Name: ____

Topic 3: Electrical Circuits Part 3

Date:

Time:

Total marks available:

Total marks achieved: ______

Questions

Q1.

Two copper wires are joined in series in a circuit. Wire A has twice the radius of wire B.

The drift velocity of the electrons in wire A is v_A and the drift velocity of the electrons in wire B is v_B.

The ratio $v_A : v_B$ is

☒ **A** 1 : 2

☒ **B** 1 : 4

☒ **C** 2 : 1

☒ **D** 4 : 1

(Total for question = 1 mark)

Q2.

An electric torch uses two 1.5 V cells. The torch bulb is marked 2.4 V, 270 mA.

What is the resistance of the torch bulb?

☒ **A** 0.81Ω

☒ **B** 0.65Ω

☒ **C** 8.9Ω

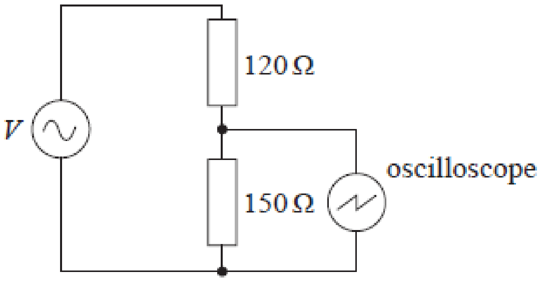
☒ **D** 11Ω

(Total for question = 1 mark)

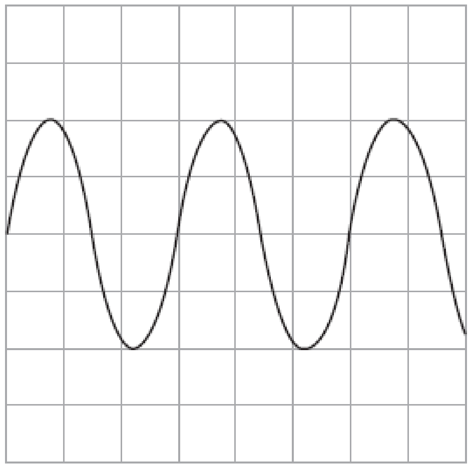
Q3.

A student connected the output from a source of alternating potential difference (p.d.) to a series resistor combination.

She connected an oscilloscope across the 150 Ω resistor as shown.



The trace obtained on the oscilloscope is shown below.



(i) Determine the peak p.d. across the 150 Ω resistor.

y-sensitivity of oscilloscope = 2.0 V per division

(2)

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Peak p.d. across 150 Ω resistor = ...

(ii) Calculate the root mean square (r.m.s.) value of the current in the circuit.

(3)

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r.m.s. value of current = ...

(iii) Calculate the power dissipated in the circuit.

(3)

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Power dissipated in circuit = ...

(Total for question = 8 marks)

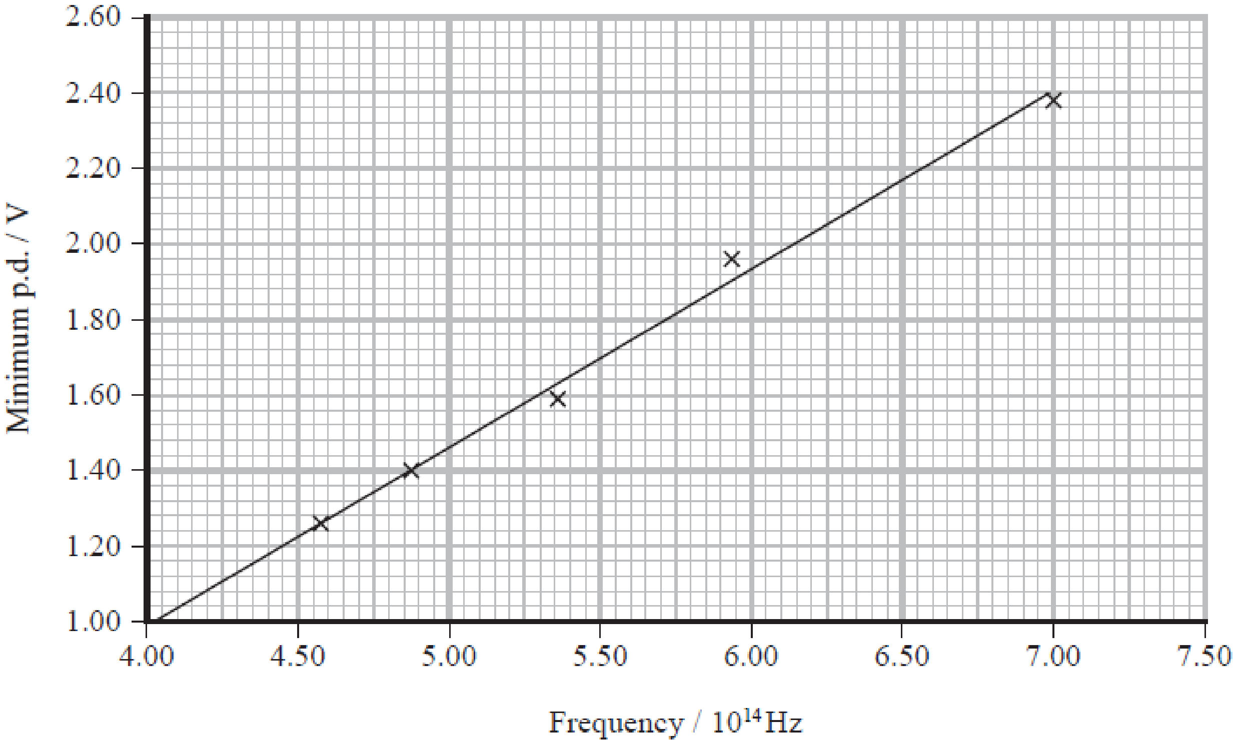
Q4.

The Planck constant can be determined in a school laboratory using light emitting diodes (LEDs).

An LED emits light when the potential difference (p.d.) across it is large enough to transfer sufficient energy to an electron to result in the emission of a photon.
The electron must have energy greater than or equal to the photon energy.

The minimum p.d. required to produce light from LEDs emitting different frequencies was measured by increasing the p.d. from zero until light was first seen.

The graph shows the results.



Determine the value of the Planck constant given by this graph.

(4)

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Value of Planck constant given by graph = ...

(Total for question = 4 marks)

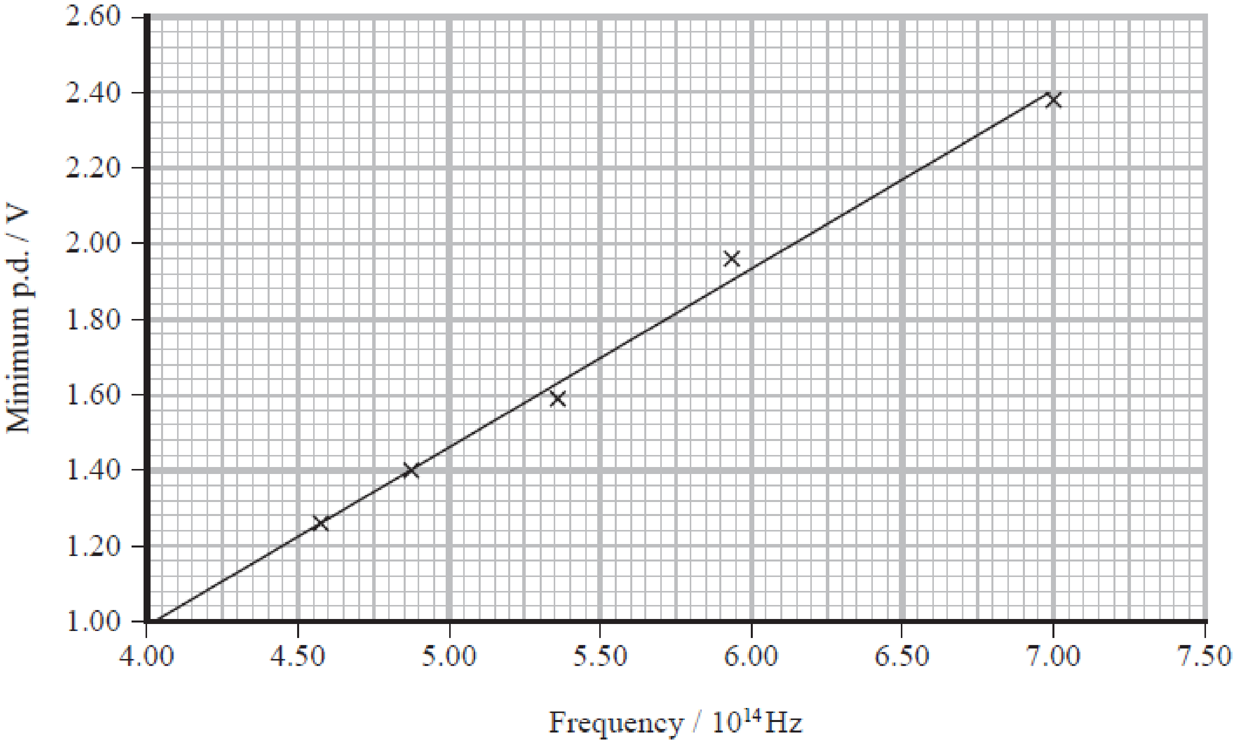
Q5.

The Planck constant can be determined in a school laboratory using light emitting diodes (LEDs).

An LED emits light when the potential difference (p.d.) across it is large enough to transfer sufficient energy to an electron to result in the emission of a photon.
The electron must have energy greater than or equal to the photon energy.

The minimum p.d. required to produce light from LEDs emitting different frequencies was measured by increasing the p.d. from zero until light was first seen.

