Physics Year 11 ATAR

Test 3: Electricity

SIDE Teachers name: SOLUTIONS

Student authentication statement

I hereby certify that I completed this test according to the instructions below.

Name: ____________________ Signature: _____________________ Date: ________

Supervisor authentication statement

I verify that this test was completed according to the instructions below.

Name: ____________________ Signature: _____________________ Date: ________

- This test must be completed under supervision.
- The supervisor and student must sign the authentication statements above.
- Answer all questions in the spaces provided.
- Formulas and data are provided in a separate booklet.
- Ruler, pen, pencil, eraser and approved calculator may be used.
- A standard or non-programmable scientific calculator that does not have a full alphabetic display or graphical display may be used.
- No other materials, notes, etc are to be used in the test.
- All working should be shown for calculations. Marks are awarded for working and final answers.
- Time allowed = **60 minutes**

Section	Number of questions available	Your Mark	Marks available	Percentage of Test
Section One: Short answer	4		18	30
Section Two: Extended answer	3		30	50
Section Three: Comprehension and data analysis	1		12	20
			60	**100**

Section One: Short Answers

Question 1 **(4 marks)**

Two table tennis balls are rubbed vigorously with a woollen cloth so that they receive equal size positive charges.

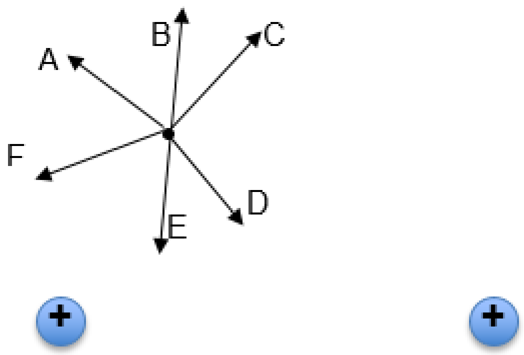
(a) Briefly explain how each ball acquires a positive charge when rubbed. (2 marks)

When rubbed, friction between the cloth and ball causes electrons to be transferred from the ball to the cloth (1) ,

leaving the ball with a deficiency of electrons and hence a positive charge. (1)

(b) The two positively charged balls are placed a fixed distance apart. A small test charge is placed at the position indicated by the black dot in the diagram below. Which direction, as indicated by the arrows labelled A to F, shows the direction of the electrostatic force on the test charge due to the two balls if it was. (2 marks)

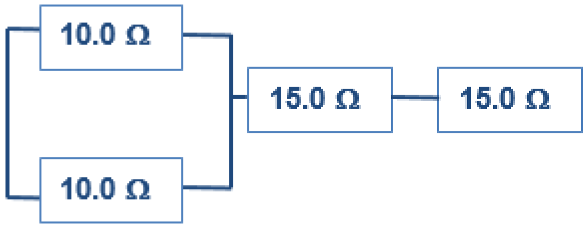
(i) positively charged _____B_____ (ii) negatively charged ____E_____

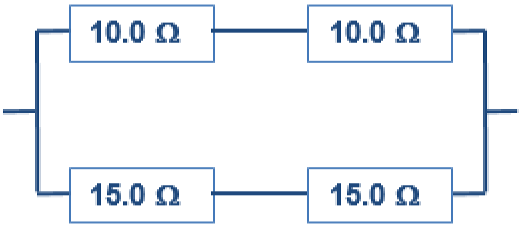


Question 2 **(4 marks)**

You have been provided with two 10.0 Ω and two 15.0 Ω resistors. Draw simple circuit diagrams to show how you could connect these resistors to create the following combined resistances.

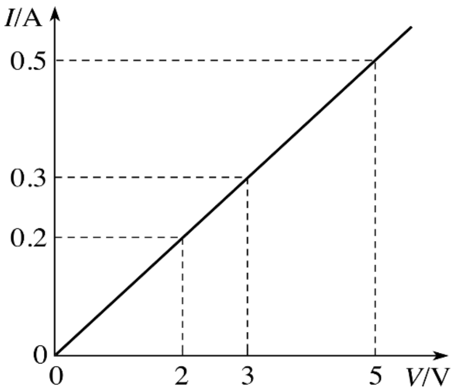
(a) 35.0 Ω (2 marks) (b) 12.0 Ω (2 marks)



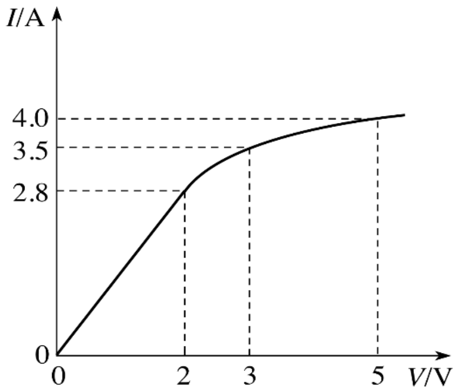


Question 3 **(6 marks)**

The graphs below show the current versus voltage behaviour of two electrical devices.



