



GuideMyGrades

— YOUR GOALS. OUR EXPERTISE. —

EDEXCEL INTERNATIONAL GCSE PHYSICS: QUESTIONS BY TOPIC

Electricity (2)

IGCSE Physics Topic 2

42 questions · 451 marks · Mark schemes included

Pearson Edexcel International GCSE (9-1) Physics 4PH1, Papers 1P/1PR & 2P/2PR, 2019-2025

 [guidemygrades.com](https://www.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
2.1 MAINS ELECTRICITY, POWER AND SAFETY		7 Qs · 62 marks	4
1. Q5 <i>also Topic 4</i>	Paper 1PR November 2020	6	5
2. Q2	Paper 1PR June 2024	6	7
3. Q2	Paper 1P November 2021	8	9
4. Q3 <i>also Topic 4</i>	Paper 1P June 2023	8	10
5. Q7 <i>also Topic 4</i>	Paper 1P June 2023	9	11
6. Q7	Paper 1P June 2024	12	13
7. Q4	Paper 1P January 2021	13	15
2.2 CURRENT, CHARGE, VOLTAGE AND RESISTANCE IN CIRCUITS		12 Qs · 143 marks	18
8. Q11	Paper 1P June 2023	8	19
9. Q7	Paper 1PR January 2020	9	21
10. Q10 <i>also Topic 6</i>	Paper 1P June 2019	11	23
11. Q11	Paper 1P June 2024	11	26
12. Q11	Paper 1P November 2021	12	29
13. Q3	Paper 1P January 2021	13	31
14. Q3	Paper 1P January 2020	14	33
15. Q12 <i>also Topic 1</i>	Paper 1PR January 2021	15	36
16. Q5	Paper 1PR June 2019	17	40
17. Q11 <i>also Topic 3</i>	Paper 1P June 2025	12	44
18. Q3	Paper 1PR June 2025	12	48
19. Q3 <i>also Topic 4</i>	Paper 2P June 2025	9	51
2.3 CURRENT-VOLTAGE CHARACTERISTICS AND SENSORS		10 Qs · 119 marks	53
20. Q6	Paper 1P November 2020	8	54
21. Q5	Paper 1P November 2020	9	55
22. Q2	Paper 1P June 2023	10	58
23. Q6 <i>also Topic 8</i>	Paper 1P June 2019	12	60
24. Q6	Paper 1PR January 2020	12	62
25. Q9	Paper 1PR November 2020	12	64
26. Q7	Paper 1PR June 2024	13	66
27. Q5	Paper 1P June 2021	14	69
28. Q6	Paper 1PR June 2023	14	72
29. Q3	Paper 1P June 2025	15	75



QUESTION	SOURCE	MARKS	PAGE
2.4 ELECTROSTATICS		13 Qs · 127 marks	79
30. Q3	Paper 2PR June 2019	6	80
31. Q7	Paper 2P November 2021	6	82
32. Q3	Paper 2PR June 2023	8	84
33. Q1	Paper 2PR November 2020	9	86
34. Q4	Paper 2P June 2024	9	88
35. Q2	Paper 2P November 2020	10	90
36. Q3	Paper 2P June 2021	11	92
37. Q4	Paper 2P January 2020	12	94
38. Q3	Paper 2P June 2023	12	97
39. Q8	Paper 2P January 2021	13	100
40. Q7	Paper 2PR January 2021	13	103
41. Q5	Paper 2P June 2025	12	105
42. Q1	Paper 2PR June 2025	6	110



QUESTIONS

42 questions · 451 marks · 4 sub-topics



SUB-TOPIC 2.1

MAINS ELECTRICITY, POWER AND SAFETY

Sub-topic 2.1 · 7 questions · 62 marks · lowest tariff first



5 A toaster is an electrical device used for toasting bread.



© Levent Konuk/Shutterstock

The toaster contains thin metal wires.

These wires get hot when there is a current in them.

The wires transfer energy to the bread by heating and by radiation.

(a) Give a reason why the wires in the toaster are connected in parallel.

(1)

(b) (i) State the formula linking power, current and voltage.

(1)

(ii) The power rating of the toaster is 2.8 kW.

Calculate the total current in the toaster.

[mains voltage = 230V]

(3)

current = ... A

(iii) The toaster contains 48 thin metal wires.

Calculate the current in each of the thin metal wires.

(1)

current = ... A

(Total for Question 5 = 6 marks)



- 2 The photograph shows an electric heater connected to the mains electricity supply.



(Source: © Yevhen Prozhyrko / Shutterstock)

The circuit the heater is connected to is fitted with a circuit breaker, which breaks the circuit if the current gets too high.

- (a) Give an advantage of using a circuit breaker instead of using a fuse.

(1)

.....

.....

.....

(b) The voltage of the mains electricity supply is 230V.

(i) State the formula linking power, current and voltage.

(1)

(ii) The normal operating current of the heater is 11 A.

Calculate the input power to the heater for this current.

Give your answer in kW.

(3)

power = ... kW

(c) The circuit breaker has a rating of 16 A.

Suggest a reason why the heater may switch off before it reaches its normal operating current.

(1)

.....

.....

.....

(Total for Question 2 = 6 marks)



2 This question is about electric current.

(a) State what is meant by the term **electric current**.

(1)

.....

.....

(b) Give the name of the particles that flow if there is an electric current in a wire.

(1)

.....

(c) An electric heater contains wires that heat up when there is a current in the wires.

The electric heater has a power of 1.4 kW when connected to a mains voltage of 230 V.

(i) State the formula linking power, current and voltage.

(1)

(ii) Calculate the current in the wires.

(3)

current = ... A

(iii) Explain why the current in the wires causes the temperature of the wires to increase.

(2)

.....

.....

.....

.....

(Total for Question 2 = 8 marks)



3 A family has a television set.

(a) The television set has a low power mode called standby.

When on standby, the power rating of the television set is 0.27 W.

Calculate the energy transferred to the television set on standby in 12 hours.

(3)

energy transferred = ... J

(b) In normal use, the current in the television set is 0.31 A.

(i) Explain how a fuse works to protect the television set if there is a fault.

(3)

.....

.....

.....

.....

.....

.....

(ii) Explain why a 13 A fuse is not an appropriate choice of fuse to use in the plug of this television set.

(2)

.....

.....

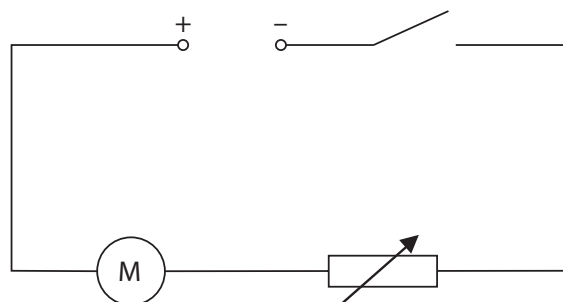
.....

.....

(Total for Question 3 = 8 marks)



- 7 The circuit diagram shows a motor, power supply, switch and variable resistor connected in series.



- (a) The switch is open and the motor is not moving.

State how much energy is in the kinetic energy store of the motor.

(1)

kinetic energy = ... J

- (b) The switch is closed.

The motor takes 0.42 seconds to reach its maximum speed of rotation.

The mean current in the motor is 3.9 A.

The voltage across the motor is 7.1 V.

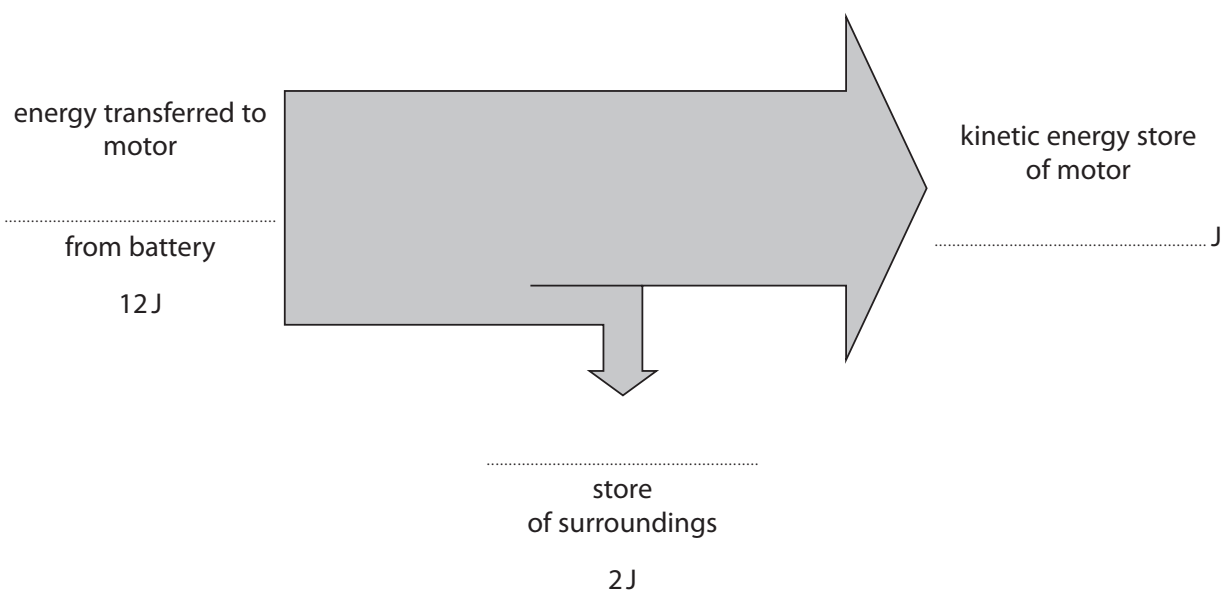
Show that the work done on the motor during the 0.42 seconds is about 12 J.

(2)

work done = ... J

- (c) Complete the Sankey diagram for the electric motor during the 0.42 seconds by giving the missing information.

(3)



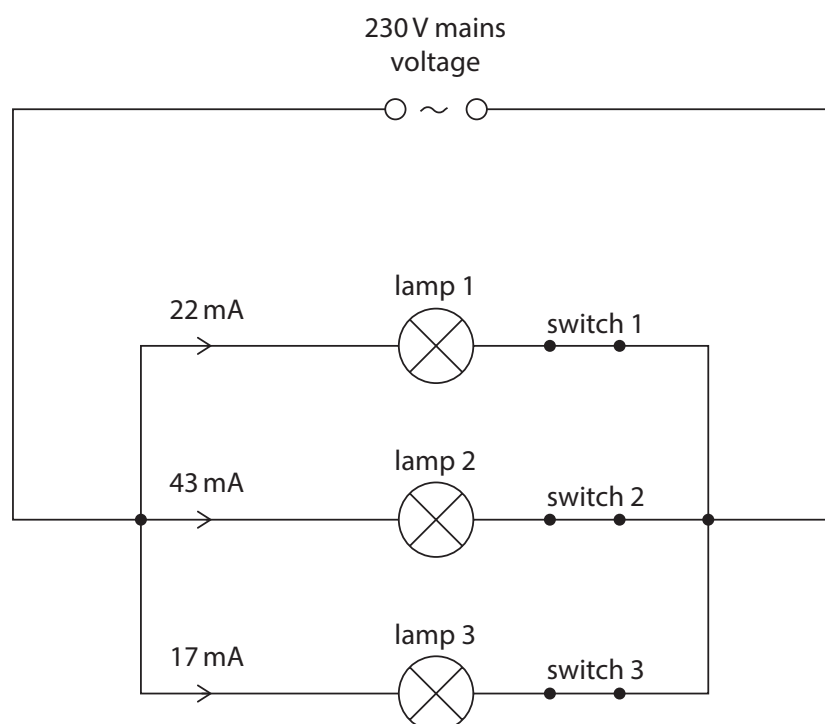
- (d) Use the Sankey diagram to calculate the efficiency of the process of bringing the motor to its maximum speed of rotation.

(3)

efficiency = ... %

(Total for Question 7 = 9 marks)

7 The diagram shows a domestic lighting circuit.



(a) Explain an advantage of using this circuit for domestic lighting.

(2)

.....

.....

.....

.....

(b) When switch 1 is closed, the current in lamp 1 is 22 mA.

(i) Give the name of the charged particle that moves in an electric current.

(1)

.....

(ii) Show that lamp 1 has a power of about 5W.

(3)

(iii) Calculate the energy transferred by lamp 1 when it is on for 30 seconds.

(3)

energy transferred = ... J

(c) The circuit is connected to the mains supply. Mains voltage is 230V.

(i) State what is meant by the term **voltage**.

(1)

(ii) Switches 1 and 3 are closed, which turn on lamps 1 and 3.

Switch 2 is open.

Calculate the current in the mains supply.

(2)

current = ... mA

(Total for Question 7 = 12 marks)



- 4 The photograph shows a hair dryer plugged into the mains supply.

The hair dryer contains a fuse.



© Cristina Bernardo/Shutterstock

- (a) State which wire in the hair dryer should be in series with the fuse.

(1)

- (b) The fuse is an electrical safety feature used in mains-operated domestic appliances.

State two other electrical safety features that can be used in mains-operated domestic appliances.

(2)

1

.....

2

.....

(c) The hair dryer has a current of 9.6 A.

The mains supply voltage is 230 V.

(i) State the formula linking power, current and voltage.

(1)

(ii) Calculate the power of the hair dryer.

Give the unit.

(3)

power = ... unit

(iii) The hair dryer contains a coil of wire which is used to heat air passing through the hair dryer.

Explain why the coil of wire heats up when there is a current in it.

(3)

.....

.....

.....

.....

.....

.....



(d) Explain how a fuse protects a domestic appliance.

(3)

(Total for Question 4 = 13 marks)



SUB-TOPIC 2.2

CURRENT, CHARGE, VOLTAGE AND RESISTANCE IN CIRCUITS

Sub-topic 2.2 · 12 questions · 143 marks · lowest tariff first



- 11** Diagram 1 shows a light-emitting diode (LED) and a resistor in series with a cell and an ammeter.

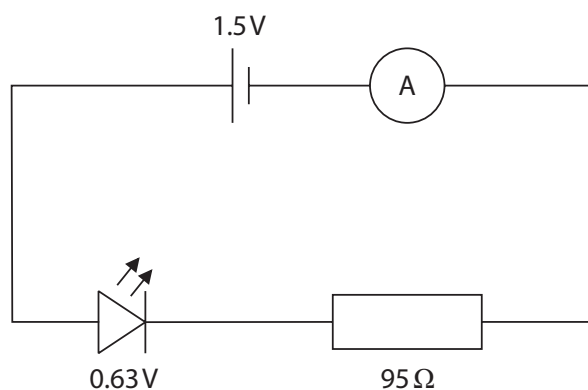


Diagram 1

- (a) The voltage across the LED is 0.63V.

Calculate the current in the circuit.

Give your answer in milliamps.

(4)

current = ... mA

- (b) Diagram 2 shows a second LED and an extra resistor connected in parallel with the cell.

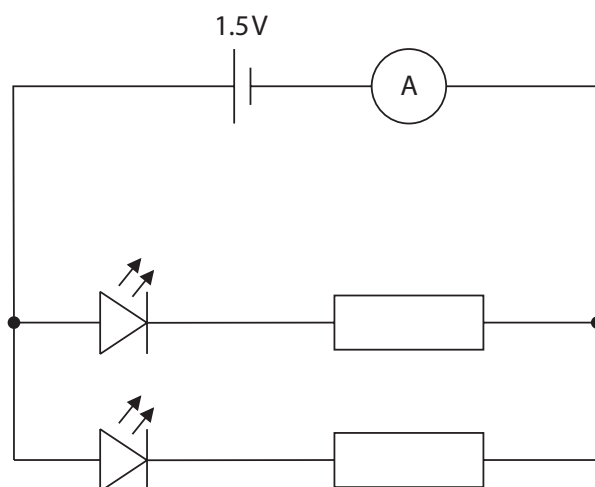


Diagram 2

The resistor and the LED are the same as the components used in diagram 1.
The two resistors are identical and the two LEDs are identical.

Explain how the ammeter reading will change.

(4)

.....

.....

.....

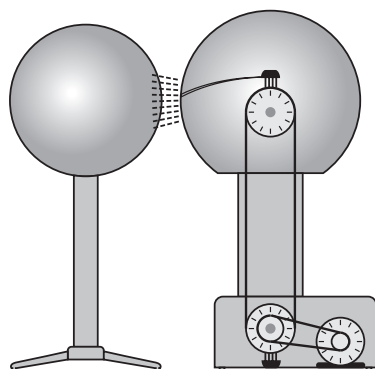
.....

.....

.....

(Total for Question 11 = 8 marks)

- 7 The diagram shows a van der Graaff generator, which is designed to provide very high voltages.



Source: www.shutterstock.com

- (a) (i) The unit of voltage is the volt.

Which of these units is a volt?

(1)

- ☐ A coulomb per second
- ☐ B joule per coulomb
- ☐ C joule per second
- ☐ D newton per coulomb

- (ii) State the formula linking energy transferred, voltage and charge.

(1)

- (iii) Calculate the energy transferred to an electron when it passes through a voltage of 150 kV.

[charge of electron = $1.6 \times 10^{-19} \text{ C}$]

(3)

energy transferred = ... J

(b) When the van der Graaff generator is fully charged, it stores $2.9 \times 10^{-8} \text{ C}$ of charge.

(i) State the formula linking charge, current and time.

(1)

(ii) The charge on the generator discharges through the air as a spark.

The charge takes a time of 0.68 ms to leave the generator.

Calculate the mean (average) current in the air.

(3)

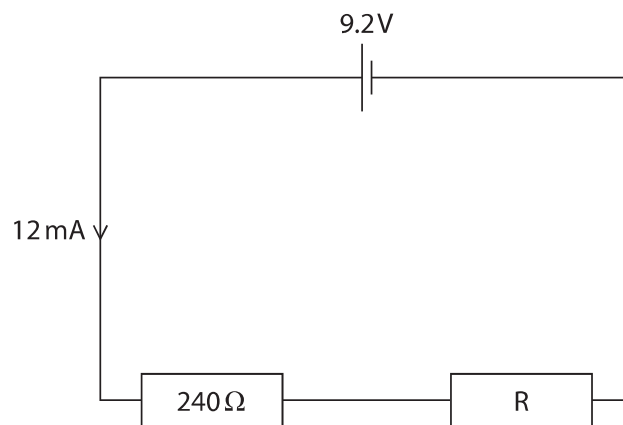
mean current = ... A

(Total for Question 7 = 9 marks)



10 This question is about voltage and current.

(a) The diagram shows two resistors connected to a battery.

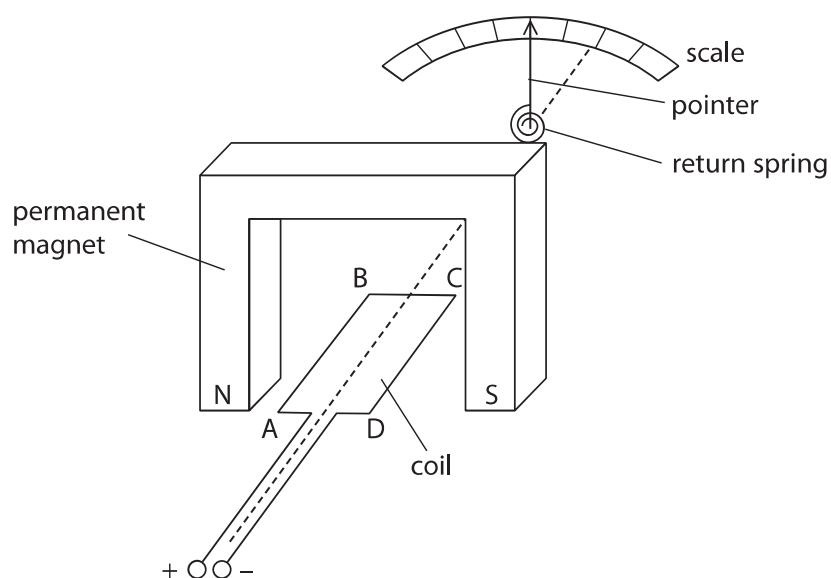


Calculate the voltage across resistor R.

(4)

voltage = ... V

- (b) The diagram shows the parts of an ammeter.
The pointer is connected to the coil so they can move together.



- (i) Explain what happens when there is a current in the coil.

(3)

.....

.....

.....

.....

.....

.....

- (ii) Draw an arrow on the diagram to show the force acting on side CD of the coil when there is a current in the coil.

(1)

(iii) Explain how the ammeter could be changed so that it could measure smaller currents.
(3)

(Total for Question 10 = 11 marks)



- 11** The photograph shows a power bank used to recharge the battery in an electronic device.



- (a) The power bank stores charge.

The charge stored can be measured in amp-hours (Ah). 1 Ah is the amount of charge transferred by a current of 1 A in a time of 1 hour.

Calculate the charge stored in coulombs when the charge stored is 1 Ah.