The graph shows the results.



There are two problems with using LEDs to determine the Planck constant:

- when the p.d. is increased and the LED first emits light it is difficult to see
- the LEDs do not emit a single frequency but also light of frequencies slightly above and below the recorded frequency.

Discuss the extent to which these problems are consistent with obtaining a result from this graph for the Planck constant which is higher than the accepted value.

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(Total for question = 3 marks)

Q6.

Photograph 1 shows a toy known as a popper. It is a hollow hemisphere made of rubber.

Photograph 1

When the top of the popper is pushed down, it changes shape as in Photograph 2.

Photograph 2

It remains in this shape for two to three seconds. It then returns to its original shape and is launched from the surface, rising nearly a metre.

A student concludes that the material of the popper should be classed as a plastic material rather than an elastic material because it remains inverted.

Explain whether you think this conclusion is correct.

(3)

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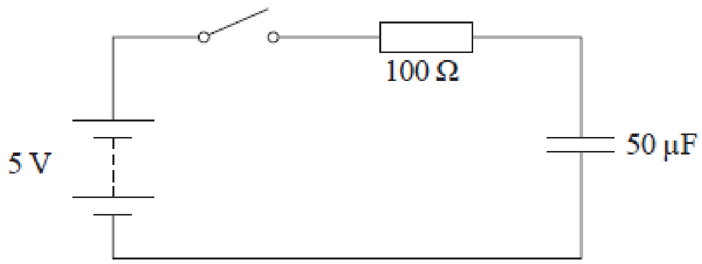
(Total for question = 3 marks)

Q7.

A circuit consists of a battery of e.m.f. 5 V and negligible internal resistance, a switch, a 100 Ω resistor and an uncharged 50 μF capacitor.



Describe what happens to the potential difference across the resistor and the potential difference across the capacitor after the switch is closed.

(4)

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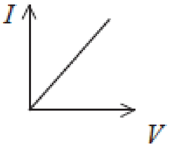
(Total for question = 4 marks)

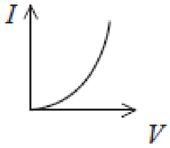
Q8.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

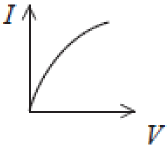
Which of the following graphs shows how the current varies with potential difference for a filament lamp?



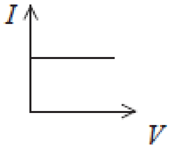
A



B



C



D

☐ **A**

☐ **B**

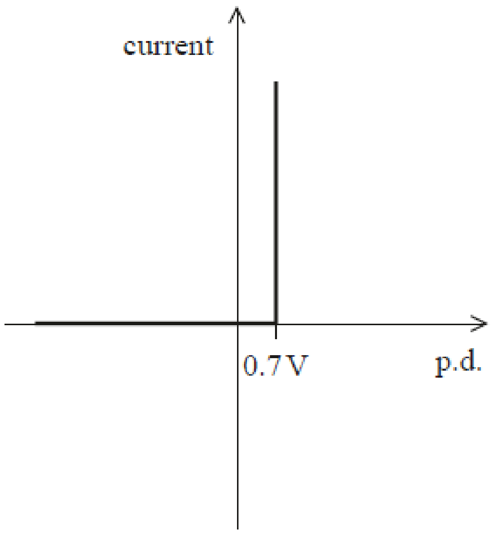
☐ **C**

☐ **D**

(Total for question = 1 mark)

Q9.

The graph shows how current varies with potential difference (p.d.) for an ideal diode.



Describe how the current through this diode varies for positive p.d.s and negative p.d.s.

(2)

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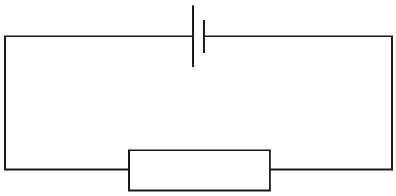
(Total for question = 2 marks)

Q10.

A cell of e.m.f. 1.5 V is connected to a 5.0 Ω resistor. The terminal potential difference across the cell is 1.0 V.



Which of the following is the current in the circuit?

☐ **A** 0.1 A

☐ **B** 0.2 A

☐ **C** 0.3 A

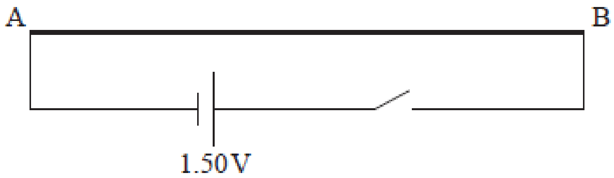
☐ **D** 0.5 A

(Total for question = 1 mark)

Q11.

A "metre bridge" is a circuit which can be used to measure an unknown resistance accurately. The metre bridge includes a metre length of nichrome wire.

This metre length of wire, labelled AB, is connected to a 1.50 V cell of negligible internal resistance and a switch as shown.



(i) Explain how the potential along this wire varies with distance from A when the switch is closed.

(2)

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(ii) Show that the potential difference between A and a point 75.0 cm along the wire from A is about 1.1 V.

(2)

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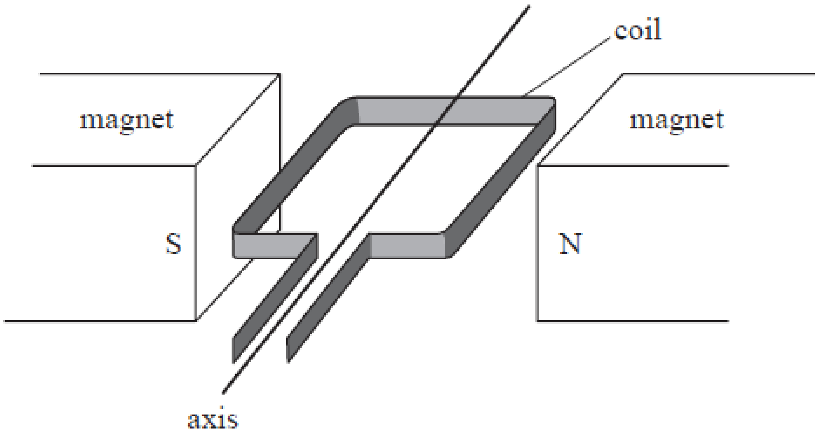
(Total for question = 4 marks)

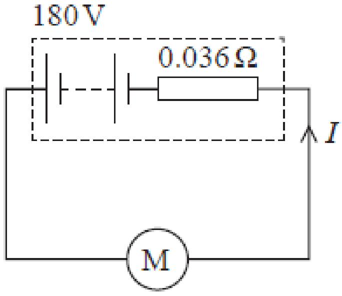
Q12.

Hybrid electric vehicles (HEV) use the same device both as a generator to charge the car battery and as an electric motor to support the propulsion system. A simplified diagram of the device is shown. The coil can rotate freely around the axis.



The circuit diagram shows a car battery connected to an electric motor for a HEV.

The battery has an electromotive force (e.m.f.) 180 V and internal resistance 0.036 Ω.



The motor has a maximum power of 88 kW.

(i) Show that the current *I* drawn by the electric motor when operating at this power would be given by the equation

$$0.036I^2 - 180I + 88\,000 = 0$$

(3)

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(ii) Solving the equation above produces an answer of *I* = 550 A. At maximum power, the car can accelerate from rest to sixty miles per hour in under 7 s.

The maximum charge capacity of the battery within this HEV is 6.1 amp-hour.

Deduce whether the battery could maintain this current for up to 7 s.

(2)

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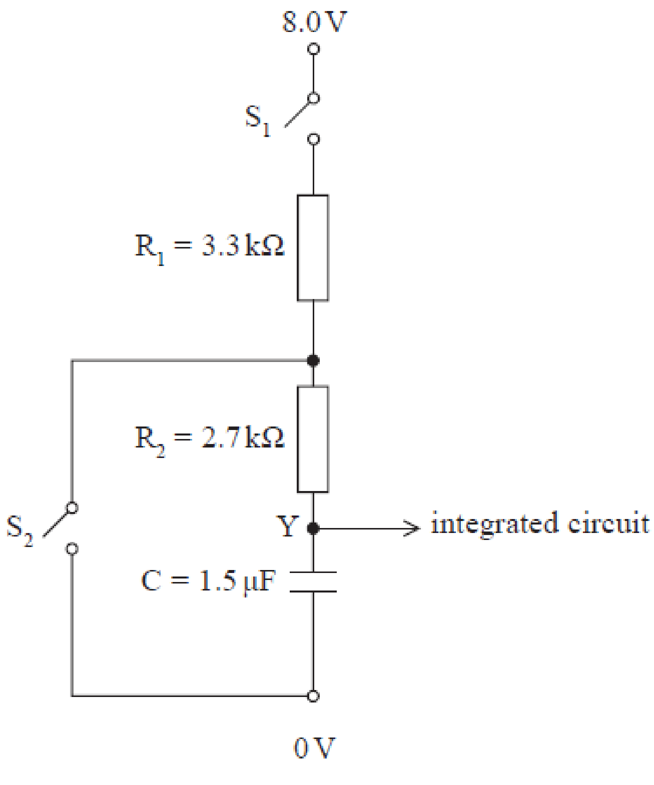
(Total for question = 5 marks)

Q13.

The properties of capacitors make them useful in timing circuits.

The following circuit is used to provide an input Y to an integrated circuit.



When the potential at Y is 2.0 V, the switch S_2 is opened.

Calculate the power dissipated by the resistance R_1 when the potential at Y is 2.0 V.

(3)

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Power dissipated = ...