Device X



Device Y

(a) Find the resistance of device X at each of the nominated values of voltage. (2 marks)

2.0 V: $R = \frac{V}{I} = \frac{2}{0.2} = 10\ \Omega$ (1)

5.0 V: $R = \frac{V}{I} = \frac{5}{0.5} = 10\ \Omega$ (1)

(b) Find the resistance of device Y at each of the nominated values of voltage. (2 marks)

2.0 V: $R = \frac{V}{I} = \frac{2}{2.8} = 0.71\ \Omega$ (1)

5.0 V: $R = \frac{V}{I} = \frac{5}{4.0} = 1.25\ \Omega$ (1)

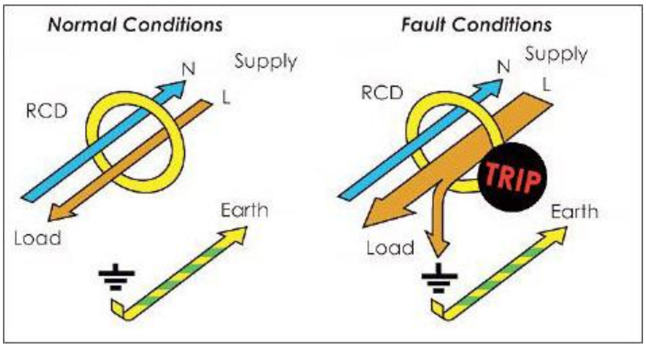
(c) Which device is non-ohmic? Briefly explain why. (2 marks)

Device Y is non-ohmic (1)

Its resistance changes as the voltage across it changes (1)
(graph is non-linear)

Question 4 **(4 marks)**

The basic operating principle of a residual current device (RCD), which is a safety device found in the meter box of a house, is illustrated in the sketch at right.



(a) Briefly describe how the residual current device protects residents from electric shock. (2 marks)

The RCD compares the active and neutral currents flowing in the meter box (1)

If a short circuit occurs within the house (e.g. a resident touching a live wire), so that the active current becomes larger than the neutral, then the RCD trips and breaks the circuit (1)

(b) Explain the difference between the neutral wire and the earth wire in a typical household circuit. (2 marks)

The neutral wire completes the circuit back to the ground from the live components of an electrical device (1)

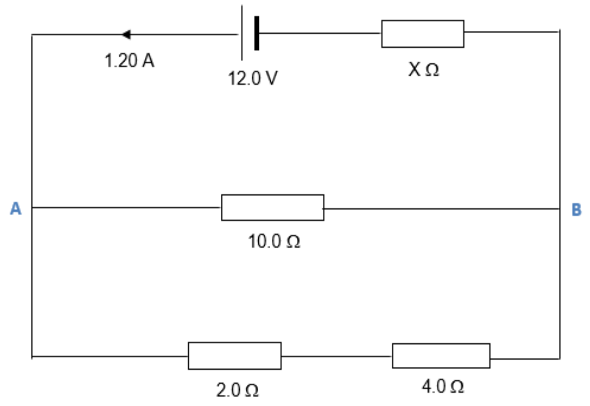
The earth wire completes the circuit back to the ground from the metal casing of an electrical device in the event it becomes live (1)

End of Section One

Section Two: Problem Solving

Question 5 **(12 marks)**

A 12.0 volt battery is connected in a circuit with four resistors, as shown in the diagram below. The current flowing from the battery is measured to be 1.20 A.



