and (b)

32 A ball is projected horizontally twice with different velocities from 44 m above the base of a vertical cliff as shown in **Fig. 32**.

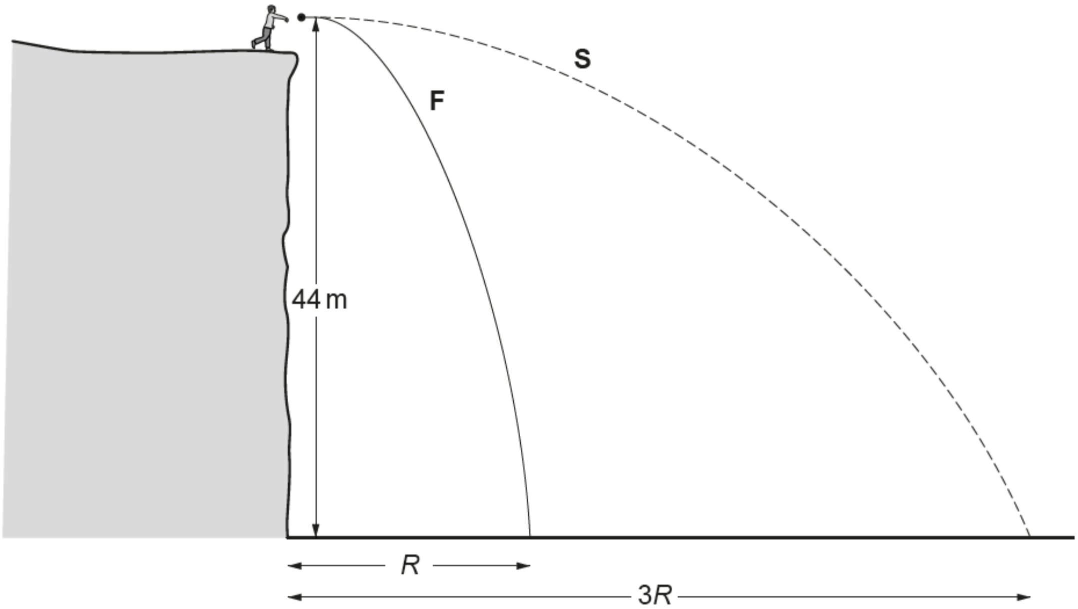


Fig. 32

(a) The first throw path **F** has initial horizontal velocity of $8.0\,\mathrm{m\,s^{-1}}$.

Calculate the horizontal range R for this path. You may ignore the effects of air resistance.

Gravitational acceleration, $g = 9.8\,\mathrm{m\,s^{-2}}$.

R = ... m **[3]**

(b) The second path **S** is also from a horizontal projection and achieves a range that is three times larger (3 R) than the first path **F**.

State the initial horizontal projection velocity for path **S**. Make your reasoning clear.

initial projection velocity = ... $\mathrm{m\,s^{-1}}$ **[2]**

Exemplar 3

A ball is projected horizontally twice with different velocities from 44 m above the base of a vertical cliff as shown in **Fig. 32**.

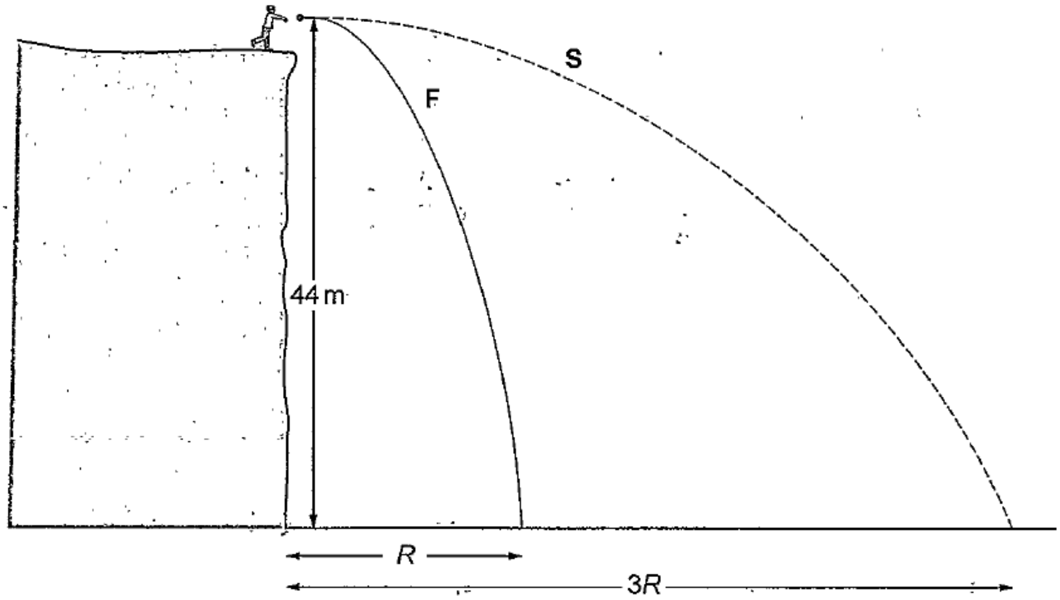


Fig. 32

(a) The first throw path **F** has initial horizontal velocity of $8.0\,\mathrm{m\,s^{-1}}$.