(Total for question = 3 marks)

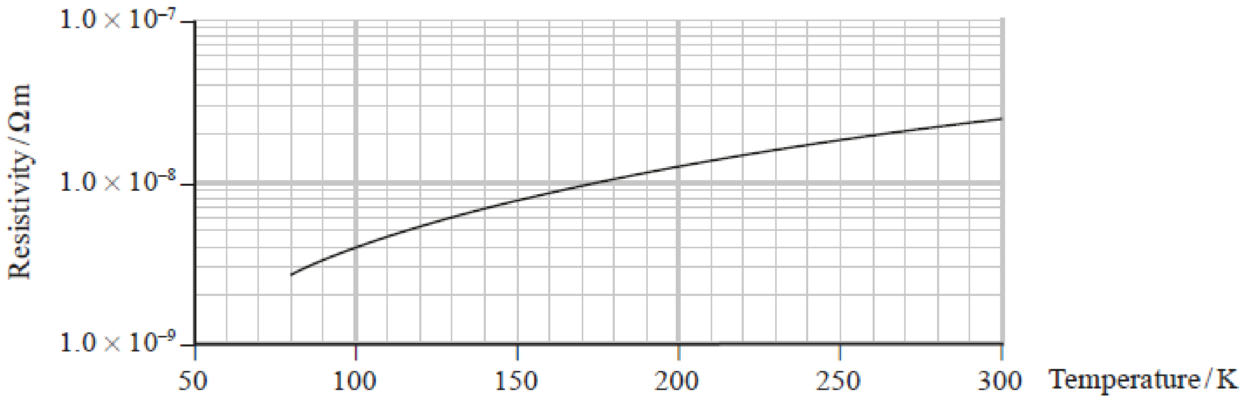
Q14.

Electrical transmission systems are used to transmit electrical power from place to place. Transformers are used to change potential differences (p.d.) and power transmission cables are used to transmit power.

Efficient electrical transmission systems are being developed using superconductors. Superconductors have zero resistance at low temperatures, and therefore no power is wasted by transfer to thermal energy unlike copper cable systems.

In one project a 1.05 km length of copper cable at a temperature of 270 K has been replaced by a superconductor. The superconductor has a cooling system which requires power.

The graph shows the variation of resistivity with temperature for copper.



Deduce whether the power requirement of the superconductor cooling system is less than the power losses in the copper cable.

transmission power = 40 MW

transmission potential difference = 110 kV

cross-sectional area of copper cable = 145 mm^2

power requirement of cooling system for the superconductor = 7 kW

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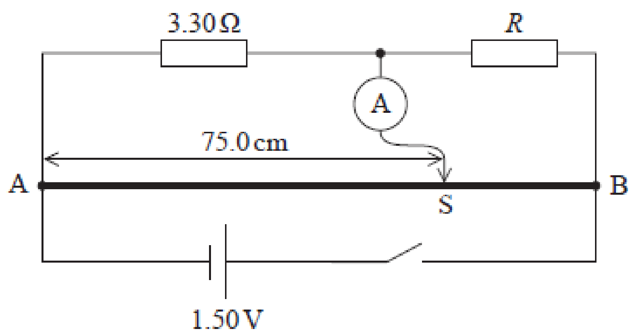
(Total for question = 5 marks)

Q15.

A "metre bridge" is a circuit which can be used to measure an unknown resistance accurately. The metre bridge includes a metre length of nichrome wire.

The metre bridge circuit is shown. The circuit includes a resistor of resistance 3.30Ω, a very sensitive ammeter and a resistor of unknown resistance *R*.



A metal slider S can be moved along the nichrome wire and pressed firmly against it to make an electrical connection.

When the switch is closed and S is 75.0 cm along the nichrome wire, the ammeter reads 0 A because the potential difference across the ammeter is zero.

Calculate *R*.

(2)

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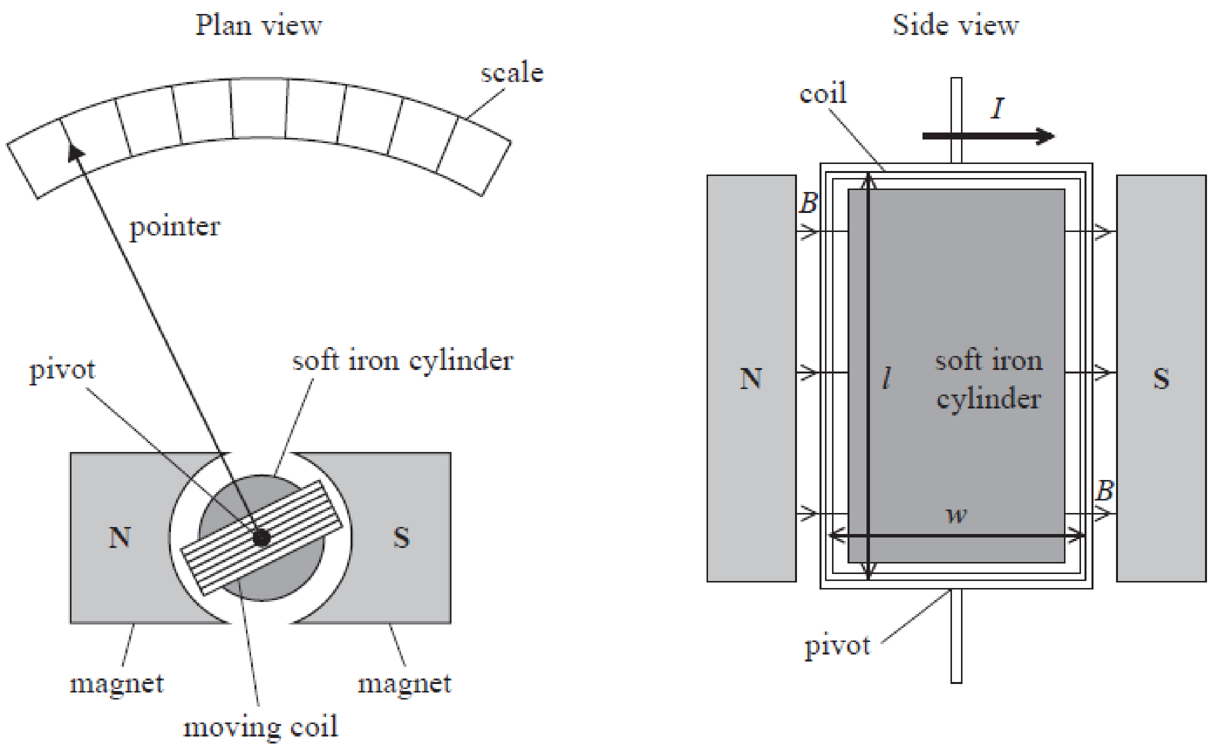
R = ...

(Total for question = 2 marks)

Q16.

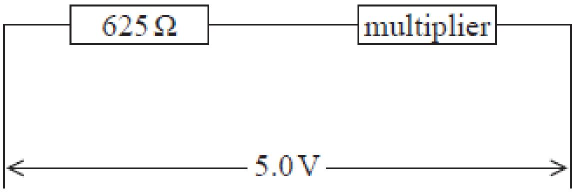
The diagrams show the plan view and side view of a moving coil ammeter.



An ammeter of this type has a resistance of 625 Ω and will measure a maximum current of 1.6 mA.

The ammeter can be adapted to measure potential difference by adding a resistor in series with the ammeter. This resistor is known as a multiplier.

The ammeter is adapted so that it can measure potential differences up to 5.0 V as shown.



The following multipliers are available:

200 Ω 2500 Ω 3125 Ω 3750 Ω

Deduce which multiplier should be used.

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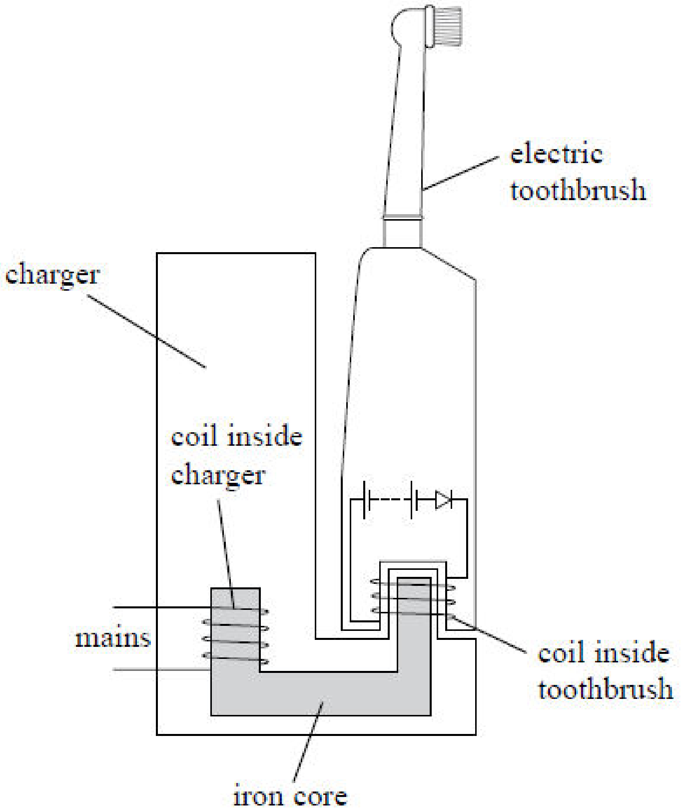
(Total for question = 3 marks)

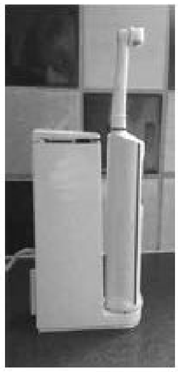
Q17.

The diagram shows the inside of an electric toothbrush and a charger.

The charger contains a coil wrapped around an iron core. The coil is plugged into the mains a.c. supply.