(a) Calculate the resistance between points A and B in the circuit. (2 marks)

Top branch has 10 Ω of resistance, bottom branch has 6.0 Ω of resistance (1)

$$R_{AB} = (10^{-1} + 6^{-1})^{-1} = 3.75\ \Omega \quad (1)$$

(b) Find the potential difference (voltage) between points A and B. (2 marks)

$$V_{AB} = IR = 1.2\ x\ 3.75 \quad (1)$$

$$= 4.50\ V \quad (1)$$

(c) State the potential difference across each of the resistors in the circuit. (4 marks)

10 Ω resistor: ________4.50 V________(1)

2 Ω resistor: ________1.50 V________(1)

4 Ω resistor: ________3.00 V________(1)

X Ω resistor: ________7.50 V________(1)

(d) Find the resistance of resistor X. (2 marks)

$$R_X = \frac{V}{I} = \frac{7.5}{1.2} \quad (1)$$

$$= 6.25\ \Omega \quad (1)$$

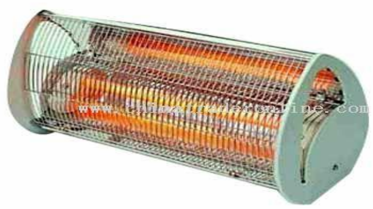
(e) Calculate the current that passes through the 2.0 Ω resistor. (2 marks)

$$I_{2\Omega} = \frac{V}{R} = \frac{1.5}{2} \quad (1)$$

$$= 0.75\ A \quad (1)$$

Question 6 **(8 marks)**

A 1.8 kW electric heater operates on the domestic electricity supply (240V) for a period of three hours.



(a) What current does the heater draw? (2 marks)

$$I = \frac{P}{V} = \frac{1800}{240} \quad (1)$$

$$= 7.50\ A \quad (1)$$

(b) What is the resistance of the heater when operating? (2 marks)

$$R = \frac{V}{I} = \frac{240}{7.5} \quad (1)$$

$$= 32.0\ \Omega \quad (1)$$

(c) When first switched on, the heater draws a larger current than that calculated in part (a) above. How do you explain this? (2 marks)

When first switched on, the element of the heater is cold and so its <u>resistance is lower</u> (1) than its operating resistance when warmed up.

Since $I = {}^{V}/_{R}$, a lower resistance means a larger current is drawn. (1)

(d) Given that electricity costs 25 cents per kilowatt-hour, find the cost (to the nearest cent) of using the heater for the three hour period. (2 marks)

Cost = P(in kW) x t(in hours) x unit cost (1)

= 1.8 kW x 3 h x 25c = <u>135c</u> ($1.35) (1)

Question 7 **(10 marks)**

A power bank is a portable battery used to charge phones and other devices. An ideal power bank can deliver 2.20 A for an hour at a voltage of 3.3 V.

a) Describe how a power bank (or battery) stores electrical potential energy which can be used to power devices. (2 marks)

- Stored as chemical potential energy (1)
- Inside positive and negative charges are held separately
- Charge separation produces an electrical potential difference that drives current (1)

b) Calculate the total amount of work the power bank is able to do before running out of energy. (4 marks)

$q = It$

$q = 2.2 \times 3600$ (1)

$q = 7.92 \times 10^3\ C$ (1)

$W = Vq$

$W = 3.3 \times 7.92 \times 10^3$ (1)

$W = 2.61 \times 10^4\ J$ (1)

c) Calculate the total number of electrons the power bank is able to supply. (2 marks)

$\#e = \frac{q}{e}$

$\#e = \frac{7.92\times10^3}{1.6\times10^{-19}}$ (1)

$\#e = 4.95 \times 10^{22}$ (1)

d) Some students used a power meter to measure how much energy the power bank could supply and found it was $2.32 \times 10^4\ J$. Calculate how efficient the power bank is. (2 marks)

$\eta = \frac{energy\ output\ actual}{energy\ output\ theoretical} \times 100$

$\eta = \frac{2.32\times10^4}{2.61\times10^4} \times 100$ (1)

$\eta = 88.8\ \%$ (1)

End of Section Two

Section Three: Comprehension

Question 10 **(12 marks)**

The power output and resistance of a coiled heating element were investigated by measuring the current flowing through the heating element for different values of voltage applied across it.

