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OCR
Oxford Cambridge and RSA

AS LEVEL

Examiners' report

PHYSICS A

H156

For first teaching in 2015

H156/01 Summer 2024 series

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Paper 1 series overview

H156/01 is one of the two assessed components of AS Level Physics A. This component is worth 70 marks and is split into two sections. Section A contains 20 multiple-choice questions (MCQs) and allows the breadth coverage of the specification. Section B includes short-answer style questions, problem solving, calculations and practical. The assessment of practical skills, as outlined in Module 1 (Development of practical skills in physics) and Module 2 (Foundations of physics), forms an integral part of the assessment. The *Data, Formulae and Relationships* booklet forms a valuable resource in examination and allows candidates to demonstrate their application of physics without the need to rote learn physical data, equations and mathematical relationships. The weighting of this component is 50% and duration of the exam paper is 1 hour 30 minutes.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• answered most of the MCQs and made good use of the spaces provided to do any rough analysis or calculations • made good use of calculators, especially handling values given in standard form • understood and correctly selected formulae • correctly applied concepts of mechanics and demonstrated a good knowledge and understanding of this area of the specification • correctly selected equations from the Data, Formulae and Relationship booklet • gave well-structured solutions with clear manipulation of equations, good substitution and expressed the final answers to appropriate significant figures and units, even though units were given on the answer line • overall showed a good comprehension of command terms such as describe, explain, show and compare • generally made good use of information and data given whether numerical or displayed in a table.	• did not underline or circle key data within a question to help with the calculations - if a question specifically asks to candidates to refer to information/data in a figure or graph it must be used or manipulated in their responses • rounded numbers in the middle calculations: they need to try to retain all the digits on their calculator for subsequent stages of a calculation. Truncating numbers in the middle of calculations may result in the loss of marks as it could result in rounding errors and values given to an incorrect number of significant figures • did not make good use of technical and scientific vocabulary in descriptions and explanations, such as using 'strain' instead of 'force' • did not show an understanding of the photoelectric effect, in particular as demonstrated in an electroscope and the use and interpretation of data related to this effect • did not calculate the difference in a calculated value and accepted value, to then calculate the percentage uncertainty of a calculated value.

Section A overview

Section A contains 20 MCQs from topics across the four modules of the specification. This section is worth 20 marks and candidates are expected to spend about 25 minutes. Questions can assess understanding from all aspects of the specification including knowledge and application of practical skills. Space is provided on the exam paper for any working. It is important for candidates to insert their correct response in the box provided.

All questions showed a positive discrimination, and most candidates attempted all the MCQs which was demonstrated by an improved performance across all MCQs. Candidates are allowed to annotate text and diagrams if it helps to get to the correct response. No detailed calculations are expected on the pages, so any shortcuts, or intuitiveness, can be employed to get to the correct responses.

Questions 4, 11**,** 12, 16 and 20 allowed most of the candidates to demonstrate their knowledge and understanding of physics. Questions 3, 5, 9, 13, 17 and 18 proved to be more challenging.

Question 1

1 Which is an S.I. base unit?

A amp

B coulomb

C ohm

D volt

Your answer ☐ **[1]**

This should have been a straightforward starting question for all the candidates in identifying the correct S.I. base unit but only some gave the correct response of A. The most common distractor was B.

Question 2

2 Two waves, of wavelength λ, undergo constructive interference.

What is a possible path difference between the two waves?

A $\frac{\lambda}{4}$

B $\frac{\lambda}{2}$

C $\frac{3\lambda}{2}$

D λ

Your answer ☐ **[1]**

Overall, candidates performed well on this question as they correctly identified that the path difference for constructive interference is λ to give answer D. The most common distractor was B as some candidates confused the path difference for constructive interference with destructive interference.

Question 3

3 A copper wire **P** has electrical resistance *R* and number density of charge carriers *n*.

A copper wire **Q** has:

- area of cross section equal to **P**
- twice the length of **P**.

Which row gives the correct values of resistance and number density of charge carriers for **Q**?

	Resistance of Q	**Number density of charge carriers in Q**
A	$\frac{R}{2}$	n
B	$\frac{R}{2}$	$2n$
C	$2R$	n
D	$2R$	$2n$

Your answer ☐ **[1]**

Overall, candidates performed well. They correctly determined that because the copper wire, **Q**, has an equal cross-sectional area to copper wire, **P**, that *n* (the number density of charge carriers) is the same for both wires. Most candidates determined that the resistance of **Q** would double in size due to the length of wire **Q** being twice as long, hence why the most common distractor was D.

Question 4

4 The light emitted by a laptop screen is polarised.

The laptop screen is viewed through a polarising filter.

Initially the brightness of the screen appears normal.

The filter is rotated gradually through an angle of 180°.

How does the brightness of the laptop screen appear after the filter has been rotated by 90°, and then by 180°?

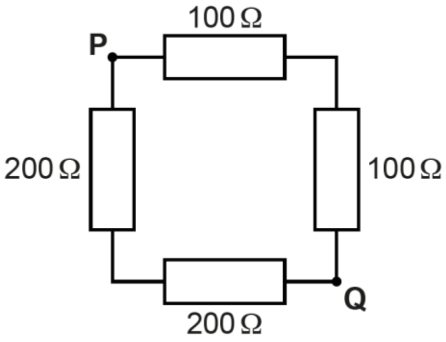
	After a rotation of 90°	**After a rotation of 180°**
A	Dark	Dark
B	Dark	Normal
C	Normal	Dark
D	Normal	Normal

Your answer ☐ **[1]**

This question was answered well as candidates were able to apply knowledge and understanding of electromagnetic waves passing through a polarising filter to give the correct answer B.

Question 5

5 The diagram below shows a network of four resistors.



What is the total resistance between the points **P** and **Q**?