Use the formula

$$\text{charge stored} = \text{current} \times \text{time taken}$$

(2)

charge stored = ... C

- (b) An electronic device is connected to the power bank.

Whilst recharging, the electronic device receives a constant current of 2.4 A and $3.8 \times 10^3 \text{ C}$ of charge is transferred.

- (i) Calculate the time taken to recharge the electronic device.

Give your answer in minutes.

(3)

time = ... minutes

- (ii) The electronic device is connected to the power bank using a long cable.

Suggest how using a long cable affects the time taken to recharge the electronic device when compared with a short cable.

(2)

.....

.....

.....

.....

.....

.....

(c) A student owns three electronic devices. Each electronic device stores a different amount of charge.

The table gives some information about the charge stored by the electronic devices and how often they need to be recharged.

Electronic device	Charge stored in Ah	Frequency of recharging
A	2.4	once every day
B	4.2	once during the week
C	6.8	once during the week

The power bank stores a maximum charge of 26.8 Ah.

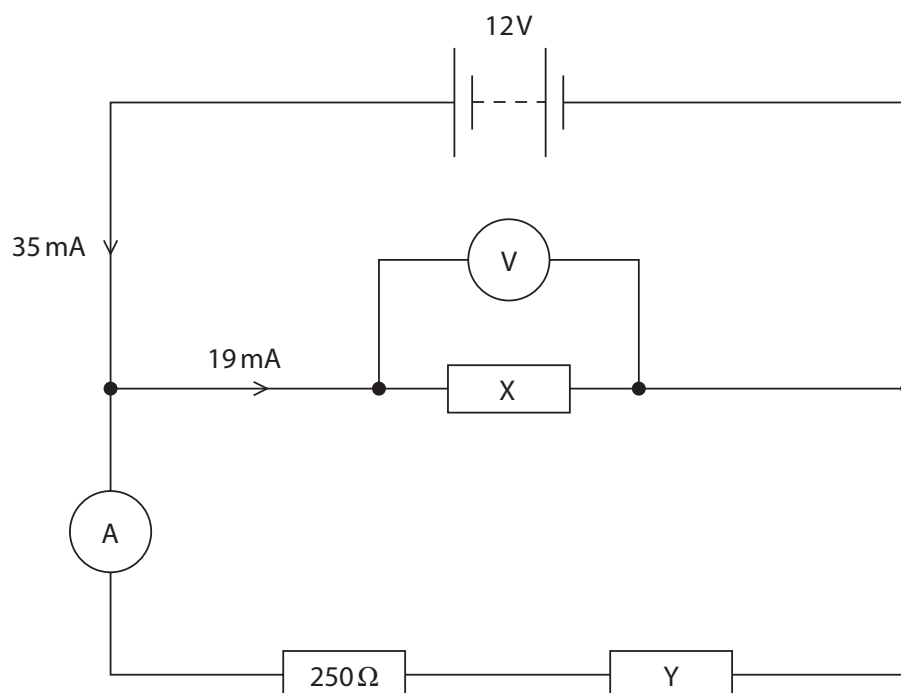
The student needs to take these three electronic devices on a school trip for one week.

Determine whether the maximum charge of the power bank is enough to recharge the batteries of the three electronic devices during the school trip.

(4)

(Total for Question 11 = 11 marks)

- 11** The diagram shows a circuit that includes a battery, an ammeter, a voltmeter and three different resistors.



- (a) (i) Give the voltmeter reading.

(1)

voltage = ... V

- (ii) State the formula linking voltage, current and resistance.

(1)

- (iii) Calculate the resistance of resistor X.

(3)

resistance = ... Ω

(b) (i) Give the reason why the reading on the ammeter would be 16 mA.

(1)

.....

.....

(ii) Calculate the resistance of resistor Y.

(4)

resistance = ... Ω

(c) Resistor X and the voltmeter are removed from the circuit, leaving a break in this part of the circuit.

Explain how the current in the battery changes when these components are removed.

(2)

.....

.....

.....

.....

.....

.....

(Total for Question 11 = 12 marks)



- 3 The photograph shows a mains-operated, decorative lamp, X.



Lamp X has seven identical bulbs that are connected in series.

- (a) Give a disadvantage of connecting the bulbs in series.

(1)

- (b) Suggest an advantage of connecting the bulbs in series.

(1)

- (c) Each bulb has a working resistance of $390\ \Omega$.

The voltage across each bulb is 33 V .

- (i) State the formula linking voltage, current and resistance.

(1)

- (ii) Calculate the current in each bulb.

(3)

current = ... A

(iii) Calculate the energy transferred to lamp X when it is used for 2.5 hours.

(4)

energy transferred = ... J

(d) Another decorative lamp, Y, uses five of the same $390\ \Omega$ bulbs connected in series.

Both lamps are mains operated.

Explain how the brightness of a single bulb in lamp Y compares to the brightness of a single bulb in lamp X.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 3 = 13 marks)



3 This question is about electric circuits.

(a) Which quantity is defined as the rate of flow of charge?

(1)

- ☐ A current
- ☐ B power
- ☐ C resistance
- ☐ D voltage

(b) Which quantity is defined as the energy transferred per unit charge passed?

(1)

- ☐ A current
- ☐ B power
- ☐ C resistance
- ☐ D voltage

(c) Diagram 1 shows an electric circuit with two resistors, R and S.

Some of the values of the current are also shown.

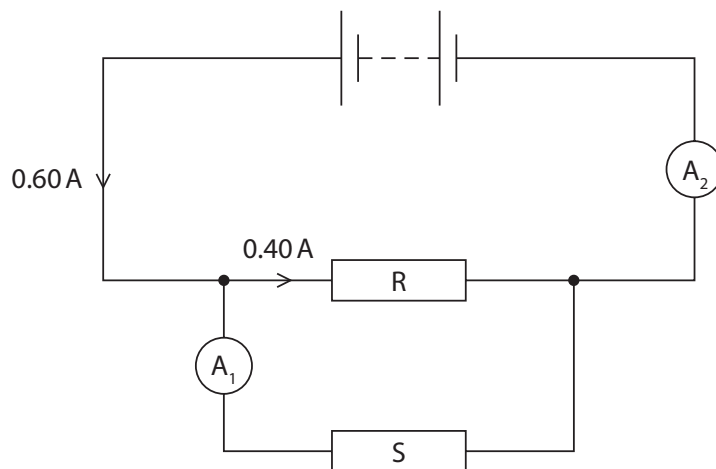


Diagram 1

(i) On Diagram 1, draw a voltmeter to measure the voltage of resistor S.

(2)

(ii) Deduce the readings on the ammeters.

(2)

current measured by A_1 = ... A

current measured by A_2 = ... A

(iii) Resistor R has a resistance of $11\ \Omega$.

Calculate the voltage across resistor R.

(3)

voltage = ... V

(iv) Explain how the voltage across resistor R compares with the voltage across the battery.

(2)

.....

.....

.....

.....



(d) Diagram 2 shows a different circuit containing a battery, an ammeter and a thermistor.

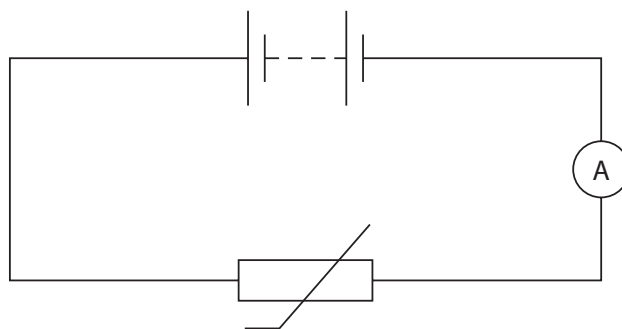


Diagram 2

Explain how the thermistor can be used to vary the current in this circuit.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

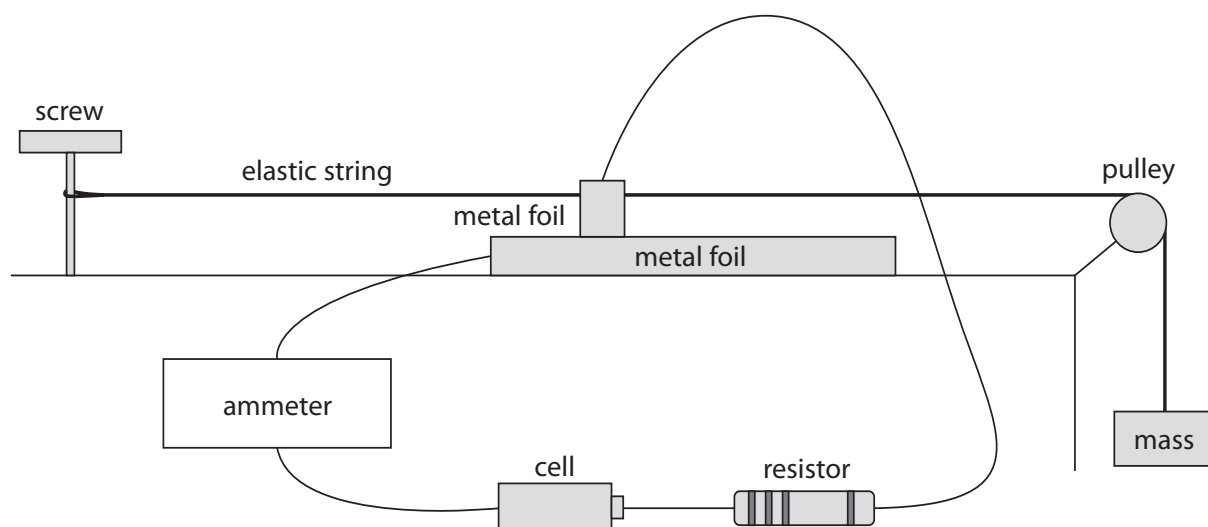
.....

(Total for Question 3 = 14 marks)

12 The diagram shows some apparatus used to find the mass of an object.

The two pieces of metal foil act as a variable resistor.

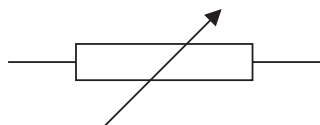
When more mass is added, the elastic string stretches and the small piece of metal foil moves to the right.



- (a) (i) Draw the circuit diagram for this electrical circuit.

The variable resistor has been drawn for you.

(4)



- (ii) Draw a voltmeter on the diagram to measure the voltage of the variable resistor.

(2)

- (b) Explain how the voltage across the variable resistor changes if more mass is added to the end of the elastic string.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

- (c) The student extends the investigation by keeping the mass constant and replacing the cell with a variable power supply.

The student measures the current in the circuit for different voltages.

These are the results.

Voltage in V	Current in mA
0.0	0.0
2.0	4.0
4.0	7.0
6.0	11.0
8.0	14.0

- (i) State the independent variable in the student's investigation.

(1)

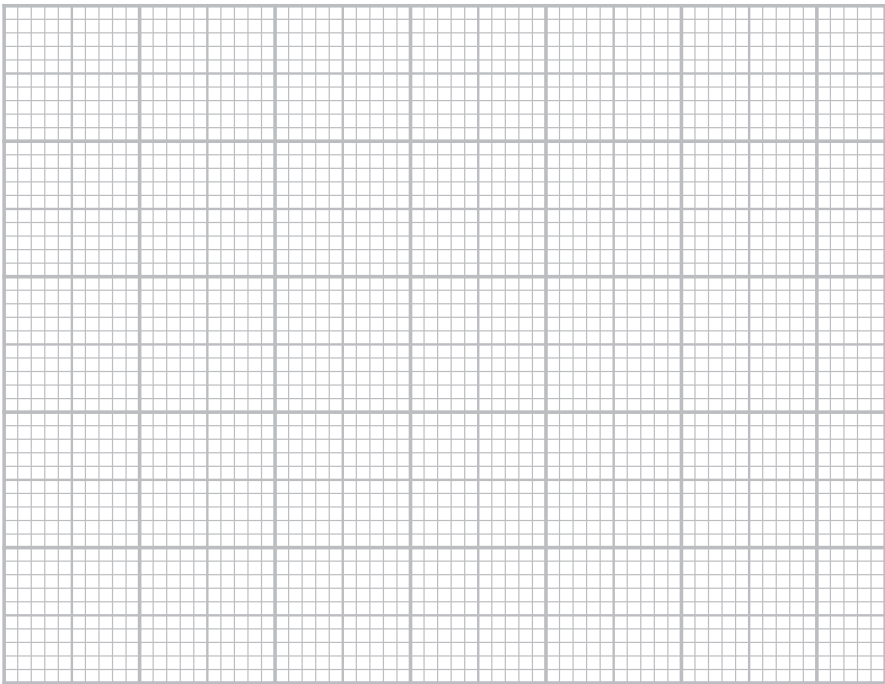
-
- (ii) Plot the student's results on the grid.

(3)

- (iii) Draw a line of best fit.

(1)





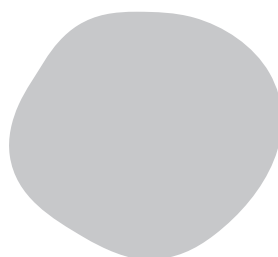
(Total for Question 12 = 15 marks)

- 5 A student is given a type of putty that conducts electricity.
He rolls the putty into cylinders of different cross-sectional area.
The photograph shows the cylinders.



The student investigates how the electrical resistance of the putty is affected by its cross-sectional area.

- (a) The diagram shows the cross-sectional area of one of the cylinders of putty.



drawn to scale

- (i) Use the diagram to determine the mean diameter of the cylinder of putty.

(2)

mean diameter = ... cm

- (ii) Calculate the cross-sectional area of the cylinder of putty in cm^2 .

[area of a circle = $\pi \times \text{radius}^2$]

(2)

cross-sectional area = ... cm^2

- (b) The student connects a cylinder of putty to a battery.

He measures the voltage of the cylinder and the current in the circuit.

Complete the circuit diagram, adding suitable instruments to measure the voltage of the cylinder and the current in the circuit.



putty cylinder

(3)

- (c) The student uses his voltage and current measurements to calculate the resistance of this cylinder.

He repeats this for other cylinders.

The table shows some of his results.

Cross-sectional area in cm ²	Voltage in V	Current in A	Resistance in Ω
4.5	4.56	0.049	91.2
6.2	4.56	0.059	77.3
9.1	4.56	0.068	67.1
13.9	4.56	0.085	53.6
18.1	4.56	0.094	48.5
24.6	4.56	0.107	

- (i) Calculate the resistance of the cylinder when the cross-sectional area of the cylinder is 24.6 cm².

Give your answer to 3 significant figures.

(2)

resistance = ... Ω

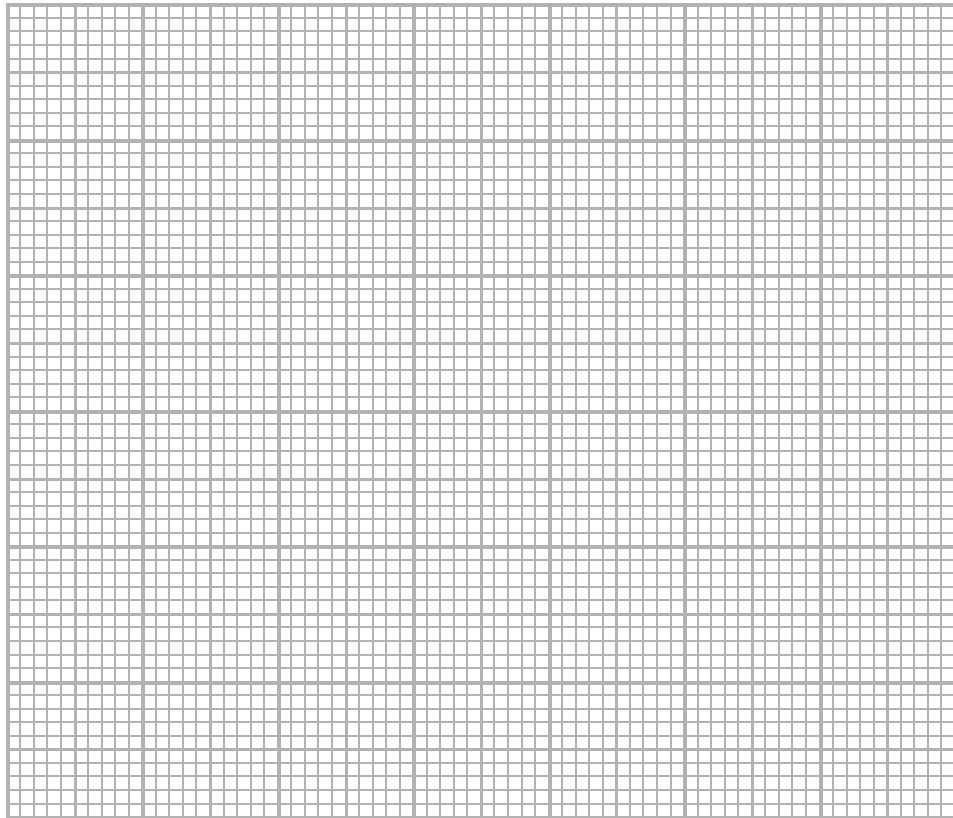


(ii) Plot a graph of resistance on the y-axis and cross-sectional area on the x-axis.

(3)

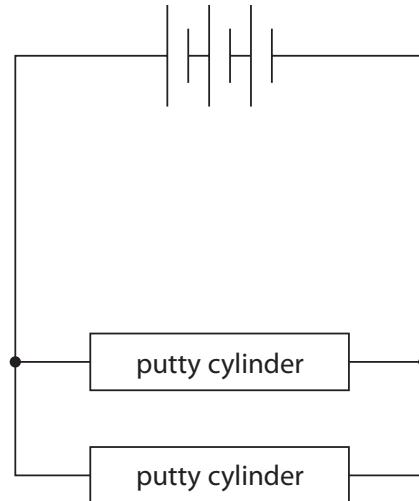
(iii) Draw the curve of best fit.

(1)



- (d) The student extends his investigation by connecting two new identical cylinders to a battery.

The diagram shows the circuit he uses.



He measures the voltage of each cylinder and the total current in the circuit.

Discuss how his measurements of voltage and current compare with the measurements when only one of these cylinders is used.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 5 = 17 marks)

11 Fluorescent tube lamps can be used in schools and office buildings for lighting.

The photograph shows an engineer installing a fluorescent tube lamp.



(Source: © Naparat / Shutterstock)

Diagram 1 shows a simplified view of the components of a fluorescent tube lamp.

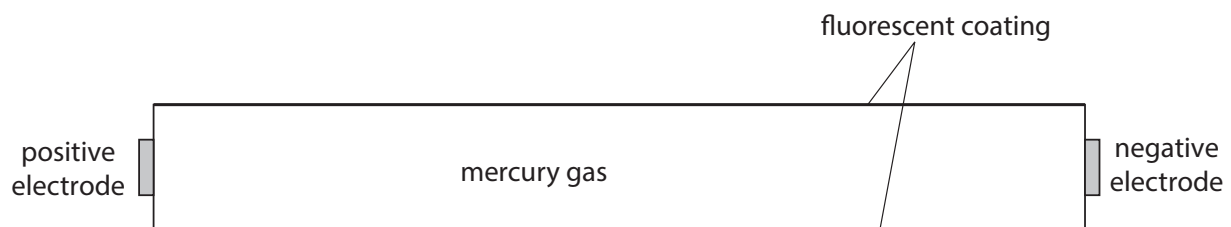


Diagram 1

(a) When the lamp is on, a large voltage is applied between the positive electrode and the negative electrode.

(i) State what is meant by the term **voltage**.

(1)

- (ii) The large voltage causes electrons to accelerate from the negative electrode towards the positive electrode.

An electron gains $1.0 \times 10^{-16} \text{ J}$ of energy when it accelerates between the electrodes.

Show that the voltage between the electrodes is about 600V.

[magnitude of electron charge = $1.6 \times 10^{-19} \text{ C}$]

(3)

- (iii) The electron gains $1.0 \times 10^{-16} \text{ J}$ of energy in its kinetic store when it accelerates from the negative electrode to the positive electrode.

Calculate the speed of an electron when it reaches the positive electrode.

Assume the electron is initially at rest.

[electron mass = $9.1 \times 10^{-31} \text{ kg}$]

(4)

speed = ... m/s



- (b) When the electrons accelerate between the electrodes, they collide with mercury atoms.

Energy is transferred to the mercury atoms during the collisions. This causes the mercury atoms to emit ultraviolet light.

Atoms in the fluorescent coating absorb this ultraviolet light, which is then re-emitted as light from a different part of the electromagnetic spectrum.

Diagram 2 shows this process.