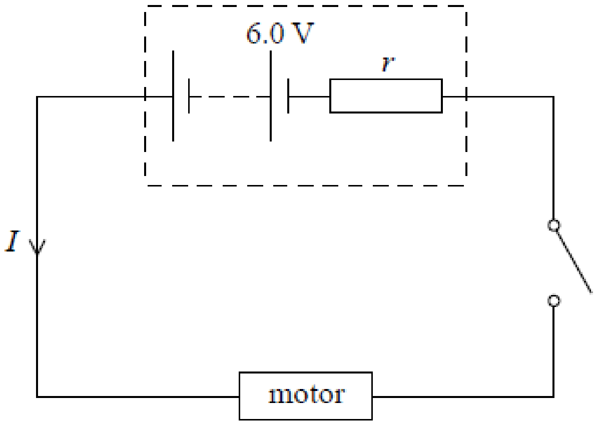
The toothbrush also contains a coil that sits around the iron core when the toothbrush is placed on the charger to recharge the battery of the toothbrush.





When fully charged the battery has an e.m.f. of 6 V.

When the toothbrush is in use, the battery supplies a current of 57 mA with a terminal p.d. of 2.7 V to a motor.



(i) Show that the resistance of the motor R is about 50 Ω.

(1)

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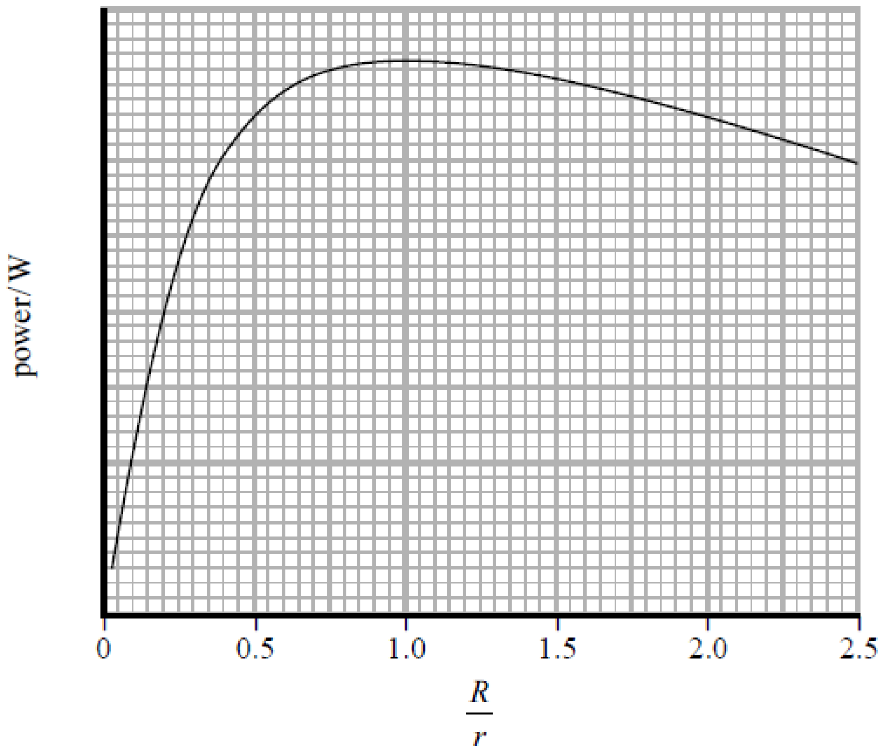
(ii) The power transferred from the battery to the motor depends on the ratio $\frac{R}{r}$ as shown in the graph below.



Determine whether maximum power is transferred to the motor.

(3)

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(Total for question = 4 marks)

Q18.

All electrical components have resistance.

In which of the following situations would the resistance of the stated component **not** increase?

☒ **A** Increasing the current through a filament lamp.

☒ **B** Increasing the temperature of a metal wire.

☒ **C** Increasing the temperature of a negative temperature coefficient thermistor.

☒ **D** Reversing the direction of a diode in forward bias in a circuit.

(Total for question = 1 mark)

Q19.

A "metre bridge" is a circuit which can be used to measure an unknown resistance accurately. The metre bridge includes a metre length of nichrome wire.

Calculate the resistance of a 1.00 m length of the nichrome wire.

(3)

resistivity of nichrome = 1.12×10^{-6} Ωm
diameter of wire = 4.00×10^{-4} m

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Resistance = ...

(Total for question = 3 marks)

Q20.

A student is taking measurements in order to determine the resistance of a component in a circuit. He connects a voltmeter in parallel with the component and an ammeter in series with the component.

Explain why the voltmeter should have a very high resistance.

(2)

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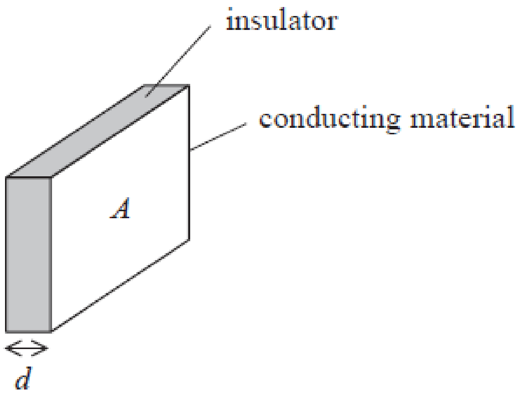
(Total for question = 2 marks)

Q21.

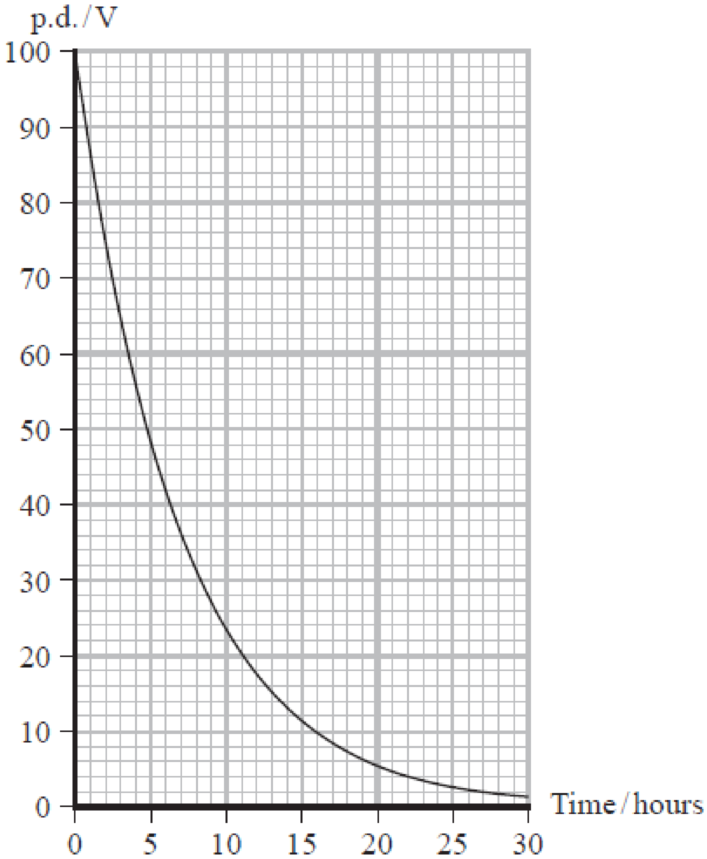
A parallel plate capacitor consists of a thin layer of insulator of thickness *d* between two plates of conducting material of area *A*.



The capacitor has a capacitance 0.1 μF and is charged to a p.d. of 100 V by connecting it to an electrical supply.

The capacitor is then disconnected from the supply and the p.d. between the two plates slowly decreases. This is because the insulator is not perfect and a small charge can flow through it.

The graph shows how the p.d. varies with time.



The insulator is a type of plastic and should have a resistivity greater than 10^{14} Ω m.

Deduce whether the plastic used in this capacitor has a resistivity greater than this value.

$A = 5.6 \times 10^{-3}$ m^2

$d = 0.6 \times 10^{-6}$ m

(5)

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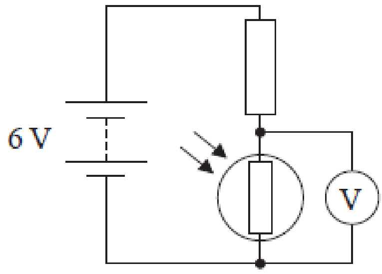
(Total for question = 5 marks)

Q22.

A light-dependent resistor (LDR) and resistor are connected in series with a 6V battery as shown. A voltmeter measures the potential difference across the LDR.



In daylight the voltmeter reads 3.0V.

Which reading is most likely if the circuit is now in total darkness?

(1)

☐ **A** a little above 0 V

☐ **B** a little below 3 V

☐ **C** a little above 3 V

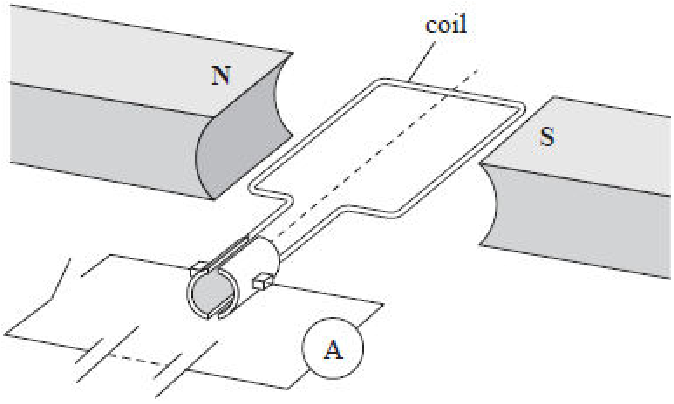
☐ **D** a little below 6 V

(Total for question = 1 mark)

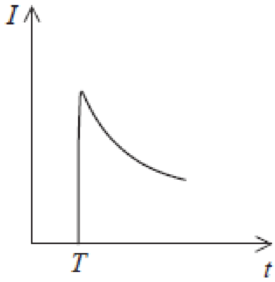
Q23.