A 50 Ω

B 133 Ω

C 150 Ω

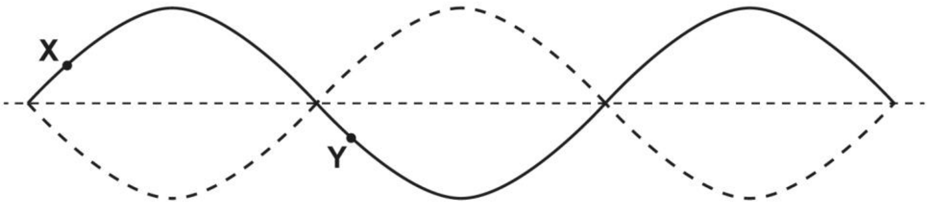
D 600 Ω

Your answer [ ] **[1]**

Overall, candidates performed well on this question as many correctly applied their understanding of resistance in series and parallel to give a total resistance between **P** and **Q** as 133 Ω. The most common distractor was D, where candidates incorrectly calculated the total resistance as the sum of each individual resistance as they did not apply understanding that each pair of resistors where in a parallel arrangement around points **P** and **Q**.

Question 6

6 The diagram shows a stationary wave on a string.



What is the phase difference between the points on the wave labelled **X** and **Y**?

A 0

B $\frac{\pi}{4}$

C $\frac{\pi}{2}$

D π

Your answer ☐ **[1]**

Many candidates correctly determined the correct phase difference as π between points **X** and **Y** as they interpretated that the fraction of the wave between points **X** and **Y** was the equivalent to λ/2. The most common distractor was C.

Question 7

7 In a demonstration of the photoelectric effect the clean surface of a metal is radiated with photons of electromagnetic radiation.

Electrons are released from the surface of the metal.

The intensity of the radiation is then increased.

Which statement is correct?

A The energy of the photons increases.

B The rate of emission of electrons increases.

C The maximum kinetic energy of the emitted electrons increases.

D There is no change to the emitted electrons.

Your answer ☐ **[1]**

Candidates performed well on this question with many correctly relating an increase in intensity of radiation to an increase in the rate of emission of electrons.

Question 8

8 Electromagnetic waves pass through a gap of approximately 3 cm.

Which of the following will undergo a significant amount of diffraction?

A microwaves

B ultraviolet waves

C visible light waves

D X-rays

Your answer ☐ **[1]**

Candidates performed well on this question as they determined that when a wave passes through a gap with a similar size to its wavelength, it results in greater diffraction to give the response A.

Question 9

9 According to Newton's third law, forces always occur in pairs.

Which statement is **not** true for a Newton's third law force pair?

A The forces are acting in opposite directions.

B The forces are acting on the same body.

C The forces have the same magnitude.

D The forces are the same type.

Your answer ☐ **[1]**

Many candidates correctly identified the correct response, B, by applying their understanding that an interaction pair of forces according to Newton's third law do not act on the same body. The most common distractor answer was D.

Misconception

A common misconception when applying Newton's third law of motion is that the interaction pair of forces are acting on the same body and/or that the pair of forces are different types of forces. Newton's third law states:

*Whenever **two** bodies interact, the forces they exert on each other are equal in size, act in opposite directions, and are of the **same** type.*

For example, if object A exerts a force on object B, then object B exerts an **equal** and **opposite** force on object A and if object A exerts a **gravitational force** on object B, then object B exerts an equal and opposite **gravitational force** on object A.

Most candidates correctly identified that the pair of forces are equal in magnitude and opposite in direction but display a common misconception that the two forces are different and that they act on the same one body.

Question 10

10 A particle **X** collides with a stationary particle **Y**.

No external forces act and the collision is inelastic.

Which quantity is conserved in the collision?

A momentum of **X**

B momentum of **Y**

C momentum of **X** + momentum of **Y**

D kinetic energy of **X** + kinetic energy of **Y**

Your answer [ ] **[1]**

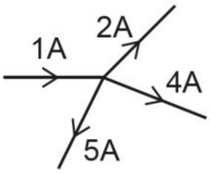
Many candidates correctly applied understanding of inelastic collisions that momentum is conserved, but the kinetic energy is not conserved to give the correct answer C.

Question 11

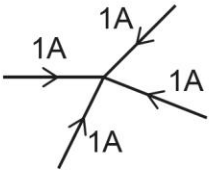
11 The diagrams show the currents entering and leaving a junction in an electric circuit.

Which diagram could be correct?

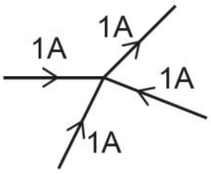
A



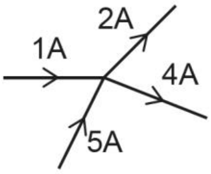
B



C



D



Your answer ☐ **[1]**

Candidates performed well on this question by correctly applying Kirchoff's current law that the current flowing into a junction must be equal to the current flowing out of it to give the correct answer D.

Question 12

12 In the Young double-slit experiment, light passes through two narrow slits and a pattern of light is observed on a screen.

Which property of light is **not** demonstrated by this experiment?

A diffraction

B refraction

C wave nature

D superposition

Your answer ☐ **[1]**

Candidates performed well on this question by correctly identifying that the Young's double-slit experiment does not demonstrate the property of refraction of light to give the correct answer B.

Question 13

13 In a Young double-slit experiment, electromagnetic radiation is incident on a double slit. The following results are obtained.

distance from slits to screen = 3.5 m
distance between slits = 1.5 mm
distance between central fringe and 6th order fringe = 9 mm

What is the wavelength of the radiation?

A 6.4×10^{-7} m

B 3.9×10^{-6} m

C 6.4×10^{-1} m

D 2.3×10^{-5} m

Your answer [ ] **[1]**

Some candidates correctly calculated the wavelength of radiation to be 6.4×10^{-7}m by determining that the fringe width was 9 mm/6 = 1.5 mm. Therefore, the most common distractor was answer B as candidates had used the value of 9 mm as the fringe width and had therefore not understood that the fringe width is the distance between successive bright fringes. Giving the answer B did demonstrate an understanding of consistent units by correctly converting mm to m.

