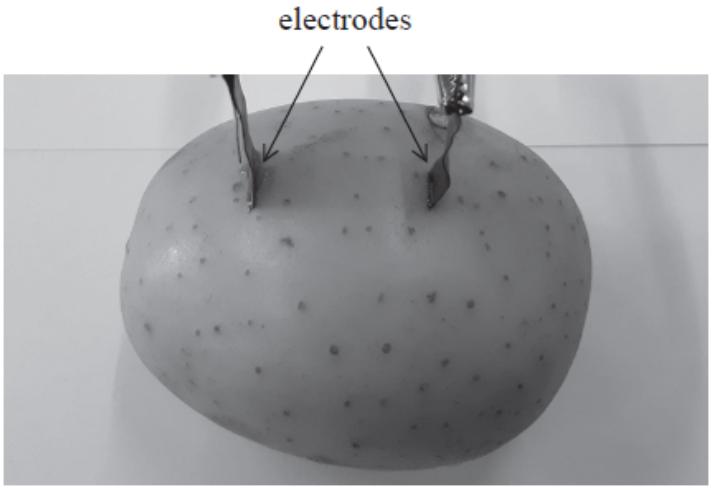
Questions

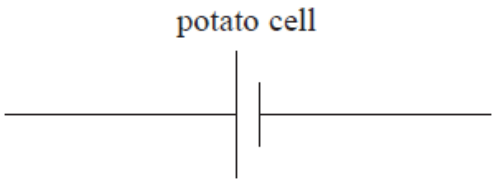
Q1.

A student carried out an experiment to determine the e.m.f. ε and internal resistance r of a potato cell. The potato used in the experiment was connected to the rest of the circuit using electrodes of two different metals as shown.

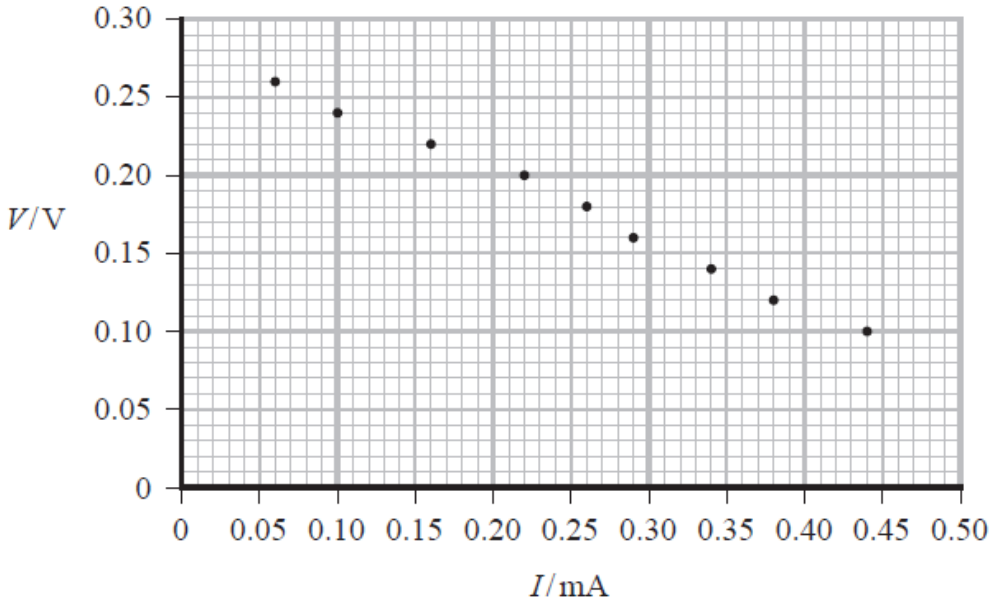


(a) Complete the diagram below to show a circuit that could be used in order to determine ε and r for the potato cell.

(2)



(b) The student completed the experiment and plotted a graph showing the relationship between potential difference V and current I as shown.



Use the graph to determine values for ε and r.

(4)

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ε = ...

r = ...

(c) In a separate experiment two resistors, with equal resistance R, are connected

to a battery (with internal resistance r) with the two resistors firstly in a series arrangement (diagram A) and then in a parallel arrangement (diagram B).