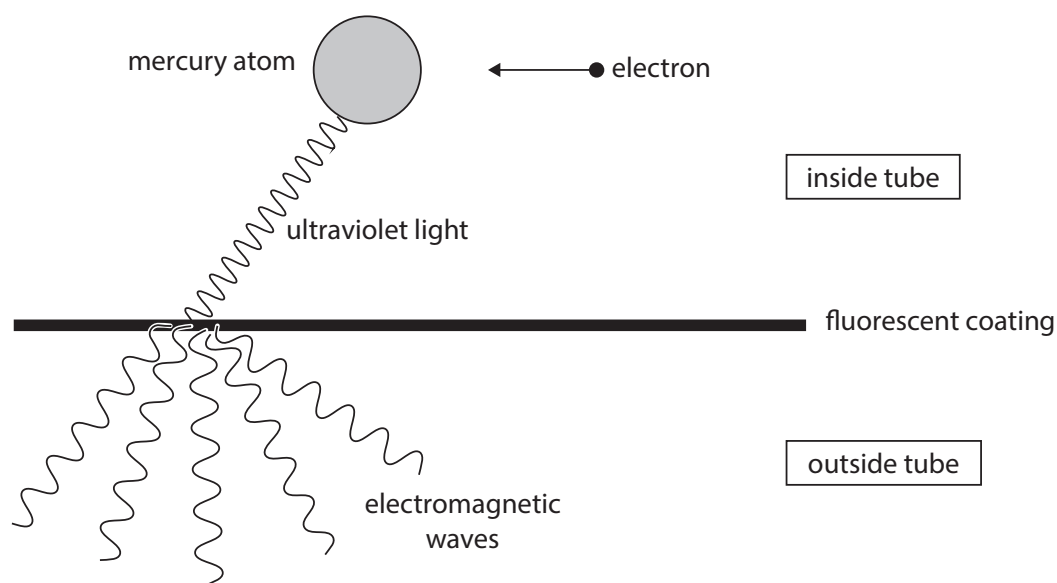


Diagram 2

- (i) Suggest why the tube must have a fluorescent coating for the lamp to operate effectively.

(2)

.....

.....

.....

.....

- (ii) Explain why the fluorescent tube lamp is dangerous if the fluorescent coating becomes damaged.

(2)

(Total for Question 11 = 12 marks)

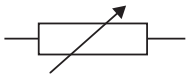
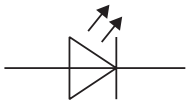
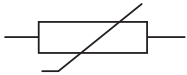
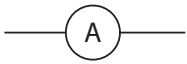


3 This question is about electrical circuits.

(a) The table shows the circuit symbols for some electrical components.

Complete the table by placing ticks (✓) to show whether each component can visibly indicate the presence of a current in a circuit.

(3)

Electrical component	Can visibly indicate the presence of a current
	
	
	
	
	
	

(b) Diagram 1 shows an electrical circuit containing a cell and component X.

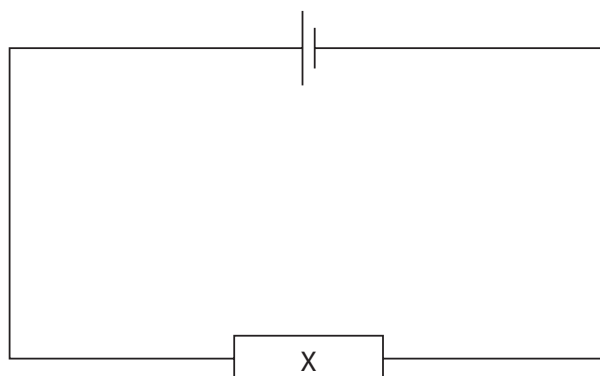
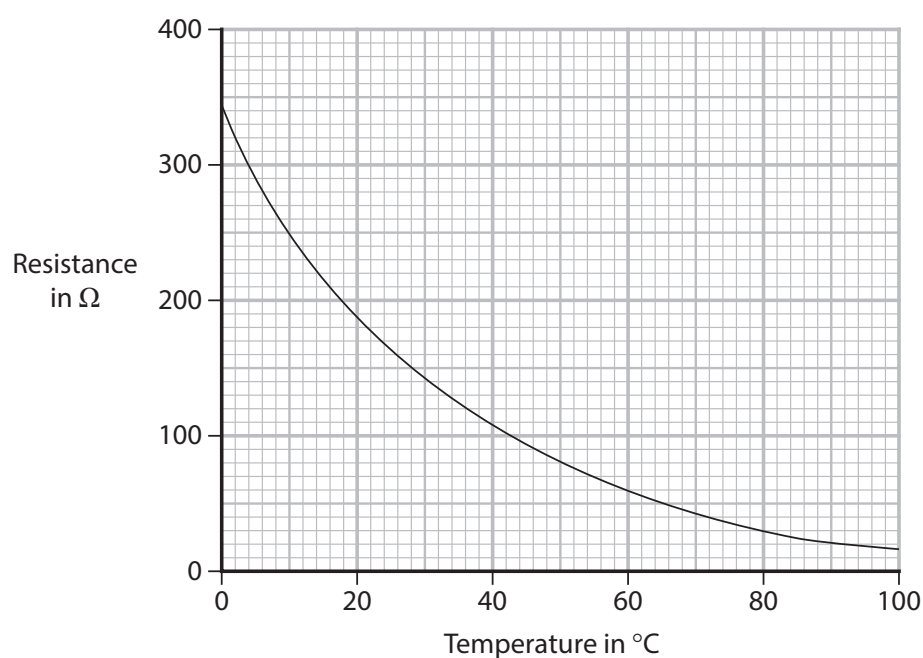


Diagram 1

The graph shows how the resistance of component X varies with temperature.



(i) Give the name of component X.

(1)

- (ii) Using the graph, determine the resistance of component X when its temperature is 50 °C.

(1)

resistance = ... Ω

- (iii) The cell in diagram 1 has a voltage of 9.0V.

Calculate the current in component X when its temperature is 50 °C.

Use the formula

$$\text{voltage} = \text{current} \times \text{resistance}$$

(3)

current = ... A

- (iv) The circuit in diagram 1 is modified by adding a second identical component X in series with the other components.

The temperatures of the first component X and second component X are reduced to 26 °C.

Explain how the resistance of the circuit is affected by these changes.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 3 = 12 marks)



- 3 The photograph shows a camper van with a solar panel on its roof. The solar panel is made from lots of solar cells connected together.



(Source: © kostasgr/Shutterstock)

The solar panel is connected to a battery. The solar panel receives energy from the Sun to charge the battery.

- (a) Describe how energy is transferred from the Sun's energy store to the battery's energy store.

(3)

.....

.....

.....

.....

.....

.....

- (b) The petrol engine can also be used to charge the battery of the camper van.

Give an advantage of using the solar panel instead of the petrol engine to charge the battery.

Do not refer to cost in your answer.

(1)

.....

.....

- (c) The surface of the solar panel is black.

Explain why black is a suitable colour for the solar panel.

(2)

- (d) The solar panel can charge the battery in the camper van with a maximum current of 15 A.

Calculate the minimum time to transfer 360 000 C of charge through the battery.

Use the formula

$$\text{charge transferred} = \text{current} \times \text{time}$$

(3)

minimum time = ... s

(Total for Question 3 = 9 marks)



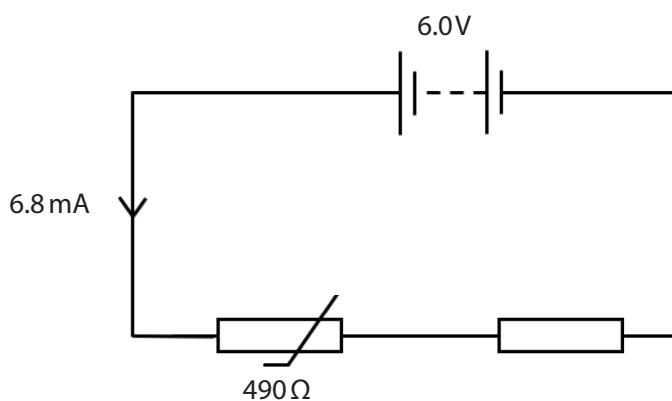
SUB-TOPIC 2.3

CURRENT-VOLTAGE CHARACTERISTICS AND SENSORS

Sub-topic 2.3 · 10 questions · 119 marks · lowest tariff first



6 The diagram shows an electric circuit.



(a) When the thermistor is in hot water, its resistance is $490\ \Omega$.

Show that the resistance of the fixed resistor is about $400\ \Omega$.

(5)

(b) Explain how the voltage across the fixed resistor changes when the hot water is replaced with cold water.

(3)

.....

.....

.....

.....

.....

.....

(Total for Question 6 = 8 marks)

- 5 A student does an investigation to determine the current-voltage graph for an unknown component, X.

The student uses this equipment

- component X
- cell
- variable resistor
- ammeter
- voltmeter
- connecting wires

- (a) Complete the circuit diagram to show how the student should set up this equipment for her investigation.

(4)

component X



(b) The student completes her investigation.

The table shows her results.

Voltage in V	Current in mA
0.00	0
0.10	0
0.20	0
0.30	0
0.40	0
0.50	2
0.60	8
0.70	33
0.80	140

(i) Plot a graph of the student's results on the grid.

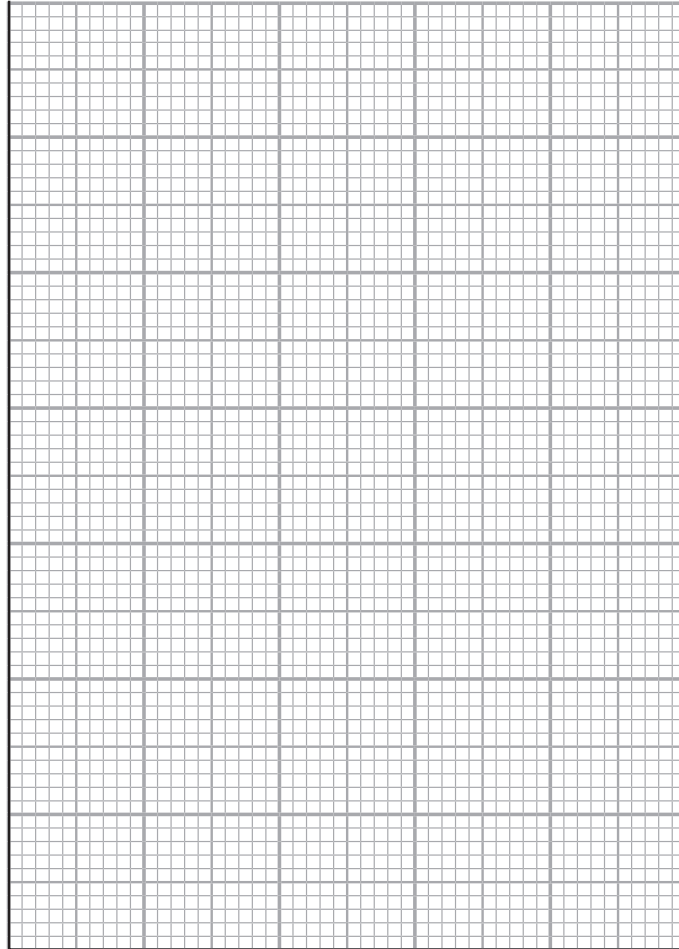
Plot current on the y-axis and voltage on the x-axis.

(3)

(ii) Draw a curve of best fit.

(1)





(iii) State the name of component X.

(1)

(Total for Question 5 = 9 marks)

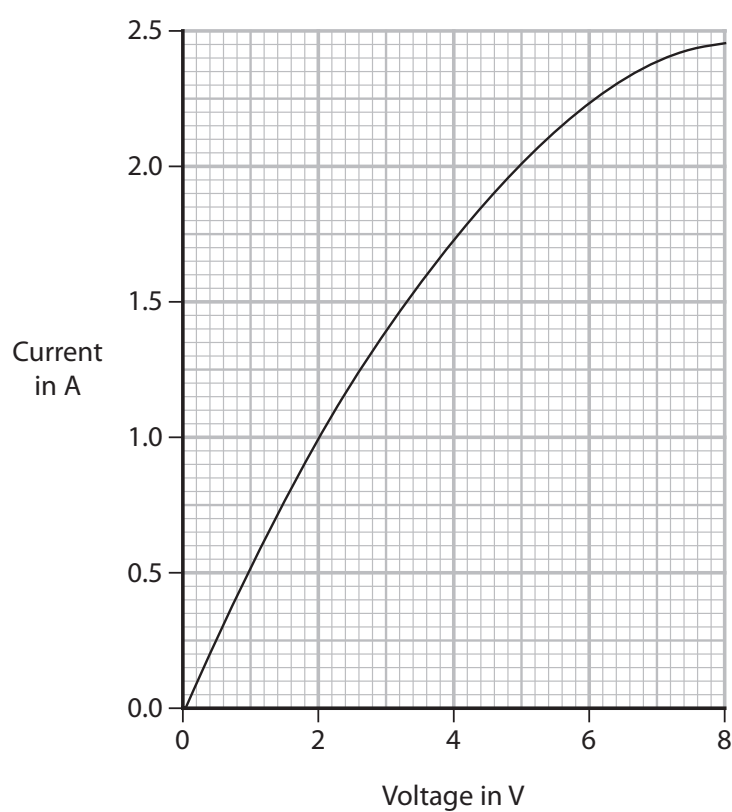


- 2 A student investigates how the current in a filament lamp changes when the voltage across the lamp is varied.

(a) Draw a circuit diagram the student could use in their investigation.

(4)

(b) The graph shows the student's results.



(i) Describe the relationship between current and voltage shown on the graph.

(2)

(ii) State the formula linking resistance, voltage and current.

(1)

(iii) Use the graph to determine the resistance of the filament lamp when the voltage across the lamp is 7.2V.

(3)

resistance = ... Ω

(Total for Question 2 = 10 marks)



- 6 (a) (i) A student investigates how current varies with voltage for a metal filament lamp.

Draw a diagram of the circuit that a student could use for this investigation.

(4)

- (ii) Describe a method the student could use for their investigation.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....



(b) The student extends the investigation by recording additional data for the lamp.

This is her method.

For each voltage

- switch the current on for 45 seconds
- record the current and colour of the lamp
- calculate the power and the energy transferred by the lamp

The table shows the student's results.

Voltage in V	Current	Power in W	Energy in J	Colour of lamp
0.0	0.00	0.0	0.0	off
2.0	0.40	0.8	36	red
4.0	0.90	3.6		orange
6.0	1.60	9.6	430	yellow
8.0	2.80	22.4	1000	white

(i) State the unit for current.

(1)

(ii) Calculate the missing value of energy for the voltage of 4.0 V.

Give your answer to 2 significant figures.

(2)

energy = ... J

(iii) The colour of a star is related to its surface temperature.

The Sun is yellow.

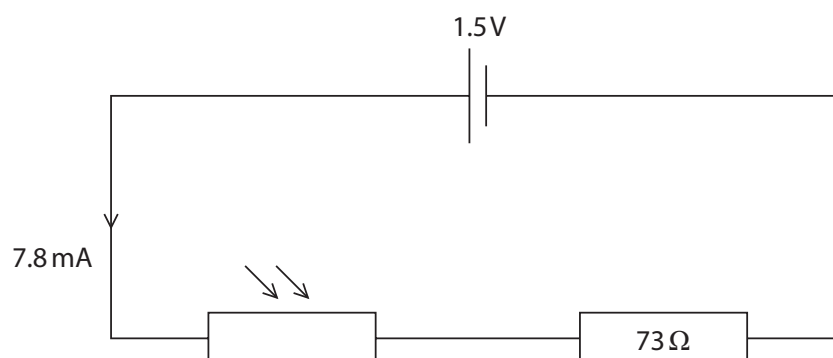
Use the student's results to identify a colour for a star that is cooler than the Sun.

(1)

(Total for Question 6 = 12 marks)



- 6 The circuit diagram shows a light dependent resistor (LDR) and a $73\ \Omega$ resistor connected in series with a 1.5V cell.



- (a) Complete the diagram by adding an instrument to measure the voltage of the LDR. (2)

- (b) (i) State the formula linking voltage, current and resistance. (1)

- (ii) The current in the circuit is 7.8 mA.

Calculate the voltage across the 73 ohm resistor.

(2)

voltage across resistor = ... V

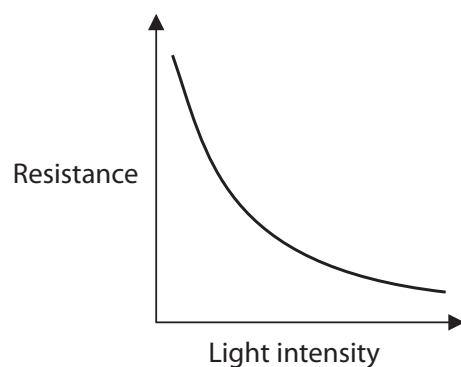
- (iii) Calculate the voltage across the LDR.

(2)

voltage across LDR = ... V



(c) The graph shows how the resistance of the LDR changes with light intensity.



(i) Describe the relationship between the resistance of the LDR and light intensity.

(2)

.....

.....

.....

.....

(ii) The resistance of the LDR decreases.

State the effect on the current in the circuit.

(1)

.....

.....

(iii) Explain why the voltage across the LDR decreases when the resistance of the LDR decreases.

(2)

.....

.....

.....

.....

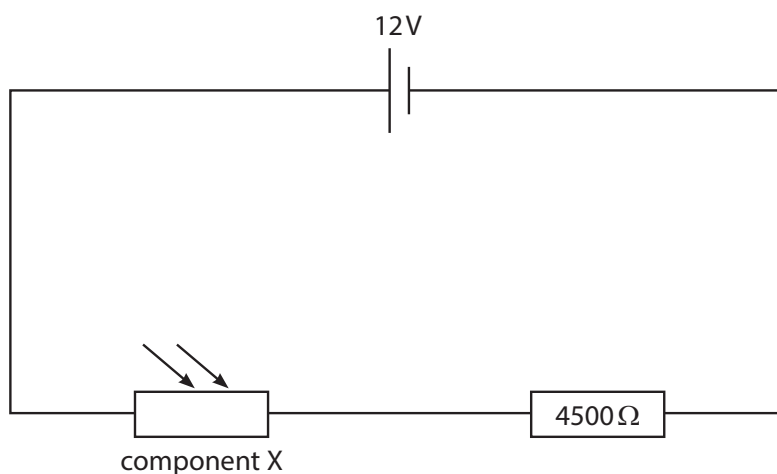
.....

.....

.....

(Total for Question 6 = 12 marks)

- 9 The diagram shows part of a circuit used for an outdoor lighting system.



- (a) Draw a voltmeter on the diagram to measure the voltage of the 4500Ω resistor.

(2)

- (b) Give the name of component X.

(1)

- (c) The voltage across component X is 3.0V .

- (i) Calculate the voltage across the 4500Ω resistor.

(1)

voltage = ... V

- (ii) Calculate the current in the circuit.

[voltage = current $\times$ resistance]

(2)

current = ... A



(iii) Calculate the resistance of component X.

Give your answer in $\text{k}\Omega$.

(3)

resistance = ... $\text{k}\Omega$

(d) Explain where a lamp should be connected in this circuit, so that the voltage across it increases as the light received by component X decreases.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 9 = 12 marks)



7 A student investigates the voltage-current characteristics of an unknown component, X.

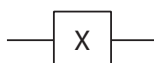
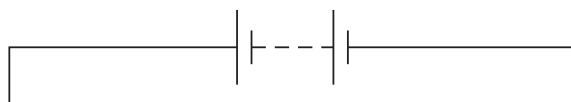
(a) The student is given this equipment to investigate component X.

- battery
- variable resistor
- ammeter
- voltmeter
- connecting wires

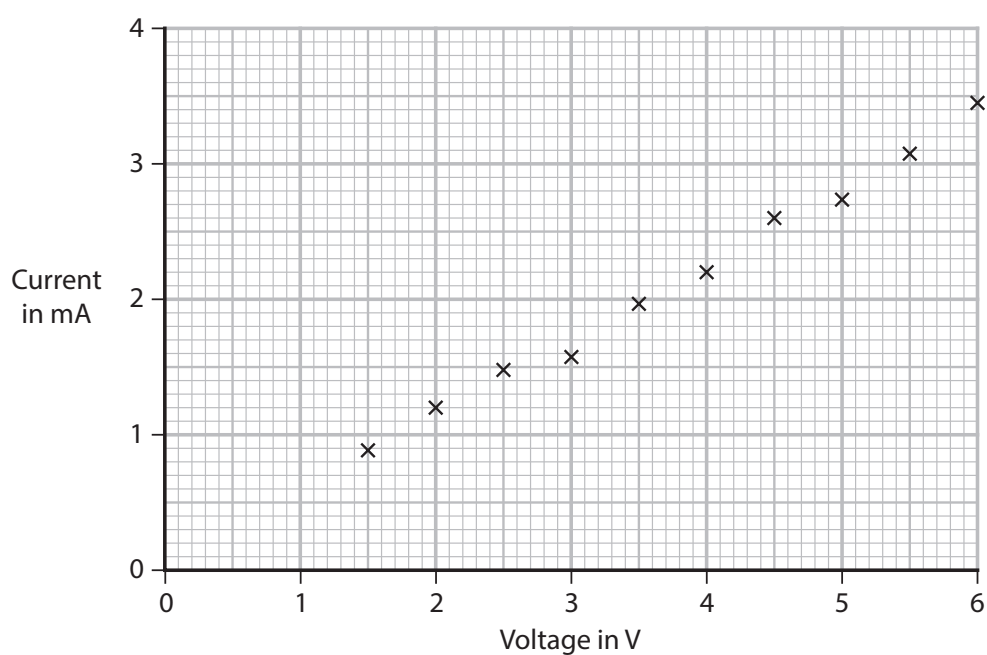
The diagram shows an incomplete circuit containing the battery and component X.

