



GuideMyGrades

— YOUR GOALS. OUR EXPERTISE. —

OCR A LEVEL PHYSICS A (H556): QUESTIONS BY TOPIC

Charge and current (4.1)

A Level Physics A (H556) · Module 4: Electrons, waves and photons

19 questions · 143 marks · Mark schemes included

OCR A Level Physics A (H556), June 2017 – June 2025

 guidemygrades.com

 @Guidemygrades

 @Guidemygrades

 @Guidemygrades

 info@guidemygrades.com

 Piccadilly Business Centre, Unit C, Aldow Enterprise Park
Blackett Street, Manchester, M12 6AE

HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic and run from the lowest mark tariff to the highest within each one.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

QUESTION	SOURCE	MARKS	PAGE
4.1.1 CURRENT AND CONSERVATION OF CHARGE		15 Qs · 128 marks	3
1. Q1	H556/02 Exploring physics June 2017	1	4
2. Q2	H556/02 Exploring physics June 2017	1	5
3. Q6	H556/02 Exploring physics June 2018	1	6
4. Q3	H556/02 Exploring physics June 2019	1	7
5. Q1	H556/02 Exploring physics June 2022	1	8
6. Q17 <i>also 2.1 & 4.5 & 4.4 & 4.3</i>	H556/02 Exploring physics June 2022	8	9
7. Q16 <i>also 3.2 & 4.3 & 4.2</i>	H556/02 Exploring physics June 2025	10	11
8. Q16 <i>also 2.1 & 4.3 & 4.2</i>	H556/02 Exploring physics June 2018	11	13
9. Q6 <i>also 4.5 & 4.4 & 6.5</i>	H556/03 Unified physics June 2018	11	15
10. Q19 <i>also 2.1 & 2.2 & 4.5 & 4.4</i>	H556/02 Exploring physics November 2020	11	17
11. Q1 <i>also 3.5 & 3.3 & 3.1 & 6.3 & 6.2</i>	H556/03 Unified physics June 2025	13	19
12. Q20 <i>also 2.1 & 2.2 & 4.5 & 4.4 & 4.3</i>	H556/02 Exploring physics June 2018	14	23
13. Q22 <i>also 6.1</i>	H556/02 Exploring physics June 2019	14	27
14. Q18 <i>also 3.2 & 4.3 & 4.2</i>	H556/02 Exploring physics November 2021	14	31
15. Q5 <i>also 3.2 & 3.1 & 4.4 & 5.3</i>	H556/03 Unified physics June 2022	17	35
4.1.2 CHARGE CARRIERS AND DRIFT VELOCITY		4 Qs · 15 marks	39
16. Q6 <i>also 4.3 & 4.2</i>	H556/02 Exploring physics June 2019	1	40
17. Q2 <i>also 3.2</i>	H556/02 Exploring physics November 2020	1	41
18. Q4 <i>also 3.2</i>	H556/02 Exploring physics June 2025	1	42
19. Q2 <i>also 3.2 & 6.3</i>	H556/03 Unified physics June 2017	12	43



QUESTIONS

19 questions · 143 marks · 2 sub-topics



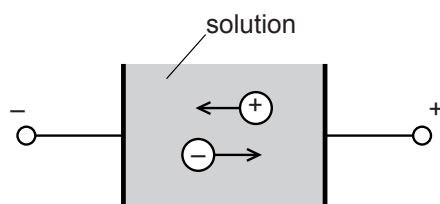
SUB-TOPIC 4.1.1

CURRENT AND CONSERVATION OF CHARGE

Sub-topic 4.1.1 · 15 questions · 128 marks · lowest tariff first



- 1 The diagram below shows the motion of positive and negative particles in a conducting solution.



Which statement is correct?

- A The current in the solution is zero.
- B The conventional current is to the left.
- C The positive particles are always protons.
- D The negative particles are always electrons.

Your answer

[1]

- 2 One million electrons travel between two points in a circuit.
The **total** energy gained by the electrons is $1.6 \times 10^{-10} \text{ J}$.

What is the potential difference between the two points?

A $1.6 \times 10^{-16} \text{ V}$

B $1.6 \times 10^{-4} \text{ V}$

C $1.0 \times 10^3 \text{ V}$

D $1.0 \times 10^9 \text{ V}$

Your answer

[1]

© OCR 2017

Turn over



6 Which is the **best** value for the elementary charge e in terms of both accuracy and precision?

A $(1.5 \pm 0.5) \times 10^{-19} \text{ C}$

B $(1.5 \pm 0.4) \times 10^{-19} \text{ C}$

C $(1.7 \pm 0.2) \times 10^{-19} \text{ C}$

D $(1.8 \pm 0.2) \times 10^{-19} \text{ C}$

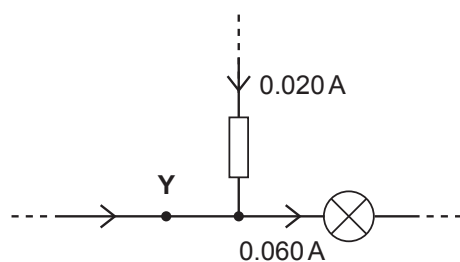
Your answer

[1]

© OCR 2018



3 Part of an electric circuit is shown below.



The direction of all the currents and the magnitude of two currents are shown.

How many electrons pass through the point Y in 10 s?

A 1.25×10^{18}

B 2.50×10^{18}

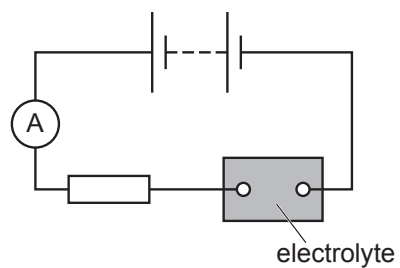
C 3.75×10^{18}

D 5.00×10^{18}

Your answer

[1]

- 1 A current is present in the circuit below.



The resistor is made from a length of wire.

Which row gives the correct charge carriers in the resistor and in the electrolyte?

	Charge carriers in the resistor	Charge carriers in the electrolyte
A	Electrons	Electrons
B	Electrons	Ions
C	Electrons and protons	Ions and electrons
D	Electrons and ions	Ions and protons

Your answer

[1]

- 17 A light-emitting diode (LED) can be used to determine the Planck constant h . When the LED just starts to emit light, the equation below is valid

$$eV = \frac{hc}{\lambda}$$

where V is the potential difference (p.d.) across the LED, λ is the wavelength of the light emitted, c is the speed of light in vacuum and e is the elementary charge.

- (a) In the equation above, $\frac{hc}{\lambda}$ is the energy of a photon emitted from the LED.

Determine the S.I. base units for h .

base units = ... [2]

- (b)* Describe how an experiment can be carried out in the laboratory to determine h from a graph. Your description must include how V and λ are accurately determined. Assume that the values of e and c are known. [6]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....



Additional answer space if required

.....

.....

.....

.....

.....

.....

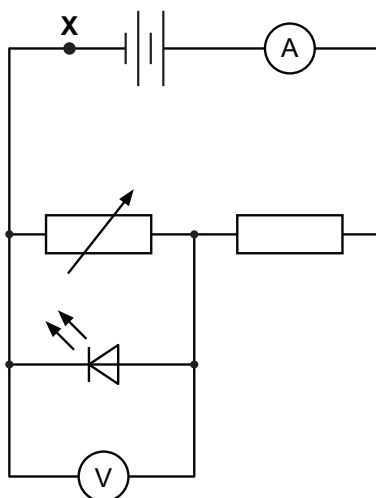
.....

.....



- 16** A student is investigating the behaviour of a light-emitting diode (LED).

They use the circuit below to determine the lowest potential difference (p.d.) at which the LED lights.



- (a) State the name of the circuit arrangement of the battery, variable resistor and resistor in this circuit.

..... [1]

- (b) Draw an arrow on the circuit to show the direction of conventional current. [1]

- (c) State how the readings on the ammeter and the voltmeter change when the resistance of the variable resistor is increased.

Ammeter reading

Voltmeter reading

[2]

- (d) The LED is made from two semiconducting materials.

Compare the number density of charge carriers in semiconductors, metals and insulators.

.....