Calculate the horizontal range R for this path. You may ignore the effects of air resistance.

Gravitational acceleration, $g = 9.8\,\mathrm{m\,s^{-2}}$.

$-44 = \frac{1}{2} \times 9.8 \times t^2$ $3 \times 8 = 24$

$t \simeq 3s$

R = ...24...... m **[3]**

(b) The second path **S** is also from a horizontal projection and achieves a range that is three times larger ($3R$) than the first path **F**.

State the initial horizontal projection velocity for path **S**. Make your reasoning clear.

t will be the same
so for 3x the range
v must be 3x larger

initial projection velocity = ...24...... $\mathrm{m\,s^{-1}}$ **[2]**

Most candidates were able to correctly calculated R as 24m for part (a). For part (b) most candidates were able to correctly identity that the initial projection velocity as $24\mathrm{ms^{-1}}$; this candidate has also successfully shown their reasoning, i.e. "that t will be the same" to support their statement, enabling them to gain full credit.

Question 33 (a) (i), (ii), and (b)

33 A step-down transformer is shown in **Fig. 33**. Treat it as an ideal transformer.

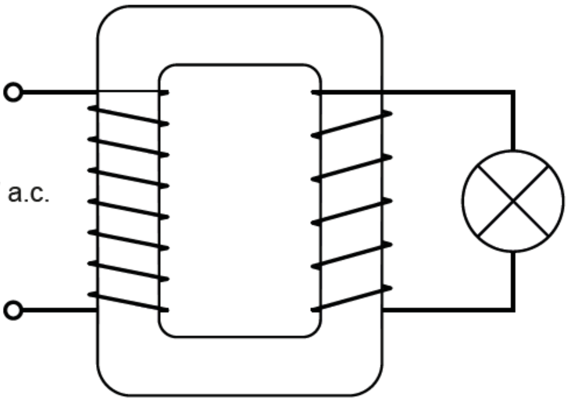


Fig. 33

(a) **(i)** Calculate the voltage across the lamp on the secondary coil.

voltage = ... V **[2]**

(ii) Calculate the current flowing in the primary coil.

current = ... A **[2]**

(b) Real transformers are not ideal because of energy losses.

State **one** reason for energy losses in transformers.

....

.... **[1]**

Exemplar 4

33 A step-down transformer is shown in **Fig. 33**. Treat it as an ideal transformer.

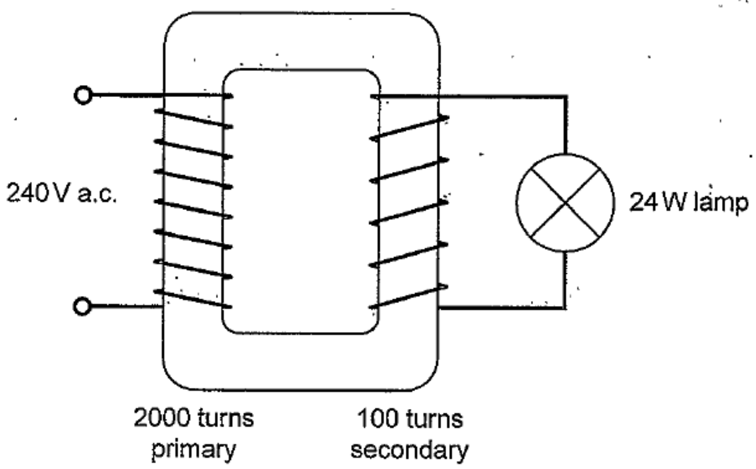


Fig. 33

(a) (i) Calculate the voltage across the lamp on the secondary coil.

$\frac{2000}{100} = 20 \quad \frac{240}{20} = 12V$

voltage = 12 V **[2]**

(ii) Calculate the current flowing in the primary coil.

$P = IV \quad \frac{P}{V} = I = \frac{24W}{12 AV} = 2 Amps \quad \frac{2}{20} = 0.1$

Alternativly: $\frac{24}{240} = 0.1$

current = 0.1 A **[2]**

(b) Real transformers are not ideal because of energy losses.