Complete the diagram by drawing a circuit the student could use for their investigation.

(4)



(b) The graph shows the results of the investigation.



(i) Draw a line of best fit on the graph.

(1)

(ii) Calculate the resistance of component X when the voltage is 4.2V.

Give the unit.

(5)

resistance = ... unit



(iii) Which of these is equivalent to 4.2V?

(1)

- ☐ **A** 4.2 coulombs per second (C/s)
- ☐ **B** 4.2 seconds per joule (s/J)
- ☐ **C** 4.2 joules per second (J/s)
- ☐ **D** 4.2 joules per coulomb (J/C)

(iv) The student concludes that component X is a filament lamp.

Comment on the student's conclusion.

(2)

.....

.....

.....

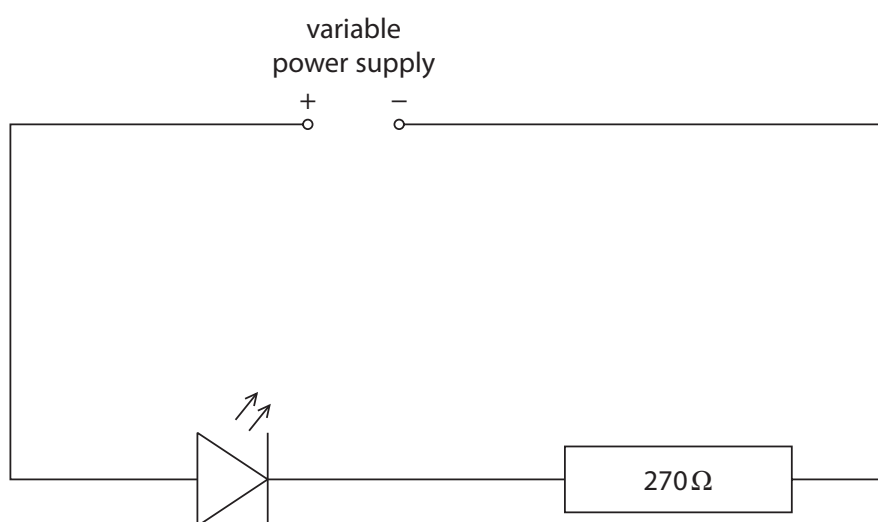
.....

.....

.....

(Total for Question 7 = 13 marks)

- 5 The diagram shows a circuit used to investigate the relationship between current and voltage for a light-emitting diode (LED).



- (a) Draw meters on the diagram to measure the voltage of the LED and the current in the LED. (3)

(b) The table shows the results of the investigation.

Voltage in V	Current in mA
0.00	0.0
0.30	0.5
0.35	2.5
0.40	1.5
0.45	2.0
0.50	4.5
0.55	9.0
0.60	15.0

(i) Plot the results on the grid.

(3)

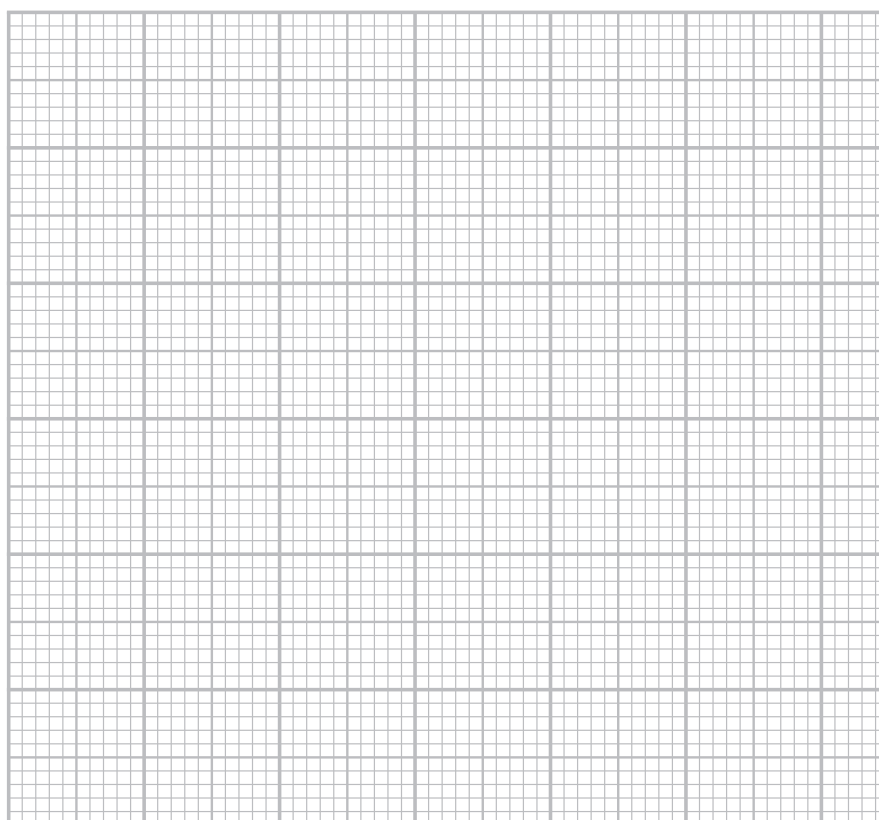
(ii) One of the results is anomalous.

On the graph, draw a circle around the anomalous result.

(1)

(iii) Draw a curve of best fit.

(1)



(iv) Give a reason why a line graph is the best way of showing these results.

(1)

(v) State the formula linking voltage, current and resistance.

(1)

(vi) Any current larger than 15 mA will permanently damage the LED.

The resistor in the circuit has a resistance of $270\ \Omega$.

Use the results from the investigation to determine the maximum voltage of the power supply without damaging the LED.

(4)

maximum voltage = ... V

(Total for Question 5 = 14 marks)

6 A student investigates how the current in a $60\ \Omega$ resistor varies with the voltage across the resistor.

(a) The student has access to this equipment

- 12 V battery
- ammeter and voltmeter
- $60\ \Omega$ resistor
- variable resistor
- switch
- connecting wires

Draw a circuit diagram to show how the student could connect this equipment to carry out the investigation.

(4)

(b) Describe a suitable method the student could use for this investigation.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

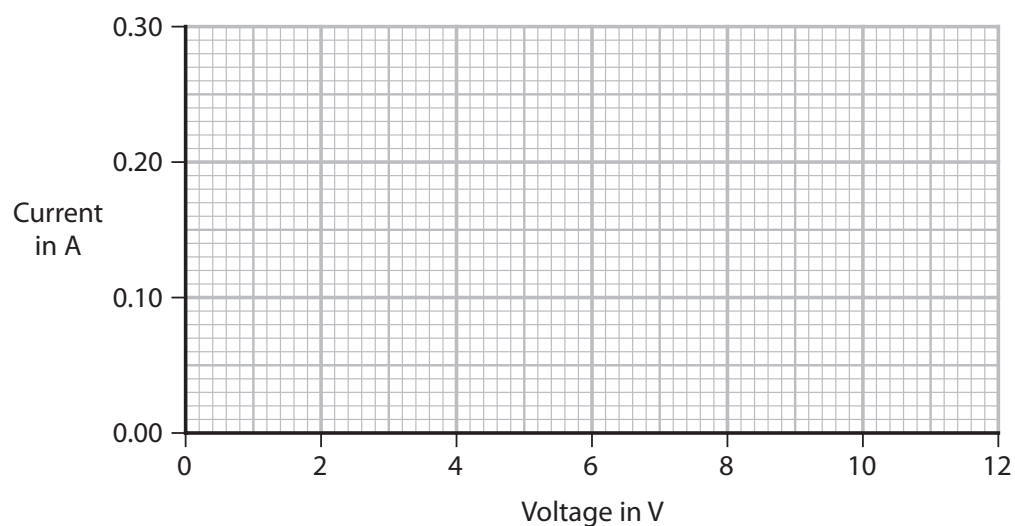
.....

.....

.....

(c) (i) Complete the current–voltage graph by drawing a line that shows the expected results of the investigation.

(3)



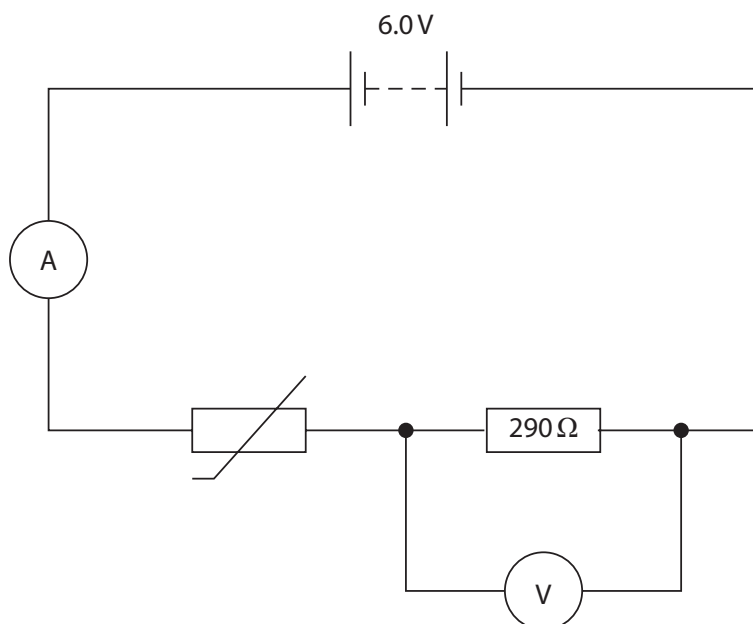
(ii) The student repeats their investigation with a $120\ \Omega$ resistor.

Explain how a current–voltage graph for a $120\ \Omega$ resistor compares with the current–voltage graph for the $60\ \Omega$ resistor.

(3)

(Total for Question 6 = 14 marks)

3 A student builds this electric circuit to measure the temperature of a room.



(a) At 20 °C, the voltage across the thermistor is 3.9V.

(i) Explain why the reading on the voltmeter is 2.1 V.

(2)

.....

.....

.....

.....

- (ii) The resistor in the circuit has a resistance of $290\ \Omega$.

Calculate the current in the resistor.

Use the formula

$$\text{voltage} = \text{current} \times \text{resistance}$$

(3)

$$\text{current} = \dots\dots\dots \text{ A}$$

- (iii) State the reading on the ammeter.

(1)

$$\text{ammeter reading} = \dots\dots\dots \text{ A}$$

- (iv) Calculate the resistance of the thermistor.

(3)

$$\text{resistance} = \dots\dots\dots \Omega$$



(b) The student observes that the voltmeter reading increases as the temperature of the room increases.

(i) Explain this observation.

(3)

(ii) The student wants to use the circuit as a temperature-measuring device.

They have this additional equipment

- a large beaker
- water at different temperatures
- a thermometer

Describe what measurements the student needs to take so that the circuit could be used as a temperature-measuring device.

Assume that the thermistor in the circuit is waterproof.

You may draw a diagram to help your answer.

(3)

(Total for Question 3 = 15 marks)



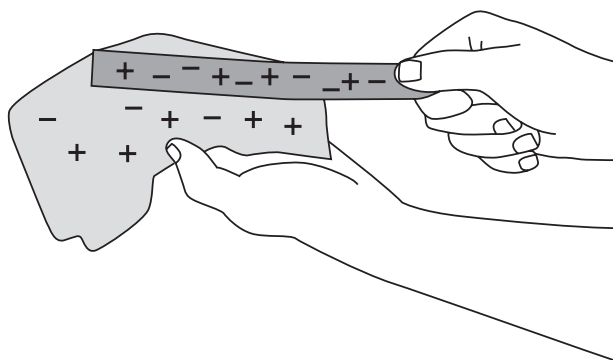
SUB-TOPIC 2.4

ELECTROSTATICS

Sub-topic 2.4 · 13 questions · 127 marks · lowest tariff first



- 3 (a) A student charges a plastic rod by rubbing it with a cloth.



The rod becomes negatively charged.

- (i) Which statement explains how the rod becomes negatively charged?

(1)

- ☐ **A** the rod gains positively charged electrons
- ☐ **B** the rod loses positively charged electrons
- ☐ **C** the rod gains negatively charged electrons
- ☐ **D** the rod loses negatively charged electrons

- (ii) Describe how the student could demonstrate that the rod is charged.

(2)

.....

.....

.....

.....

(b) The student has several other rods made from different kinds of plastic.

Some rods can be charged positively and some can be charged negatively.

Describe an experiment to show that different rods have different types of charge.

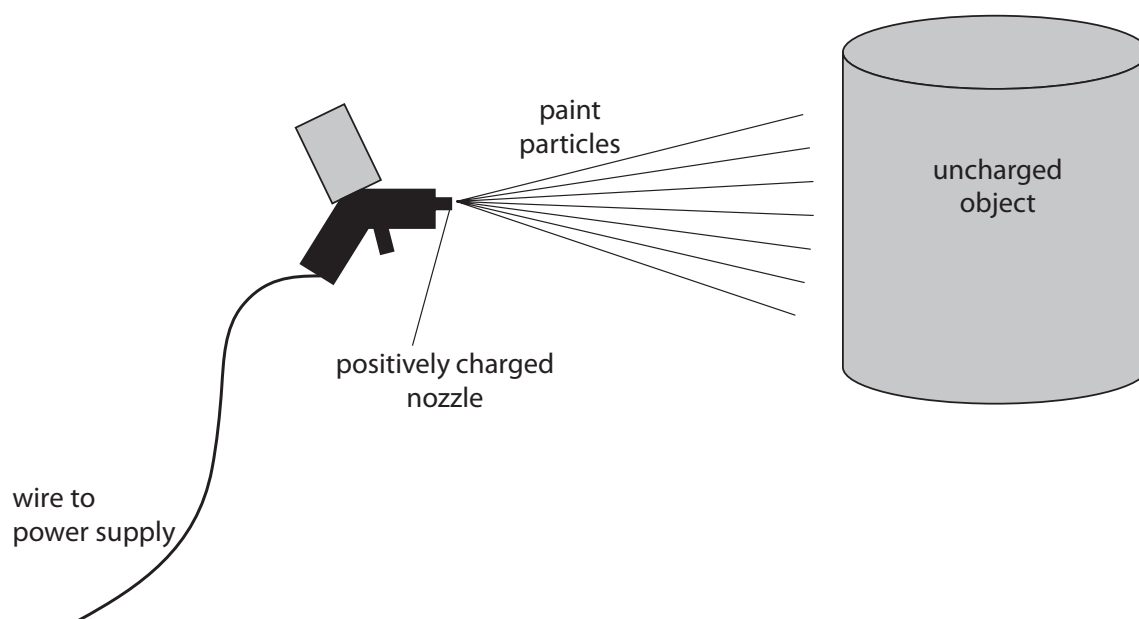
You may draw a diagram to help your answer.

(3)

(Total for Question 3 = 6 marks)



7 An electrostatic paint sprayer is used to paint an object.



(a) The nozzle of the paint sprayer is positively charged.

Explain the advantage of using a charged nozzle.

(3)

.....

.....

.....

.....

.....

.....

(b) The object is an electrical conductor and is initially uncharged.

Explain why the painting process would be more effective if the object were earthed.

(3)

(Total for Question 7 = 6 marks)



- 3** A cleaning product is applied to a car using a sponge pad.

The sponge pad is rubbed against the car to apply the cleaning product.



(Source: © Nor Gal/Shutterstock)

- (a) Some parts of the car are made of metal and other parts are made of plastic.

The metal parts of the car are earthed.

Explain why the pad becomes charged when rubbing the plastic parts, but not when rubbing the metal parts.

(3)

.....

.....

.....

.....

.....

.....

- (b) The sponge pad is held near a metal post that is connected to the ground.

The sponge pad discharges with a small spark through the air to the metal post.

- (i) The sponge pad stores 5.0 mJ of energy in its electrostatic store.

The voltage between the sponge pad and the metal post is 6000 V.

Calculate the charge transferred by the spark.

(3)

charge transferred = ... C

- (ii) The small spark between the sponge pad and the metal post demonstrates that the sponge pad is charged.

Describe a different experiment that could demonstrate that the sponge pad is charged.

You may draw a diagram to support your answer.

(2)

.....

.....

.....

.....

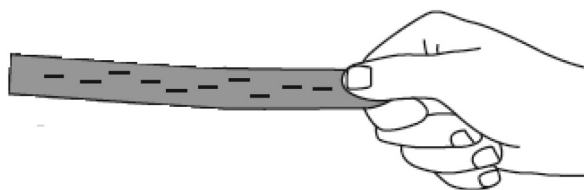
.....

(Total for Question 3 = 8 marks)



1 This question is about electrostatics.

(a) A student uses a plastic rod to investigate electrostatics.



(i) Describe how the student could have charged the plastic rod.

(2)

.....

.....

.....

.....

(ii) The student uses a meter to measure the amount of charge on the rod.

The meter displays a reading of -5.2 mC .

Which of these is the same as -5.2 mC ?

(1)

- ☐ A -0.52 C
- ☐ B -0.052 C
- ☐ C -0.0052 C
- ☐ D -0.00052 C

(iii) The rod is negatively charged.

Which statement correctly explains why the rod is negatively charged?

(1)

- ☐ A the rod has gained negatively charged electrons
- ☐ B the rod has gained positively charged electrons
- ☐ C the rod has lost negatively charged electrons
- ☐ D the rod has lost positively charged electrons

(iv) Using a meter is one method of demonstrating that the rod is charged.

Describe another method of demonstrating that the rod is charged.

(2)

(b) Electrostatic charges can be useful but they can also be dangerous.

(i) Give one use of electrostatic charges.

(1)

(ii) Explain why electrostatic charges can be dangerous when fuelling an aeroplane.

(2)

(Total for Question 1 = 9 marks)



4 This question is about electrostatics.

(a) A polythene rod is rubbed with a cloth, which causes both the rod and the cloth to become charged.

(i) Which of these is the force that causes the rod and the cloth to become charged?

(1)

- ☐ A friction
- ☐ B gravitational
- ☐ C magnetic
- ☐ D tension

(ii) The polythene rod becomes negatively charged.

Which of these statements explains how the rod has become negatively charged?

(1)

- ☐ A the rod gains electrons
- ☐ B the rod loses electrons
- ☐ C the rod gains protons
- ☐ D the rod loses protons

(b) A student has rods made from different materials.

The student rubs each rod the same way with a cloth.

The student measures the charge gained by each rod three times.

The table shows the results.

Material	Charge in nanocoulombs (nC)			
	1	2	3	Mean
glass	+35	+38	+36	+36
ebonite	-168	-170	-171	-170
polythene	-61	-80	-59	
acetate	-20	-20	-18	-19



- (i) One of the readings for the polythene rod is anomalous.

Circle the anomalous result in the results table.

(1)

- (ii) State how the student should deal with the anomalous result.

(1)

.....

.....

.....

- (iii) Calculate the mean charge for the polythene rod.

(2)

mean charge = ... nC

- (iv) Describe how the student could use the rods to demonstrate that there are two different types of electric charge.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

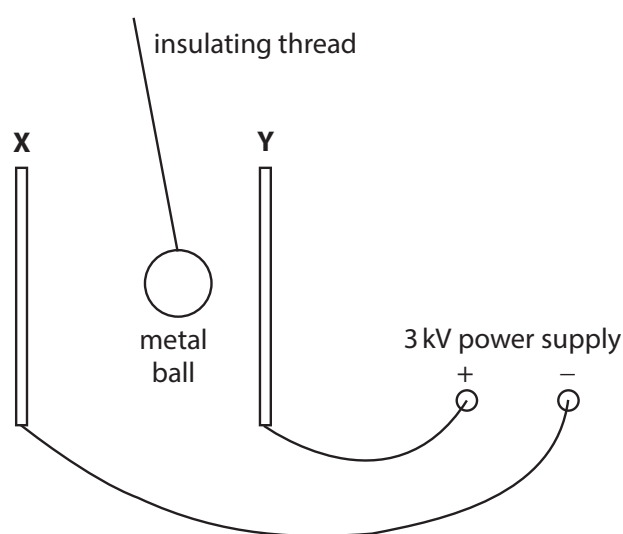
.....

(Total for Question 4 = 9 marks)



2 This question is about a demonstration to show the link between current and charge.

The diagram shows two metal plates, X and Y, with a metal ball moving between them.



(a) The two metal plates have no charge before the power supply is connected.