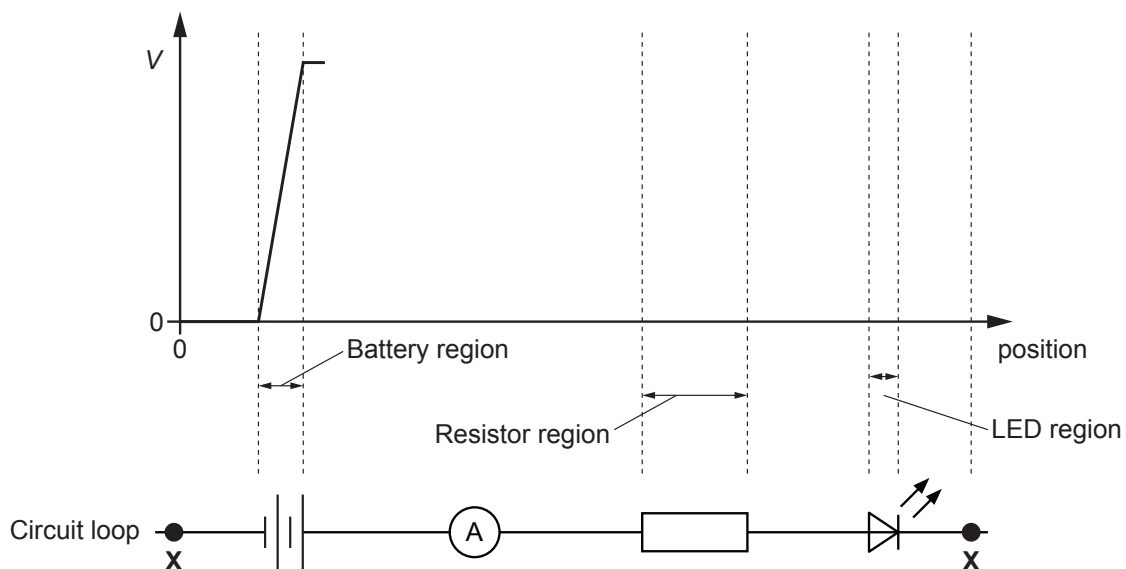
.....

..... [2]

(e) This question is about a clockwise circuit loop starting at **X**.

This loop is shown beneath the graph.

Assume the battery has negligible internal resistance. The resistance of the ammeter is also negligible.



On the axes above this loop, complete the graph to show the variation of the potential difference V relative to the point **X** with the position along this loop. **[4]**

16 (a) Derive the S.I. base units for resistance.

base units: [2]

(b) Fig. 16.1 shows the I - V characteristics of two electrical components **L** and **R**.

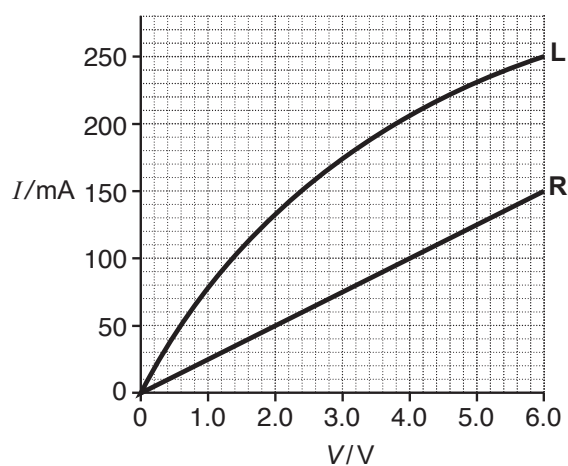


Fig. 16.1

The component **L** is a filament lamp and the component **R** is a resistor.

(i) Show that the resistance of **R** is $40\ \Omega$.

- (ii) Fig. 16.2 shows the components **L** and **R** connected in series to a battery of e.m.f. 6.0V.

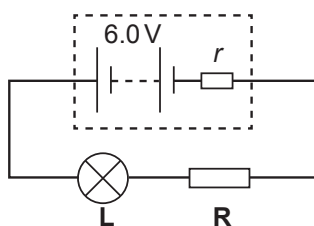


Fig. 16.2

The resistor **R** is a cylindrical rod of length 8.0 mm and cross-sectional area $2.4 \times 10^{-6} \text{ m}^2$. The current in the circuit is 100 mA.

- 1 Use Fig. 16.1 to determine the internal resistance r of the battery.

$$r = \dots\dots\dots \Omega \text{ [3]}$$

- 2 Calculate the resistivity ρ of the material of the resistor **R**.

$$\rho = \dots\dots\dots \Omega \text{ m [2]}$$

- 3 There are 6.5×10^{17} charge carriers within the volume of **R**.

Calculate the mean drift velocity v of the charge carriers within the resistor **R**.

$$v = \dots\dots\dots \text{ ms}^{-1} \text{ [3]}$$

Turn over

- 6 Fig. 6.1 shows a single photomultiplier tube and its internal components. The tube can detect gamma photons in high-energy physics experiments.

A single gamma photon incident on the scintillator crystal generates many photons of blue light. These visible light photons travel to the photocathode where they are converted into photoelectrons. The number of electrons is then multiplied in the photomultiplier tube with the help of electrodes called dynodes. A short pulse of electric current is produced at the output end of the photomultiplier tube.

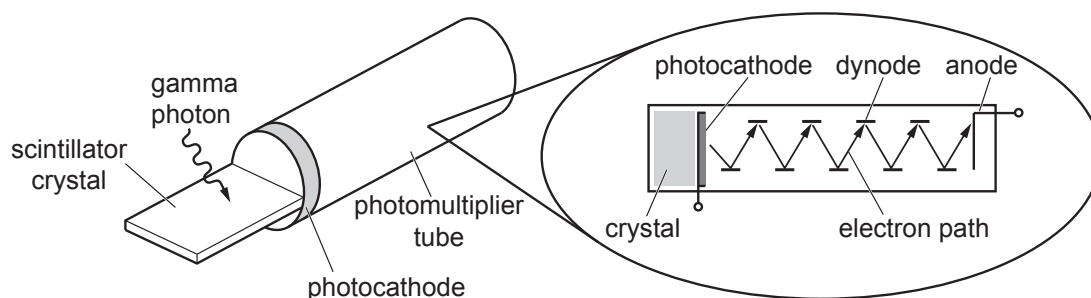


Fig. 6.1

- (a) Fig. 6.2 shows a section through the scintillator crystal in air.

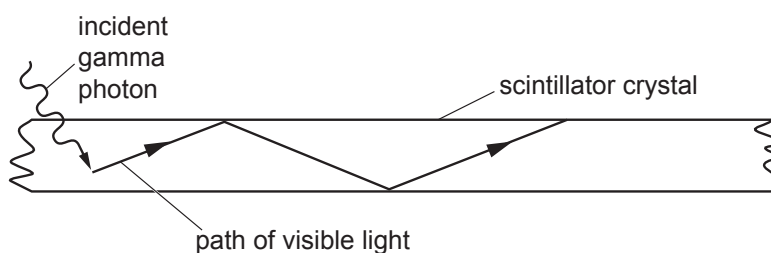


Fig. 6.2

- (i) The refractive index of the scintillator crystal for visible light is 1.69. The refractive index of air is 1.00. Calculate the critical angle C for this crystal.

$$C = \dots\dots\dots^\circ \text{ [2]}$$

- (ii) Explain why the visible light inside the scintillator crystal follows the path shown in Fig. 6.2.

.....

.....

.....

..... [2]

- (b) A high energy gamma photon passing through the scintillator crystal converts some of its energy into visible light photons of mean wavelength 450 nm.

Show that the energy of a single photon of wavelength 450 nm is less than 3 eV.

[3]

- (c) The photocathode is coated with potassium which has a work function of 2.3 eV. Each emitted photoelectron is accelerated by a potential difference of 100 V between the photocathode and a metal plate, called the first dynode.

- (i) Show that the maximum kinetic energy of an emitted electron at the photocathode is very small compared to its kinetic energy of 100 eV at the first dynode.

[1]

- (ii) 2000 photoelectrons are released from the photocathode. Each photoelectron has enough energy to release four electrons from the first dynode at the collision. These four electrons are then accelerated to the next dynode where the process is repeated. There are 9 dynodes in the photomultiplier tube. The total number of electrons collected at the anode for each photoelectron is 4^9 .

The pulse of electrons at the anode lasts for a time of 2.5×10^{-9} s.

Calculate the average current due to this pulse.

average current = ... A [3]



- 19 (a) The Planck constant h is an important fundamental constant in quantum physics.

Determine the S.I. base units for h .

base units = ... [2]

- (b) A researcher is investigating the de Broglie wavelength of charged particles.