Question 14

14 A stationary sound wave is created in air.

The distance between two adjacent nodes of the stationary wave is 0.7 m.

What is the frequency of the sound wave?

Speed of sound in air = 340 m s^{-1}

A 243 Hz

B 476 Hz

C 486 Hz

D 971 Hz

Your answer [ ] **[1]**

Candidates performed well on this question with many candidates correctly determining the wavelength of the standing wave as 1.4 m to then use this value to calculate the frequency of the wave as 243 Hz. This demonstrated understanding that the distance between adjacent nodes is $\lambda/2$ and not λ which was indicative of the most common distractor given by the answer B.

Question 15

15 A spring has a force constant of $4900\,N\,m^{-1}$.

A force is applied to the spring, causing it to compress by 0.50 m.

What is the change in the elastic potential energy stored in the spring?

A decreases by 610 J

B decreases by 1200 J

C increases by 610 J

D increases by 1200 J

Your answer ☐ **[1]**

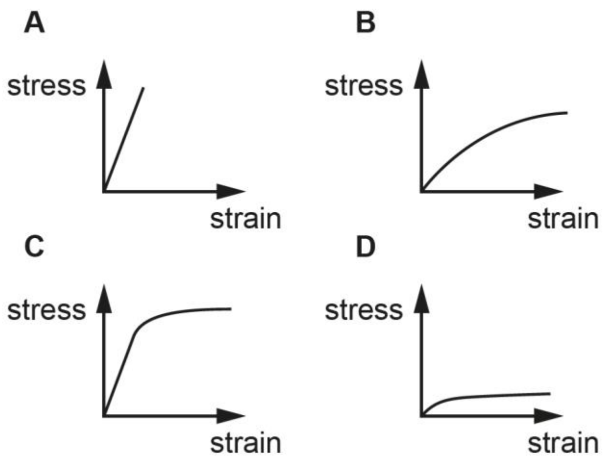
Overall, candidates performed well on this question with many correctly calculating the change in elastic potential energy as 610 J. The most common distractor was answer A, with candidates relating compression to a decrease in the change of elastic potential energy rather than an increase in the store of elastic potential energy.

Misconception

This question highlighted a possible common misconception that when a spring or object is compressed, there is a decrease in the change of elastic potential energy. This is probably as a result that a compression results in a decrease in the length of an object which candidates then relate to a decrease in the change in elastic potential energy. Even though an object is compressed the change in potential energy will always be positive as work is done by a force in the same direction as the displacement.

Question 16

16 Which graph shows the stress-strain characteristics of a brittle material?



Your answer ☐ **[1]**

Candidates performed well on this question with most candidates correctly identifying graph A as most indicative of the stress-strain characteristics for a brittle material, as brittle materials exhibit minimal plastic deformation and the relationship between stress and strain is linear.

Question 17

17 Which of the following is a correct statement about the e.m.f. of a cell?

A It is equal to the energy transferred from chemical energy per volt.

B It is equal to the energy transferred to thermal energy in the load resistance.

C It is equal to the p.d. measured across the internal resistance of the cell.

D It is equal to the p.d. measured across the terminals of the cell when there is no current.

Your answer ☐ **[1]**

Some candidates correctly identified the statement defining e.m.f as answer D. The most common distractor was answer A, as candidates confused the definition of e.m.f as the energy transferred per coulomb of charge with per volt.

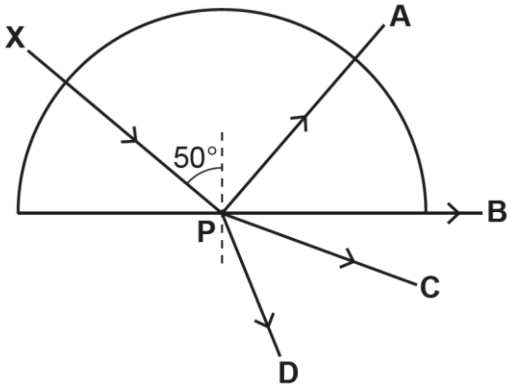
Question 18

18 The diagram shows a semi-circular glass block with a refractive index of 1.5.

The glass block is surrounded by air.

A ray of light follows the path shown from **X** to **P**.

Which path will the ray follow after it arrives at **P**?



Not to scale

Your answer ☐ **[1]**

Some candidates correctly identified that the ray would follow path A after arriving at point P. To determine the correct path that the ray of light would follow, candidates were required to calculate the critical angle from the refractive index of the glass block to give 42°. If candidates calculated the critical angle they could determine that Total Internal Reflection would occur (as angle of incidence > critical angle) and hence that the ray would follow path A. The most common distractors were answers C and D.

Question 19

19 A student makes measurements to determine the total energy *W* transferred by a filament lamp.

They record the measurements shown below.

Potential difference / V	12 ± 0.20
Current / mA	80 ± 1.0
Time / s	60 ± 0.01

What is the percentage uncertainty in their calculated value of *W*?

A 0.2%

B 1.2%

C 2.9%

D 7.2%

Your answer [ ] **[1]**

Candidates performed well on this question to correctly calculate the percentage uncertainty in the calculated value of W as answer C, by calculating the sum of each individual percentage uncertainty in each measurement.

Question 20

20 An object is completely immersed in water.

Upthrust acts on the object.

Which calculation will correctly give the magnitude of the upthrust?

A density of the object × g

B density of the water × g

C mass of water displaced × g

D volume of object × g

Your answer [ ] **[1]**

Candidates performed well on this question to correctly give that the magnitude of the upthrust of an object in a fluid is the weight of the fluid displaced by the object.