The relationship between power, current and resistance is given by

$$P \;=\; I^2 R$$

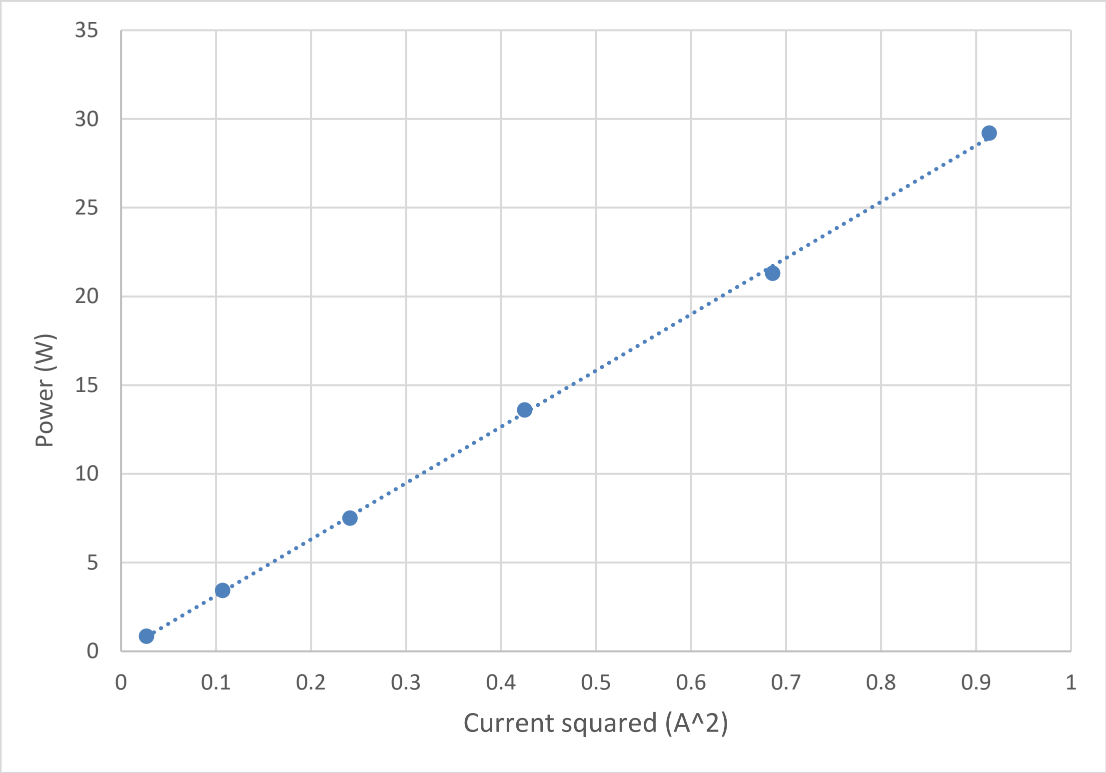
The measurements obtained over half a dozen trials during this investigation are recorded in the table below.

Voltage(V)	5.2	10.5	15.3	20.8	25.7	30.5	
Current(mA)	165	327	491	652	828	956	
Power P (W)	0.858	3.43	7.51	13.6	21.3	29.2	(1)
I^2 (A^2)	0.027	0.107	0.241	0.425	0.686	0.914	(1)

(a) Calculate the power produced by the heating element during each of these trials, and enter the values in the table above. (1 mark)

(b) Calculate the value of the square of the current for each of these trials, and enter the values in the table above. (1 mark)

(c) Sketch a graph of power versus current squared for the heating element, on the graph paper on the next page, using your data from the table above. (4 marks) labelled axes (1) uniform scales (1) plotted points (1) LOBF (1)



(d) Use your graph to calculate the resistance of the coiled heating element. (2 marks)

$$R = gradient = \frac{rise}{run} \quad points\ must\ be\ from\ LOBF \quad (1)$$

$$R = \frac{(28.5 - 3.0)}{(0.9 - 0.1)} = 31.9\ \Omega \quad (1)$$

(e) If the voltage across the heating element was 18.0 V, then

(i) use your answer from part (d) to find the current drawn by the heating element (if no answer from part (d), use a resistance value of 35 Ω) (2 marks)

$$I = \frac{V}{R} = \frac{18}{31.9} \quad (1)$$

$$I = 0.565\ A \quad or \quad 0.514\ A \quad (1)$$

(ii) use the graph to find the power output of the heating element (2 marks)

$$I^2 = 0.565^2 = 0.319\ A^2 \quad (1)$$

$$From\ graph, 0.319\ A^2 \rightarrow 10.2\ W \quad (1)$$

END OF TEST