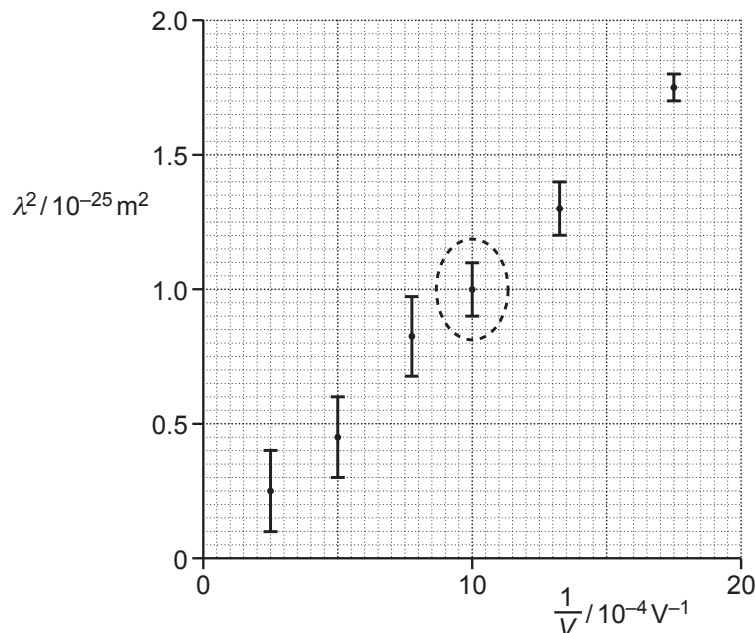
The charged particles are accelerated through a potential difference V . The de Broglie wavelength λ of these particles is then determined by the researcher.

Each particle has mass m and charge q .

- (i) Show that the de Broglie wavelength λ is given by the expression $\lambda^2 = \frac{h^2}{2mq} \times \frac{1}{V}$.

[2]

- (ii) The researcher plots data points on a λ^2 against $\frac{1}{V}$ grid, as shown below.



- 1 Calculate the percentage uncertainty in λ for the data point circled on the grid.

percentage uncertainty = ... % [2]

- 2 Draw a straight line of best fit through the data points. [1]

- 3 The charge q on the particle is $2e$, where e is the elementary charge.

Use your best fit straight line to show that the mass m of the particle is about 10^{-26} kg.

[4]



- 1 The Earth's aurora is an atmospheric effect visible in the polar regions.

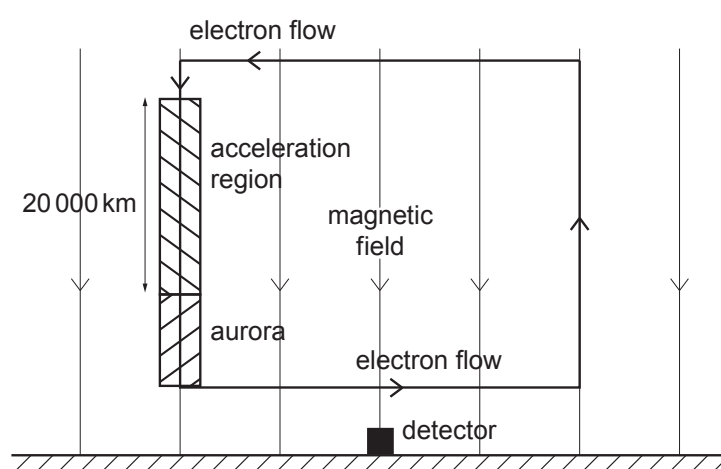
Electrons in the upper atmosphere initially move vertically downwards along one of the Earth's **magnetic** field lines. They are accelerated by an **electric** field.

These electrons collide with oxygen atoms causing atomic electrons to be excited to higher energy levels. The atomic electrons then return to lower energy levels, releasing photons of green light, red light and ultraviolet.

The accelerated electrons then travel horizontally through the atmosphere, before travelling vertically along a different magnetic field line, and then completing the circuit by travelling horizontally back to their starting point.

The situation is shown in **Fig. 1.1**.

Fig. 1.1



not to scale

- (a) The accelerated electrons are accelerated by electric fields parallel to the magnetic field lines.

The length of the acceleration region is 20 000 km and the electric field value is 0.2 mV/m. The electric field can be assumed to be uniform.

- (i) Calculate the kinetic energy gained by the electrons as they pass through the electric field, in joules.

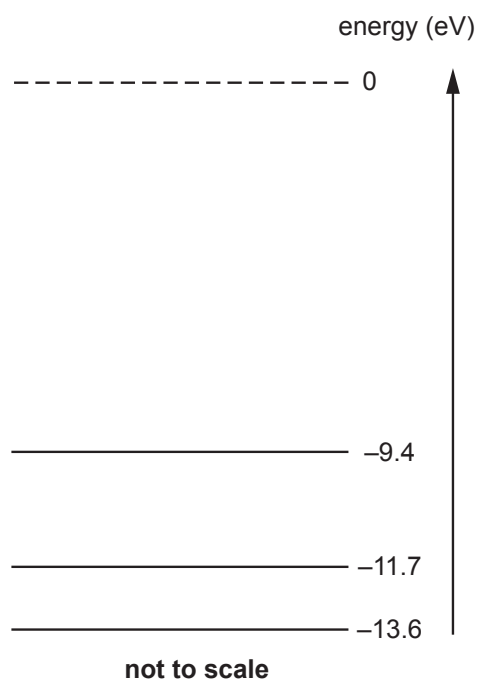
kinetic energy = ...J [3]

- (ii) State and explain the direction of the electric field required to accelerate the electrons **downwards**.

.....

 [2]

- (b) A simplified energy level diagram for atomic oxygen is shown below.



Determine the wavelength of the green light emitted.

Fully justify your answer.

wavelength = ... m [4]

- (c) The horizontal current closest to the Earth produces a magnetic field which can be detected at ground level.

With reference to **Fig. 1.1**, state and explain the direction of this magnetic field.

.....

.....

.....

..... [2]

- (d) Suggest **two** ways that the horizontal current may affect the atmosphere.

1

.....

2

..... [2]

BLANK PAGE

DO NOT WRITE ON THIS PAGE



- 20 (a) An approximate value of the Planck constant h can be determined in the laboratory using light-emitting diodes (LEDs). An LED suddenly starts to conduct and emit monochromatic light when the potential difference across an LED exceeds a minimum value V_0 . The potential difference V_0 and the wavelength λ of the emitted light are related by the equation

$$V_0 = \left(\frac{hc}{e} \right) \times \frac{1}{\lambda}$$

where e is the elementary charge and c is the speed of light in a vacuum.

Fig. 20.1 shows some data points plotted by a student on a V_0 against $\frac{1}{\lambda}$ graph for five different LEDs.

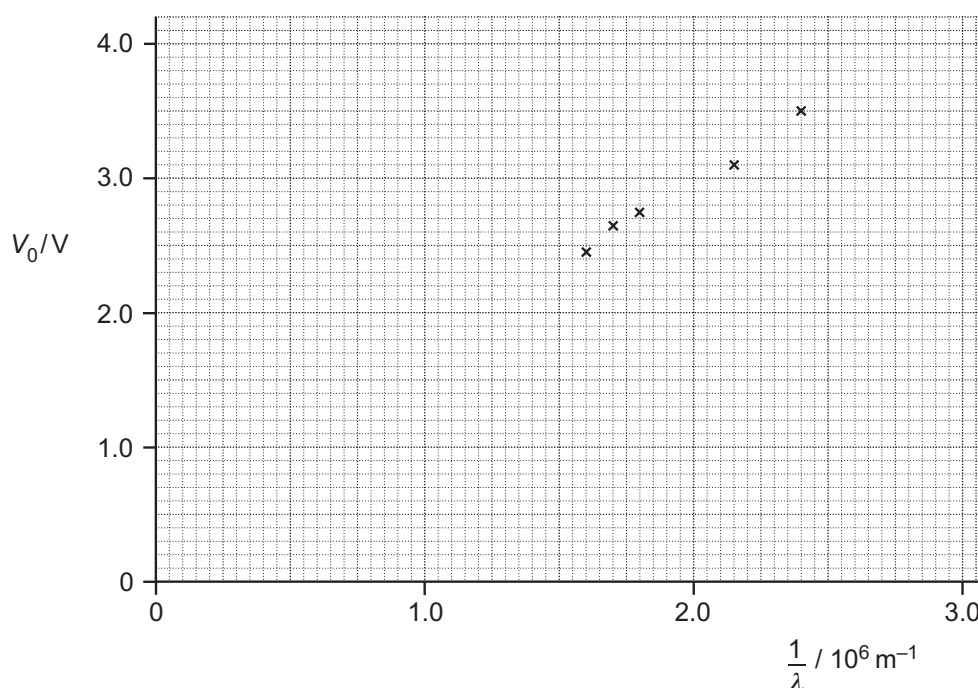


Fig. 20.1

The potential difference across each LED was measured using a digital voltmeter with divisions $\pm 0.01 \text{ V}$. The values for the wavelengths are accurate and were provided by the manufacturer of the LEDs.

The value of V_0 was determined by directly observing the state of the LED in the **brightly** lit laboratory.

- (i) Draw the straight line of best fit on Fig 20.1 and determine the gradient of the line.

- (ii) Use your answer in (i) and the equation on page 20 to determine a value for h to 2 significant figures. Show your working.