When plate Y is connected to the positive terminal of the power supply, the plate becomes positively charged.

Explain how plate Y gains a positive charge.

(2)

.....

.....

.....

.....

(b) (i) The metal ball becomes positively charged when it touches plate Y.

The metal ball then moves away from plate Y towards plate X.

Explain why the metal ball moves away from plate Y.

(2)

.....

.....

.....

.....

(ii) Give a reason why the ball is made of metal.

(1)

(c) When the metal ball moves away from plate Y to plate X, a charge of $5.1 \times 10^{-6} \text{ C}$ is transferred.

(i) State the formula linking charge transferred, current and time taken.

(1)

(ii) Calculate the current if the metal ball takes 0.45 seconds to travel from plate Y to plate X.

(2)

current = ... A

(iii) Suggest why the current increases if the voltage of the power supply is increased.

(1)

(iv) Give the name of the apparatus that can be used to measure current.

(1)

(Total for Question 2 = 10 marks)

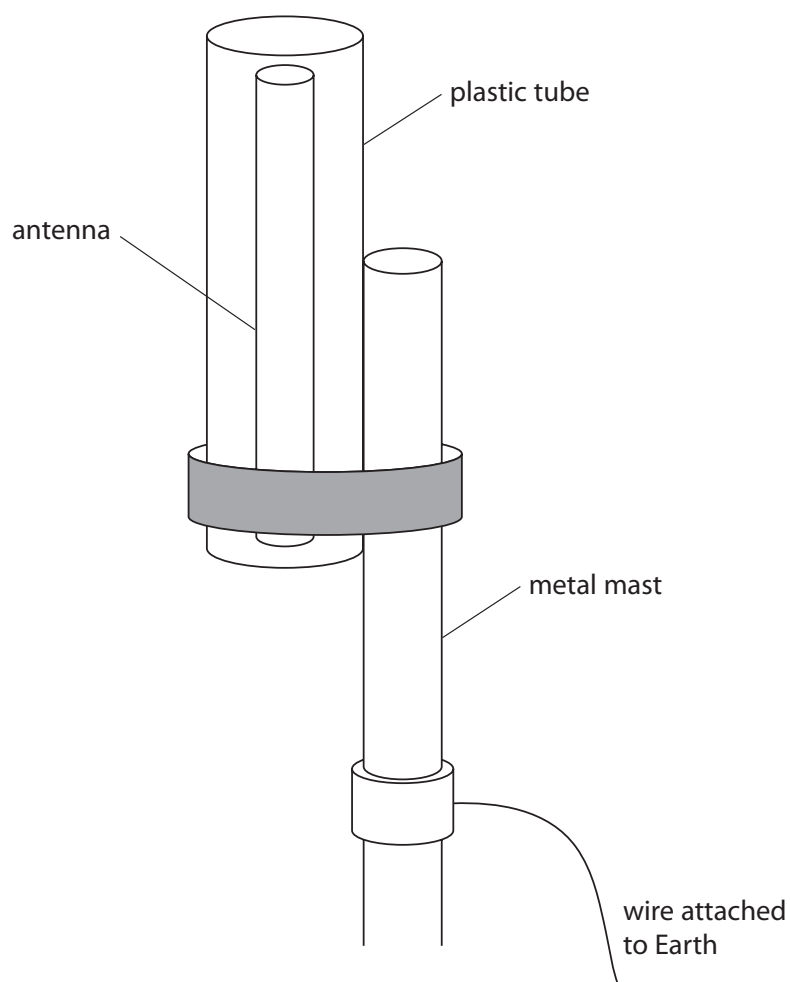


3 The diagram shows part of a radio antenna.

The plastic tube protects the radio antenna from bad weather.

Dust particles carried by the wind rub against the plastic tube.

After some time, the dust particles cause the tube to become positively charged.



(a) State the property of plastic that allows it to become electrostatically charged.

(1)

(b) Explain how the plastic tube becomes positively charged.

(2)

- (c) The plastic tube is attached to a metal mast.

This would cause the metal mast to become positively charged.

Explain why there is a wire connecting the metal mast to the Earth.

(3)

- (d) The plastic tube gains a charge of 4.3 mC.

The energy stored on the tube is 3.7 J.

Calculate the voltage between the plastic tube and the metal mast.

(3)

voltage = ... V

- (e) An engineer is working on the radio antenna.

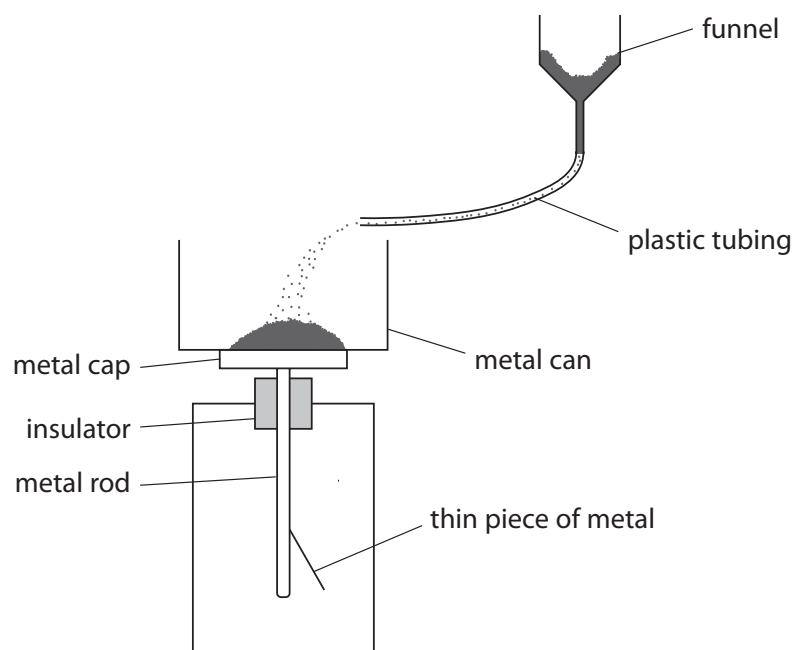
Describe the hazard to the engineer if there is no earth wire.

(2)

(Total for Question 3 = 11 marks)



- 4 A student uses this apparatus to demonstrate the effect of electric charge.



He pours some fine powder into a funnel.

The fine powder moves through a length of plastic tubing and falls into a metal can.

The metal can rests on a metal cap.

The metal cap is connected to a thin piece of metal via a metal rod.

When the powder lands in the can, the thin piece of metal moves away from the metal rod.

- (a) Explain why the thin piece of metal moves away from the metal rod.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(b) A coulombmeter measures electric charge.

The student connects a coulombmeter to the metal can.

When all the powder has landed in the can, the coulombmeter shows a reading of $-9.4 \times 10^{-9} \text{ C}$.

(i) Which statement is true for the metal can?

(1)

- ☐ **A** it gains negatively charged electrons
- ☐ **B** it loses negatively charged electrons
- ☐ **C** it gains positively charged electrons
- ☐ **D** it loses positively charged electrons

(ii) State the formula linking charge, current and time.

(1)

(iii) It takes a time of 12 s from when the powder starts landing in the metal can until all the powder has landed in the can.

Calculate the mean charging current.

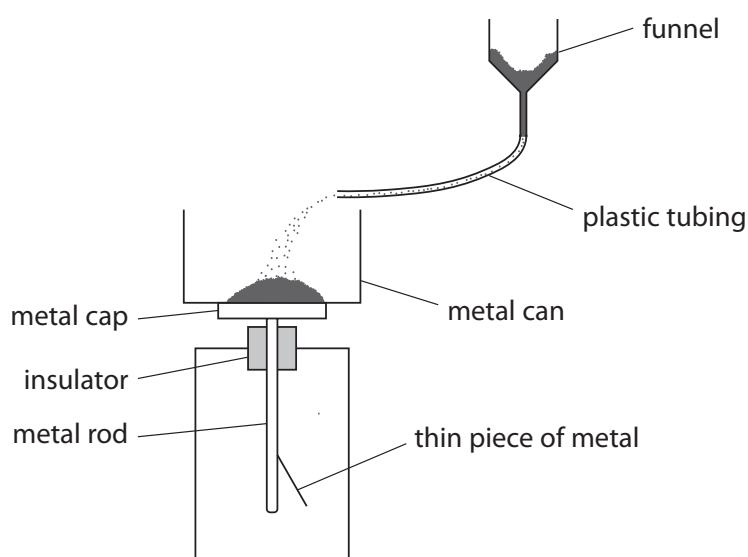
(3)

current = ... A



(c) The student suggests that this demonstration is similar to refuelling an aircraft.

The powder represents the fuel and the metal can represents the fuel tank in the aircraft.



Explain how the student should modify this apparatus to demonstrate how to minimise the dangers when refuelling an aircraft.

You may add to the diagram to help your answer.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

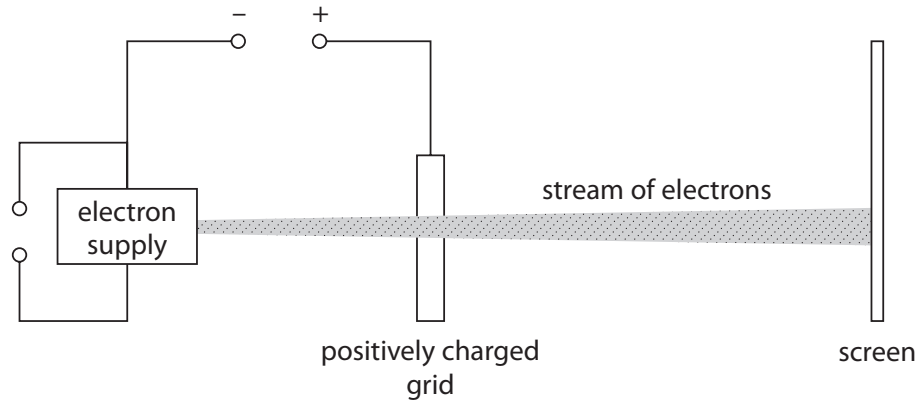
.....

(Total for Question 4 = 12 marks)

3 The diagram shows the inside of an oscilloscope.

Electrons leave the electron supply and accelerate towards the screen.

The stream of electrons hits the screen.



(a) The grid is connected to the positive terminal of a high voltage power supply.

(i) Explain, in terms of the movement of particles, how the grid has become positively charged.

(2)

.....

.....

.....

.....

(ii) State the formula linking kinetic energy, mass and speed.

(1)

(iii) Calculate the speed of an electron when it has 1.3×10^{-15} J of kinetic energy.

The mass of an electron is 9.1×10^{-31} kg.

(3)

speed = ... m/s

- (b) The stream of electrons spreads out as it travels towards the screen.

Explain why the electrons in the stream move apart from each other.

(2)

.....

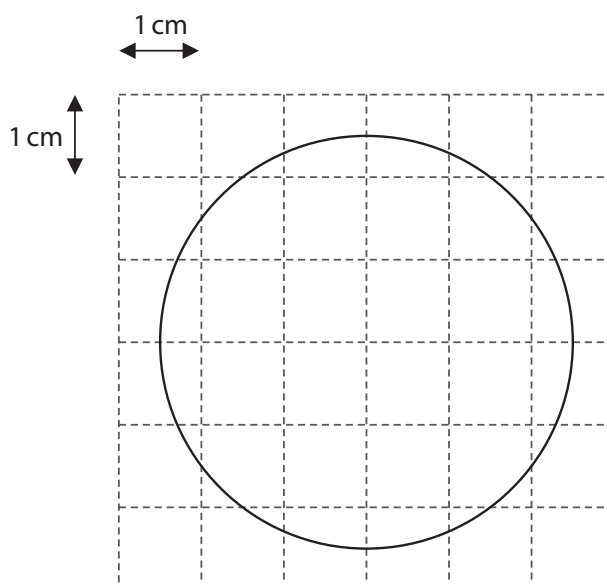
.....

.....

.....

- (c) The oscilloscope can cause the electrons to move in a circle.

This produces a circular pattern on the screen.



- (i) Use the scale to determine the **radius** of the circle.

(1)

radius = ... cm

- (ii) The time taken for the electrons to complete one orbit of the circle is 24 ms.

Calculate the orbital speed of the electrons.

Use the formula

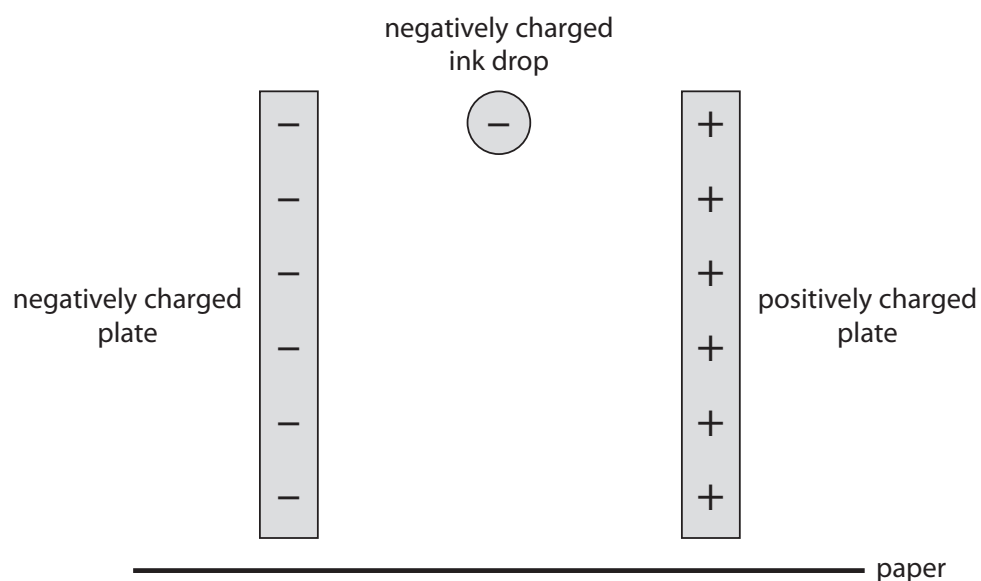
$$\text{orbital speed} = \frac{2\pi \times \text{orbital radius}}{\text{time period}} \quad (3)$$

orbital speed = ... m/s

(Total for Question 3 = 12 marks)



- 8 The diagram shows a simplified view of part of an inkjet printer.



A negatively charged ink drop falls vertically between a pair of charged plates.

- (a) The ink drop experiences a horizontal electrostatic force as it falls.

Explain the direction of the electrostatic force exerted on the ink drop by the charged plates.

(2)

.....

.....

.....

.....

- (b) On the diagram, draw the path of the ink drop as it falls between the charged plates until it hits the paper.

(2)

- (c) (i) The ink drop experiences a horizontal force of $8.5 \times 10^{-7} \text{ N}$ when it is between the charged plates.

The mass of the ink drop is $1.1 \times 10^{-10} \text{ kg}$.

Calculate the horizontal acceleration of the ink drop when it is between the charged plates.

(3)

acceleration = ... m/s^2

- (ii) The ink drop has no initial horizontal velocity before it passes between the charged plates.

After passing between the charged plates, the horizontal velocity of the ink drop is 3.9 m/s .

Calculate the horizontal distance travelled by the ink drop as it passes between the charged plates.

Give your answer in mm.

(4)

distance = ... mm



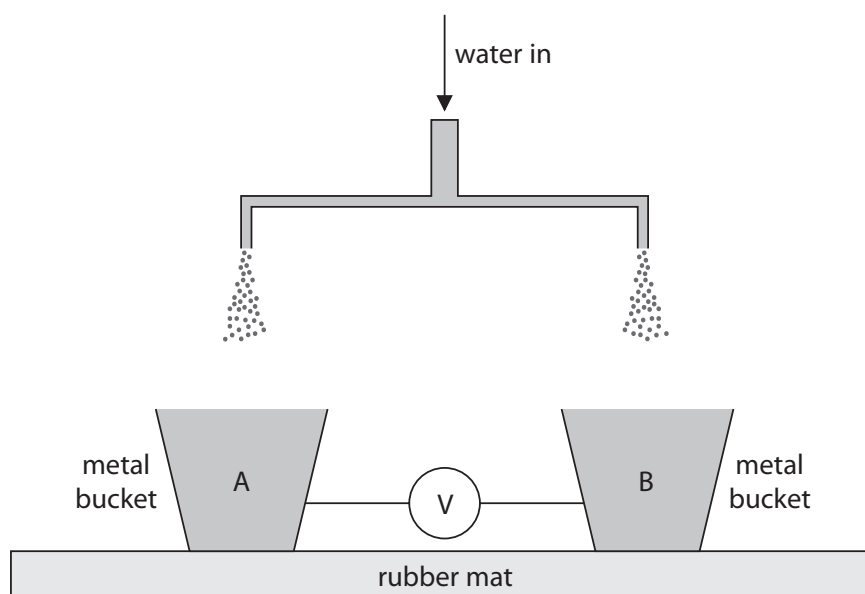
(d) Explain how another ink drop could be deflected in the opposite direction by a greater distance using the charged plates in the inkjet printer.

(2)

(Total for Question 8 = 13 marks)



7 The diagram shows part of a device used to demonstrate electrostatic charge.



(a) Negatively charged water droplets fall into bucket A.

Describe how bucket A becomes negatively charged.

(2)

.....

.....

.....

.....

(b) Explain why the negatively charged droplets spread out as they fall.

(2)

.....

.....

.....

.....

- (c) (i) A droplet hits bucket A with a speed of 3.8 m/s.

Calculate the kinetic energy of the droplet when it hits bucket A.

[mass of droplet = 6.2×10^{-9} kg]

(3)

kinetic energy = ... J

- (ii) The total charge stored in bucket A is -1.1×10^{-10} C.

This charge passes through the air between the buckets in 9.2×10^{-3} s,
causing a spark between bucket A and bucket B.

Calculate the mean current between the buckets.

(3)

mean current = ... A

- (iii) The spark transfers a charge of -1.1×10^{-10} C.

The mean voltage between the buckets is 1.7 kV.

Calculate the energy transferred by the spark.

(3)

energy transferred = ... J

(Total for Question 7 = 13 marks)



5 A student uses this apparatus to investigate static electricity.

The positively charged ball is suspended vertically on a long length of string.

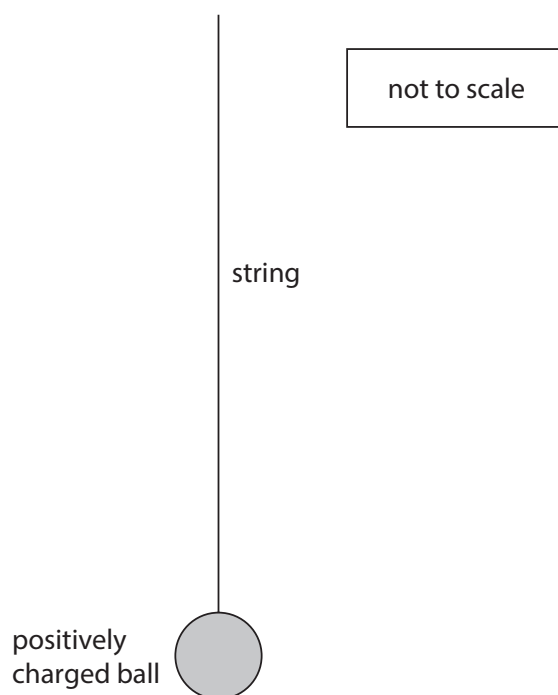


Diagram 1

(a) The ball is made of a material that is a good electrical conductor.

Name a material that is a good electrical conductor.

(1)

(b) Explain, in terms of the movement of charged particles, how the ball has become positively charged.

(2)

- (c) The student places a centimetre scale behind the length of string.

The string lines up with the 5.0 cm mark on the scale when the ball is in its resting position, as shown in diagram 2.

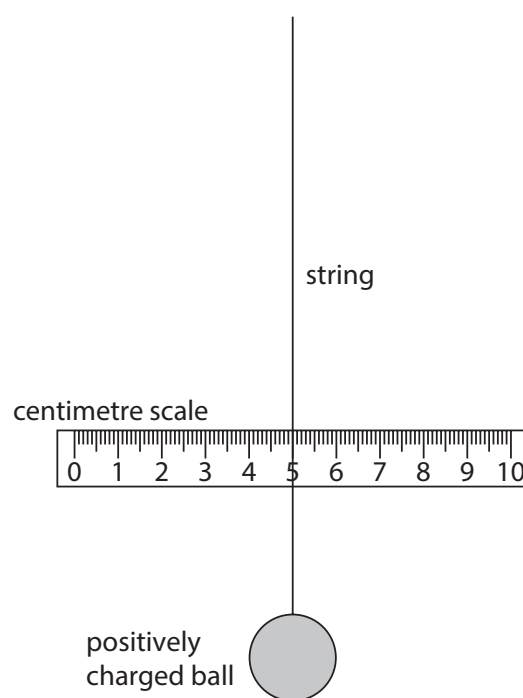


Diagram 2

The student brings a negatively charged polythene rod near to the right side of the ball.