Section B overview

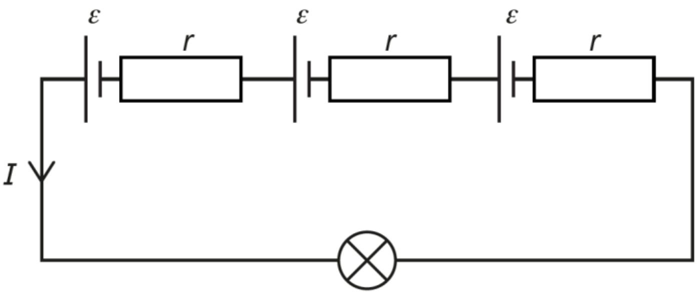
Section B includes short-answer style questions, problem solving, calculations and practical. This section is worth 50 marks and candidates are expected to spend about 1 hour 5 minutes completing questions.

Questions can assess understanding from all aspects of the specification including knowledge and application of practical skills.

Question 21 (a)

21 A torch uses three identical cells connected in series to a bulb.

Each cell has e.m.f. ε and internal resistance r.



(a) The current in the circuit is I.

Show that the power P delivered to the bulb is given by

$P = 3I(\varepsilon - Ir)$

[3]

Most candidates achieved 1 mark for this question, for stating the correct expression for e.m.f, ε, e.g. ε = Ir + V with some candidates showing clearly that the power, P delivered to the bulb is given by the expression P = 3I(ε - Ir). Responses that were given 1 mark did not give clear working to express their understanding that the e.m.f. ε and internal resistance, r, were increased by 3. Often, candidates would just give an unqualified expression for P, e.g. P = 3 x I(ε - Ir), but from this expression it was not clear whether the factor of 3 was for current I or ε and r despite the correct application of P=IV.

The responses that achieved 3 marks showed a clear rationale in their working and that for the 3 cells in series the total e.m.f. was 3ε, and the total internal resistance was 3r. These candidates then showed clear steps in finding an expression for the potential difference across the bulb using ε = Ir + V to be, e.g. V = 3ε - 3Ir. By showing clear working, it was evident that candidates understood that the potential difference across the bulb was equal to the total terminal potential difference across the three cells in series. These candidates then correctly substituted their expression for the potential difference into an equation for power, e.g. P=IV to show the power P delivered to the bulb given in the stem of the question.

Exemplar 1

$P = IV$

e.m.f $= \varepsilon + \varepsilon + \varepsilon = 3\varepsilon$

total internal resistance $= r + r + r = 3r$

volts lost due to internal resistance $= 3Ir$

volts delivered to bulb $= (3\varepsilon - 3IR)$

$\therefore \; P = I(3\varepsilon - 3Ir)$

$P = 3I(\varepsilon - Ir)$ //

Exemplar 1 demonstrates clear working and rationale to show the given expression for the power P delivered to the bulb. The response is given 3 marks.

Question 21 (b)

(b) Suggest why a torch battery with a large internal resistance may be undesirable.

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.... **[2]**

Some candidates achieved 1 mark for this question for suggesting the most common response that the potential difference across the bulb would decrease or that there would be more lost volts across the cells but only a few linked these suggestions to achieve 2 marks. Most candidates mixed suggestions by referencing energy transfer and potential difference which meant that they only achieved 1 mark. Some candidates gave suggestions in terms of current and efficiency, which did not link to the undesirability of a large internal resistance and so were not given any marks.

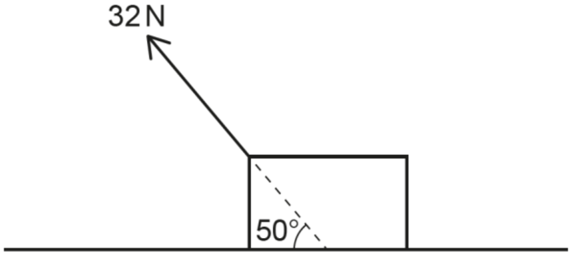
Question 22 (a)

22 A lab technician is moving boxes.

(a) The technician pulls a box using a rope with a force of 32 N.

The force acts at an angle of 50° to the horizontal.

The box moves a horizontal distance of 3.5 m along the floor in a time of 6 s.



Calculate the power of the technician as they move the box along the floor.

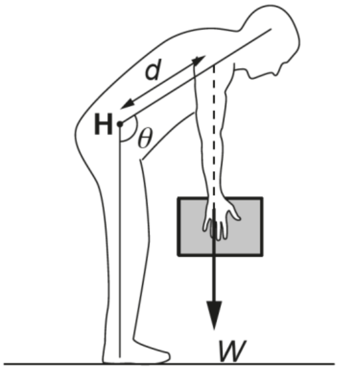
power = ... W **[3]**

Candidates performed well on this question by correctly applying P=Fv by calculating the horizontal component of the 32N force acting on the box and the velocity as it moved along the floor to calculate the power of the technician as 12W.

Question 22 (b)

(b) The technician lifts a box from the floor without bending their knees.

The diagram shows the force W due to the weight of the box.



The box has a mass of 5 kg.

The distance d is 0.6 m and can be assumed to remain constant.

Calculate the moment about the point **H**, due to the weight of the box, when $\theta = 90°$.

State the unit.

moment = ... unit .... **[2]**

Candidates performed well on this question as they correctly applied the equation moment = force x perpendicular distance from the pivot to calculate the moment as 29.4 Nm and most also gave the correct unit for moment as Nm.

Question 22 (c)

(c) The diagrams show how the technician can pick up the box while bending their knees.

This keeps their spine more vertical.

Explain why bending the knees is less likely to cause damage to the spine.

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.... **[3]**

There were not many successful responses for this question and many were given 0 marks. Most responses were often vague and unspecific descriptions of a change in the centre of mass, or a distribution of the weight of the box. Most candidates did not establish that by bending the knees, the perpendicular distance to the pivot/hips decreased. Hence the moment about the pivot/hips would be reduced, which in turn reduced the force acting on the spine, resulting in less damage. Some candidates did describe that the moment about the pivot/hips would be reduced by bending the knees. However, a significant number of candidates would then follow this by explaining that there would be 'less stress' on the spine, rather than less force acting on the spine.