$h =$ Js [3]

- (iii) Calculate the percentage difference between your value in (ii) and the accepted value of the Planck constant.

difference = ... % [1]

- (iv) Identify the two types of errors shown by the data in Fig. 20.1 and suggest how you could have refined the experiment to reduce or eliminate these errors.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

BLANK PAGE

Question 21 is on page 24
PLEASE DO NOT WRITE ON THIS PAGE



- 22 (a) Fig. 22.1 shows two horizontal metal plates in a vacuum.

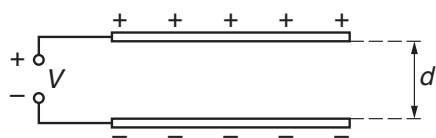


Fig. 22.1

The plates are connected to a power supply. The potential difference V between the plates is constant. The magnitude of the charge on each plate is Q . The separation between the plates is d .

Fig. 22.2 shows the variation with d of the charge Q on the positive plate.

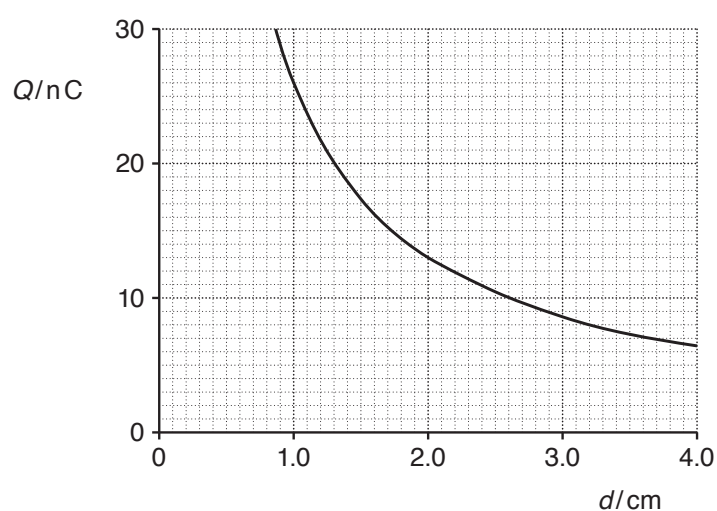


Fig. 22.2

- (i) Use Fig. 22.2 to propose and carry out a test to show that Q is inversely proportional to d .

Test proposed:

.....

Working:

- (ii) Use capacitor equations to show that Q is inversely proportional to d .

[2]

- (b) Fig. 22.3 shows a negatively charged oil drop between two oppositely charged horizontal plates in a vacuum.

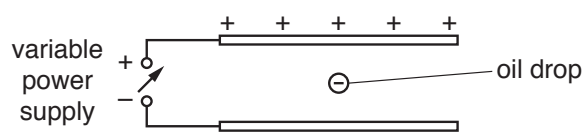


Fig. 22.3

The plates are fixed and connected to a variable power supply. The weight of the oil drop is $1.8 \times 10^{-14} \text{ N}$.

- (i) The power supply is adjusted so that the potential difference between the plates is 200 V when the oil drop becomes **stationary**.

State the magnitude of the vertical electric force F_E acting on the charged oil drop.

$$F_E = \dots\dots\dots \text{ N [1]}$$

- (ii) The potential difference between the plates is now increased to 600 V. The oil drop accelerates upwards.

Calculate the acceleration a of the oil drop.

$$a = \dots\dots\dots \text{ ms}^{-2} [3]$$

Question 22 continues on page 26

- (c)* Fig. 22.4 shows an arrangement used by a student to investigate the forces experienced by a small length of charged gold foil placed in a uniform electric field.

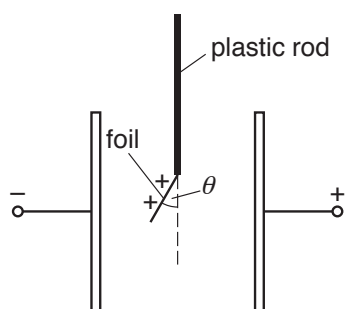


Fig. 22.4

The two vertical metal plates are connected to a high-voltage supply.

The foil is given a positive charge by briefly touching it to the positive plate.

The angle θ made with the vertical by the foil in the electric field is given by the expression

$$\tan \theta = \frac{qE}{W}$$

where q is the charge on the foil, E is the electric field strength between the plates and W is the weight of the foil.

The angle θ can be determined by taking photographs with the camera of a mobile phone.

Describe how the student can safely conduct an experiment to investigate the relationship between θ and E .

Identify any variables that must be controlled.

[6]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Additional answer space if required.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

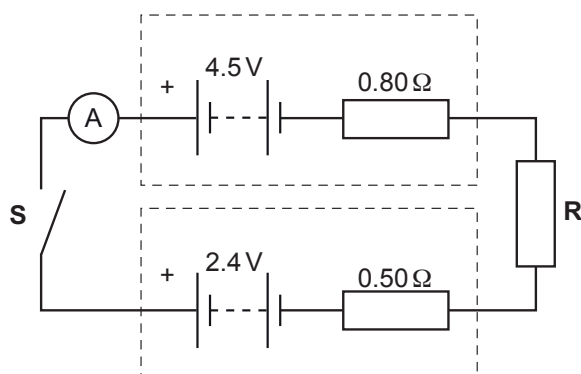
.....

.....

.....



18 (a) The circuit diagram of an electrical circuit is shown below.



The positive terminals of the batteries are connected together.

One battery has electromotive force (e.m.f.) 4.5 V and internal resistance 0.80 Ω .

The other battery has e.m.f. 2.4 V and internal resistance 0.50 Ω .

R is a coil of insulated wire of resistance 1.2 Ω at room temperature.

The switch **S** is closed.

(i) On the diagram, draw an arrow to show the direction of the conventional current. [1]

(ii) Calculate the current I shown by the ammeter.

$I =$ A [3]

- (iii) The insulated wire has diameter $4.6 \times 10^{-4} \text{ m}$.
The number density of charge carriers in **R** is $4.2 \times 10^{28} \text{ m}^{-3}$.

Calculate the mean drift velocity v of the charge carriers in **R**.

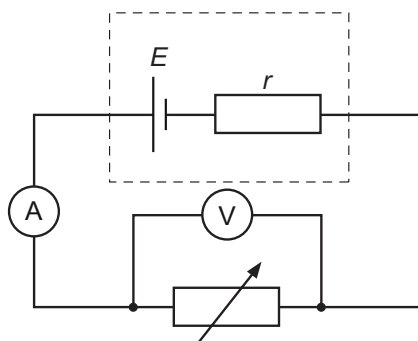
$v = \dots\dots\dots \text{ ms}^{-1}$ [2]

- (iv) The current measured by the ammeter is smaller than that calculated in (ii). This is because the temperature of **R** increased due to heating by the current.

Without any changes to the circuit itself, state and explain what practically can be done to make the measured current the same as the calculated current..

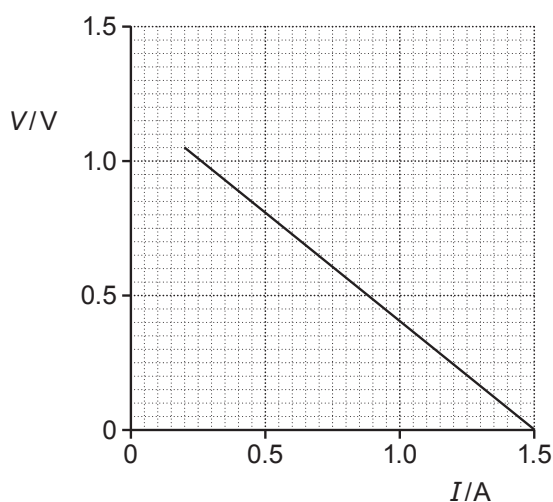
.....
.....
..... [2]

- (b)* A student is doing an experiment to determine the e.m.f. E of a cell and its internal resistance r . The circuit diagram of the arrangement is shown below.



The student changes the resistance of the variable resistor. The potential difference V across the variable resistor and the current I in the circuit are measured.

The V against I graph plotted by the student is shown below.



V/V	I/A	R/Ω	P/W
0.20	1.25		
0.40	1.00		
0.60	0.75		
0.80	0.50		
1.00	0.25		

There is an incomplete table next to the graph.

R is the resistance of the variable resistor and P is the power dissipated by the variable resistor.

- Use the graph to determine E and r . Explain your reasoning.
- Calculate R and P to complete the table. Describe how P depends on R .

[6]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Additional answer space if required

.....

.....

.....

.....

.....

.....

.....

.....

.....



- 5 A student experiments with microwaves emitted from a transmitter. The frequency f of the microwaves from the transmitter can be adjusted.