State **one** reason for energy losses in transformers.

Eddy currents disapate energy through heat.

[1]

Most candidates, as in this exemplar, correctly completed the calculations required in part (a). Part (b) provided good discrimination between candidates as the mark scheme required candidates to correctly identify a reason for the losses, making this a challenging question to get full marks. Responses often lacked sufficient detail by just stating, for example, "due to heat loss". In this exemplar, however, the candidate has correctly identified the reason - eddy currents – and the nature of the loss, in this case through heating.

Question 34 (b)

(b) The mean lifetime of π^- mesons at low speeds is 2.6×10^{-8} s.

Calculate the mean distance the fast mesons will travel before decaying.

mean distance = ... m **[2]**

Candidates found this part of Question 34 challenging. Successful candidates usually gained both marks for correctly using $L = \gamma \tau v$ to give a mean distance of 8.9m. The most common error was to omit the relativistic time dilation factor, γ, leading to an incorrect answer of 5.9.

Question 35

35 **Fig. 35** (not to scale) shows a double slit illuminated by laser light.
The positions of the central maximum and the first minimum for the waves incident on a distant screen are shown. The phasors representing these waves are given in the first and fourth rows of the table below. Positions **A** and **B** divide the distance between the central maximum and the first minimum into equal thirds.

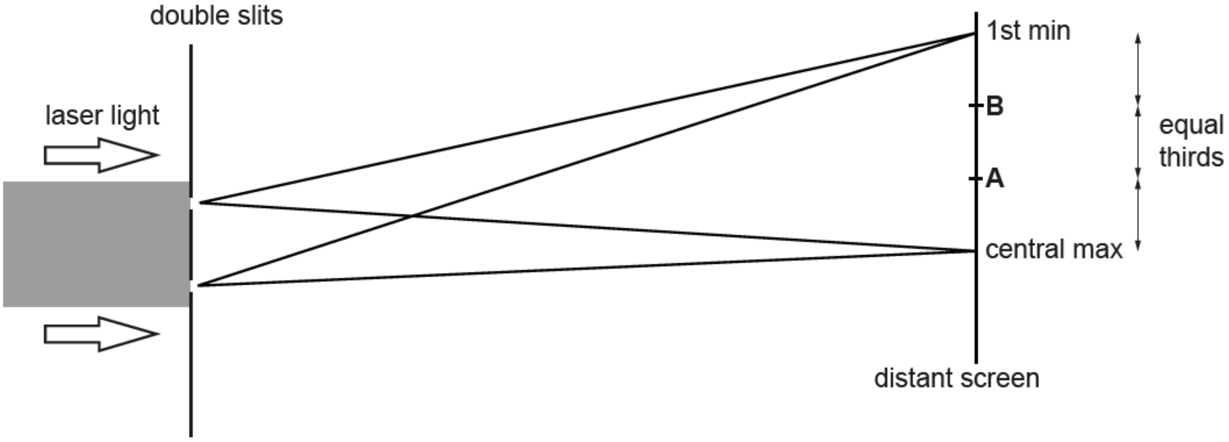
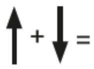


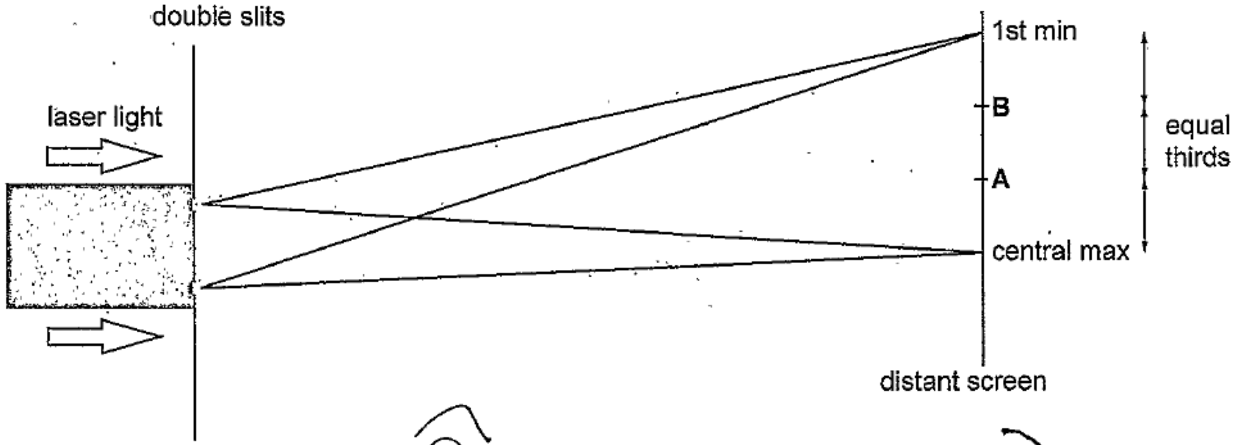
Fig. 35 (not to scale)