Question 23 (a)

23 A thermistor has a resistance that decreases as temperature increases.

(a) A student makes measurements to plot the variation of resistance with temperature of the thermistor.

They submerge the thermistor into distilled water at 50 °C.

They then record measurements from a voltmeter and ammeter as the temperature of the water falls to about 20 °C.

Describe how the student obtains sufficient data to plot a graph of resistance against temperature.

Your answer should include a circuit diagram.

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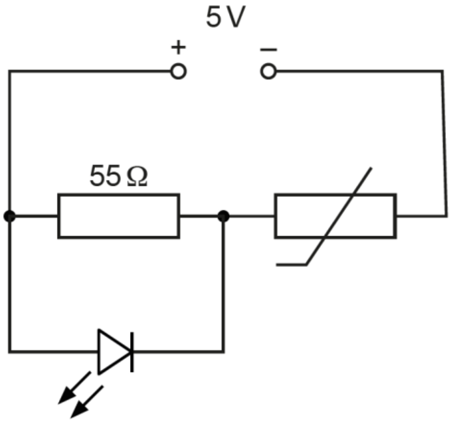
.... **[4]**

Overall, candidates performed well on this question with most achieving at least 1 mark and some achieving over 2 marks. Most candidates were given marks for a correctly drawn circuit diagram (including current circuit symbols for the components required for the investigation) and for a correct rearrangement of V=IR to be able calculate the resistance. Some candidates would describe that measurements would need to be read from the ammeter and voltmeter, which was insufficient as the measurements of current and potential difference needed to be specified to achieve the mark.

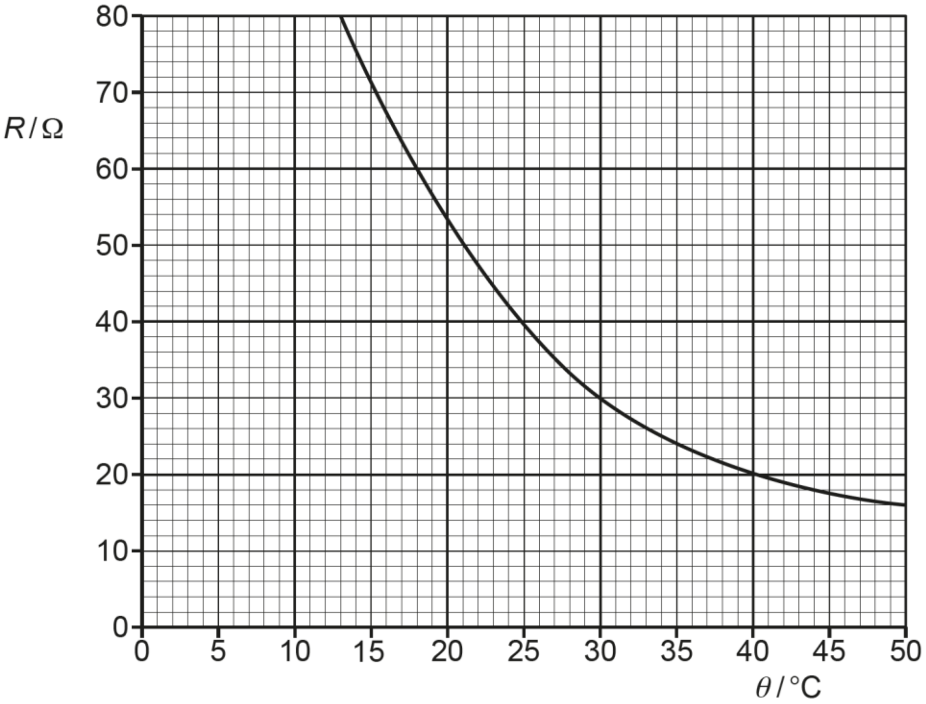
Question 23 (b)

(b) The circuit diagram shows a potential divider circuit using a thermistor to detect changes in temperature.

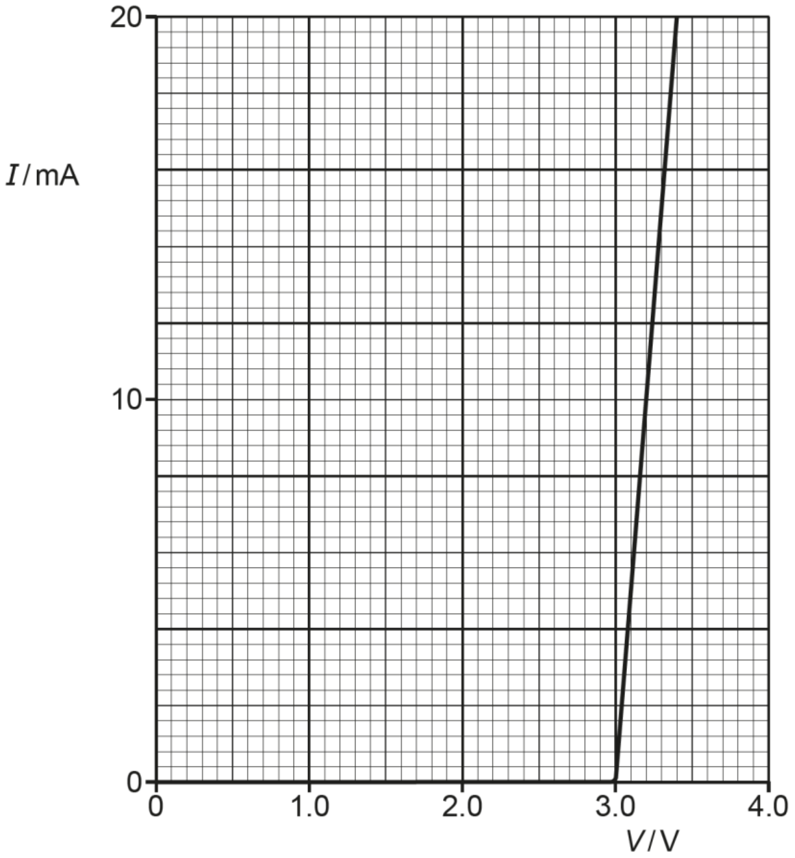
The LED switches on to indicate when the temperature is above 30 °C.