(a) The microwaves are produced by an alternating current in the transmitter.

In one experiment, f is 11 GHz. In a wire in the transmitter, the magnitude of the **maximum** alternating current is 20 mA. The wire has cross-sectional area $1.4 \times 10^{-8} \text{ m}^2$ and is made of a metal with free electron number density $8.0 \times 10^{28} \text{ m}^{-3}$.

- (i) Show that the maximum drift velocity of each free electron in the wire is about 0.1 mm s^{-1} .

[3]

- (ii) The student models the average motion of the free electrons in the wire as simple harmonic motion.

Use your answer to (i) to calculate the amplitude A of this motion.

$A = \dots\dots\dots \text{ m}$ [3]

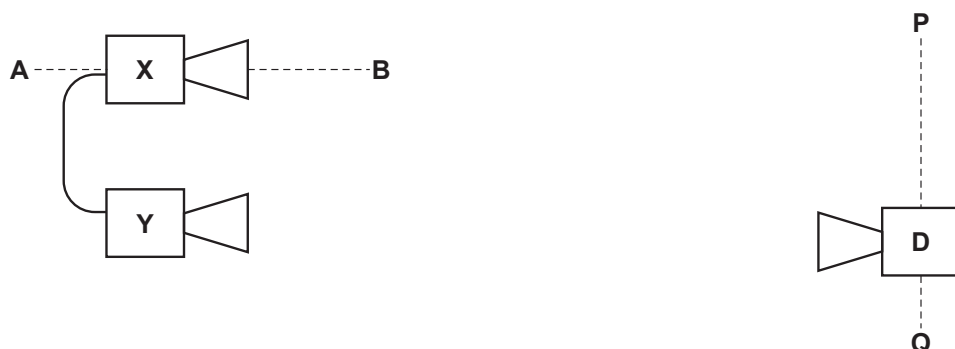
- (iii) Without further calculation, explain how the maximum acceleration of a free electron varies as the frequency f is adjusted, provided that the maximum alternating current remains constant.

.....

 [2]



- (b) The student connects two microwave transmitters **X** and **Y**, and places them in front of a microwave detector **D**, as shown in the diagram below.



The transmitters **X** and **Y** produce **coherent** vertically polarised microwaves with the same frequency f .

The detector **D** is sensitive to vertically polarised microwaves only.

When the detector **D** is moved along the line **PQ**, a pattern of maximum and minimum intensity is observed. Adjacent maxima are separated by a distance x .

- (i)* Explain:

- why this pattern of intensity occurs
- the expected relationship between the frequency f and the distance x
- how to verify this relationship experimentally.

[6]

[illegible]

.....
.....

Additional answer space if required

.....
.....
.....
.....
.....
.....
.....
.....
.....

- (ii) Transmitter **X** is rotated about the line **AB** and the experiment is repeated at different orientations until it has been rotated by 180° .

Describe and explain the observed patterns of maximum and minimum intensity.

.....
.....
.....
.....
.....
.....
.....
.....
..... [3]

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE



SUB-TOPIC 4.1.2

CHARGE CARRIERS AND DRIFT VELOCITY

Sub-topic 4.1.2 · 4 questions · 15 marks · lowest tariff first



- 6 Wires **P** and **Q**, made from the same metal, are connected in **parallel** across a cell of negligible internal resistance.
The table shows some data.

Wire	Length of wire	Diameter of wire	Mean drift velocity of electrons in the wire / mm s^{-1}
P	L	d	0.60
Q	$3L$	$2d$	v

What is the mean drift velocity v of the electrons in wire **Q**?

- A** 0.15 mm s^{-1}
B 0.20 mm s^{-1}
C 0.30 mm s^{-1}
D 0.60 mm s^{-1}

Your answer

[1]



- 2 Which sequence shows the materials arranged in the order of increasing number density of charge carriers?

increasing number density —————→

- A conductor, insulator, semiconductor
- B conductor, semiconductor, insulator
- C insulator, semiconductor, conductor
- D semiconductor, insulator, conductor

Your answer

[1]

© OCR 2020



- 4 The current in a copper wire of radius $2.5 \times 10^{-4} \text{ m}$ is 1.4 A .

The number density of charge carriers (electrons) in copper is $8.5 \times 10^{28} \text{ m}^{-3}$.

What is the mean drift velocity of the electrons in the wire?

- A** $2.1 \times 10^{-4} \text{ mm s}^{-1}$
B 0.13 mm s^{-1}
C 0.52 mm s^{-1}
D 1.9 mm s^{-1}

Your answer

[1]

© OCR 2025

Turn over



- 2 A small thin rectangular slice of semiconducting material has width a and thickness b and carries a current I . The current is due to the movement of electrons. Each electron has charge $-e$ and mean drift velocity v . A uniform magnetic field of flux density B is perpendicular to the direction of the current and the top face of the slice as shown in Fig. 2.1.

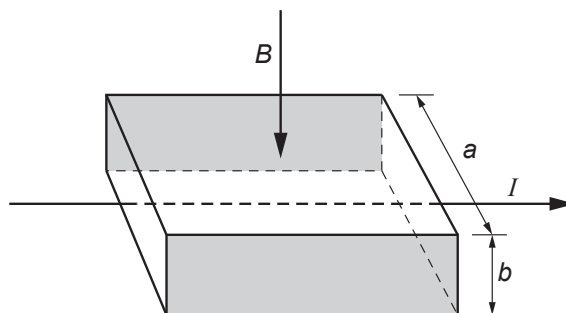


Fig. 2.1

- (a) As soon as the current is switched on, the moving electrons in the current are forced towards the shaded rear face of the slice where they are stored. This causes the shaded faces to act like charged parallel plates. Each electron in the current now experiences both electric and magnetic forces. The resultant force on each electron is now zero.

Write the expressions for the electric and magnetic forces acting on each electron and use these to show that the magnitude of the potential difference V between the shaded faces is given by

$$V = Bva.$$

[3]

(b) Here are some data for the slice in a particular experiment.

number of conducting electrons per cubic metre, $n = 1.2 \times 10^{23} \text{ m}^{-3}$

$a = 5.0 \text{ mm}$

$b = 0.20 \text{ mm}$

$I = 60 \text{ mA}$

$B = 0.080 \text{ T}$

Use this data to calculate

(i) the mean drift velocity v of electrons within the semiconductor

$v = \dots\dots\dots \text{ ms}^{-1}$ [3]

(ii) the potential difference V between the shaded faces of the slice.

$V = \dots\dots\dots \text{ V}$ [1]

- (c) The slice is mounted and used as a measuring instrument called a Hall probe. A cell is connected to provide the current in the slice. The potential difference across the slice is measured by a separate voltmeter.

A student wants to measure the magnetic flux density between the poles of two magnets mounted on a steel yoke as shown in Fig. 2.2. The magnitude of the flux density is between 0.02 T and 0.04 T.

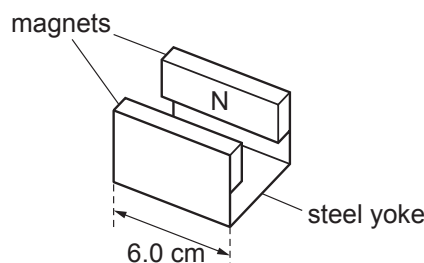


Fig. 2.2

- (i) Suggest **one** reason why this Hall probe is **not** a suitable instrument to measure the magnetic flux density for the arrangement shown in Fig. 2.2.

.....

 [1]

- (ii) Another method of measuring the magnetic flux density for the arrangement shown in Fig. 2.2 is to insert a current-carrying wire between the poles of the magnet. Explain how the magnetic flux density can be determined using this method and discuss which measurement in the experiment leads to the greatest uncertainty in the value for the magnetic flux density.

.....