The ball moves, as shown in diagram 3.

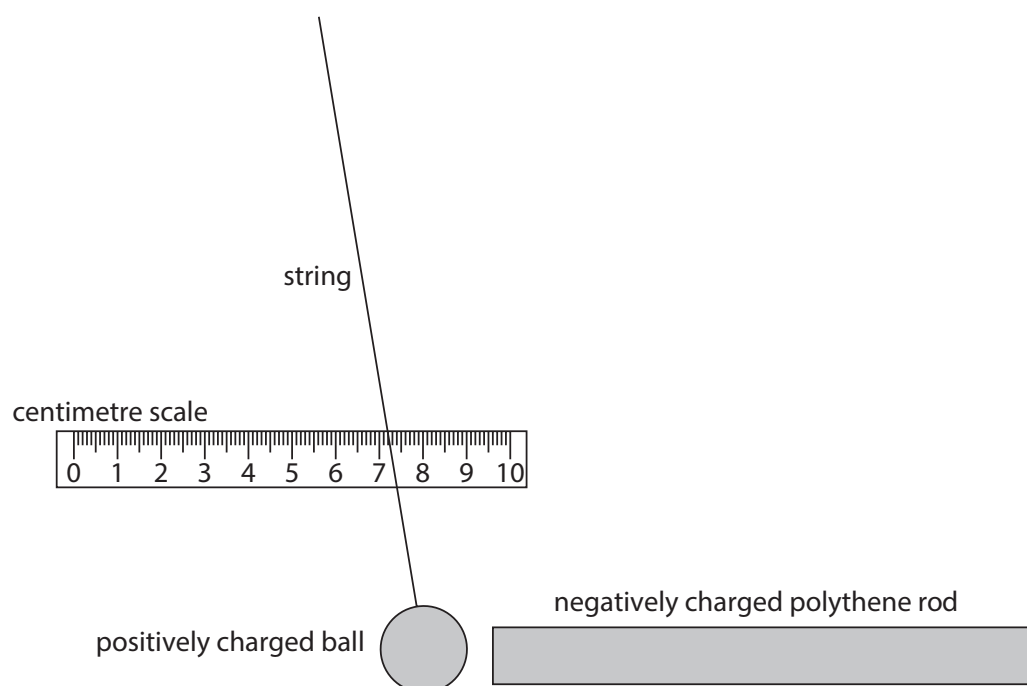


Diagram 3

- (i) Explain how the movement of the ball shows that the charge on the polythene rod is negative.

(2)

.....

.....

.....

.....

- (ii) In diagram 3, the string lines up with the 7.2 cm mark on the scale.

The student moves the polythene rod slightly further away from the ball.

Predict a possible reading on the scale.

(1)

reading = ... cm

- (d) The student extends the investigation by measuring the reading on the scale for rods made from different materials.

As a control variable, the student charges each rod by rubbing it with a cloth the same number of times.

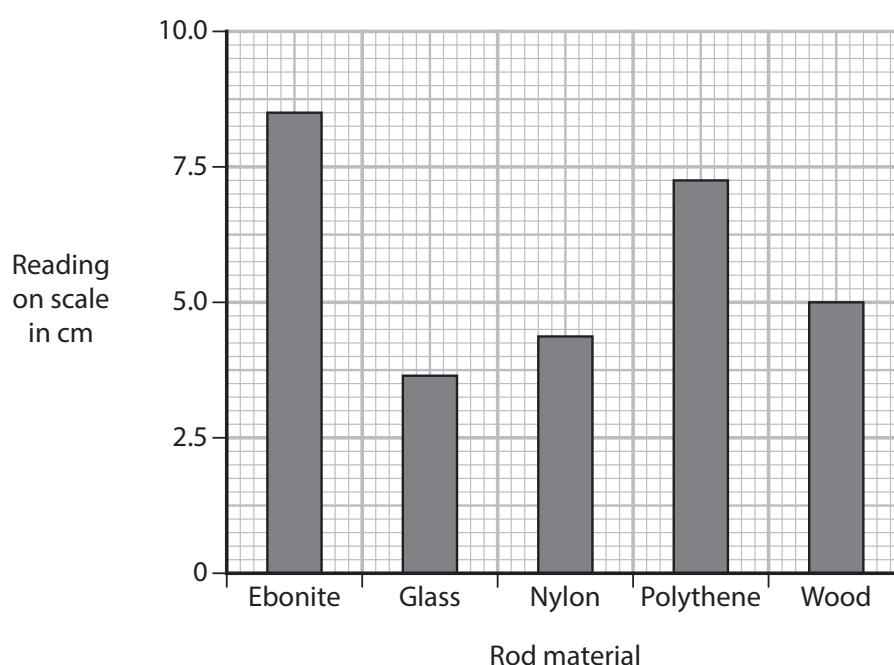
Give two other control variables for the student's investigation.

(2)

1

2

- (e) The bar chart shows the results of the student's investigation.



- (i) Justify the use of a bar chart to present the student's results.

(1)

.....

.....

.....

- (ii) Deduce what can be concluded about the charge on each of the rods used in the investigation.

Use information from the bar chart to help your answer.

(3)

(Total for Question 5 = 12 marks)



1 A flour mill is a factory where flour is produced.

The photograph shows some flour moving through metal channels in the flour mill.



(Source: © Retan/Shutterstock)

(a) The flour particles can become charged as they move through the metal channels.

(i) Explain how the flour particles can become charged.

(2)

.....

.....

.....

.....

.....

.....

(ii) The charged flour particles move away from each other as they fall from the end of each channel.

Complete the passage by writing a suitable word or words in each blank space.

(2)

Flour particles move away from each other because they have

..... charges. This causes the flour particles

to exert forces on each other.

- (b) The dust created by producing flour in a flour mill is dangerous because the dust is flammable. This creates a risk of an explosion.

Explain why connecting the metal channels to earth reduces the risk of an explosion in a flour mill.

(2)

(Total for Question 1 = 6 marks)



MARK SCHEMES

official mark schemes



Question number	Answer	Notes	Marks
5 (a)	wires have a higher current / voltage;	allow idea that if one breaks the rest will keep working / some can be on but not others / eq	1
(b) (i)	power = current $\times$ voltage;	allow standard symbols and rearrangements e.g. $P = I \times V$ reject C for current, W for power	1
(ii)	substitution; rearrangement; evaluation; e.g. $2800 = \text{current} \times 230$ (current =) $2800 / 230$ (current =) 12 (A)	in either order -1 for POT error allow 12.17...(A)	3
(iii)	(current = $12 / 48 =$) 0.25 (A)	allow ecf from (ii)	1

Total for Question 5 = 6 marks

Question number	Answer	Notes	Marks
2 (a)	any of: - idea that circuit breaker can easily be reset; - idea that circuit breaker turns off circuit more quickly;	allow 'does not need to be replaced' cf fuse	1
(b) (i)	power = current × voltage;	allow standard symbols and rearrangements e.g. $P = I \times V$ ignore C, c for current	1
(ii)	substitution; evaluation in W; evaluation in kW; e.g. power = 11×230 (power =) 2500 (W) (power =) 2.5 (kW)	allow 2530 W if candidate's intention is clear i.e. removal of 'k' or 2530 with W seen. allow 2.53 (kW)	3
(c)	any of: - idea that there are likely to be other appliances on same circuit; - fuse in heater may be rated at less than 16A; - idea that heater may have a (thermal) safety cut-out; - idea that thermostat turns off heater;	ignore reference to an electric fault in the heater	1

Total for Question 2 = 6 marks

Question number	Answer	Notes	Marks
2 (a)	the rate of flow of charge/electrons;	allow amount of charge per second, amount of charge per unit time	1
(b)	electron(s);	ignore words written in addition to electron(s)	1
(c) (i)	power = current $\times$ voltage;	allow standard symbols and rearrangements e.g. $I = P / V$	1
(ii)	substitution; rearrangement; evaluation; e.g. $1400 = \text{current} \times 230$ (current =) $1400 / 230$ (current =) 6.1 (A)	-1 for POT error allow 6, 6.09, 6.086...	3
(iii)	any two from: MP1. idea that wire has resistance; MP2. electrons collide with lattice ions; MP3. idea of transferring energy (from electrons to wire/eq); MP4. increasing vibrations of lattice ions;	ignore friction allow sensible alternatives for lattice ions e.g. atoms in the wire etc. ignore generic references to "heat" allow sensible alternatives for lattice ions e.g. atoms in the wire etc.	2

Total for Question 2 = 8 marks

Question number	Answer	Notes	Marks
3 (a)	substitution into given formula; rearrangement; correct evaluation; e.g. $0.27 = \text{energy} / 43\,200$ $\text{energy} = 0.27 \times 43\,200$ $(\text{energy} =) 12\,000 \text{ (J)}$	ignore units allow $E = P \times t$ -1 for not converting units or converting units incorrectly if no other mark scored then evidence of 43 200 seen in working scores 1 mark allow 11 700, 11 660, 11 664 (J) 3.24 (J), 194.4 (J) or answers rounded from these values score 2 marks	3
(b) (i)	idea that current exceeds the fuse rating; fuse (wire) melts; idea that device is isolated;	allow when current is too high, surge of current etc. ignore current increasing allow fuse breaks, fuse blows ignore fuse burns allow idea that circuit is broken	3
(ii)	any two from: MP1. idea that fuse rating is much higher than normal current; MP2. idea that there is still current (even if there is a fault); MP3. idea that (connecting lead/TV) will overheat/cause a fire;	allow fuse value is too high allow fuse will not melt/break/blow allow idea of causing damage to TV / circuit	2

Total for Question 3 = 8 marks

Question number	Answer	Notes	Marks
7 (a)	0 / none / zero (J);		1
(b)	substitution into given formula $E = V \times I \times t$; correct evaluation to at least 3 s.f.; e.g. energy = $7.1 \times 3.9 \times 0.42$ energy = 11.6... (J)	allow use of $P = E/t$ and $P = VI$	2
(c)	energy transferred to motor electrically from battery 12 J; kinetic energy store of motor 10 J; thermal store of the surroundings 2 J;	allow electric, electrical condone heat	3
(d)	useful and total energies correctly selected; substitution into efficiency formula; evaluation; e.g. 10 (J) and 12 (J) seen in working efficiency = $10/12 (\times 100\%)$ efficiency = 83 (%)	allow ecf from (c) allow lack of 100 i.e. 0.83 if % sign removed from answer line allow 83.3... (%)	3

Total for Question 7 = 9 marks

Question number	Answer	Notes	Marks
7 (a)	idea that lamps can be controlled independently; (because) circuit is a parallel circuit;	allow some lights on whilst others off / if one lamp blows the others still work etc. allow all lamps get full voltage / 230V allow idea that lamps are on (three) separate paths/branches of the circuit	2
(b) (i)	electron(s);	allow ion(s), cation(s), anion(s)	1
(ii)	substitution into formula; conversion from mA to A; evaluation to 2 or more s.f.;	ignore units allow if 0.022 or $\div 1000$ seen anywhere in working condone a calculation of current or voltage given to at least 3 s.f. using a power of 5 W for full marks	3
(iii)	substitution into $P = E/t$; rearrangement; evaluation; e.g. $5 = E / 30$ $E = 5 \times 30$ $E = 150 \text{ (J)}$	allow ecf from (ii) allow use of $E = V \times I \times t$ or other valid methods -1 for POT error allow $E = 230 \times 22(\times 10^{-3}) \times 30$ allow 151.8, 152, 153	3
(c) (i)	energy (transferred) per unit charge (passed);	allow $V = E/Q$ only if all terms defined allow work done for energy transferred allow coulomb for unit charge	1
(ii)	any attempt to add any currents together; (current =) 39 (mA);	60, 65, 82 (mA) scores 1 mark	2

Total for Question 7 = 12 marks

Question number	Answer	Notes	Marks
4 (a)	live / L;	allow red / brown wire	1
(b)	any two from: MP1. earth wire; MP2. circuit breaker; MP3. double insulation; MP4. insulated cables;	allow RCD, trip switch, surge protector allow any mention of insulated wires	2
(c) (i)	power = current $\times$ voltage;	allow standard symbols e.g. $P = I \times V$ ignore C, c for current	1
(ii)	substitution; evaluation; unit; e.g. (P =) 9.6×230 (P =) 2200 watts / W	mark independently 2.2 kW = full marks allow 2208, 2210 allow J/s	3
(iii)	coil has resistance; electrons transfer/lose energy (as they flow through coil); (due to) electron collisions with (lattice) ions in the coil;	allow wire for coil throughout allow atoms, particles for ions	3
(d)	idea of excessive current; melts the fuse (wire); breaking the circuit ;	e.g. "current becomes too high" allow breaking the fuse condone "blows the fuse" allow "stops the current" / eq	3

Total for Question 4 = 13 marks

Question number	Answer	Notes	Marks
11 (a)	idea that voltage across resistor is difference between cell and diode voltage; rearrangement of $V = IR$; evaluation in A; conversion to mA; e.g. voltage across resistor = $1.5 - 0.63 = 0.87$ (V) $I = V/R = 0.87/95$ current = 0.00915... (A) current = 9.2 (mA)	allow 0.87 seen or 1.5–0.63 seen condone use of incorrect voltage to give 0.0066, 0.0224, 0.0158 (A) = 1 mark 6.6, 22.4, 15.8 (mA) = 2 marks allow current = 9.15...(mA)	4
(b)	any four from: MP1. resistance (of circuit) decreased; MP2. (because) extra path in circuit; MP3. resistance (of circuit) halved; MP4. idea that voltage across parallel branches is the same (as previous voltage); MP5. current (in ammeter) increased; MP6. current (in ammeter) doubled;	also scores MP1 allow calculation of resistance (=81.9Ω) reject if idea that cell voltage is shared between branches allow current in ammeter is sum of currents in branches also scores MP5 allow calculation of current (=18mA)	4

Total for Question 11 = 8 marks

Question number	Answer	Notes	Marks
7 (a) (i)	B - joule per coulomb; A is incorrect because this is not a correct unit for volt C is incorrect because this is not a correct unit for volt D is incorrect this is not a correct unit for volt		1
(ii)	energy (transferred) = charge × voltage;	allow standard symbols and rearrangements	1
(iii)	substitution; conversion of kV to V; evaluation; e.g. energy = $1.6 \times 10^{-19} \times 150 \times 10^3$ energy = 2.4×10^{-14} (J)		3
(b) (i)	charge = current × time;	allow standard symbols and rearrangements	1
(ii)	substitution and re-arrangement; conversion of ms to s; evaluation; e.g. charge = current × time current = $2.9 \times 10^{-8} / 0.68 \times 10^{-3}$ current = 4.3×10^{-5} (A)	accept conversion to microamps or milliamps provided micro- (μ) or milli- (m) clear on answer line allow 4.265×10^{-5} (A)	3

Total for Question 7 = 9 marks

Question number	Answer	Notes	Marks
10 (a)	use of voltage = current $\times$ resistance; calculation of voltage across 240 ohm resistor (2.88 V); idea that voltages of two resistors in series adds up to supply voltage; evaluation of voltage across R; e.g. $V = I \times R$ $V_{240} = (0.012 \times 240 =) 2.88 \text{ (V)}$ $V_R + V_{240} = 9.2$ $(V_R =) 6.3 \text{ (V)}$	allow rearrangements and standard symbols calculate total resistance of circuit (767 Ω) evaluation of resistance of R (527 Ω) evaluation of voltage across R (using $V = IR$) allow 2.9 (V) allow $9.2 - 2.88$ or $V + 2.88 = 9.2$ allow 6.32 (V) if mA not converted to A and 2880 seen then award 2 marks max.	4
(b) (i)	any three from: MP1. coil produces a magnetic field; MP2. (which) interacts with the magnetic field of the (permanent) magnet; MP3. producing a force acting on the coil; MP4. opposite forces on either side of coil; MP5. coil rotates / turns;	allow coil becomes an electromagnet allow one side is pushed up and the other is pushed down allow coil spins, pointer moves (to the left)	3
(ii)	vertical arrow UP (on wire CD);		1
(iii)	any three from: MP1. more turns on the coil; MP2. stronger (permanent) magnet; MP3. add an iron core; MP4. producing a larger force (for the same current); MP5. use of a longer pointer; MP6. use of a weaker return spring; MP7. producing a greater movement at the end of the pointer (for the same current);	allow "more coils" allow method to increase field strength e.g. moving magnets closer together allow producing the same force for a smaller current allow same movement for a smaller current	3

Total for Question 10 = 11 marks

Question number	Answer	Notes	Marks
11 (a)	conversion of hours into seconds; evaluation; e.g. 1 hour = $(60 \times 60 =)$ 3600 (s) (charge = $1 \times 3600 =$) 3600 (C)	allow 3600 or 60×60 seen in working	2
(b) (i)	substitution OR rearrangement; evaluation in seconds; conversion to minutes; e.g. $3.8 \times 10^3 = 2.4 \times t$ OR $t = Q/I$ (t =) 1600 (s) (t =) 26 (minutes)	mark independently and apply ecf allow 1580, 1583... allow 26-27 (minutes)	3
(ii)	idea that longer cable has more resistance; (so) charging current will be less AND time taken will increase;	ignore longer distance both ideas needed for the mark	2
(c)	any four from: MP1. determination of total charge needed for the week; MP2. quantitative comparison to power bank charge; MP3. idea that power bank cannot recharge all devices (from completely flat); MP4. idea that devices will not always be completely empty when recharged; MP5. idea that devices could be used less (which would make them last longer before recharging); MP6. idea that other charging facilities might be available;	27.8 (Ah) or 100080 C allow 27.8 is greater than 26.8 allow power bank is 1 Ah less than needed allow ecf from MP1 allow power bank is not suitable/enough allow idea that devices could be partially charged allow idea that power bank could be recharged during trip	4

Total for Question 11 = 11 marks

Question number	Answer	Notes	Marks
11 (a) (i)	12 (V);		1
	(ii) voltage = current $\times$ resistance;	allow standard symbols and rearrangements e.g. $R = V / I$	1
	(iii) substitution; rearrangement; evaluation; e.g. $12 = 0.019 \times R$ $(R =) 12 / 0.019$ $(R =) 630 (\Omega)$	allow ecf from (i) -1 for POT error 0.631... scores 2 marks if 35mA used as the current (giving 342.8...) then award 2 marks max. allow 632, 631.6, 631.57...	3
(b) (i)	idea that current is conserved at a junction in a circuit;	e.g. current before and after junction must be the same, $16 + 19 = 35$ etc. ignore "current is shared"	1
	(ii) <u>use</u> of voltage = current $\times$ resistance; calculation of total resistance of path (750 Ω); idea that resistances of two resistors in series adds up to total resistance; evaluation of resistance of Y; e.g. $12 = 0.016 \times R_T$ $R_T = 750 (\Omega)$ $750 = 250 + R_Y$ $R_Y = 500 (\Omega)$	must be more than just quoting the formula for the mark calculation of voltage across 250 Ω resistor (4.0 V) evaluation of voltage across R (8.0V) evaluation of resistance of R (using $V=IR$) if mA not converted to A and 0.75 seen then award 2 marks max.	4
	(c) current decreases; with any one from: (total) resistance of circuit has increased; - idea that there are now less paths for the current in the circuit;	DOP	2

Total for Question 11 = 12 marks

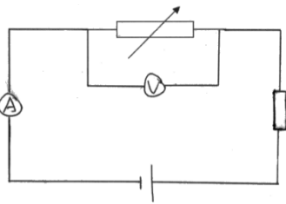
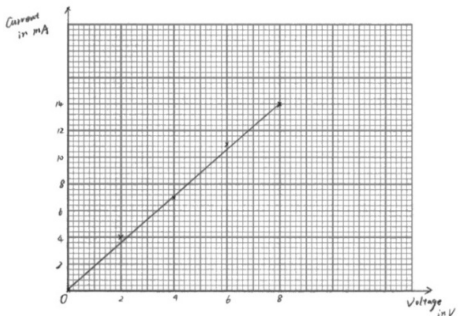


Question number	Answer	Notes	Marks
3 (a)	idea that if one bulb fails all bulbs turn off;	allow idea that bulbs cannot be controlled individually	1
(b)	any one from: - less likely to overheat; - idea that the circuit is simpler; - lower voltage bulbs; - all bulbs controlled with one switch;	accept uses fewer wires	1
(c) (i)	voltage = current $\times$ resistance;	allow standard symbols and rearrangements e.g. $I = V / R$	1
(ii)	substitution; rearrangement; evaluation; e.g. $33 = I \times 390$ ($I =$) $33 / 390$ ($I =$) 0.085 (A)	allow 0.08, 0.0846... condone 0.084	3
(iii)	dimensionally correct substitution into $E = V \times I \times t$; conversion of hours to seconds; use of 7 bulbs; evaluation; e.g. $E = 33 \times 0.085 \times 2.5$ 2.5 hours = 9000 seconds voltage used = 231 OR $\times 7$ used in working ($E =$) 180 000 (J)	allow ECF from (ii) allow 60×60 or 9000 seen anywhere in working 23760-25245 = 3 marks ($\times 7$ not used) 6.60-7.01 = 2 marks allow answer between 165000 to 180000	4
(d)	brightness is greater in lamp Y; with any two from: more energy transferred to each bulb in lamp Y; bulbs in lamp Y have a larger voltage / 46 V; resistance of (circuit in) lamp Y is less; current in bulb / circuit in lamp Y is greater;	allow RA	3