Position	**Phasors**	**Resultant phasor**	**Relative intensity**
1st min		0	0
B		1	1
A			
central max		2	4

Complete the table above for positions **A** and **B**, showing the phasors, their addition and the value of the relative intensity at the distant screen. **[3]**

Exemplar 5

35 **Fig. 35** (not to scale) shows a double slit illuminated by laser light.
The positions of the central maximum and the first minimum for the waves incident on a distant screen are shown. The phasors representing these waves are given in the first and fourth rows of the table below. Positions **A** and **B** divide the distance between the central maximum and the first minimum into equal thirds.



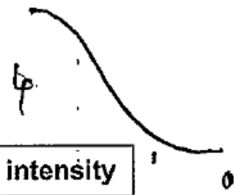


Fig. 35 (not to scale)

Position	Phasors	Resultant phasor	Relative intensity
1st min	↑ + ↓ =	0	0
B	↗ + ↘ = →	1	1
A	↑ + → = ↗	$\sqrt{2}$	2
central max	↑ + ↑ = ↑	2	4

Complete the table above for positions **A** and **B**, showing the phasors, their addition and the value of the relative intensity at the distant screen. **[3]**

Candidates of all abilities found this question challenging. This exemplar shows how examiners applied professional judgement where the mark has been awarded for the attempt at an equilateral triangle in position B. The exemplar also shows a common error where the candidate has incorrectly drawn a right-angled triangle leading to a resultant phasor of magnitude √2.

Section C overview

This section consisted of six questions worth 59 marks in total.

Question 36 (a) (i)

36 This question considers the digital image processing of medical images. **Fig. 36.1** compares the response to radiation of photographic film **F** and a digital X-ray detector **D**.

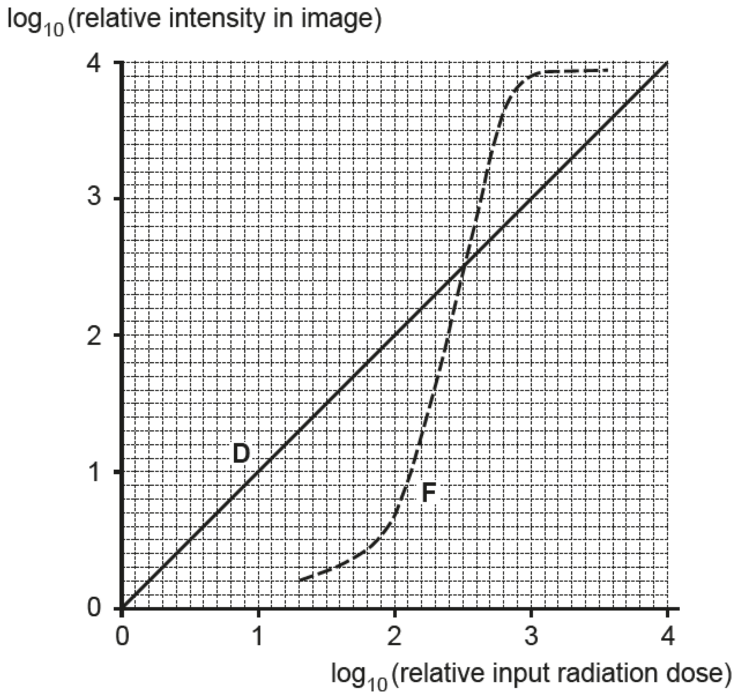


Fig. 36.1

(a) (i) State why a log – log scale has been used to represent the data.

....

.... **[1]**

Exemplar 6

This question considers the digital image processing of medical images. **Fig. 36.1** compares the response to radiation of photographic film **F** and a digital X-ray detector **D**.