 [4]

MARK SCHEMES

official mark schemes



1	B	1	
----------	----------	----------	--



2	C		1	
---	---	--	---	--



6	C		1	
---	---	--	---	--



3	B	1	
---	---	---	--

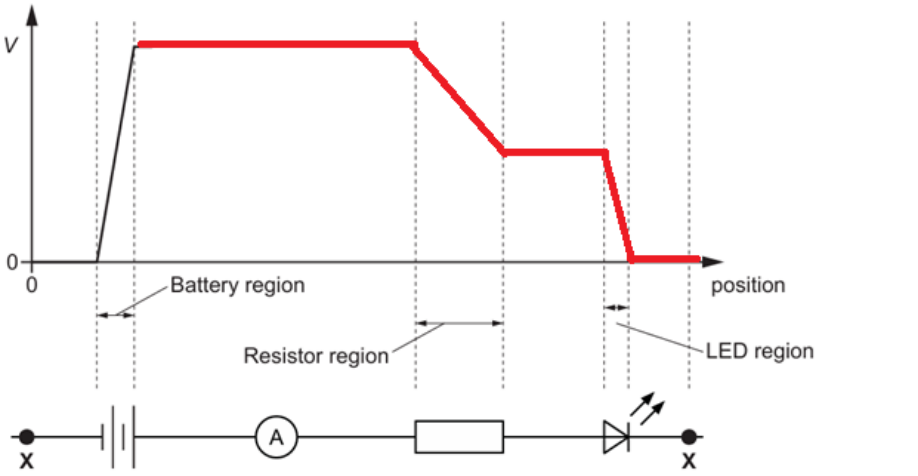


1	B	1	
---	---	---	--



17	(a)	eV or J $\rightarrow$ [kg m ² s ⁻²] in base units by any method base units = kg m ² s ⁻¹	C1 A1	Allow kg (m s ⁻¹) ² Allow base units in any order
	*(b)	Level 3 (5–6 marks) Clear description of method and analysis of data <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Some description of method and analysis of data or Clear description or Clear analysis <i>There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.</i> Level 1 (1–2 marks) Limited description or Limited analysis <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit.</i>	B1× 6	Indicative scientific points may include: Description • Circuit with LED connected to a variable supply (and series /current limiting resistor) / or use of variable resistor • p.d. across LED increased until LED emits light • Voltmeter (across LED) used to measure V • Use a range of LEDs • λ determined using diffraction grating / spectrometer / double-slit / use $n\lambda = d \sin \theta$ / $\lambda = ax/D$ OR λ determined from manufacturer's data / known wavelength • Darkroom used / tube placed over LED used to establish switching of LED / switch-on identified from finite ammeter reading Analysis of data • Plot of V against λ^{-1} / eV against λ^{-1} / eV against c/λ • Line of best-fit drawn through the points • Straight line (through origin) • Correct gradient for described graph hc/e or hc or h • Correct arrangement for determination of h $h = (\text{gradient} \times e) / c$ or $h = \text{gradient} / c$ (allow numerical values for e and/or c)
		Total	8	

16	(a)	Potential divider / Series (circuit)	B1	IGNORE potentiometer
16	(b)	An arrow pointing in the correct direction (clockwise)	B1	ALLOW any arrow indicating correct direction All arrows drawn must be in the correct direction
16	(c)	(Ammeter reading) decreases (Voltmeter reading) increases	B1 B1	
16	(d)	Number density is high(est) in metals / low(est) in insulators Number density in semiconductors is higher than in insulators and lower than metals	B1 B1	ALLOW for use of n for number density in both marking points ALLOW answers in terms of charge carriers ALLOW any numbers as method of comparison in both marking points 2 nd marking point is for idea that semiconductors lie in the correct position between metals and insulators and will score both B marks.

Question		Answer	Mark	Guidance
16	(e)	Continuous line, not rising at any point and at least one decrease Non-zero horizontal line across ammeter AND lower non-zero horizontal line from RHS of resistor and to LHS of LED ALLOW very small decrease of voltage across either/both Any decrease shown across the resistor and any decrease shown across LED Zero at (and beyond) RHS of LED	B1 B1 B1 B1	 The graph shows voltage (V) on the vertical axis and position on the horizontal axis. The red line starts at the origin, rises linearly through the 'Battery region', remains constant through the 'Resistor region' (which contains the ammeter 'A'), drops linearly through the 'LED region', and then remains at zero. Below the graph is a circuit diagram showing a battery, an ammeter (A), a resistor, and an LED in series. The regions are marked with vertical dashed lines corresponding to the components.

Question	Answer	Guidance
----------	--------	----------



16	(a)	$(R = \frac{V}{I} = \frac{W}{QI}; Q = It)$ charge $\rightarrow A\ s$ or energy $\rightarrow kg\ m\ s^{-2} \times m$ or $kg\ m^2\ s^{-2}$ (base units) $kg\ m^2\ A^{-2}\ s^{-3}$	C1 A1	Allow other correct methods Allow Q or C or coulomb for 'charge'; E or W or joule or J or work done for 'energy' Allow 1 mark for $J\ s^{-1}\ A^{-2}$ Allow $\frac{kg\ m^2}{A^2\ s^3}$ or $kg\ m^2 / (A^2\ s^3)$ Not $kg\ m^2 / A^2 / s^3$ or $kg\ m^2 / s^3 / A^2$
	(b) (i)	$(R =) \frac{6.0}{0.150}$ $R = 40\ \Omega$	M1 A0	Allow any correct value of V ($\pm 0.1\ V$) divided by the correct value of I ($\pm 10\ mA$) from the straight line for R
	(ii)1	$(V_L =) 1.4\ (V)$ or $(V_R =) 4.0\ (V)$ or $(R_T =) 6.0/0.1\ (\Omega)$ $(V_{terminal} =) 5.4\ (V)$ or $(V_r =) 0.6\ (V)$ or $(r =) 60 - 54\ (\Omega)$ $r = 6.0\ (\Omega)$	C1 C1 A1	Allow full credit for other correct methods Possible ECF from (i) Allow $\pm 0.1\ V$ for the value of p.d. from the graph Note getting to this stage will also secure the first C1 mark Allow 1 SF answer here without any SF penalty
	(ii)2	$\rho = \frac{40 \times 2.4 \times 10^{-6}}{8.0 \times 10^{-3}}$ (Any subject) $\rho = 0.012\ (\Omega\ m)$	C1 A1	Allow ECF Allow 1 mark for either 0.018 for using $60\ \Omega$, 0.016(2) for using $54\ \Omega$ or for 0.0018 for $6.0\ \Omega$
	(ii)3	$n = \frac{6.5 \times 10^{17}}{2.4 \times 10^{-6} \times 0.008}$ or $n = 3.385 \times 10^{25}\ (m^{-3})$ $v = \frac{0.100}{2.4 \times 10^{-6} \times 3.385 \times 10^{25} \times 1.60 \times 10^{-19}}$ (Any subject) $v = 7.7 \times 10^{-3}\ (m\ s^{-1})$	C1 C1 A1	Note do not penalise again for the same POT error Allow 1 mark for $4(.0) \times 10^5\ (m\ s^{-1})$; $n = 6.5 \times 10^{17}$ used
		Total	11	



Question	Answer	Mark	Comments	
6	(a) (i)	$\sin C = 1/n = 1/1.69 (= 0.592)$ $C = 36^\circ$	C1 A1	
	(ii)	<u>Total internal reflection</u> occurs because the <u>angle of incidence</u> (at the surface) is greater than the <u>critical angle/ 36°</u>	B1 B1	allow because <u>i</u> > <u>C</u>
	(b)	$E = (hc/\lambda) = 6.63 \times 10^{-34} \times 3.0 \times 10^8 / 450 \times 10^{-9}$ $E = 4.42 \times 10^{-19}$ (J) energy = 2.76 (eV)	C1 C1 A1	N.B. the answer here must be 2 SF or more
	(c) (i)	$2.76 - 2.3 = 0.46$ eV (so only 0.5% of energy/AW)	B1	allow $2.8 - 2.3 = 0.5$ eV and $3.0 - 2.3 = 0.7$ eV possible ecf from (b)
	(ii)	$n = 2000 \times 4^9 (= 5.24 \times 10^8)$ $Q = ne = 8.4 \times 10^{-11}$ (C) $I = 8.4 \times 10^{-11} / 2.5 \times 10^{-9}$ average current = 0.034 (A)	C1 C1 A1	allow ecf for wrong n allow 34 m(A); answer is 1.7×10^{-5} A if 2000 omitted (2/3)
		Total	11	



19	(a)		$h \rightarrow \text{J s} \quad / \quad h \rightarrow \text{N m s} \quad / \quad \text{J} \rightarrow \text{kg m}^2 \text{s}^{-2}$ base unit = $\text{kg m}^2 \text{s}^{-1}$	C1	
				A1	
	(b)	(i)	$Vq = \frac{1}{2} mv^2$ and $\lambda = \frac{h}{mv}$ Clear algebra leading to $\lambda^2 = \frac{h^2}{2mq} \times \frac{1}{V}$	M1	Allow p for mv Allow e for q in (b)(i) – this is to be treated as a ‘slip’
				A1	
		(ii)1	(% uncertainty in λ^2) 10%	C1	
			(% uncertainty in λ) 5%	A1	Note 10 (%) on answer line will score the C1 mark
		(ii)2	Straight line of best fit passes through all error bars	B1	
		(ii)3	gradient = $1.0 (\times 10^{-22})$ $\frac{h^2}{2mq} = \text{gradient}$ $\frac{(6.63 \times 10^{-34})^2}{2 \times m \times 3.2 \times 10^{-19}} = \text{gradient}$ $m = 6.9 \times 10^{-27} \text{ (kg)}$ (hence about 10^{-26} kg)	C1	Ignore POT for this mark; Allow $\pm 0.20 (\times 10^{-22})$
				C1	
				C1	Possible ECF for incorrect value of gradient
				A1	Note check for AE (condone rounding error here) and answer must be about 10^{-26} (kg) for any incorrect gradient value for this A1 mark Special case: $1.37 \times 10^{-26} \text{ kg}$ scores 3 marks for $q = 1.6 \times 10^{-19} \text{ C}$ because answer is about 10^{-26} kg
			Total	11	

