

2015 SCORING GUIDELINES

Question 2

15 points total

Distribution
of points

(a)

i. 2 points

Using Ohm's law:

$$V = IR$$

For a correct application of Kirchhoff's loop rule

$$\mathcal{E} = Ir + IR$$

$$I = \frac{\mathcal{E}}{(r + R)}$$

For a correct expression for the measured voltage across the variable resistor

$$V = \frac{\mathcal{E}}{(r + R)} R$$

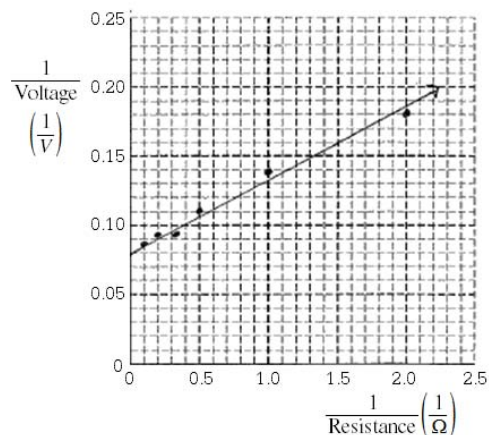
ii. 1 point

For an expression of $1/V$ as a function of $1/R$ consistent with answer from part

(a)(i)

$$\frac{1}{V} = \left(\frac{r}{\mathcal{E}}\right) \frac{1}{R} + \frac{1}{\mathcal{E}}$$

(b) 4 points



For correctly labeling both axes with variables and units

For correctly scaling both axes with an acceptable and appropriate scale

For correctly plotting the data points

For correctly drawing a straight line that best represents the data

1 point

1 point

1 point

1 point

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Question 2 (continued)

Distribution
of points

(c)

i. 2 points

For using a value for the y-intercept consistent with the straight line drawn in part (b)

$$y = mx + b$$

$$b = 0.080 \text{ 1/V}$$

For a correct substitution into the equation from part (a)(ii)

$$\frac{1}{V} = \frac{(r + R)}{\mathcal{E}} \frac{1}{R}$$

$$\frac{1}{V} = \frac{r}{\mathcal{E}} \frac{1}{R} + \frac{1}{\mathcal{E}}$$

$$b = 1/\mathcal{E}$$

$$\mathcal{E} = 1/(0.080 \text{ 1/V})$$

$$\mathcal{E} = 12.5 \text{ V}$$

1 point

1 point

ii. 2 points

For calculating the slope using the straight line from part (b) and not data points

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{(0.151 - 0.100)}{(1.50 - 0.40)} = 0.0463 \text{ } \Omega/\text{V}$$

For a correct substitution into equation from part (a)(ii)

$$m = \frac{r}{\mathcal{E}}$$

$$r = m\mathcal{E}$$

$$r = (0.0463 \text{ } \Omega/\text{V})(12.5 \text{ V})$$

$$r = 0.58 \text{ } \Omega$$

1 point

1 point

(d) 2 points

For using Ohm's law

$$\mathcal{E} = Ir$$

For a correct substitution of values from part (c):

$$(12.5 \text{ V}) = I(0.58 \text{ } \Omega)$$

$$I = 21.6 \text{ A}$$

1 point

1 point

(e) 2 points

For selecting "The voltmeter with high resistance"

For a correct justification

Example: The voltmeter acts like a resistor in a circuit with the battery. It will measure the potential difference across its own internal resistance. The higher its internal resistance, the closer its potential difference will be to the emf of the battery.

1 point

1 point