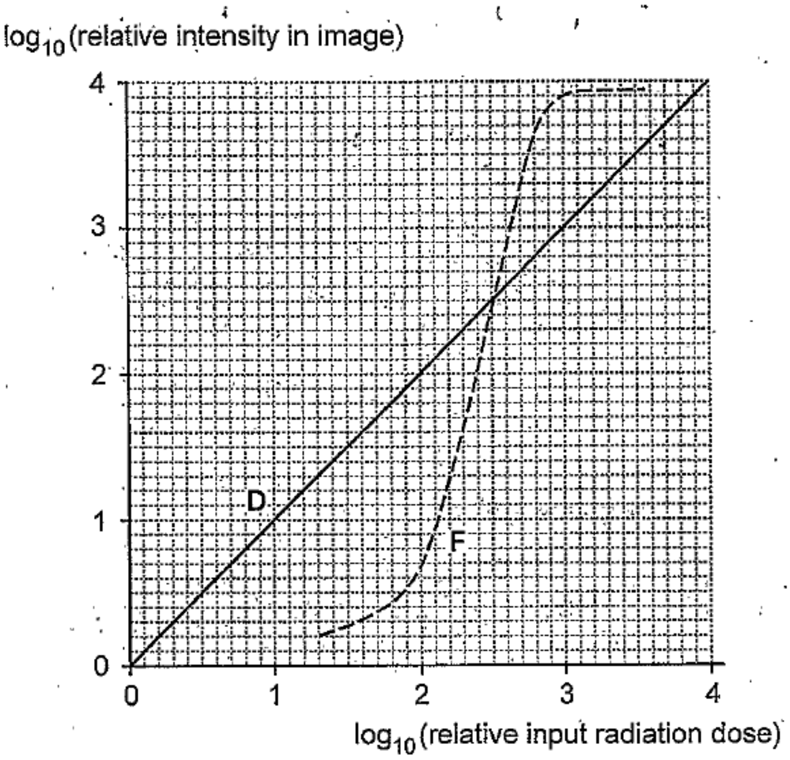


Fig. 36.1

(a) (i) State why a log – log scale has been used to represent the data.

To express a large range of data on a set of axes. **[1]**

This exemplar is typical of many candidates who, whilst realising that the spread of data across orders of magnitude is the underlying issue, did not explain, for example, the difficulty of "bunching" that may be apparent if plotted on a linear scale.

Question 36 (b) (ii) and (iii)

(ii) During image processing the radiologist interpreting the image can stretch the contrast of the bone structures (whiter parts of image) more than the darker regions.

Suggest a benefit to the radiologist of having different contrast adjustment applied to different pixel value ranges.

....

....

....

.... **[1]**

(iii) Identify **one** process (other than contrast improvement) that has been applied to the image in **Fig. 36.2** to produce the enhanced image in **Fig. 36.3**. Suggest the benefit to the radiologist interpreting the image.

....

....

....

....

.... **[1]**

Exemplar 7

(ii) During image processing the radiologist interpreting the image can stretch the contrast of the bone structures (whiter parts of image) more than the darker regions.

Suggest a benefit to the radiologist of having different contrast adjustment applied to different pixel value ranges.

The contrast of white parts can be increased allowing the bone to be seen in more detail to identify breaks, whilst not ~~wasting~~ increasing the contrast of the background **[1]**

(iii) Identify **one** process (other than contrast improvement) that has been applied to the image in **Fig. 36.2** to produce the enhanced image in **Fig. 36.3**. Suggest the benefit to the radiologist interpreting the image.

edge detection, allowing areas with a high gradient of change in colour to be identified. This could make it easier to see/identify a break in the bone. **[1]**

This candidate was awarded the mark for both parts b(ii) and b(iii). Examiners expected to see in b(iii), as this candidate has, reference to breaks or fractures in the bone. Responses that just referred to helping the radiologist identify the edges of the bones were not considered to be worthy of credit.

Question 37 (a) (ii)

(ii) Use data from **Fig. 37.1** to show that the binding energy released in this reaction is more than 15 MeV.
You should calculate the binding energy of the reactants (hydrogen nuclei) and products.

1 reactants binding energy = ...

2 products binding energy = ...

[2]

Most candidates attempted this question and examiners accepted a final answer of either -18.5MeV or +18.5MeV. Candidates who did not gain full marks typically either just added the binding energies per nucleon, neglecting to multiply by the number of nucleons, or did not go on to take away the reactants' binding energy from the products' binding energy to calculate the binding energy released.

Question 37 (a) (iii)

(iii) Use ideas about momentum to explain why the neutron carries away about $\frac{4}{5}$ of this energy.

....

....

....

.... **[2]**

This stretch and challenge question was successfully completed by only the most able candidates. Most candidates simply stated that energy is conserved or described in vague terms the relative masses. In this exemplar, however, the candidate has explained that the neutron's speed is four times that of the nucleus, and then gone on to compare their respective kinetic energies for full credit.