1	(a)	(i)	$V (= Ed) = 0.2 \times 10^{-3} \times 20,000 \times 10^3$ or $V = 4000 \text{ (V)}$ $W (= QV) = 1.6 \times 10^{-19} \times 4000$ $6.4 \times 10^{-16} \text{ (J)}$	C1 C1 A1	Allow $F (= QE) = 1.6 \times 10^{-19} \times 0.2 \times 10^{-3}$ or $F = 3.2 \times 10^{-23} \text{ (N)}$ Allow $W (= Fd) = 3.2 \times 10^{-23} \times 20,000 \times 10^3$
1	(a)	(ii)	electrons move in opposite direction to (electric) field/conventional current (so electric field is) upwards	M1 A1	Allow electrons are negatively charged
1	(b)		$11.7 - 9.4 (= 2.3 \text{ eV})$ $\lambda = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{2.3 \times 1.6 \times 10^{-19}}$ $5.4 \times 10^{-7} \text{ (m)}$ Correct reasoning to select 540 nm - the middle wavelength (from red, green, UV) - the middle frequency - the middle photon energy - the middle-sized electron transition	C1 C1 A1 B1	Allow $13.6 - 11.7 (= 1.9 \text{ eV})$ or $13.6 - 9.4 (= 4.2 \text{ eV})$ Allow a <u>full</u> substitution with an energy level change of 9.4, 11.7 or 13.6 eV for this C1 mark only Allow an answer consistent with 1.9 eV or 4.2 eV (i.e. 296 nm or 654 nm gains 3 marks) Allow up to 4 marks for working backwards from stating wavelength of green light is ~550 nm i.e. $E = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{550 \times 10^{-9} \times 1.6 \times 10^{-19}}$ $E = 2.3 \text{ eV}$ $11.7 - 9.4 (= 2.3 \text{ eV})$

Question			Answer	Mark	Guidance
1	(c)		(conventional) current opposite to electron flow or (right) to left (magnetic field) out of the page	B1 B1	Allow annotation of figure to show circular magnetic field lines around current or arrow labelled current towards left on Fig 1.1
1	(d)		heating effect ionisation of atoms / lightning strikes	B1 B1	 Allow (ionisation causes) horizontal force / acceleration of gas (due to $F = BIL$ / motor effect)
			Total	13	



20	(a)	(i)	A straight line with non-zero V_0 intercept gradient = 1.3×10^{-6}	B1 B1	Ignore spread of data points on either side of the line Allow Intercept > 0 and < 1.0 V Allow $(1.10 \text{ to } 1.60) \times 10^{-6}$; no need to check calculation
		(ii)	gradient = $\frac{hc}{e}$ (Any subject) $h = \frac{1.3 \times 10^{-6} \times 1.60 \times 10^{-19}}{3.00 \times 10^8}$ (Any subject) $h = 6.9 \times 10^{-34}$ (J s)	C1 C1 A1	Possible ECF from (i) Note the answer must be given 2 SF only
		(iii)	difference = $\frac{6.9 \times 10^{-34} - 6.6(3) \times 10^{-34}}{6.6(3) \times 10^{-34}} \times 100 \%$ difference = 4.1 %	B1	Possible ECF from (ii) Ignore sign Not division by value from (ii) Allow 1 SF answer
		(iv)	Random (error) / data points are spread about line Systematic (error) / line does not pass through origin Take (many) repeat readings (of V_0) and average Conduct the experiment in a darkroom / use (black) tube over the LED to view when it is lit / use a (digital) voltmeter with no zero error	B1 B1 B1 B1	Allow other sensible suggestion Not faulty voltmeter

Question		Answer	Marks	Guidance
	(b)	Any one from: Energy of visible light photon < work function (of zinc) (frequency of) visible (light/photon) < threshold frequency Any one from: Energy of UV photon > work function (of zinc) (frequency of) UV (radiation/photon) > threshold frequency Any two from: • Collapse of leaf linked to removal of electrons • One-to-one interaction of photon and (surface) electron • Photon energy is independent of intensity / Intensity linked to rate of photons (incident on the zinc plate)	B1 B1 B1 × 2	Allow f for frequency, λ for wavelength and ϕ for work function throughout Allow 'overcome' / 'met' / 'reached' when describing > or < Allow photons Not f_0 for threshold frequency Allow equivalent statement with wavelength Allow = instead of > or < throughout for UV Allow equivalent statement with wavelength Ignore stem / plate / leaf / electroscope becoming positive
		Total	14	



22	(a)	(i)	$Qd = \text{constant}$ At least two pairs of values substituted to show that $Qd = \text{constant}$	C1 Allow straight-line graph of Q against $1/d$ passes through the origin Allow as d increases by a given factor (e.g. doubles) then Q decreases by the same factor (e.g. halves) A1 Allow numbers that show when d doubles then Q halves Ignore prefixes and POT errors
		(ii)	$Q = VC$ and $C = \frac{\epsilon_0 A}{d}$ Hence $Q = \frac{V\epsilon_0 A}{d}$ (and $Q \propto \frac{1}{d}$)	C1 Allow ϵ A1 Note Q , or Q/V must be the subject here Allow $Q \propto C$ and $C \propto \frac{1}{d}$
	(b)	(i)	$1.8 \times 10^{-14} \text{ (N)}$	B1 Ignore sign
		(ii)	$(F_E =) 3 \times 1.8 \times 10^{-14} \text{ (N)}$ or $(F_E =) 5.4 \times 10^{-14} \text{ (N)}$ or (mass =) $\frac{1.8 \times 10^{-14}}{g}$ (resultant force = $3.6 \times 10^{-14} \text{ N}$) $(a =) \frac{3.6 \times 10^{-14}}{(1.8 \times 10^{-14}/g)}$ $a = 20 \text{ (m s}^{-2}\text{)}$	C1 Note this mark is for either electric force on the oil drop or the calculating the mass of the oil drop Allow for ECF from (b)(i) C1 A1 Allow $g = 9.8$, but not $g = 10$ Note answer to 3SF is 19.6 Allow 2 marks for $a = 2g$ Note a bald answer of 20 will score 3 marks, if however, we see evidence for $g = 10$, then maximum score will be 2 mark

Question			Answer	Marks	Guidance
	(c)*		Level 3 (5–6 marks) Clear description and at least two from control of variables <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Some description and at least one from control of variables <i>There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.</i> Level 1 (1–2 marks) Any description but no control of variables or Limited mention of control of variable(s) <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit.</i>	B1 × 6	Use level of response annotations in RM Assessor Indicative scientific points may include: Description • $E = V/d$ • Voltmeter used to measure p.d. • Ruler used to measure separation d plates • Plastic rod held in a stand • Safety: Do not touch the terminals of high-voltage supply / (positive) plate • Vary d or V to change E • θ determined for each value of E • Experiment repeated for several values of E • Sensible techniques used to determine θ, e.g. use a protractor • Plot $\tan \theta$ against E or $\tan \theta$ against $1/d$ graph • Straight line through origin (expected) Control of variables • Charge q kept constant (ignore method) • Method for keeping q constant (e.g. same V for the (positive) plate, use separate constant voltage supply, etc) • Use the same foil / keep W the same • Keep d or V constant • Foil in between plates (where the field is uniform) • Draught-free room • Do the experiment quickly to avoid leakage of charge
			Total	14	



18	(a)	(i)	Arrow in anticlockwise direction	B1	Allow this mark for correct direction shown on diagram either on or off connecting wires
		(ii)	$(E =) 4.5 - 2.4$ or $(R_T =) 0.80 + 0.50 + 1.2$ $4.5 - 2.4 = I \times (0.80 + 0.50 + 1.2)$ $I = 0.84 \text{ (A)}$	C1 C1 A1	$E = 2.1 \text{ (V)}; R_T = 2.5 \text{ (}\Omega\text{)}$ Treat missing 1.2 resistance as TE Allow 2 marks for 2.8 (A); $E = 6.9 \text{ V}$ used
		(iii)	$(I = Anev)$ $0.84 = \pi \times (2.3 \times 10^{-4})^2 \times 4.2 \times 10^{28} \times 1.60 \times 10^{-19} \times v$ $v = 7.5 \times 10^{-4} \text{ (m s}^{-1}\text{)}$	C1 A1	Possible ECF from (ii) Note answer is $2.5 \times 10^{-3} \text{ (m s}^{-1}\text{)}$ for $I = 2.76 \text{ (A)}$ Allow 1 mark for 1.9×10^{-4} ; diameter used as radius
		(iv)	Sensible suggestion, e.g. use a water bath / fan / only switch on when taking readings Need to lower the temperature / reduce resistance of R	M1 A1	Allow keep the surroundings cold Allow to keep the temperature / resistance constant OR allow increase in temperature increases resistance