* A simple electric motor consists of a coil that is free to rotate in a magnetic field.

A student connects the motor to an ammeter and a battery.



The graph shows how the current *I* in the coil varies with time *t*. The switch is closed at time *T*.



Explain why the current rises to a maximum then decreases.
Your answer should include a reference to Faraday and Lenz's laws.

(6)

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(Total for question = 6 marks)

Q24.

The photograph shows a 'quiet boil' electric kettle. The makers of the kettle claim that it boils water with much less noise than a standard kettle.

A laboratory technician takes some measurements to compare a 'quiet boil' electric kettle with a standard electric kettle.

The table shows the results recorded by the technician.

	Quiet boil kettle	Standard kettle
Mass of water / kg	1.20	1.20
Initial temperature of water / °C	10	10
Final temperature of water / °C	100	100
Potential difference / V	243	247
Current / A	11.9	11.8
Time taken to heat water to boiling point / s	168	172
Average sound intensity / mW m^{-2}	3.72	10.5

A student uses the values in the table to calculate the efficiency of each kettle at heating the water to boiling point. He calculates the efficiency of the 'quiet boil' kettle to be 0.93

Calculate the efficiency of the standard kettle.

specific heat capacity of water = 4180 J kg^{-1} K^{-1}

(4)

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Efficiency = ...

(b) The intensity of the sound produced by each kettle was measured with a sound meter which was 30.0 cm from the centre of the kettle.

Calculate the energy transferred by sound while the water in the standard kettle is brought to the boil. You may treat the kettle as a point source.

(4)

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Energy transferred = ...

(c) The label on the original packaging of the quiet boil electric kettle states, 'This kettle is much more efficient than a standard kettle because it produces less sound.'

Explain the extent to which this statement is supported by your calculations.

(2)

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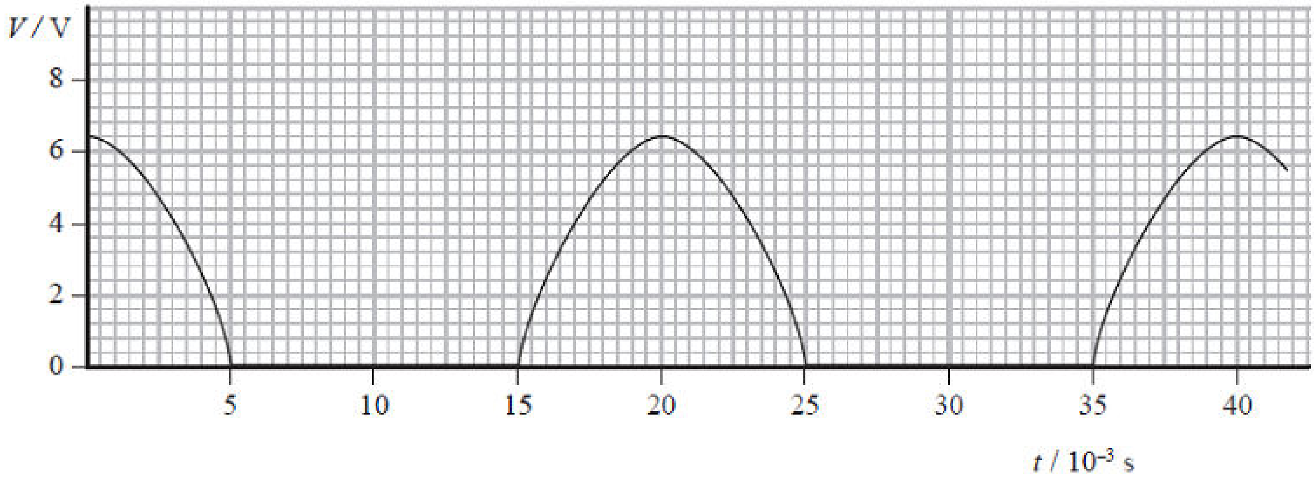
(Total for question = 10 marks)

Q25.

The graph shows how the output *V* from the terminals of a power supply labelled d.c. (direct current) varies with time *t*. This type of supply will not allow current to flow backwards through it.



(a) A student connects a capacitor across the terminals of this power supply in order to try to produce a constant voltage.

Suggest how this produces a constant voltage.

(2)

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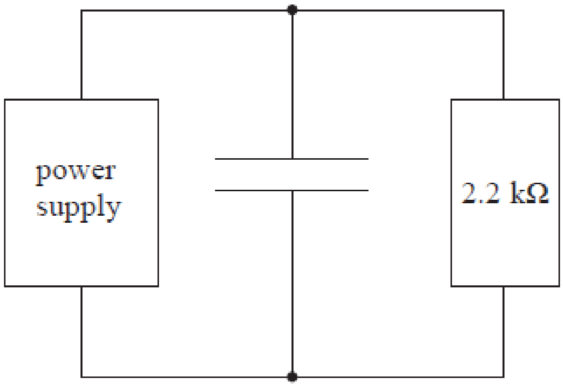
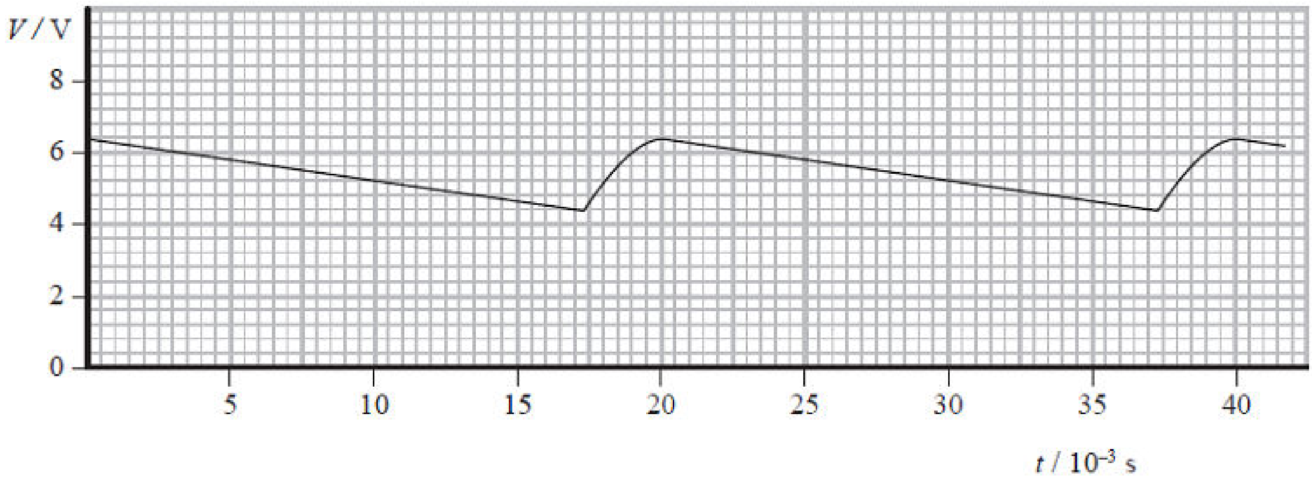
(b) The student then connects a resistor across the capacitor as shown.



The graph shows the variation of the potential difference *V* across the resistor with time *t*.



(i) Estimate the average potential difference across the resistor.

(1)

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Average potential difference = ...

(ii) Calculate the average current in the resistor.

(2)

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Average current = ...

(iii) Determine the time in each cycle for which the capacitor discharges through the resistor.

(1)

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Discharge time = ...

(iv) Calculate the charge passing through the resistor during one discharge of the capacitor and hence determine the capacitance of the capacitor.

(4)

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Charge = ...

Capacitance = ...

(c) The student wants to produce a potential difference across the same resistor that has less variation in magnitude.
State, with a reason, what the student could do to achieve this.

(2)

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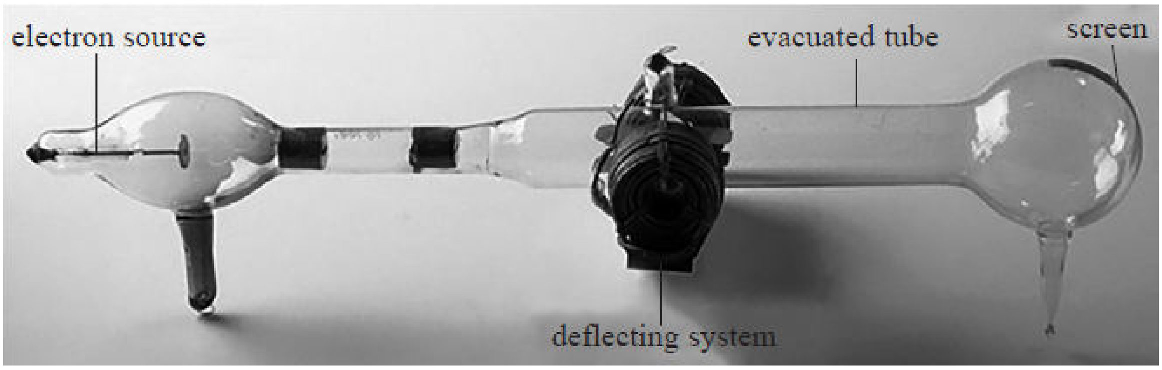
(Total for question = 12 marks)

Q26.

At the end of the 19^{th} century, J.J. Thompson used electric and magnetic fields to deflect beams of charged particles. A photograph of his apparatus is shown.