Exemplar 8

(iii) Use ideas about momentum to explain why the neutron carries away about $\frac{4}{5}$ of this energy.

m_n = mass of neutron M_{he} = mass of helium
v_n = velocity of it v_{he} = velocity of helium

Due to conservation of momentum $M_{he} \times V_{he} = m_n V_n$

thus $\frac{v_n}{v_{he}} = \frac{m_{he}}{m_n} \simeq 4$ thus $V_n = 4V_{he}$ thus ~~kinetical~~ $\frac{1}{2} \times m_n \times v_n^2$ energy that helium

~~he occupied by neutron = $\frac{1}{2} \times m_n \times v_n^2 + \frac{1}{2} m_{he} \times v_{he}$~~

has $= \frac{1}{2} \times 4m_n \times v_{he}^2$ and for the ~~other~~ neutron $= \frac{1}{2} \times m_n \times 16V_{he}^2$ = 4 times energy of the ~~proton~~ neutron **[2]**

thus it occupies $\frac{4}{4+1} = \frac{4}{5}$ of energy

Question 37 (b) (i)

(b) (i) To estimate the temperature at which ^{2}H and ^{3}H nuclei will fuse, a student writes down the formula:

$$\frac{e^2}{4\pi\varepsilon_0 R} \approx kT$$

Explain what the two sides of the approximation tell us:

1 $\frac{e^2}{4\pi\varepsilon_0 R}$

2 kT

[2]

Exemplar 9

(b) (i) To estimate the temperature at which ^2H and ^3H nuclei will fuse, a student writes down the formula: energy by the neutron.

$$\frac{e^2}{4\pi\varepsilon_0 R} \approx kT$$

Explain what the two sides of the approximation tell us: ~~attack~~

1 $\frac{e^2}{4\pi\varepsilon_0 R}$ The electric potential energy between ^2H ~~of~~ and ^3H, so the energy required to bring ^2H and ^3H together.

2 kT The average kinetic energy of ^2H and ^3H at the temperature T, kelvin.

[2]

This exemplar is typical of most lower ability candidates where responses did not contain significant errors of physics but lacked detail or did not give a full explanation. The response to the left hand side of the approximation demonstrates this – whilst the candidate had identified that proton charges are being brought together, the response does not make any reference to the separation R identified in the equation, or that this separation is where strong attractive nuclear forces overcome electrical repulsion. The candidate does, however, correctly identify that the right hand side of the approximation represents the average kinetic energy at the specified temperature, T. Other candidates either omitted the specified temperature, or just mentioned energy, rather than specifying kinetic or thermal energy as required by the mark scheme.

Question 37 (b) (ii)

(ii) Use the equation in **(b)(i)** to estimate this temperature when $R \approx 2 \times 10^{-14}$ m.

temperature = ... K **[1]**

Questions that were generally well-answered are not usually covered in this report, but centres may wish to know that this high level question was answered well by the majority of the most able candidates who were able to demonstrate algebraic manipulation as well as multiple substitutions to evaluate the temperature as 820MK.

Question 37 (c) (i), (ii) and (iii)

(c) An experimental fusion reactor uses many powerful lasers focused onto a small spherical bead of solid ^2H and ^3H. The volume of the bead is 4.2 mm^3.
The aim is to produce a plasma implosion where fusion will begin when the temperature and density are high enough.

(i) The density of the bead of solid ^2H and ^3H (1:1 ratio by atoms) is 230 kg m^{-3}.

Estimate the energy needed to produce plasma at 400 MK from this bead of material.

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

(ii) Compare this to the possible fusion energy released by the bead.

Use your answer to **(a)(ii)**. You can assume 100% conversion to ^4He.

[2]

(iii) Suggest **one** practical difficulty in obtaining energy by this method.

....

....

.... **[1]**

This stretch and challenge question was demanding for candidates. In part (i) whilst most high ability candidates showed some working toward the use of $\rho V N_A$ / $m_{average}$ to calculate the number of atoms, a common error was to omit the Avogadro number, N_A. In part (ii) candidates struggled to find or establish a route through the problem. Of those that did, a common error was to multiply the binding energy found in part a (ii) by the number of atoms calculated in c(i) – neglecting to halve the value to take into account the ^2H ^3H pairs. Part (iii) was also challenging for candidates as many responses did not have the clarity required by the mark scheme – superficial answers such as "a high temperature is needed" or "lots of energy is required" were not given credit.

Question 38 (a)

38 This question is about the orbits of two comets **A** and **B** around the Sun.
Fig. 38.1 shows that comet **A** is in a circular orbit and comet **B** is in an elliptical orbit.
Comet **B** is shown in two positions: **B1** approaching the Sun and **B2** receding from the Sun.
Vectors have been added to represent the velocities and the gravitational forces acting on the comets in the positions shown.