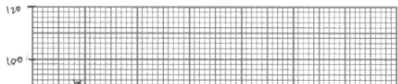
Total for Question 3 = 13 marks

Question number	Answer	Notes	Marks
3 (a)	A (current); B is incorrect because power is the rate of energy transferred C is incorrect because resistance is the ratio of voltage and current D is incorrect because voltage is the energy transferred per unit charge passed		1
(b)	D (voltage); A is incorrect because current is the rate of flow of charge B is incorrect because power is the rate of energy transferred C is incorrect because resistance is the ratio of voltage and current		1
(c) (i)	correct voltmeter symbol used; voltmeter drawn in parallel with S;	condone drawn in parallel with R or the battery	2
(ii)	0.20 (A); 0.60 (A);	this order only allow 0.2 (A) this order only allow 0.6 (A)	2
(iii)	voltage = current $\times$ resistance; substitution; evaluation; e.g. $V = I \times R$ (V =) 0.40×11 (V =) 4.4 (V)	formula should be seen or implied by calculation allow standard symbols and rearrangements ignore C, c for current	3
(iv)	idea that voltage across battery is the same as voltage across R; (because) battery and R are connected in parallel / no other resistive components on loop with battery and R;	allow numerical value given e.g. 'voltage of battery = 4.4V'	2
(d)	idea that resistance (of thermistor) changes; when temperature increases, resistance decreases; (therefore) current increases when temperature increases;	allow even if relationship is the wrong way round ORA ORA	3

Total for Question 3 = 14 marks

Question number	Answer	Notes	Marks
12 (a) (i)	correct symbol for resistor; correct symbol for cell; correct symbol for ammeter; circuit is complete series circuit;	reject extra components allow ECF for missing/incorrect symbols	4
			2
(ii)	voltmeter symbol is correct and in parallel with any component; voltmeter is in parallel with variable resistor;		
(b)	any FOUR from: stretchy resistor increases in resistance (when mass increased); total resistance increases; $I = V/R$; current in circuit less; voltage across fixed resistor decreases; so voltage across stretchy resistor increases; as total voltage is constant/voltage of cell constant;	reject $V=IR$ or $I=V/R$ with assumption of constant current	4
(c) (i)	voltage;	allow 'V'	1
(ii)	suitable linear scale chosen (>50% of grid used); axes labelled with quantities and unit; <u>all</u> plotting correct to nearest half square;	ignore orientation	3
			
(iii)	correct best fit line judged by eye;		1

(Total for Question 12 = 15 marks)

Question number	Answer	Notes	Marks																												
5 (a) (i)	diameter measured within range 3.5-4.0 cm; evidence of finding a mean of the diameter;		2																												
(ii)	substitution of radius into given formula; evaluation of area within range 9.6-12.6 cm ² ;	1 mark max if diameter used instead of radius	2																												
(b) (i)	correct circuit symbols for both voltmeter and ammeter; ammeter connected in series; voltmeter connected in parallel with putty cylinder;	accept voltmeter connected in parallel with battery allow voltmeter connected in parallel across putty and ammeter	3																												
(c) (i)	42.6; 3 s.f. used;	allow 42.6168... mark independently	2																												
(ii)	suitable linear scale chosen (>50% of grid used); axes labelled with quantities and units; plotting correct to nearest half square; <table border="1"> <thead> <tr> <th>Cross-sectional area in cm²</th><th>Voltage in V</th><th>Current in A</th><th>Resistance in Ω</th></tr> </thead> <tbody> <tr><td>4.5</td><td>4.56</td><td>0.049</td><td>91.2</td></tr> <tr><td>6.2</td><td>4.56</td><td>0.059</td><td>77.3</td></tr> <tr><td>9.1</td><td>4.56</td><td>0.068</td><td>67.1</td></tr> <tr><td>13.9</td><td>4.56</td><td>0.085</td><td>53.6</td></tr> <tr><td>18.1</td><td>4.56</td><td>0.094</td><td>48.5</td></tr> <tr><td>24.6</td><td>4.56</td><td>0.107</td><td></td></tr> </tbody> </table>	Cross-sectional area in cm ²	Voltage in V	Current in A	Resistance in Ω	4.5	4.56	0.049	91.2	6.2	4.56	0.059	77.3	9.1	4.56	0.068	67.1	13.9	4.56	0.085	53.6	18.1	4.56	0.094	48.5	24.6	4.56	0.107		orientation needs to be correct all points must be correct ignore plotting of final point	3
Cross-sectional area in cm ²	Voltage in V	Current in A	Resistance in Ω																												
4.5	4.56	0.049	91.2																												
6.2	4.56	0.059	77.3																												
9.1	4.56	0.068	67.1																												
13.9	4.56	0.085	53.6																												
18.1	4.56	0.094	48.5																												
24.6	4.56	0.107																													
(iii)	line (curve) of best fit acceptable; 	allow ECF from plotting i.e. smooth curve with points evenly distributed about it	1																												
(d)	voltage stays the same; (because) each putty cylinder is connected in parallel (with the cells); total current doubles; (because) current in each putty cylinder stays the same (as before) and these currents add together;	allow current increases allow resistors in parallel have lower total resistance allow correct use of resistors in parallel formula	4																												

Total for Question 5 = 17 marks



Question number	Answer	Notes	Marks
11 (a) (i)	energy (transferred) per unit charge (passed);	allow $V = E/Q$ only if all terms defined allow work done for energy transferred allow coulomb for unit charge ignore joules per coulomb (equivalent to the volt)	1
(ii)	substitution into $E = Q \times V$; rearrangement; evaluation to at least 2s.f.; e.g. $1.0 \times 10^{-16} = 1.6 \times 10^{-19} \times V$ $V = 1.0 \times 10^{-16} / 1.6 \times 10^{-19}$ $V = 625 \text{ (V)}$		3
(iii)	substitution into $KE = \frac{1}{2} \times m \times v^2$; rearrangement for v^2 ; rearrangement for v ; evaluation; e.g. $1.0 \times 10^{-16} = 0.5 \times 9.1 \times 10^{-31} \times v^2$ $v^2 = 2 \times 1.0 \times 10^{-16} / 9.1 \times 10^{-31}$ $v = \sqrt{[2 \times 1.0 \times 10^{-16} / 9.1 \times 10^{-31}]}$ $v = 1.5 \times 10^7 \text{ (m/s)}$	allow standard form or decimal $2.1978... \times 10^{14} \text{ (m/s)}$ scores 3 marks ... allow $1.48... \times 10^7$, $14824986.33 \text{ (m/s)}$	4
(b) (i)	idea that humans can't see ultraviolet; fluorescent coating emits/produces visible light;	allow idea that coating produces light that humans can see	2
(ii)	any two from: MP1. idea that mercury/ultraviolet would escape from the tube; MP2. UV is ionising (radiation); MP3. named harmful effect of UV; MP4. idea that mercury (vapour) is poisonous/toxic/harmful;	e.g. skin cancer, damage/mutation to skin cells, skin burns, damage to eyes, blindness	2

Total for Question 11 = 12 marks

Question number	Answer	Notes	Marks														
3 (a)	one mark for each correct tick;;; <table><thead><tr><th>Electrical component</th><th>Can visibly indicate the presence of a current</th></tr></thead><tbody><tr><td></td><td></td></tr><tr><td></td><td>✓</td></tr><tr><td></td><td>✓</td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td>✓</td></tr></tbody></table>	Electrical component	Can visibly indicate the presence of a current				✓		✓						✓	ignore names of components if more than 3 ticks then -1 for each incorrect tick	3
Electrical component	Can visibly indicate the presence of a current																
	✓																
	✓																
	✓																
(b) (i)	(NTC) thermistor;		1														
(ii)	80 (Ω);	allow 75-85 (Ω)	1														
(iii)	substitution; rearrangement; evaluation; e.g. 9.0 = current × 80 (current =) 9.0 / 80 (current =) 0.11 (A)	allow ecf from (ii) allow in either order allow any value that would round to either 0.11 (A) or 0.12 (A)	3														

(iv)	any four from:		4
	MP1. resistance of component X is 160 (Ω);	allow resistance doubles ignore resistance increases unless qualified e.g. accept reference to increase of thermistor's resistance because of reduction in temperature	
	MP2. idea that two components in series have more resistance;	accept idea that resistors in series add up	
	MP3. idea that two components in series have double the resistance;	also scores MP2	
	MP4. resistance of circuit increases;		
	MP5. resistance of circuit is 320 (Ω);	also scores MP4 accept circuit resistance is four times that previously	

Total for Question 3 = 12 marks

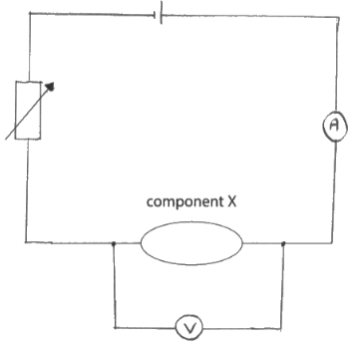
Question number	Answer	Notes	Marks
3 (a)	any three from: MP1. idea of reduction of nuclear store of Sun; MP2. (transferred) by radiation (to the solar panel); MP3. energy absorbed by solar panel; MP4. energy transferred (from panel to battery) electrically; MP5. idea of increase of chemical store of battery;	allow by light/ by IR/ by infrared NOT by electricity alternate description MP1 nuclear energy of sun transferred to light energy MP2 light energy from sun transferred to electrical energy of panel MP3 electrical energy of panel transferred to chemical energy of battery NOTE: marks can be scored from either the answer column scheme or the alternate description but not from both	3
(b)	any one from: • solar power is renewable; • solar panel does not produce CO₂; • idea of using less petrol; • idea that it can be used if petrol runs out;	allow it won't run out etc. ignore 'greenhouse gas(es)'	1
(c)	black is a good absorber; of radiation;	allow light allow infra-red / IR condone heat ignore reference to emission ignore reference to conduction or insulation	2
(d)	substitution; rearrangement; evaluation; e.g. $360\,000 = 15 \times \text{time}$ $\text{time} = 360\,000 \div 15$ (time =) 24 000 (s)	-1 POT error	3

Total for Question 3 = 9 marks



Question number	Answer	Notes	Marks
6 (a)	use of voltage = current $\times$ resistance; substitution and rearrangement of formula; evaluation of total circuit resistance; subtraction of thermistor resistance; correct evaluation of fixed resistor resistance; e.g. voltage = current $\times$ resistance $R_{\text{total}} = 6.0 / 6.8 \text{ (mA)}$ $R_{\text{total}} = 882 \text{ } (\Omega)$ $R_{\text{fixed}} = 882 - 490$ $R_{\text{fixed}} = 392(.35...) \text{ } (\Omega)$	seen or implied allow current in mA or A allow ECF from POT error accept, for full marks, answers that calculate voltage of thermistor to find voltage of resistor voltage = current $\times$ resistance $V_{\text{thermistor}} = 6.8 \text{ (mA)} \times 490 \text{ } (= 3.332) \text{ V}$ $V_{\text{fixed}} = (6.0 - 3.332) = 2.668 \text{ V}$ $R_{\text{fixed}} = 2.668 / 6.8 \times 10^{-3}$ $R_{\text{fixed}} = 392(.35...) \text{ } (\Omega)$	5
(b)	resistance of thermistor increases; current through circuit decreases; (so) voltage (across fixed resistor) decreases;	dependent on scoring one of previous two marking points allow 2 max. as ECF for correct description with incorrect R_{therm} change allow correct potential divider argument for full marks	3

Total for Question 6 = 8 marks

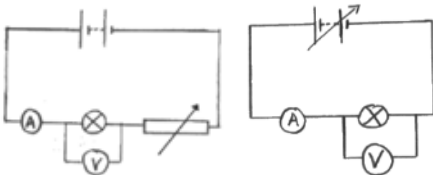
Question number	Answer	Notes	Marks
5 (a)	symbols for cell, variable resistor, ammeter and voltmeter all correct; cell and variable resistor in series with component X; ammeter in series with component X; voltmeter in parallel with component X only; e.g. 	allow higher level potential divider type circuits condone symbols for more than one cell or battery allow voltmeter in parallel with component X and ammeter	4
(b) (i)	sensible linear scales; axes labelled with units;	must have voltage on x-axis e.g. occupy >50% of the grid and not multiples of 3 etc.	3

	all points plotted correctly within $\frac{1}{2}$ a small square; e.g.																						
	<table><tr><th>Voltage in V</th><th>Current in mA</th></tr><tr><td>0.00</td><td>0</td></tr><tr><td>0.10</td><td>0</td></tr><tr><td>0.20</td><td>0</td></tr><tr><td>0.30</td><td>0</td></tr><tr><td>0.40</td><td>0</td></tr><tr><td>0.50</td><td>2</td></tr><tr><td>0.60</td><td>8</td></tr><tr><td>0.70</td><td>33</td></tr><tr><td>0.80</td><td>140</td></tr></table>	Voltage in V	Current in mA	0.00	0	0.10	0	0.20	0	0.30	0	0.40	0	0.50	2	0.60	8	0.70	33	0.80	140		
Voltage in V	Current in mA																						
0.00	0																						
0.10	0																						
0.20	0																						
0.30	0																						
0.40	0																						
0.50	2																						
0.60	8																						
0.70	33																						
0.80	140																						
(ii)	smooth curve with increasing gradient that passes through all data points;	allow if within $\frac{1}{2}$ a small square of each data point	1																				
(iii)	diode / light emitting diode;	allow LED	1																				

Total for Question 5 = 9 marks

Question number	Answer	Notes	Marks
2 (a)	correct circuit symbols for all of; - suitable power source - ammeter - voltmeter - filament lamp ammeter drawn in series with lamp; voltmeter drawn in parallel with lamp; means of varying current or voltage i.e. variable resistor/variable power supply;	allow cell, battery or power supply for power source allow  or  filament lamp symbol condone lines drawn through ammeter and voltmeter symbols allow voltmeter drawn in parallel with power source if no other resistive components in circuit ignore thermistor or LDR allow  or  for variable resistor	4
(b) (i)	current increases as voltage increases; idea of non-linear relationship;	condone proportional relationship for this mark only reject this mark if proportional relationship described allow decreasing gradient, current increases at a decreasing rate condone slowing rate	2
(ii)	voltage = current × resistance;	allow rearrangements and standard symbols e.g. $R = V/I$ ignore 'c' or 'C' for current ignore formulae expressed in units e.g. $V = A \times \Omega$	1
(iii)	substitution; rearrangement; evaluation; e.g. $7.2 = 2.40 \times R$ $R = 7.2/2.40$ $R = 3.0 (\Omega)$	allow current = 2.40-2.45 (A) allow $R = V/I$ seen anywhere in working allow 2.9-3.0 (Ω)	3

Total for Question 2 = 10 marks

Question number	Answer	Notes	Marks
6 (a) (i)	circuit with symbols for ammeter, voltmeter, lamp, any power supply all correct; voltmeter in parallel with lamp; ammeter in series with lamp; correct means of varying voltage of lamp i.e. variable power supply/rheostat/potentiometer; e.g. 	variable power supplies or variable number of cells can be shown using labelled standard symbols if no lamp in circuit, allow ammeter drawn in series with power supply allow variable resistor in series with lamp	4
(ii)	any four from: MP1. record ammeter and voltmeter reading; MP2. repeat readings (for each voltage) and find average; MP3. idea of changing the voltage / current; MP4. plot a graph of voltage and current; MP5. switch off current/circuit between readings;	allow 'measure voltage and current' allow repeating experiment to find average allow described method that would change voltage or current e.g. adding more cells, changing circuit resistance etc. ignore "let lamp cool between readings"	4
(b) (i)	ampere / amp / A / mA;	reject I	1
(ii)	correctly evaluated energy; given to 2 significant figures; e.g. 162 (J) gets 1 mark 160 (J) gets 2 marks	DOP	2
(iii)	red or orange;		1

Total for Question 6 = 12 marks

Question number	Answer	Notes	Marks
6 (a)	correct symbol for voltmeter in parallel with any component; voltmeter drawn in parallel with the LDR;		2
(b) (i)	$V = I \times R$;	allow any re-arrangement allow word equation condone 'i' for current reject 'c' or 'C' for current	1
(ii)	substitution; evaluation; e.g. $V = 7.8 \times 10^{-3} \times 73$ $V = 0.57 \text{ (V)}$	POT error gives 1 mark penalty allow 0.5694 (V) for both marks '0.6 (V)' scores 1 mark	2
(iii)	idea that voltages of two resistors in series adds up to supply voltage; calculation of correct voltage; e.g. $V_{\text{cell}} = 1.5 = V_{\text{LDR}} + V_{\text{resistor}}$ $V_{\text{LDR}} = 1.5 - 0.56(94)$ $V_{\text{LDR}} = 0.93 \text{ (V)}$	allow ecf from 6(c)(ii) allow 0.9306 (V) for both marks	2
(c) (i)	resistance decreases (with increasing L.I); non-linear/decreasing rate/curve;		2
(ii)	increases;		1
(iii)	larger current means larger voltage across fixed resistor; total voltage remains constant;		2

Total for Question 6 = 12 marks

Question number	Answer	Notes	Marks
9 (a)	correct voltmeter symbol; voltmeter connected in parallel with resistor;		2
(b)	light dependent resistor;	allow LDR	1
(c) (i)	9(.0) (V);		1
(ii)	substitution OR rearrangement; evaluation; e.g. $9.0 = \text{current} \times 4500$ OR $\text{current} = \text{voltage} / \text{resistance}$ (current =) 0.0020 (A)	allow ecf from (i) allow 0.002 (A)	2
(iii)	substitution OR rearrangement; evaluation in Ω ; conversion to $k\Omega$; e.g. $3.0 = 0.0020 \times \text{resistance}$ OR $\text{resistance} = \text{voltage} / \text{current}$ (resistance =) 1500 (Ω) (resistance =) 1.5 ($k\Omega$)	allow ecf from (ii)	3
(d)	lamp should be connected in parallel with component X / LDR; resistance of component X increases when it gets dark; voltage across component X increases / becomes greater than 10V when it gets dark;		3

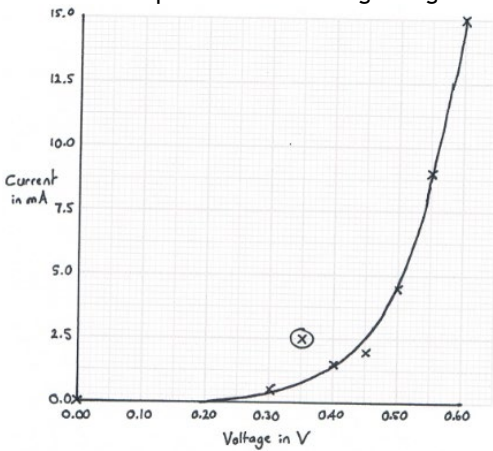
Total for Question 9 = 12 marks



Question number	Answer	Notes	Marks
7 (a)	circuit symbols for variable resistor, ammeter and voltmeter drawn correctly; variable resistor drawn in series with battery and component X; ammeter drawn in series with component X; voltmeter drawn in parallel with component X;	allow variable power supply allow potentiometer circuit if clear	4
(b) (i)	straight line of best fit drawn with points distributed equally either side;	ignore extrapolation below $V = 1.5V$	1
(ii)	use of voltage = current $\times$ resistance; correct reading of current from graph; substitution OR rearrangement; evaluation; matching unit; e.g. $V = I \times R$ current = 2.35×10^{-3} (A) $4.2 = 2.35 \times 10^{-3} \times R$ OR $R = V / I$ (resistance =) 1800 ohms / Ω	seen in words or symbols or implied by working allow ecf from (i) ignore non-conversion of mA to A at this point expect Ω but allow k Ω if matched to appropriate value -1 POT error allow 2.3-2.4 (mA) allow 1750 - 1826	5
(iii)	D (4.2 joules per coulomb); A is incorrect because this is the unit for current B is incorrect because this is the reciprocal of the unit for power C is incorrect because this is the unit for power		1
(iv)	graph for lamp should be a curve; (because) a lamp does not obey Ohm's Law/ lamp does not have I directly proportional to V. component X is a resistor;	allow line is straight allow reference to (direct) proportionality allow component X is an ohmic conductor accept component X could be a lamp but it's not warm enough yet for the graph to curve for 2 marks	2

