

**Q1.** Columns **A** and **B** show some of the results from an experiment in which the current  $I$  through a component X was measured for various values of the potential difference  $V$  applied across it.

column A	column B	column C	column D
potential difference $V / V$	current $I / \text{mA}$	$(V - 0.55) / V$	$\ln (I / \text{mA})$
0.70	12.5		
0.75	17.0		
0.80	22.0		
0.85	29.0		
0.90	39.0		
0.95	51.5		

(a) Draw a diagram of a circuit which could have been used to obtain these results.

(2)

(b) (i) Calculate the resistance of X when the potential difference is 0.70 V.

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 .....

(ii) By considering **one** other value of potential difference, explain whether or not X is an ohmic conductor.

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

(3)

- (c) It is suggested that for potential differences greater than 0.55 V, the current voltage relationship for X is of the form.

$$I = A e^{k(V-0.55)}$$

where  $A$  and  $k$  are constants.

- (i) Complete **column C** and **column D** in the table above
- (ii) Plot a graph of  $\ln(I/\text{mA})$  on the  $y$ -axis against  $(V - 0.55)$  on the  $x$ -axis.

*(Allow one sheet of graph paper)*

- (iii) Use your graph to determine the constants  $k$  and  $A$ .

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- (iv) On the basis of your graph, discuss the validity of the above relationship.

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(10)  
(Total 15 marks)

**Q2.** A student wishes to collect data so he can plot the  $I$ - $V$  curve for a semiconductor diode.

- (a) (i) Draw a suitable diagram of the circuit that would enable the student to collect this data.

(3)

- (ii) Describe the procedure the student would follow in order to obtain an  $I$ - $V$  curve for the semiconductor diode.

The quality of your written communication will be assessed in this question.

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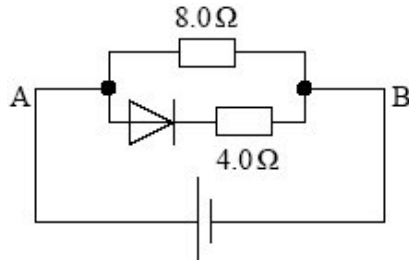
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(6)

(b) The diagram below shows an arrangement of a semiconducting diode and two resistors.



A 12.0 V battery is connected with its positive terminal to A and negative terminal to B.

(i) Calculate the current in the 8.0 Ω resistor

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answer ..... A

(2)

(ii) Calculate the current in the 4.0 Ω resistor if the p.d. across the diode, when in forward bias, is 0.65 V expressing your answer to an appropriate number of significant figures.

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answer ..... A

(3)

(Total 14 marks)

- M1.** (a) circuit diagram to show:  
ammeter in series, voltmeter in parallel **(1)**  
variable source (e.g. battery + rheostat or potential divider) **(1)**

2

(b) (i)  $R_x = \frac{0.70}{12.5 \times 10^{-3}} = 56 \Omega$  **(1)**

(ii)  $R_x =$  (e.g.)  $\frac{0.90}{39 \times 10^{-3}} = 23 (\Omega)$  **(1)**

$R_x$  depends on current (or voltage)  $\therefore$  non-ohmic

3

- (c) (i)

col C	col D
0.15	2.53
0.20	2.83
0.25	3.09
0.30	3.37
0.35	3.66
0.40	3.94

four pairs of values correct **(1)**

all six pairs correct and col D to no more than 4 s.f **(1)**

- (ii) axes labelled **(1)**  
suitable scales chosen **(1)**  
at least five points plotted correctly **(1)**  
acceptable straight line **(1)**

- (iii)  $k =$  gradient **(1)**

$$\text{gradient} = \frac{3.95 - 1.68}{0.40} = 5.7 (\text{V}^{-1})$$
 **(1)**

intercept on y-axis =  $\ln A$  **(1)**

(intercept = 1.68 gives)  $A = e^{1.68} = 5.4$  (mA) **(1)**

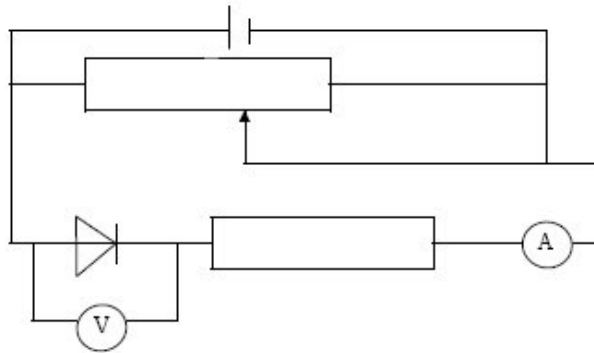
unit for  $k$  or  $A$  correct **(1)**

- (iv) the points define a straight line **(1)**  
valid over given range **(1)**

max 10

[15]

M2. (a) (i)



suitable variable input (variable power supply or variable resistor) **(1)**

protective resistor **and** diode **forward** biased **(1)**

correct current **and** pd measuring devices **(1)**

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(ii) the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication

QWC	descriptor	mark range
good-excellent	Uses accurately appropriate grammar, spelling, punctuation and legibility. Uses the most appropriate form and style of writing to give an explanation or to present an argument in a well structured piece of extended writing. [May include bullet points and/or formulae or equations]. Answer refers to at least 5 of the relevant points listed below.	5-6
modest-adequate	Only a few errors. Some structure to answer, style acceptable, arguments or explanations partially supported by evidence or examples. Answer refers to at least 3 of the relevant points listed below.	3-4
poor-limited	Several significant errors. Answer lacking structure, arguments not supported by evidence and contains limited information. Answer refers to no more than 2 of the relevant points.	1-2
incorrect, inappropriate or no response	No answer at all or answer refers to unrelated, incorrect or inappropriate physics.	0

**The explanation expected in a competent answer should include a coherent selection of the following physics ideas.**

connect circuit up **(1)**

measure current ( $I$ ) and pd/voltage ( $V$ ) **(1)**

vary resistance/voltage **(1)**

obtain a range of results **(1)**

reverse connections to power supply (and repeat) **(1)**

plot a graph (of pd against current) **(1)**

mention of significance of 0.6V **or** disconnect between readings **or** change range on meters when doing reverse bias **(1)**

(b) (i) (use of  $I = V/R$ )

$$I = 12/8 \text{ (1)} = 1.5\text{A (1)}$$

(ii)  $I = (12 - 0.65 \text{ (1)})/4 = 2.8 \text{ A (1) sig figs (1)}$

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[14]