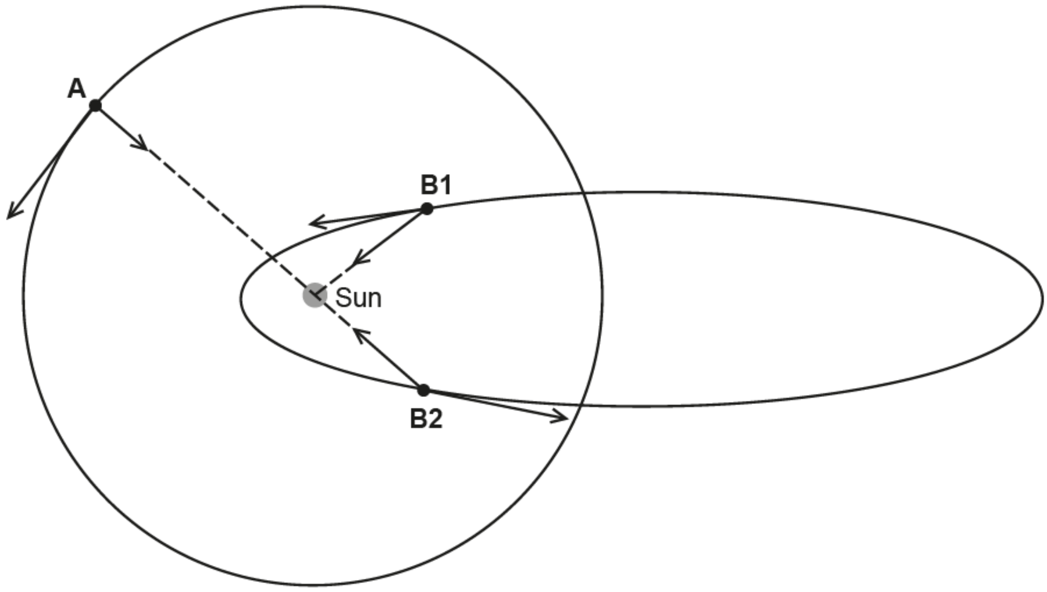


Fig. 38.1

(a)* Compare and explain the orbits of the comets.

In your answer explain how the circular orbit can have a constant speed, and why the elliptical orbit cannot. Consider the role played by the force of gravity, and gravitational potential energy, in changing the velocity of the comets around their orbits.
You may find it useful to use labels on **Fig. 38.1** as part of your answer. **[6]**

Exemplar 10

Both comets have gravitational potential energies of $-\frac{GMm}{r}$. For each of the comets, GMm is fixed, and for A, which orbits at a fixed r from the sun, this value never changes*. For B however, the radial distance from the sun changes due to its elliptical orbit, so its G.P.E changes. B will have the highest G.P.E at D, and the lowest G.P.E at C, as that's when it's farthest and closest to the sun respectively.

The magnitude of the velocity of A never changes, because the gravitational force on it from the sun is always perpendicular to its velocity, so gravity does no work on it. For B on the other hand, at every point other than C and D, there is a component of gravitational force on it parallel to its velocity, so its speed changes as it orbits. It has the highest speed at C, and the lowest speed at D, due to it having

Additional answer space if required.

*, as r never changes) the greatest gravitational potential energy at D, and hence the lowest kinetic energy, and the other way around at C, because G.P.E + K.E. = constant for a stable orbit. B is speeding up at B_1 and slowing down at B_2.

This question required candidates to write an extended response. In this exemplar the candidate has covered both strands of the mark scheme by discussing both the circular and elliptical orbits and has used ideas drawn from the concepts of energy and force to do so. Less able candidates confused velocity and speed; however, this candidate refers to "magnitude of velocity". The ideas are presented within a well-developed line of reasoning and the information presented is relevant and substantiated through the use of appropriate formulae hence the award of the higher mark, 6, within the Level 3 awarded for this response.

Question 39 (a) (i) and (ii)

39 **Fig. 39.1** shows the charging of a 50 mF capacitor by a 10 V supply.

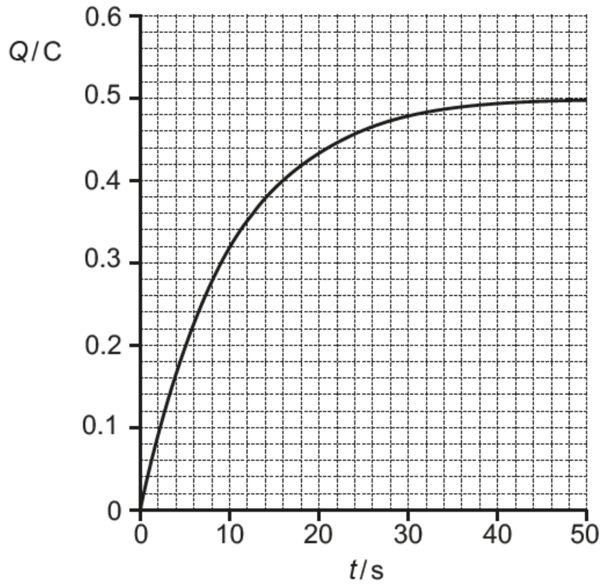


Fig. 39.1

(a) **(i)** Use the graph to find the initial current when the capacitor starts to charge.
Make your method clear.