Total for Question 7 = 13 marks



Question number	Answer	Notes	Marks
5 (a)	both ammeter and voltmeter symbols correct; ammeter drawn in series with LED; voltmeter drawn in parallel with LED;		3
(b) (i)	axes scales cover 50% of the grid in both directions and have a sensible, continuous scale; both axes labelled with quantities and units; all data plotted correctly;	reject if either scale uses multiples of 3, 7 or 9 or if discontinuous ignore orientation reject if either scale is discontinuous data should be plotted to within half a small square	3
(ii)	(0.35, 2.5) circled;		1
(iii)	smooth curve drawn with approximately even distribution of points either side ignoring anomaly; 	allow ecf from (i) so judge curve for the student's plotting	1
(iv)	(data are) continuous/not discrete;		1
(v)	voltage = current $\times$ resistance;	allow standard symbols and rearrangements reject C, c for current	1
(vi)	MP1. voltage across resistor = 0.015×270 ; MP2. voltage across resistor is 4.05 (V); MP3. voltage across power supply = voltage across LED + voltage across resistor; MP4. voltage across power supply is $(4.05 + 0.60 =) 4.7$ (V);	allow 15×270 for this mark allow 4.0, 4.1 (V) scores MP1 and MP2 allow 4.65, 4.6 (V) $V = 4050.6$ (V) = 3 marks allow alternative method of calculating resistance of LED to find total resistance of circuit	4

Total for Question 5 = 14 marks

	Answer	Notes	Marks
--	--------	-------	-------

Question number	Answer	Notes	Marks
6 (a)	resistor, battery, voltmeter, ammeter all present in a complete circuit variable resistor connected in series with resistor; ammeter in series with resistor; voltmeter in parallel with 60 ohm resistor;	all four symbols drawn correctly condone use of cell or dc power supply symbol for battery symbol drawn correctly condone incorrect yet identifiable ammeter symbol condone incorrect yet identifiable voltmeter symbol accept higher level answers involving potential divider circuits	4
(b)	any four from: MP1. measure voltage and current; MP2. idea of varying voltage (across resistor); MP3. take repeat readings and average (at each voltage); MP4. switch off circuit in between readings; MP5. other reasonable safety measure relating to equipment heating up	e.g. by altering the resistance of the variable resistor e.g. not using full range of voltages so current doesn't get too high ignore references to graph	4
(c) (i)	line passes through origin; line is straight throughout; line passes/would pass through the point (12,0.20);	by eye	3
(c) (ii)	any three from: MP1. line will be same shape / straight line through origin / both components are resistors; MP2. line (for 120Ω resistor) will have a lower gradient; MP3. line (for 120Ω resistor) will have half the gradient; MP4. (because) larger resistance will result in a lower current in the circuit;	allow (still) directly proportional also award MP2 allow relevant justification by $V=IR$ all three marks can be awarded from a correct new line on the graph.	3

Total for Question 6 = 14 marks



Question number	Answer	Notes	Marks
3 (a) (i)	components are connected in series; voltages must add up to 6(.0)V;	ignore voltmeter is in parallel (with the resistor) allow voltages must add up to battery voltage allow $6(.0) - 3.9 = 2.1$	2
(ii)	correct substitution into $V = I \times R$; rearrangement; evaluation; e.g. $2.1 = \text{current} \times 290$ $\text{current} = 2.1 / 290$ (current =) 0.0072 (A)	allow ecf from incorrect voltage allow ecf from incorrect voltage 0.0206..., 0.0134... (A) scores 2 marks allow 0.007, 0.00724... (A)	3
(iii)	same answer as (ii);	expect 0.0072 (A) allow if rounded differently to (ii) but still consistent	1
(iv)	correct substitution into $V = I \times R$; rearrangement; evaluation; e.g. $3.9 = 0.0072 \times R$ $R = 3.9 / 0.0072$ (R =) 540 (Ω)	allow ecf from current in (ii) or (iii) allow dimensionally correct rearrangement using incorrect voltage for this mark only e.g. $R = 2.1 / 0.0072$ allow 557, 542, 541.6..., 539, 538.5... (Ω)	3
(b) (i)	thermistor/circuit resistance decreases (as temperature increases); current increases; resistance of resistor is fixed/does not change AND $V=IR$ (so voltmeter reading increases);	allow idea of less voltage across thermistor allow idea that battery/total voltage is fixed/6V AND this is shared between thermistor and resistor (so voltmeter reading increases)	3

(ii)	any three from: MP1. place thermistor (and thermometer) into beaker of water; MP2. idea of varying temperature of water / thermistor; MP3. measure reading on voltmeter (at different temperatures); MP4. plot graph of voltmeter reading against temperature; MP5. idea of using graph to read off temperature at different voltmeter readings;	ignore methods involving adding bulbs to circuit etc. can be awarded from diagram allow idea of measuring current or calculating resistance (at different temperatures) allow current / resistance for voltmeter reading allow current / resistance for voltmeter reading	3
------	--	--	---

Total for Question 3 = 15 marks

Question number	Answer	Notes	Marks
3 (a) (i)	C – the rod gains negatively charged electrons;		1
(ii)	A is incorrect because electrons are not positively charged B is incorrect because electrons are not positively charged D is incorrect because this would make the rod positively charged a named demonstration; a relevant observation; e.g. put charged rod near hair hair moves towards / is attracted to rod put charged rod near (small) pieces of paper pieces of paper move towards to the rod put charged rod near stream of water water bends towards the rod put rod next to another charged rod rod will move towards / away from other rod use a gold leaf electroscope (GLE) gold leaf deflects		2
(b)	MP1. method to allow (rods) to swing freely; MP2. idea that rods are brought close together; MP3. observation of attraction AND repulsion;	marking points may be shown on a labelled diagram e.g. suspend / balance on watch glass allow if another charged insulator used e.g. a balloon allow if rod brought near another charged insulator reject if method would not give attraction and repulsion e.g. holding rod near stream of water	3

Total for Question 3 = 6 marks

Question number	Answer	Notes	Marks
7 (a)	paint particles are positively charged; paint particles repel/like charges repel; producing a thin / even coat of paint;	ignore statements relating to paint as a whole being attracted to the object allow idea of particles being given same charge condone particles being negatively charged Allow idea that paint particles are attracted to the electrons in the (metal) object allow idea that paint finish is improved allow idea that paint reaches parts that would otherwise be difficult	3
(b)	any three from: MP1. object becomes charged when paint particles land on it; MP2. (without earthing) further paint particles would be repelled by the object as they have the same charge; MP3. earthing discharges object; MP4. electrons transferred between Earth and object; MP5. (earthing means) paint continues to reach object/ giving thicker coat/give even coverage;	allow 'neutralises object' or 'object becomes neutral'	3

Total for question 7 = 6 marks

Question number	Answer	Notes	Marks
3 (a)	any three from: MP1. idea that plastic is an insulator OR that metal is a conductor; MP2. idea that charge/electrons are transferred (by rubbing/friction); MP3. charge/electrons remain/build up on plastic parts; MP4. charge/electrons flow through the metal parts/travel to earth;	allow plastic has no free electrons allow plastic does not conduct allow electrons gained / lost must be clearly linked to plastic must be clearly linked to metal	3
(b) (i)	substitution into energy = charge × voltage; rearrangement; evaluation; e.g. (0.00)5 = charge × 6000 charge = (0.00)5 / 6000 (charge =) 8.3×10^{-7} (C)	ignore unit conversions until evaluation -1 for POT error allow 8×10^{-7} , $8.33... \times 10^{-7}$ (C)	3
(ii)	idea of bringing pad near another uncharged insulator; attraction used to demonstrate charge on sponge;	allow water from tap, (small) pieces of paper, hair, balloon etc. as the insulator allow gold leaf electroscope reject references to repulsion unless linked to gold leaf electroscope	2

Total for Question 3 = 8 marks

Question number	Answer	Notes	Marks
1 (a) (i)	idea of rubbing / friction; with another insulator;	allow suitable named insulator e.g. duster, cloth, hair etc.	2
(ii)	C (-0.0052 C); A is incorrect because this is equivalent to -520 mC B is incorrect because this is equivalent to -52 mC D is incorrect because this is equivalent to -0.52 mC		1
(iii)	A (the rod has gained negatively charged electrons); B is incorrect because electrons are not positively charged C is incorrect because this would make the rod positively charged D is incorrect because electrons are not positively charged		1
(iv)	suitable method of demonstrating; correct observation;	e.g. - place rod on electroscope - place rod near stream of water from a tap - place rod near hair - place rod above small pieces of paper - place rod near another (charged) rod e.g. - leaf on electroscope deflects - water moves towards rod - hair moves towards rod - paper moves towards rod - rods move towards/away from each other	2
(b) (i)	photocopiers / inkjet printers / smoke precipitators / (electrostatic) spray painting;	allow any correct use	1
(ii)	risk of a spark; (causing) explosion / fire;		2

Total for Question 1 = 9 marks

Question number	Answer	Notes	Marks
4 (a) (i)	A (friction); B is incorrect because gravity is not the force C is incorrect because magnetic is not the force D is incorrect because tension is not the force		1
(ii)	A (the rod gains electrons);		1
	B is incorrect because this would produce a positive charge		
	C is incorrect because protons are not transferred		
	D is incorrect because protons are not transferred		
(b) (i)	reading at -80 circled		1
(ii)	repeat or check that test or that result / ignore the result / idea of not including (that result) in the mean;	condone idea of “repeat the whole experiment”	1
(iii)	mean calculated including anomaly giving an answer that rounds to -67 = 1 mark max;		2
	mean calculated correctly ignoring anomaly i.e. -60 = 2 marks;;	allow ecf from (i) (-59+ -61/2 =) -89.5 scores 1	
		(+)60 scores 1 (+)67 scores 0	

(iv)	MP1 : suitable apparatus that would demonstrate rod is charged MP2: indication that a charged rod will apply a force on the 'other object' MP3: evidence that both attraction and repulsive forces will happen with opposite and like charges	reject response with references to magnets e.g. suspended second rod, hair, water stream, bits of paper, electroscope, coulombmeter e.g. (charged) rods attract, (charged) rods repel, water stream bends, hair attracts, electroscope foil deflects e.g. like charged rods will move away from each other but unlike charged rods will move together, condone gold leaf deflects one way with positive object then other way with negative object, coulombmeter shows positive with one test and negative with another	3
------	--	---	---

Total for Question 4 = 9 marks

Question number	Answer	Notes	Marks
2 (a)	plate loses negatively charged particles; (loses) electrons;	reject response that infers positive electrons 'plate loses electrons' scores 2 marks.	2
(b) (i)	plate and ball have same (sign) charge; (so there is a) repulsive force on the ball (from that plate);	accept 'attractive force from other plate' / 'like charges repel' / 'plate X is negative and opposite charges attract' for 2 marks	2
(ii)	metal is a conductor;	allow 'it conducts'	1
(c) (i)	charge (transferred) = current x time;	allow standard symbols and rearrangements e.g. $I = Q / t$ reject C or c for current	1
(ii)	substitution and rearrangement; evaluation; correct answer: 1.1×10^{-5} (A) e.g. charge = current x time current = charge / time = $5.1 \times 10^{-6} / 0.45$ current = $1.1(3) \times 10^{-5}$ A	allow factor of 2 either way i.e. $\{2.2 / 0.55\} \times 10^{-5}$ POT error scores -1	2
(iii)	any ONE of: - larger charge transfer (per trip); - ball gains more kinetic energy; - more trips per second;	ignore 'V=IR' argument	1
(iv)	ammeter;		1

Total for Question 2 = 10 marks

Question number	Answer	Notes	Marks
3 (a)	insulator;	Allow 'non/not conductive'	1
(b)	any reference to electron transfer; loss (of electrons);	idea of 'loss of electrons (from tube)' scores 2. reject any reference to movement of positive charges	2
(c)	electrons move through wire; as they are attracted by or to the metal mast; idea that this makes metal mast neutral (again);	allow idea of 'opposite charges attracting' allow idea of 'to earth/earthing the mast' if no other mark scored	3
(d)	recall of equation energy = charge × voltage; substitution or re-arrangement; evaluation; correct answer = 860 (V) e.g. energy = charge × voltage voltage = energy/charge = $3.7/0.0043$ voltage = 860.465... (V) voltage = 860 (V)	allow use of standard symbols e.g. $E = Q \times V$ reject C, c for charge -1 for PoT error	3
(e)	spark/discharge; damage/harm/injury/electrocution (of engineer);		2

Total for Question 3: 11 marks



Question number	Answer	Notes	Marks
4 (a)	any four of: MP1. idea of friction/rubbing (between powder and funnel/plastic tubing); MP2. powder becomes charged; MP3. metals are conductors; MP4. charge is transferred to/from metal rod and thin piece of metal; MP5. metal rod and thin piece of metal have the same charge; MP6. therefore they repel / eq;	ignore whether positive or negative charge allow electrons transferred	4
(b) (i)	A (gains negatively charged electrons); B is incorrect because it would leave the metal can positively charged C is incorrect because electrons are not positively charged D is incorrect because electrons are not positively charged		1
(ii)	charge = current $\times$ time;	allow standard symbols and rearrangements e.g. $Q = I \times t$ reject use of C/c for charge or current	1
(iii)	substitution; rearrangement; evaluation; e.g. (-) $9.4 \times 10^{-9} = \text{current} \times 12$ (current =) (-) $9.4 \times 10^{-9} / 12$ (current =) (-) 7.8×10^{-10} (A)	-1 for POT error $7.83... \times 10^{-10}$ (A)	3
(c)	any three of: MP1. any relevant danger; MP2. idea that metal can/aircraft should be earthed; MP3. charge will flow to/from ground; MP4. idea that no charge will build up on metal can/aircraft;	e.g. spark, explosion, fire allow description of earthing e.g. 'connect metal can to ground with a wire' allow addition of earth path to diagram allow idea that 'charge is neutralised'	3

Total for Question 4 = 12 marks



Question number	Answer	Notes	Marks
3 (a) (i)	idea of transfer of electrons (from grid); grid has lost electrons;	reject reference to positive electrons this statement alone scores 2 reject “lost from electron supply”	2
(ii)	$KE = \frac{1}{2} m v^2$	accept word equation accept velocity for speed allow either case letters	1
(iii)	substitution in correct formula; re-arrangement; correct evaluation; correct answer: 5.3×10^7 (m/s) e.g. $1.3 \times 10^{-15} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$ $v^2 = 2.857... \times 10^{15}$ $v = 5.345... \times 10^7$ (m/s)	unrounded answer is 53452248 (m/s) allow full credit for correct answer with no working POT in final answer e.g. $5.345... \times 10^3$ for 2 marks POT in v^2 giving $1.69... \times 10^n$ (m/s) for v for 2 marks accept unrooted answer without POT error i.e. $2.857... \times 10^{15}$ (m/s) for 2 marks accept POT and unrooted answer e.g. 2.86×10^n (m/s) for 1 mark max accept answer in any form except fractional	3
(b)	idea that electrons are (all) negatively charged/like charged; like charges repel ;	reject idea of positive electrons for this MP only condone ‘similar charge’ accept idea of like charges experiencing a repulsive force	2

(c)	(i)	2.5 (cm);	allow 2.4 - 2.6 (cm)	1
	(ii)	substitution into given formula; conversion of ms to s and cm to m; correct evaluation using radius; correct answer: 6.5 (m/s) e.g. orbital speed = $2 \pi r \div T$ orbital speed = $2 \pi 2.5 \times 10^{-2} \div (24 \times 10^{-3})$ orbital speed = 6.544... m/s	ECF candidate's answer to (c)(i) ignore POT at this point allow 654 cm/s (i.e. cm for m on answer line) allow full credit for correct answer with no working allow answers that round to the range 6.3 to 6.8 (m/s) -1 for POT conversion of milliseconds to minutes scores 2 (393 m/s)	3

Total for question 3: 12 marks

Question number	Answer	Notes	Marks
8 (a)	(force to the) right; (because) opposite charges attract / like charges repel;	allow ‘towards the positive plate’ or ‘away from the negative plate’	2
(b)	line drawn showing the ink drop deflecting to the right of the centre and hitting paper below; line drawn starts vertical and becomes increasingly more curved as the ink drop moves towards paper;	allow ECF from (a) if direction of force to the left DOP	2
(c) (i)	substitution into force = mass × acceleration; rearrangement; evaluation; e.g. $8.5 \times 10^{-7} = 1.1 \times 10^{-10} \times a$ (a =) $8.5 \times 10^{-7} / 1.1 \times 10^{-10}$ (a =) 7700 (m/s ²)	-1 for POT error allow 7727.27...	3
(ii)	use of $v^2 = u^2 + (2 \times a \times s)$; substitution OR rearrangement; evaluation in metres; conversion to mm; e.g. $v^2 = u^2 + (2 \times a \times s)$ $3.9^2 = 0 + (2 \times 7700 \times s)$ OR $s = (v^2 - u^2) / 2a$ (s =) 9.9×10^{-4} (m) (s =) 0.99 (mm)	can be implied from substitution allow ECF from (i) independent mark award if correct conversion attempted on incorrect answer allow 9.8×10^{-4} - 9.9×10^{-4} allow 0.98 - 0.99	4
(d)	idea of swapping polarities of plates; idea of increasing the amount of charge on plates;	allow positively charging ink drop allow increasing amount of charge on ink drop allow decreasing {mass or volume} of the ink drop	2

Total for Question 8 = 13 marks

Question number	Answer	Notes	Marks
7 (a)	movement of electrons; bucket gains electrons;	scores both marks	2
(b)	(droplets in each stream are) like/same charge; (like charges) repel;	ignore attraction to bucket	2
(c) (i)	use of $KE = \frac{1}{2}mv^2$; substitution; evaluation; e.g. $KE = \frac{1}{2}mv^2$ $KE = \frac{1}{2} \times 6.2 \times 10^{-9} \times 3.8^2$ (KE =) 4.5×10^{-8} (J)	stated or implied by working -1 for POT error allow 4.4×10^{-8} , $4.47 \times 10^{-8} = 2$ marks allow 4.4764×10^{-8} (J)	3
(ii)	substitution into $Q = It$; rearrangement; evaluation; e.g. $1.1 \times 10^{-10} = \text{current} \times 9.2 \times 10^{-3}$ $\text{current} = 1.1 \times 10^{-10} / 9.2 \times 10^{-3}$ $\text{current} = 1.2 \times 10^{-8}$ (A)	stated or implied by working -1 for POT error allow $1.195... \times 10^{-8}$ (A)	3
(iii)	substitution into $E = QV$; conversion of kV to V; evaluation; e.g. $E = 1.1 \times 10^{-10} \times 1.7$ $1.7 \text{ kV} = 1700 \text{ V}$ (E =) 1.9×10^{-7} (J)	allow valid substitution into $E=VIt$ ignore units allow 1700 or $\times 1000$ seen anywhere in working -1 for POT error allow 1.87×10^{-7} (J), 1.88×10^{-7} (J), 1.8768×10^{-7} (J)	3

(Total for Question 7 = 13 marks)

Question number	Answer	Notes	Marks
5 (a)	metal;	allow any named conductor e.g., aluminium, graphite, copper, iron	1
(b)	idea of transfer of electrons or transfer of negative charge; electrons are lost from the ball / eq;	reject whole response motion of protons or motion of positive charge scores both marks	2
(c) (i)	ball moves towards rod; must be <u>opposite</u> (ly) charged;	allow rod and ball attract 'opposite charges attract' scores 2 marks	2
(ii)	any value greater than 5.0 and less than 7.2 (cm);	i.e. reject 5.0 (cm) reject 7.2 (cm)	1
(d)	any two from: MP1. distance between rod and ball; MP2. (initial) charge on ball; MP3. dimensions of rod;	accept 'rub rod with same force' or 'rub rod for the same amount of time' e.g. same length, thickness, size etc. condone 'shape of rod'	2
(e) (i)	idea that material is a categoric variable;	allow not continuous, discontinuous condone discrete	1
(ii)	any three from: MP1. wood has no charge; MP2. ebonite and/or polythene are negatively charged; MP3. glass and/or nylon are positively charged; MP4. ebonite has the most charge; MP5. (of those that have charge) nylon is the least charged; MP6. glass has the biggest positive charge; MP7. ebonite has the biggest negative charge;	nylon has the least positive charge polythene has the least negative charge	3

Total for Question 5 = 12 marks

Question number	Answer	Notes	Marks
1 (a) (i)	idea of rubbing / friction; (causing) transfer of <u>electrons</u> ;	condone rubbing between particles reject transfer of protons/positive charge	2
(ii)	like / identical / (the) same / similar; repulsive / repelling / repulsion;	allow equivalent phrases e.g. <u>both</u> have negative (charges) ignore unqualified negative, positive allow equivalent phrases ignore opposite	2
(b)	idea that earthing prevents the metal channels / particles from becoming charged; prevents a spark from occurring;	allow idea that {charge/electrons/current} can pass {through the earth wire / to earth / ground} allow idea that channel/particles remain neutral/become discharged allow idea that risk of spark is reduced ignore references to explosions	2

Total for Question 1 = 6 marks