© Science Museum London

Electrons were accelerated through a potential difference to produce a beam of high-energy electrons. The beam was then deflected in perpendicular directions by the magnetic and electric fields. The final position of the beam on the screen was determined by the charge and mass of the electrons.

Explain how electrons from the source become a beam of high-energy electrons.

(2)

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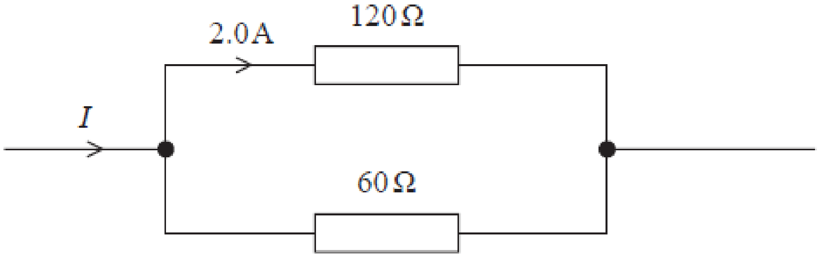
(Total for question = 2 marks)

Q27.

Two resistors are connected in parallel and the current in one of them is 2.0 A, as shown.



Which of the following is the total resistance of the resistors in parallel?

☐ **A** 20 Ω

☐ **B** 40 Ω

☐ **C** 90 Ω

☐ **D** 180 Ω

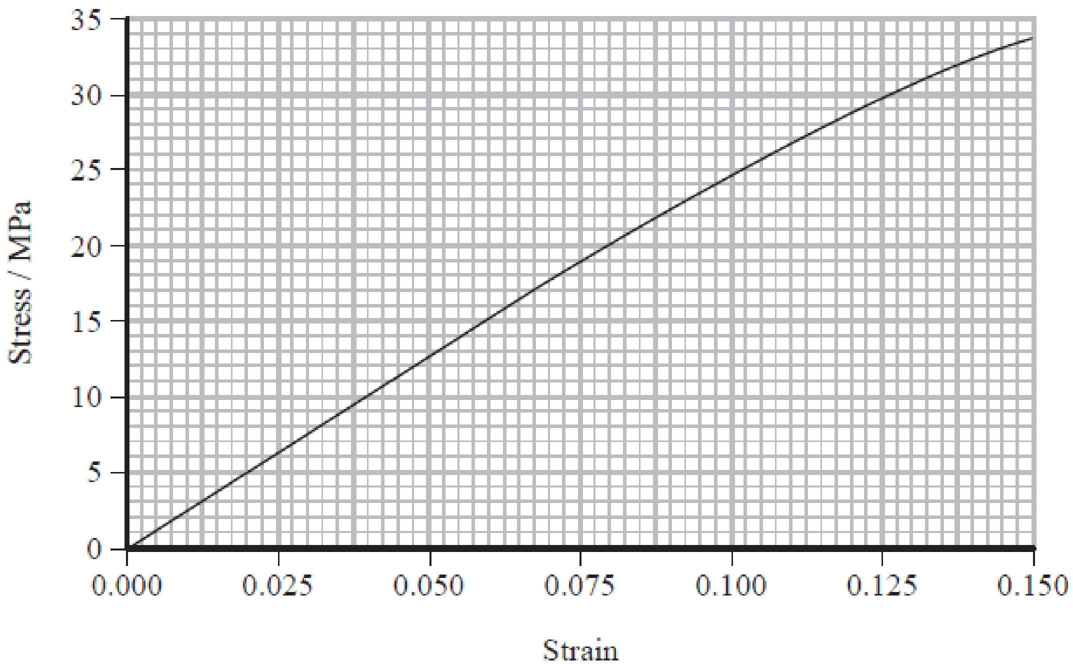
(Total for question = 1 mark)

Q28.

Seat belts are being tested by a car manufacturer. In the test, a car moving at a steady speed of 28 m s^{-1} collides with a wall and stops.

A crash-test dummy in the driving seat is wearing a seat belt made from polyester webbing. The seat belt has a cross-sectional area of 0.85 cm^2 and a total length of 2.0 m. A student suggests that in the collision the seat belt absorbs all the kinetic energy of the dummy.

The graph shows how stress varies with strain for the seat belt.



(i) Show that the area under the graph represents the energy stored per unit volume in the seat belt.

(2)

....

....

....

....

(ii) Use the graph to determine whether the seat belt absorbs all the kinetic energy of the dummy from part (a).

In this collision, the maximum strain of the seat belt is 0.075

(3)

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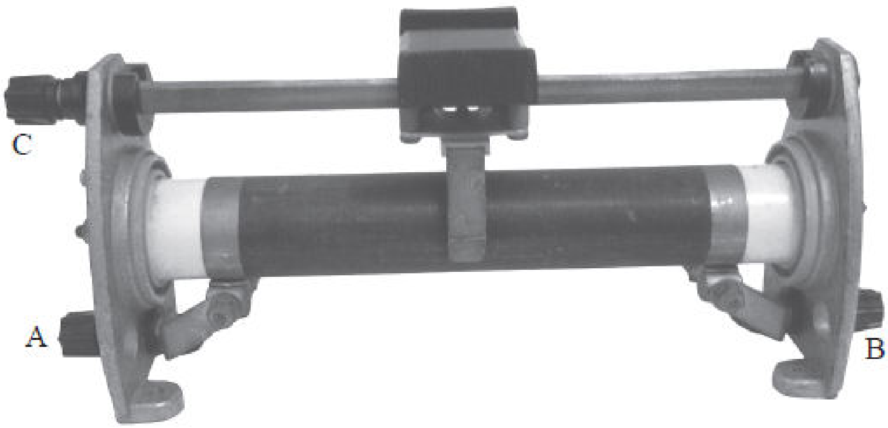
....

(Total for question = 5 marks)

Q29.

Photograph 1 shows a rheostat (a variable resistor).

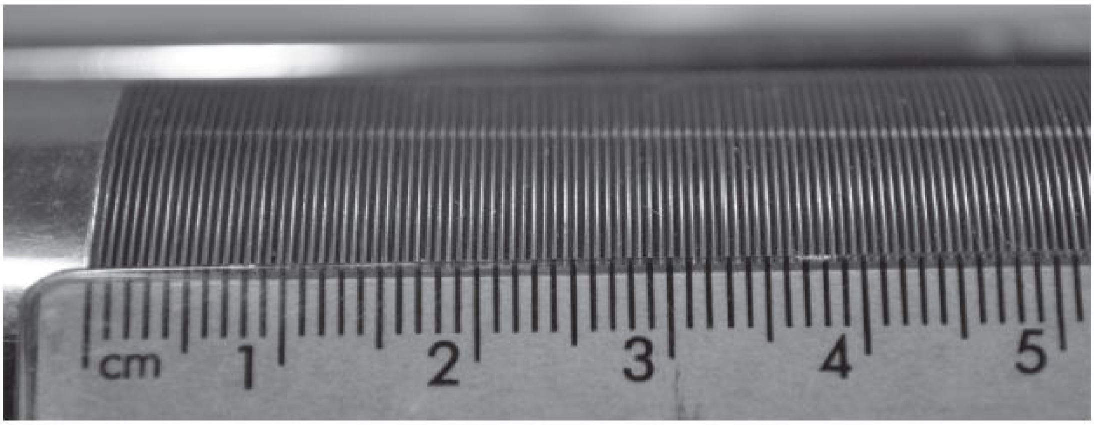


Photograph 1

The rheostat is made of a long resistance wire coiled around an insulating cylinder. The turns of wire are also separated from each other by insulation of negligible thickness. The ends of the wire are connected to the sockets A and B at either end and there is a sliding contact in the centre connected to the socket C. The resistance between A and C is varied by moving the sliding contact.

(a) A student decides to determine the resistivity of the material from which the wire is made by measuring the dimensions of the wire and its resistance.

Photograph 2 shows a section of the rheostat and a scale.



Photograph 2

(i) Take measurements from the photograph and use them to show that the cross-sectional area of the wire is about 2×10^{-7} m^2.

(3)

....

....

....

(ii) Calculate the resistivity of the material from which the wire is made.

resistance of wire = 22 Ω

length of wire = 12 m

(3)

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....

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....

Resistivity = ...

(iii) Suggest an advantage for the student of using a photograph rather than taking direct measurements.

(1)

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....

....

(b) The coil of the rheostat is 10.2 cm long. A potential difference of 12 V is applied across AB and the slider C is 7.0 cm from the end of the coil near A.

(2)

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....

....

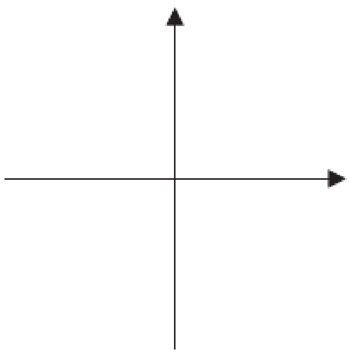
....

Potential difference = ...

(Total for question = 9 marks)

Q30.

(a) Sketch a graph to show how current varies with potential difference for a filament lamp.



(2)

(b) The temperature of a filament lamp increases as the current through it increases.

Explain this in terms of the structure of a metal.

(3)

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(Total for question = 5 marks)

Mark Scheme

Q1.

Question Number	Acceptable Answer	Additional guidance	Mark
	B	1 : 4	**(1)**

Q2.

Question Number	Answer	Mark
	C	1

Q3.