initial current = ... A **[2]**

(ii) Calculate the size of the electrical resistance in the charging circuit.

resistance = ... Ω **[2]**

The vast majority of candidates were able to recognise that the initial current is the gradient of the graph and draw a tangent that would allow them to calculate the initial current as 0.043A in part a(i). For part a(ii), however, low ability candidates did not see the apparently straightforward method of using R = V/ I with the 10V given in the question to calculate the size of the resistance in the charging circuit; many candidates instead tried unsuccessfully to manipulate a range of equations from the formulae booklet usually the capacitor discharge equation $Q=Q_o e^{-t/RC}$.

Question 39 (b)

(b) Explain why the charging current decreases as the capacitor charges.

....

....

.... **[1]**

Very few candidates were credited this mark since most candidates did not explain the three key points required for a full explanation – most candidates were able to explain that as the capacitor charges the p.d. across it increases, but did not explain that this p.d. opposes the applied 10V or that this means less than 10V is therefore across the resistor.

Question 40 (a) (iii)

(iii) Suggest a reason for this maximum rate in the case of the solar cell.

....

.... **[1]**

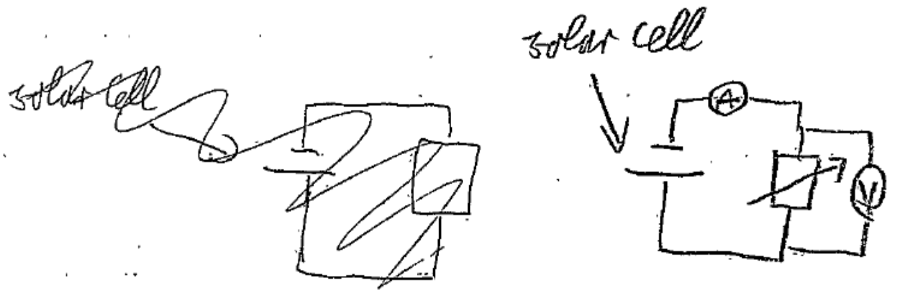
Some high ability students were able to correctly articulate that each electron is given energy by one photon being absorbed from the photon flux, but most candidates did not give that clarity of response – vague answers that stated "there is a limit to the amount of electrons that can be produced" and did not identify the reason for the limit were not given credit.

Question 40 (b)

(b)* Describe the experiment you would use to obtain the data to plot the graph in **Fig. 40.1**. Include a circuit diagram with your method, give estimated values of circuit components, and explain any precautions you would take to ensure reliability. **[6]**

Exemplar 11

(b)* Describe the experiment you would use to obtain the data to plot the graph in **Fig. 40.1.** Include a circuit diagram with your method, give estimated values of circuit components, and explain any precautions you would take to ensure reliability. **[6]**



I would connect the solar cell to a variable resistor, which has a voltmeter parallel across it and an ammeter in series with it. I would then vary the resistance of the variable resistor and acquire readings for I from the ammeter and V from the voltmeter. for Fig 40.1 to be produced, you'd need to start with a high value for your resistance and then decrease it to virtually no resistance. To ensure reliability, all of the components should be cooled to make sure there is no extra resistance in the circuit due to temperature.

This exemplar response was judged to be Level 2 since the candidate has shown a clear understanding of two strands. Although the circuit symbol is not correct for the solar cell, the circuit diagram (strand 1) shows correctly connected ammeter and voltmeter along with a variable load resistor. The experimental method is well covered with an explanation about varying the resistance and taking readings. Whilst there is mention of ensuring reliability (strand 3) there is nothing in the response that gains credit, hence the candidate has covered two of the three strands and the response is therefore at Level 2. Other candidates who covered the third strand did so usually by explaining that repeat readings should be taken at the same current setting in order to calculate mean values. The reasoning in this exemplar is clear and logically structured and the information is relevant and substantiated, hence the higher mark (4) within Level 2 was awarded.

Question 41 (a) (ii)

(ii) State the evidence that shows there is a resonant oscillation happening in this example.

....

....

....

....

....

.... **[2]**

Most candidates gained 1 mark out of the two available for this part-question. More often than not the mark was credited because the candidate described the large amplitude oscillations that build up around on input frequency. Fewer candidates were able to go on to explain that this is because there is a harmonic or periodic input - from the eddies - driving another oscillator – i.e. the air volume in the car.

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