(b)*	Level 3 (5–6 marks) <i>E and r calculated correctly and table completed correctly and clear description of P and R</i> <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Table completed correctly and some description of P and R /some attempt at E and r OR <i>E and r calculated correctly</i> OR Some attempt at calculating E and r and some description of P and R <i>There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.</i> Level 1 (1–2 marks) Limited calculation of E and r OR Table completed correctly OR Limited description of relationship between P and R <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks No response or no response worthy of credit	B1×6	Indicative scientific points may include: Calculating E and r • $E = Ir + V$ • gradient = (-) r • y-intercept = E • Line extrapolated to y-axis • $E = 1.2 \text{ (V)}$ • $r = 0.8(0 \Omega)$ Table and description • Table completed (ignore SF) – see below • R increases as V increases (or I decreases) • P increases and decreases • Maximum power is when internal resistance is equal to R (0.8 Ω) <table><tr><th>V / V</th><th>I / A</th><th>R / Ω</th><th>P / W</th></tr><tr><td>0.20</td><td>1.25</td><td>0.16</td><td>0.25</td></tr><tr><td>0.40</td><td>1.00</td><td>0.40</td><td>0.40</td></tr><tr><td>0.60</td><td>0.75</td><td>0.80</td><td>0.45</td></tr><tr><td>0.80</td><td>0.50</td><td>1.60</td><td>0.40</td></tr><tr><td>1.00</td><td>0.25</td><td>4.00</td><td>0.25</td></tr></table>	V / V	I / A	R / Ω	P / W	0.20	1.25	0.16	0.25	0.40	1.00	0.40	0.40	0.60	0.75	0.80	0.45	0.80	0.50	1.60	0.40	1.00	0.25	4.00	0.25
V / V	I / A	R / Ω	P / W																								
0.20	1.25	0.16	0.25																								
0.40	1.00	0.40	0.40																								
0.60	0.75	0.80	0.45																								
0.80	0.50	1.60	0.40																								
1.00	0.25	4.00	0.25																								
	Total	14																									

5	(a)	(i)	$I_{\max} = nAv_{\max}e$ $v_{\max} = \frac{20 \times 10^{-3}}{8 \times 10^{28} \times 1.6 \times 10^{-19} \times 1.4 \times 10^{-8}}$ $v_{\max} = 1.1 \times 10^{-4} \text{ (m s}^{-1}\text{)}$	B1 Allow v for $v_{\max}$ throughout M1 Allow I for $I_{\max}$ Allow q or Q for e/a for A/V for v but not N for n A1 Substitution must be shown in full Answer must be given initially to 2 or more sf (but may later be rounded to 1sf)
		(ii)	$\omega = 2\pi f$ $A (= v_{\max}/\omega) = \frac{1.1 \times 10^{-4}}{2\pi \times 11 \times 10^9}$ or $A (= v_{\max}/\omega) = \frac{1.1 \times 10^{-4}}{6.9 \times 10^{10}}$ $A = 1.6 \times 10^{-15} \text{ (m)}$	C1 May be inferred from working $\omega = 2\pi \times 11 \times 10^9 = 6.9 \times 10^{10} \text{ (rad s}^{-1}\text{)}$ C1 Allow use of $v_{\max} = 1 \times 10^{-4} \text{ (m s}^{-1}\text{)}$ Allow $v_{\max}$ from (a)(i) given to more than 2sf but not ECF from any value which does not round to $1 \times 10^{-4} \text{ (m s}^{-1}\text{)}$ A1 Allow use of $v_{\max} = 1 \times 10^{-4} \text{ (m s}^{-1}\text{)}^1$ giving $A = 1.4 \times 10^{-15} \text{ (m)}$ to 2sf or $1.45 \times 10^{-15} \text{ (m)}$ to 3sf Special case: Allow $A = 1 \times 10^{-15} \text{ (m)}$ to 1 sf if $v_{\max} = 1 \times 10^{-4} \text{ (m s}^{-1}\text{)}$ is used
		(iii)	$(a_{\max} = \omega^2 A \text{ and } v_{\max} = \omega A)$ $a_{\max} = 2\pi f v_{\max}$ Since $v_{\max}$ is constant, $a_{\max} \propto f$	M1 Allow $a_{\max} = \omega v_{\max}$ Allow a for $a_{\max}$ and v for $v_{\max}$ A1



Question			Answer	Marks	Guidance
5	(b)*	(i)	Level 3 (5–6 marks) Clear explanation and clear description <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Clear explanation or clear description (but not both) or Some explanation and some description <i>There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.</i> Level 1 (1–2 marks) Limited explanation or Limited description <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit.</i>	B1x 6	Use level of response annotations in RM Assessor Indicative scientific points may include: Explanation of pattern • Interference / superposition occurs • Path difference a whole number of wavelengths • means waves are (exactly) in phase (or $\Delta\phi = 0$) • giving (maximum) constructive interference • which leads to maximum intensity • Path difference an odd number of half wavelengths (or $\Delta\phi = \pi$ radians) • means waves are in antiphase • giving (maximum) destructive interference • which leads to minimum intensity Description of relationship between f and x • $\lambda = ax/D$ and $c = f\lambda \rightarrow x = cD/af$ • so $x \propto 1/f$ (provided a and D remain constant) • Use ruler along QP to measure x (or $10x/10$, say) • Connect oscilloscope to transmitter or detector to measure f • Vary f (keeping a and D constant) and measure corresponding x • Calculate fx which should remain constant • Or plot graph of $1/x$ against f (or x against $1/f$) • Should give straight line <u>through the origin</u>



Question			Answer	Marks	Guidance
5	(b)	(ii)	At 90° rotation, (interference) pattern disappears At 180° rotation, intensities are the same as at 0° but the maximum/minimum positions are switched / reversed Waves with polarisations at 90° to each other do not interfere / only waves with same polarisation interfere / only waves with a component in the same plane interfere	B1 B1 B1	Allow constant intensity along PQ Not zero intensity along PQ Allow from 0 to 90° the intensities of the maxima decrease (and the minimum intensities increase) Allow from 90° to 180° the intensities of the maxima increase (and the minimum intensities decrease) but the maximum/minimum positions are switched / reversed from between 0 and 90° Allow waves must <u>oscillate</u> in same plane to interfere Ignore at 90° rotation, only waves from Y are detected at D because D can only detect vertical polarised waves
			Total	17	



6	B	1	
---	---	---	--



2	C	1	
---	---	---	--



4	C	1	
-	-	-	



Question	Answer	Mark	Guidance
2	() F = Bev and F = eE E = V/a or F = (eE) = eV/a Bev = eV/a giving V = Bva	B1 B1 B1	allow Q or q for e
	(b) (i) $I = nAev$; $v = 60 \times 10^{-3} / 1.2 \times 10^{23} \times 1.6 \times 10^{-19} \times 5.0 \times 0.2 \times 10^{-6}$ $v = 3.1 \text{ (m s}^{-1}\text{)}$	C1 C1 A1	allow any subject
	(ii) $V = 80 \times 10^{-3} \times 3.1 \times 5.0 \times 10^{-3} = 1.2 \times 10^{-3} \text{ (V)}$	A1	ecf (b)(i); allow 1.2 mV; $1.3 \times 10^{-3} \text{ (V)}$
	(c) (i) Hall probe only compares B-fields/AW or V will be too small/less than 1 mV so not easy to measure	B1	allow any sensible comment, e.g. how do you convert the measured V into a B value
	(ii) find B using $F = BIl$; F is measured by weighing magnets (e.g. placed on top pan balance assuming wire is fixed); graph of F against I to find B(I) from gradient/AW; greatest uncertainty: measurement of I in B-field sensible reason/justification for choosing I or small masses	B1 B1 B1 B1 B1	max 4 of the 5 marking points alt measure F by adding small masses to wire to return it to zero current position or use readings of F at several I to find average F/I, etc. or measurement of small masses in alt. method, etc quantitative suggestion about % error i.e. I small (1 mm in 60) leading to large % uncertainty or difficulty in determining edge/end of B-field
	Total	12	

H556/03

Mark Scheme

June 2017

Question	Answer	Marks	Guidance
----------	--------	-------	----------