Question Number	Acceptable Answer		Additional Guidance	Mark
(i)	• Use of y-sensitivity value • $V_0 = 4.0$ V	(1) (1)	Example of calculation: $V_0 = 2 \times 2.0\ V = 4.0$ V	2
(ii)	• Use of $I = \frac{V}{R}$ • Use of $I_{rms} = \frac{I_0}{\sqrt{2}}$ Or use of $V_{rms} = \frac{V_0}{\sqrt{2}}$ • $I_{rms} = 0.019$ A ECF from(i)	(1) (1) (1)	Example of calculation $I_0 = \frac{4.0\ V}{150\ \Omega} = 0.0267$ A $I_{rms} = \frac{0.0267\ A}{\sqrt{2}} = 0.0189$ A	3
(iii)	• Use of $R = R_1 + R_2$ • Use of $P = I^2R$ (or other valid power equation) • $P = 0.096$ W ECF from(i) and (ii)	(1) (1) (1)	Example of calculation: $R = 150\ \Omega + 120\ \Omega = 270\ \Omega$ $P = I^2R$ $= (0.019\ A)^2$ $\times 270\ \Omega = 0.0964$ A	3

Q4.

Question Number	Acceptable answers		Additional guidance	Mark
	• Substitute eV for $\frac{1}{2} mv^2_{max}$ in $hf = \phi + \frac{1}{2} mv^2_{max}$ • Rearranges to identify gradient = h/e • Attempt to find gradient using large triangle • $h = 7.6 \times 10^{-34}$ J s (range: 7.5×10^{-34} J s to 7.7×10^{-34} J s)	(1) (1) (1) (1)	Example of calculation $hf = \phi + \frac{1}{2} mv^2_{max}$ $hf = \phi + eV$ $eV = hf - \phi$ $V = hf/e - \phi/e$ gradient = h/e gradient = (2.40 V – 1.00 V) ÷ (6.975×10^{14} Hz – 4.025×10^{14} Hz) gradient = 4.72×10^{-34} V s $h = 4.72 \times 10^{-34}$ V s $\times 1.6 \times 10^{-19}$ C $h = 7.58 \times 10^{-34}$ J s	4

Q5.

Question Number	Acceptable answers	Additional guidance	Mark
	• (Faint and difficult to see, so may not be seen at the correct p.d. and) recorded p.d. could be too high **(1)** • (Range of frequencies could mean light is seen before the light at the stated frequency and) recorded p.d. could be too low **(1)** • Discussion of these points, e.g. opposite effects, could cancel or could be systematic errors and not affect gradient **(1)**		**3**

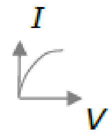
Q6.

Question number	Acceptable answers	Additional guidance	Mark
	An explanation that the student's conclusion is incorrect because: • The popper returns to its original shape, even though there is a time delay **(1)** • Elastic material returns to its original shape when the deforming force is removed **(1)** • But a plastic material would suffer a permanent deformation **(1)**		**3**

Q7.

Question Number	Acceptable answers	Additional guidance	Mark
	• p.d. across capacitor increases **Or** p.d. across resistor decreases (1) • p.d. across capacitor increases to 5V (1) • p.d. across resistor starts at 5V and reduces to 0V (1) • Exponentially (1)		**4**

Q8.

Question Number	Acceptable answers	Additional guidance	Mark
	The only correct answer is C A *is not correct because it shows constant resistance* B *is not correct because it shows decreasing resistance* D *is not correct because it shows an I independent of V*		**1**

Q9.

Question Number	Acceptable answers	Additional guidance	Mark
	• The diode only conducts (current) when the potential difference across it is (at least +) 0.7V **(1)** • The diode does not conduct current when the p.d. is negative/reversed. **(1)**		**(2)**

Q10.

Question Number	Acceptable answers	Additional guidance	Mark
	B		**1**

Q11.

Question Number	Acceptable answers		Additional Guidance	Mark
i	• As resistance increases with length of wire • potential (difference) proportional to length of wire	(1) (1)	Alt to MP1: Current same through whole length of wire and $V=IR$	2
ii	• Use of ratio of lengths = ratio of potentials • Potential at P = 1.13 V	(1) (1)	Alternative method uses ratio of resistances. Example of calculation: $=\frac{75.0}{100}\times 1.50$ $=1.125\text{V}$	2

Q12.

Question Number	Acceptable answers		Additional guidance	Mark
(i)	• Use of $P = IV$ • Use of $V = \varepsilon - Ir$ Or $V = 180 - 0.036I$ • Converts kW to W and rearranges equation to that shown	(1) (1) (1)	Example of derivation: $88\text{ kW} = I \times V$ $88\text{ kW} = I \times (180 - 0.036I)$ $88000 = 180I - 0.036I^2$ $0.036I^2 - 180I + 88000 = 0$	3
(ii)	• Use of $Q = It$ • Time that batteries can deliver this power = 40 s so more than 7 s	(1) (1)	Example of calculation: $6.1\text{ A h} = 550\text{ A} \times t$ $t = 0.011\text{ h} = 40\text{ s}$	2

Q13.

Question Number	Acceptable answers		Additional guidance	Mark
	• Deduce the p.d. across the total resistance • Use of $P = I^2 R$ or V^2/R • $P = 3.3 \times 10^{-3}$ W	(1) (1) (1)	<u>Example of calculation</u> $I = \frac{6\text{ V}}{3.3\text{ k}\Omega + 2.7\text{ k}\Omega} = 1.0\text{ mA}$ $P = (1.0\text{ mA})^2 \times 3300\Omega = 3.3 \times 10^{-3}\text{ W}$ Alternative $V = 6\text{ V} \times \frac{3.3}{3.3 + 2.7} = 3.3\text{ V}$ $P = \frac{3.3^2\text{ V}^2}{3300\,\Omega} = 3.3 \times 10^{-3}\text{ W}$	3

Q14.

Question Number	Acceptable answers		Additional guidance	Mark
	• 270K corresponds to a resistivity of 2×10^{-8} (Ω m) • Use of $P=VI$ • Use of $R=\rho l/A$ • Use of $P=I^2R$ • Power losses from copper cables 19 kW so more than 7 kW and that the superconductor would save energy. MP5 dependant on MP2,3,4 (Acceptable range for Power losses: 9.6 kW to 34 kW)	(1) (1) (1) (1) (1)	range allow $2 \times 10^{-8}\,\Omega$ m to $2.1 \times 10^{-8}\,\Omega$ m Example of calculation: $40 \times 10^6\text{ W} = 110 \times 10^3\text{ V} \times I$ $I = 364\text{ A}$ $R = \frac{2 \times 10^{-8}\,\Omega\text{m} \times 1.050 \times 10^3\text{ m}}{145 \times 10^{-6}\text{ m}^2} = 0.145\Omega$ $P = 364^2\text{ A}^2 \times 0.145\Omega = 19.2\text{kW}$	5

Q15.

Question Number	Acceptable answers	Additional Guidance	Mark
	Either • Calculates current correctly using $I=V/R$ **(1)** • $R = 1.10\ \Omega$ **(1)** **Or** • Use of ratios of lengths = ratios of resistances **(1)** • $R = 1.10\ \Omega$ **(1)** **Or** • Use ratio of resistances = ratio of p.d.s **(1)** • $R = 1.10\ \Omega$ **(1)**	Show that value gives 1.2 Ω Example of calculation: $I = \frac{1.125}{3.30} = 0.34A$ $R = \frac{0.375}{0.34} = 1.1\Omega$ Or $\frac{R}{3.30} = \frac{25}{75}$	**2**

Q16.

Question Number	Acceptable answers	Additional guidance	Mark
	• Use of $V = IR$ **(1)** • Use of $V_{total} = V_{meter} + V_{multiplier}$ **(1)** • Choice of $R = 2500\ \Omega$ **(1)**	Example of calculation V across meter = 0.0016 A × 625Ω = 1.0 V V across multiplier = 5.0 V – 1.0 V = 4.0 V $R_{multiplier} = \frac{4.0\text{ V}}{0.0016\text{ A}} = 2500\ \Omega$ MP3 dependent on MP1 or MP2	**3**

Q17.

Question number	Acceptable answers	Additional guidance	Mark
(i)	R= 47.4 Ω **(1)**	Example of calculation: R = 2.7 V/0.057 A = 47.4 Ω	**1**
(ii)	• Use of $\mathcal{E}=V+Ir$ **or** correct attempt to find r **(1)** • $r = 57.9\ \Omega$ or find ratio $\frac{R}{r}$ **(1)** • Makes conclusion by comparing r and R, recognising maximum power supplied when $\frac{R}{r} = 1$ **(1)**	Answer consistent with calculated value. Example of calculation: $r = \frac{(6.0\ V - 2.7\ V)}{0.057\ A} - 50 = 57.9\ \Omega$	**3**

Q18.

Question Number	Answer	Mark
	C	**1**

Q19.

Question Number	**Acceptable answers**	**Additional Guidance**	**Mark**
	• Use of $R = \frac{\rho l}{A}$ **(1)** • Use of area formula with correct value of radius **(1)** • $R = 8.9\ \Omega$ **(1)**	Use of: any dimensionally correct substitutions eg using a diameter squared Accept R=8.62 as due to rounding Area <u>Example of calculation</u>: R = 1.12 x 10^{-6} Ω m x 1m / $\pi(0.2 \times 10^{-3})^2$ m^2	**3**

Q20.

Question Number	Answer	Mark
	(high resistance) so very little /negligible/zero current in the voltmeter **Or** because otherwise a current would pass through the voltmeter **Or** so the total resistance of the parallel combination isn't changed **Or** because otherwise total resistance of parallel combination would be reduced **(1)** because that would change /increase the current in the ammeter **Or** because that would mean the current through the ammeter was different to (larger than) the current through the component **(1)**	**2**
	Total for question	**2**

Q21.