The variation of the resistance *R* of the thermistor with temperature *θ* is shown below.



The I–V characteristic of the LED, within its operating range, is shown below.



Explain why the LED will switch on when the temperature of the thermistor is above 30 °C.

You may assume that the resistance of the LED is always much greater than 55 Ω.

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.... **[4]**

Candidate performance on this question was variable as some were given 0 marks because they did not reference and interpret the data from the two graphs given in the question.

Exemplar 2

As the temperature increases, resistance of thermistor decreases, as the current is constant for the circuit V=IR if resistance decreases the Potential difference across that ~~component~~ thermistor decreases so the voltage across the resistor increases and because the LED and resistor are connected in parallel the voltage across LED is the same as resistor so the LED will switch on. **[4]**

Exemplar 2 demonstrates a typical response from a candidate. They describe the relationship between temperature and resistance of the thermistor, and then they relate this to the potential difference across the LED but without any reference to the data given in the two graphs.

Exemplar 3

When the temperature is above 30°C, the resistance of the thermistor is below 30Ω. This means that the resistor recieves [illegible] at least $5\left(\frac{55}{55+30}\right) \approx 3.24$ volts. This is greater than the 3V required to turn on the bulb. when the bulb has at least 3.24V, current flowing through it is at least 12A, so it will switch on.

Exemplar 3 is a correct response that uses the data from the graph of resistance R/Ω against temperature θ/°C to find the resistance at 30°C and then applies the equation for a potential divider to calculate the potential difference across the LED. They then clearly compare their calculated value of potential difference to the I-V characteristic for the LED to explain why the LED switches on above a threshold potential difference of 3V.

Question 24 (a)

24 A student investigates the motion of falling objects.

(a) The student releases a feather in air and allows it to fall.

The feather reaches a terminal velocity.

Explain this observation.

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.... **[3]**

Candidates generally performed well on this question as many were given 1 or 2 marks for correctly explaining that the feather was falling at a constant speed because the weight acting on the feather was equal to the opposing force of air resistance. Some candidates explained this further by stating that the resultant force acting on the feather was 0.

Question 24 (b)

(b) The student now releases a heavy ball and allows it to fall from a height of 2.0 m.

Calculate its expected speed when it hits the ground.

Assume that air resistance is negligible.

speed = ... $m\,s^{-1}$ **[3]**

Candidates performed very well on this question by selecting and applying the correct equation of motion to calculate the speed of the ball when it hit the ground.

Selection and application of formulae
Candidates performed well on the selection and application of equations of motion from Module 3: Forces and motion.

Question 24 (c)

(c) The student measures the time for the heavy ball to fall from a height of 2.0 m.

They release the ball and, at the same time, start a stopwatch.

They stop the stopwatch when the ball hits the floor.

The student repeats the measurement and records their results.

Time to fall / s	0.62	0.68	0.60

Calculate a value for *g* using the student's results.

g = ... m s^{-2} **[3]**

Candidates performed well on this question as many candidates correctly calculated the mean time to fall/s and then selected and applied the equation of motion $s = ut + ½at^2$ to calculate a value of *g* for the falling ball. Some candidates calculated a mean from the time values 0.62 s and 0.60 s, by omitting the result 0.68 s and this was given marks if they clearly identified the omittance of this value by identifying the result as anomalous.

Question 24 (d)

(d) Suggest **one** improvement the student could make to the investigation described in **(c)**.

[2]

There were not many successful responses to this question, with most given 0 marks. Many candidates made attempts to suggest suitable improvements, but these were often vague and unspecific, e.g. use light gates but without any reference on how this piece of equipment would be used to time (such as by connecting to a data logger or (electronic) timer). To be given 2 marks, candidates had to achieve the first method mark for a correct improvement. Therefore, most candidates were not able to access the second mark as they had not achieved the first method mark for a correct improvement. Many candidates attempted to give reasons for their improvement but again these explanations were superficial as they were expressed without relating to the error due to reaction time. Some candidates did give a suggested improvement in terms of increasing the height of the fall of the ball, which meant they were given the first method mark but corresponding explanations linked to reducing the percentage uncertainty was not always fully developed to award the second mark.

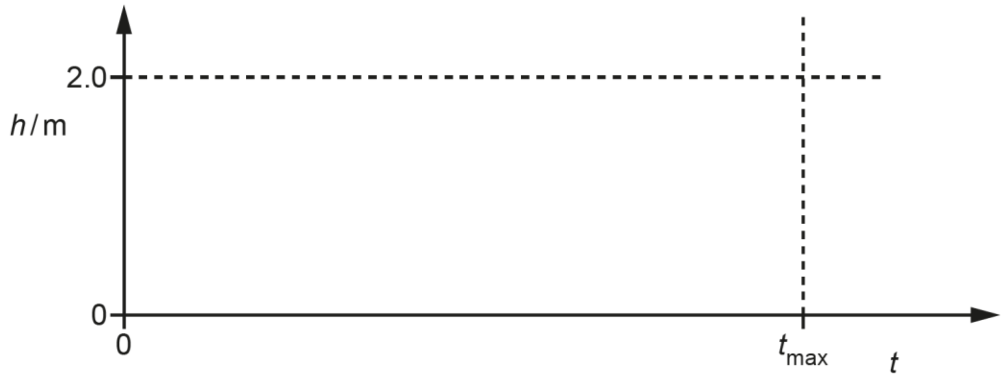
Assessment for learning

Please refer to the Practical Skills Handbook for information on practical techniques including definitions of key scientific terminology and methodology

Question 24 (e)

(e) The ball bounces when it hits the floor.