Question Number	Acceptable answers	Additional guidance	Mark
	• Use of $\ln V = \ln V_0 - \frac{t}{RC}$ **(1)** **Or** Draws initial tangent to curve and uses $T = RC$ **Or** Determines t when V has decreased to approx. 37% • Conversion hours to seconds **(1)** • Calculates resistance in range 2.4×10^{11} to 2.8×10^{11} (Ω) **(1)** • Use of $R = \rho l/A$ **(1)** • Resistivity in range 2.2×10^{15} Ω to 2.6×10^{15} Ω m so yes above 10^{14} Ω m **(1)**	Example of calculation: $ln6 = ln100 - \frac{20 \times 3600 \text{ s}}{R \times 0.1 \times 10^{-6} (\text{s})}$ $R = 2.6 \times 10^{11}$ Ω $2.6 \times 10^{11} \Omega = \frac{\rho \times 0.6 \times 10^{-6} \text{ m}}{5.6 \times 10^{-3} \text{ m}^2}$ Resistivity = 2.4×10^{15} Ω m Using $T = RC$ $7 \times 3600 \text{ s} = 0.1 \times 10^{-6} \text{ F} \times R$ $R = 2.5 \times 10^{11}$ Ω (allow T in range 7 – 8 hour)	**5**

Q22.

Question Number	Acceptable answers	Additional guidance	Mark
	D In the dark the resistance of the LDR will be very large so practically all the potential difference of 6V will be across it.	a little below 6 V	**1**
	A assumes the resistance of the LDR decreases to almost zero B assumes the resistance of the LDR decreases a little C assumes the resistance of the LDR increases a little		

Q23.

Question Number	Acceptable Answers	Additional Guidance	Mark
*	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content.	<table><tr><th>IC points</th><th>IC mark</th><th>Max linkage mark available</th><th>Max final mark</th></tr><tr><td>**6**</td><td>4</td><td>2</td><td>**6**</td></tr><tr><td>**5**</td><td>3</td><td>2</td><td>**5**</td></tr><tr><td>**4**</td><td>3</td><td>1</td><td>**4**</td></tr><tr><td>**3**</td><td>2</td><td>1</td><td>**3**</td></tr><tr><td>**2**</td><td>2</td><td>0</td><td>**2**</td></tr><tr><td>**1**</td><td>1</td><td>0</td><td>**1**</td></tr><tr><td>**0**</td><td>0</td><td>0</td><td>**0**</td></tr></table>	6
	Indicative content: • (Maximum/Initial) current is equal to battery emf divided by *R* **Or** current as switch closed **Or** current as complete circuit **Or** current due to battery • Coil rotates • (movement of) coil "cuts/changes" (magnetic) flux (linkage) / field • Which induces an emf (according to Faraday's law) • Opposes original emf/current according to Lenz's law **Or** current reduced as effect opposes change • The faster the coil rotates the larger this (back) emf/effect the smaller the current	ic3 needs a link to coil moving ic4 depends on ic3	

Q24.

Question Number	Acceptable answers	Additional guidance	Mark
(a)	• use of $W = VIt$ (1) • use of $\Delta E = mc\Delta\theta$ (1) • use of efficiency = useful power (1) • output / total power input • efficiency = 0.90 Or 90% (1)	Example of calculation: W = 247 V × 11.8 A × 172 s = 501 000 J ΔE = 1.20 kg × 4180 J kg^{-1} K^{-1} × (101 - 11) K = 451 000 J Efficiency = 451 000 / 501 000 = 0.90	**(4)**

Question Number	Acceptable answers	Additional guidance	Mark
(b)	• calculates area of sphere of radius 30 cm = 1.13 m^2 (1) • use of $I = P/A$ (1) • use of $W = Pt$ (1) • W = 2.0 J (1)	Example of calculation: Area = 4π × (0.3 m)^2 = 1.13 m^2 P = 10.5 × 10^{-3} W m $^{-2}$ × 1.13 m^2 = 1.19 × 10^{-2} W W = 1.19 × 10^{-2} W × 172 s = 2.0 J	**(4)**

Question Number	Acceptable answers	Additional guidance	Mark
(c)	An explanation that makes reference to the following: • the quiet boil electric kettle is more efficient, but only by 3% which isn't 'much' (1) • the energy transferred by sound is very small, so it is not the reason for the difference (1)	Allow 1 mark if the student gives a comment that the uncertainties are too high to draw a valid conclusion without reference to the data in the question, the candidate's calculations may be awarded one mark	**(2)**

Q25.

Question Number	Answer		Mark
(a)	The capacitor stores charge **Or** capacitor charges from the supply The idea that the capacitor doesn't fully discharge before being recharged.	(1) (1)	2
(b)(i)	$(6.4 + 4.4)/2 = 5.4$ V	(1)	1
(b)(ii)	Use of $V = IR$ Average $I = 5.4$ V/$(2.2 \times 10^3 \Omega) = 2.5 \times 10^{-3}$ A ecf value form (b)(i)	(1) (1)	2
(b)(iii)	Time = 17 ms or 17.5 ms	(1)	1
(b)(iv)	Use of $Q = It$ Use of $C = Q/V$ Use of $\Delta V = 2.0$ V $C = 21$ μF (ecf values of I and t from above) Example of calculation $Q = 2.5 \times 10^{-3}$ A $\times$ 17 $\times 10^{-3}$ s $= 4.25 \times 10^{-5}$ C $C = 4.25 \times 10^{-5}$ C / 2.0 V $C = 21$ μF	(1) (1) (1) (1)	4
(c)	Uses a larger capacitance Because a larger time constant is needed **Or** stores more charge **Or** less $\Delta V \rightarrow \Delta Q/C$	(1) (1)	2
	Total for question		**12**

Q26.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • The potential difference creates an electric field (1) • An (electric) field/force does work on the electrons (increasing their kinetic energy) **Or** an (electric) field/force accelerates the electrons (increasing their velocity) (1)		2

Q27.

Question Number	Acceptable answers	Additional guidance	Mark
	The only correct answer is B A is not correct as 120 Ω / 3 = 40 Ω C is not correct as 120 Ω / 3 = 40 Ω D is not correct as 120 Ω / 3 = 40 Ω		**1**

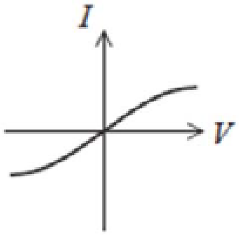
Q28.

Question Number	Acceptable Answer		Additional Guidance	Mark
(i)	• (For linear section of graph) area under graph = $\frac{1}{2}$ stress × strain • Use of stress = F/A and strain = $\Delta x/x$ to show that area $= \frac{1}{2} \times \frac{F}{A} \times \frac{\Delta x}{x} = \frac{F_{av}.\Delta x}{V} = \frac{E}{V}$	(1) (1)	Candidates who only use the graph to show that the area has units J m^{-3} can score a maximum 1 mark Accept F_{av} for $\frac{1}{2}F$	2
(ii)	• Area under graph up to 0.075 calculated • Energy per unit volume = 7.1×10^5 J m^{-3} • This is much less than the value given in (a), and so belt does not absorb all the KE. **OR** • Graph used to determine stress when strain is 0.075 and $\sigma = \frac{F}{A}$ used to calculate force • $\epsilon = \frac{\Delta x}{x}$ used to calculate extension and $W = \frac{1}{2}F\Delta x$ used to calculate energy • Statement that this energy is much less than the value in (a), and so belt does not absorb all the kinetic energy	(1) (1) (1) (1) (1) (1)	Example of calculation: When strain is 0.075 Area = $\frac{1}{2} \times 19 \times 10^6 \text{Pa} \times 0.075 = 7.13 \times 10^5$ J m^{-3}	3

Q29.

Question Number	Answer		Mark
(a)(i)	Determines width of at least 9 coils Use of half of their diameter in πr^2 Area = (1.96 to 2.42) × 10^{-7}(m^2) <u>Example of calculation</u> 18 coils = 1.00 cm Diameter = 0.0100 m ÷ 18 = 5.56 × 10^{-4} m Area = π × (5.56 × 10^{-4} ÷ 2)^2 Area = 2.42 × 10^{-7} m^2	(1) (1) (1)	3
(a)(ii)	Use of $R=\rho l/A$ Resistivity magnitude = 4.4 × 10^{-7} (show that value gives 3.7× 10^{-7}) Unit Ωm <u>Example of calculation</u> $\rho=RA/l$ = 22 Ω x 2.4 × 10^{-7} m^2 / 12 m = 4.4 × 10^{-7} Ωm	(1) (1) (1)	3
(a)(iii)	A sensible response with some detail, e.g. • Avoid difficulty in reading a small scale while holding it and counting turns • it can be enlarged and done more accurately • compare with unravelling and using a micrometer • remains stationary, so easier to measure accurately • you can mark the coils as you go so you don't lose count (treat parallax as neutral and)	(1)	1
(b)	Use of ratio of lengths × pd V = 8.2 V <u>Example of calculation</u> V = (7.0 cm / 10.2 cm) × 12 V = 8.2 V	(1) (1)	2
	Total for question		**9**

Q30.

Question Number	Answer		Mark
(a)	Correct curve in + + section (accept $V-I$ or $I-V$ graph but axes must be labelled) Symmetrical negative curve (accept if ++ curve incorrect) 	(1) (1)	2
(b)	Drift velocity (of electrons) increases (as current increases) **Or** electrons gain (kinetic) energy (as current increases) **Or** rate of flow of electrons/charge increases (as current increases) More (frequent) collisions of electrons with lattice ions lattice ion vibrations increased **Or** (More) energy dissipated as heat in lattice **Or** (More) energy transferred when electrons collide with lattice ions (accept charge carriers for electrons and atoms/ions/particles for lattice ions.)	(1) (1) (1)	3
	Total for question		**5**