On the axes below, sketch a graph of height, h, against time, t, to represent the motion of the ball from the time, t = 0 when it is released to the time $t = t_{max}$ when it reaches its maximum height **after** hitting the floor. **[2]**



There were not many successful responses to this question, as many were given 0 marks for an incorrect sketch graph of the motion of the ball when it bounced after hitting the floor. Many candidates sketched a graph for a ball falling with constant velocity or for their graph drawn to a maximum height of 2.0m at time, t_{max} which represented an elastic collision when the ball hit the floor.

Misconception

A common misconception was to draw a graph representing the motion of the ball falling with constant velocity and hence zero acceleration. This may be because candidates did not interpret the graph as a displacement - time graph and assumed that the graph was a velocity - time graph. Also, candidates had another misconception that the collision of the ball with the floor was elastic and therefore the kinetic energy of the ball was conserved rather than an inelastic collision, which would result in the transfer of kinetic energy to other energy stores during the collision.

Question 25 (a)

25 Einstein's photoelectric equation can be used to explain the photoelectric effect.

$hf = \varphi + KE_{max}$

(a) State what is meant by the quantity KE_{max}.

....

.... **[1]**

This should have been a straightforward definition of the maximum kinetic energy of electrons when they are emitted from the surface of a metal but many candidates were not given the mark as their definitions lacked specific scientific language.

Question 25 (b)

(b) The photoelectric effect can be demonstrated using a gold leaf electroscope.

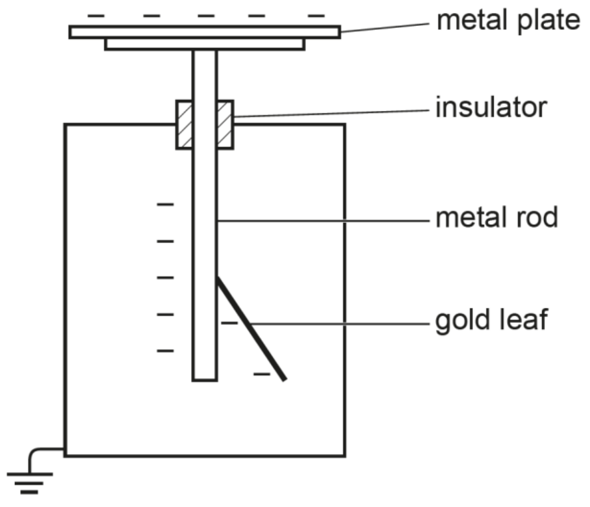
The electroscope consists of a metal plate attached to a metal rod.

A thin gold leaf is attached to the metal rod.

When the electroscope is charged the leaf rises.

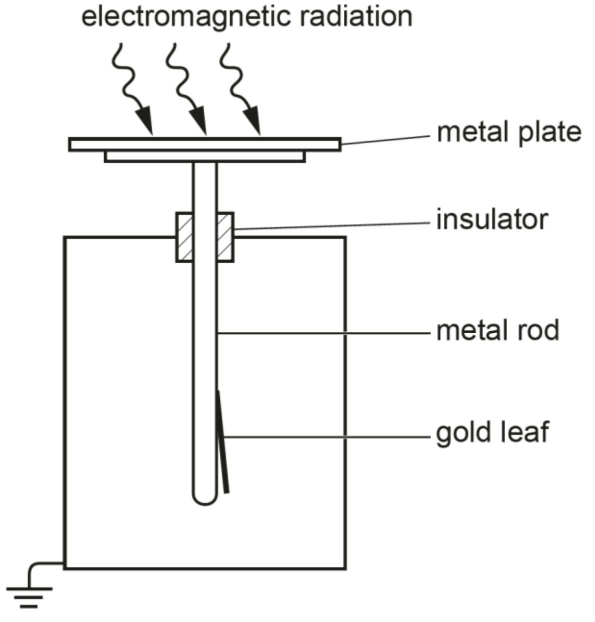
Initially the electroscope has an excess of electrons.

The electroscope is negatively charged and the leaf rises to the position shown below.



Electromagnetic radiation is then directed at the metal plate.

The leaf falls to the position shown below.



Explain this observation.

....

....

....

....

....

.... **[3]**

Most candidates were given at least 1 mark for this question for the explanation that when electromagnetic radiation is incident on the metal plate electrons are emitted. Some candidates were then given a further mark for explaining that the gold leaf fell due to losing negative charge but there were a significant number of responses that referred to positive charge and that as the leaf was losing negative charge it became positively charged. While candidates may not have observed a demonstration of a gold leaf electroscope, the question assessed their understanding and explanation of the photoelectric effect and that is only the removal of excess electrons when there is a one-to-one interaction with a photon.

Question 25 (c)

(c) The investigation is repeated using electromagnetic radiation with a frequency lower than the threshold frequency for the metal.

The leaf does **not** fall.

Explain why.

....

....

....

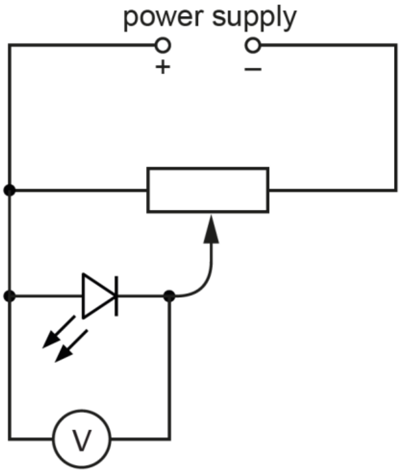
.... **[2]**

There were not many successful responses for this question and many responses were given 0 marks. These responses did not explain the reason for the leaf not falling in relation to photon energy and the work function, and hence that the electron does not receive enough energy to be emitted. Typical responses that were not given marks were for a description of threshold frequency as the minimum frequency required for electrons to be emitted and/or for simple stating that the leaf does not fall as electrons are not emitted. While these descriptions were valid, candidates had not applied E_p=hf and Φ=hf_0 to explain that the energy of the photon was less than the work function required for electrons to be emitted.

Question 26 (a)

26 A student carries out an investigation to determine the value of the Planck constant, *h*.

They use the circuit shown below.



Initially the LED emits no light.

The student slowly increases the p.d. across the LED.

They record the p.d. *V* on the voltmeter when the LED just starts to emit light.

The measurement is repeated for LEDs that emit light with different frequencies *f*.

(a) The student views the LED through a cardboard tube when making each measurement.

Explain how this can help to improve the accuracy of each measurement.

....

....

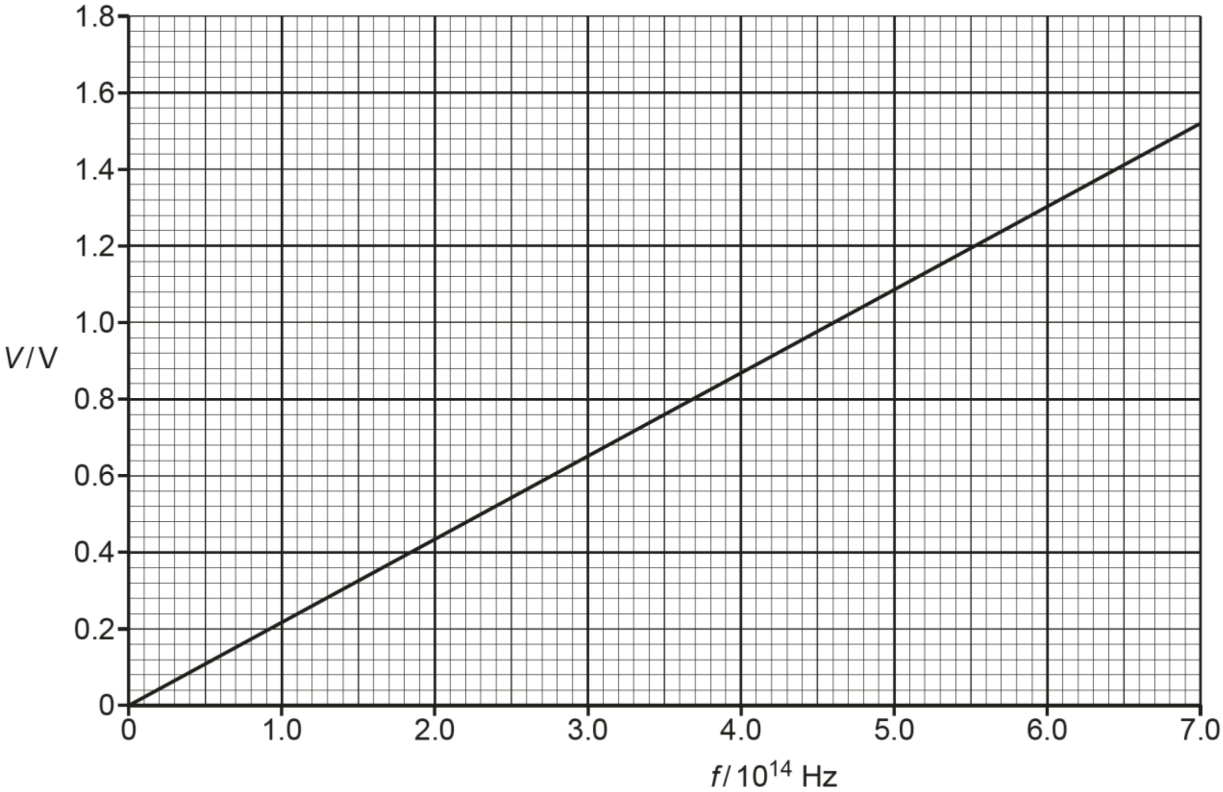
....

.... **[2]**

There were many successful responses for this question. Many responses were given 2 marks because they explained why a cardboard tube improves the accuracy of each measurement due to removing light from the surroundings, which enabled the light from the LED to be observed when it was first emitted.

Question 26 (b)

(b) The student plots a graph of *V* against *f*, as shown below.



Calculate a value for the Planck constant using the graph.

Planck constant = ...J s **[3]**

There was some variability in performance with this question, but many responses achieved 3 marks for a correct calculation and value for the Planck constant using data from the graph. The most common reason for responses being given 0 marks were for an error in their gradient calculations for either taking readings from less than half the graph, or for not including the correct power for frequency 10^{14}. Some candidates did correctly calculate the gradient from the graph, but then did not select and apply eV=hf to calculate a value of the Planck constant.

Question 26 (c)

(c) An accepted value for the Planck constant is 6.63×10^{-34} J s.

Calculate the percentage uncertainty in the student's results.

percentage uncertainty = ... % **[2]**

Candidates did not perform well on this question as many candidates were given 0 marks. The most common reason for candidates not achieving marks was for not calculating a difference between the calculated and accepted value for the Planck constant with many candidates carrying out the calculation calculated value/accepted value x 100%.

Assessment for learning

Please refer to page 36 of the Practical Skills Handbook for information on correct methodology on calculating percentage difference between calculated and accepted values.

Question 26 (d)

(d) One of the LEDs emits red light. Another of the LEDs emits blue light.

The red LED emits 3.3×10^{15} photons per second.

The blue LED emits light with frequency 6.38×10^{14} Hz.

The manufacturer lists the power rating of each of the LEDs as 1 mW.

The student states that there are more photons emitted per second from the blue LED than from the red LED.

Deduce, by calculation, whether the student is correct.

Use $h = 6.63 \times 10^{-34}$ J s.

[3]

Most candidates were given 1 mark for correctly calculating the energy of one photon of blue light by selecting and applying E=hf. Some candidates correctly converted the power of the LED to calculate the number of blue photons emitted in 1 second by using and applying P=E/t. Where candidates did not achieve any further marks, this was for selecting an incorrect equation and not applying P=E/t.

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