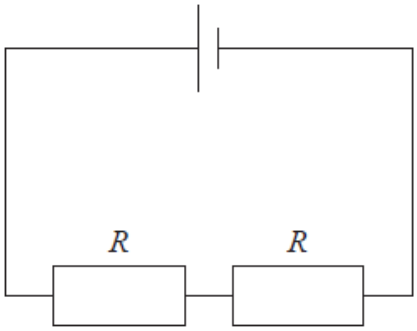

Diagram A

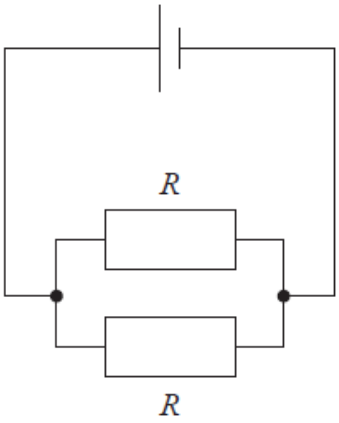

Diagram B

Explain which, if either, of the two arrangements would lead to a greater value for the terminal potential difference.

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(Total for question = 10 marks)

Q2.

(1)

A car battery is constructed using six cells connected in series, with a combined electromotive force (e.m.f.) of 12.00 V.

(a) State what is meant by e.m.f.

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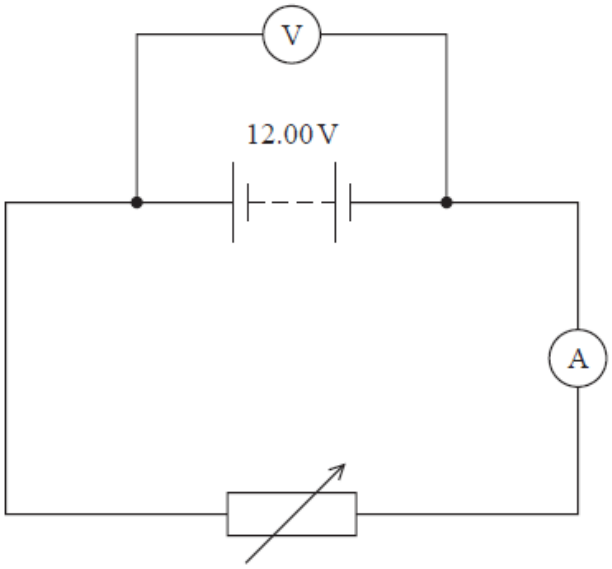
(b) A student set up the circuit shown, using the car battery.



The student adjusted the variable resistor until the reading on the voltmeter was 11.81 V. The reading on the ammeter was 9.83 A.

(i) Calculate the internal resistance of the car battery.

(2)

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Internal resistance = ...

(ii) The student adjusted the variable resistor several times and recorded corresponding values from the ammeter and voltmeter.

Describe how the values can be used to determine the internal resistance of the battery using a graphical method.

..... **(3)**

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(c) With use, the internal resistance of a battery will increase. Eventually the power available from a battery will become too small to be useful.

The student calculated the power available from a battery of e.m.f 9.0 V and internal resistance 0.10 Ω when connected across a 5.0 Ω resistor.

He concluded that when the internal resistance had risen to 0.50 Ω, the power dissipated in the 5.0 Ω resistor would reduce to 70% of its original value.

Determine whether the student's conclusion is correct.

(4)

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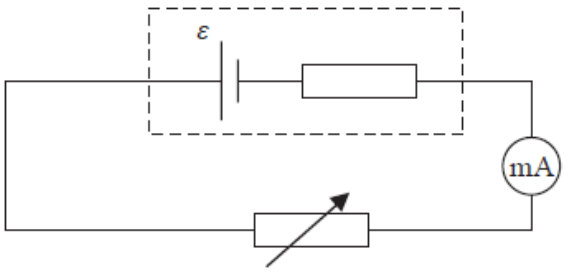
(Total for question = 10 marks)

Q3.

A cell of e.m.f. ε is connected in series with a variable resistor with resistance R as shown. The internal resistance of the cell is r.



When R is 12 Ω, the reading on the ammeter is 107 mA. The circuit is switched on for 300 seconds. In this time, 50 J of energy is transferred by the cell.

(a) Calculate r.

(5)

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r = ...

(b) Increasing R would make the terminal potential difference value closer to ε.

Explain why, without further calculation.

(2)

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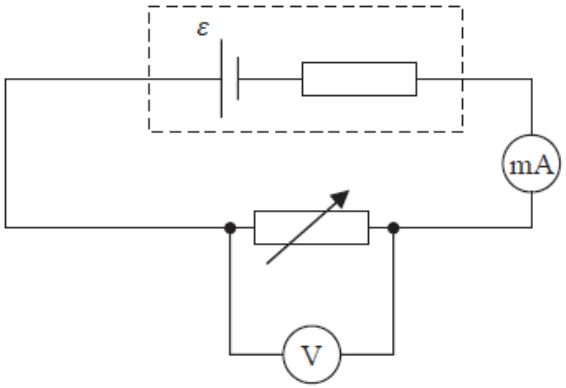
(c) A voltmeter is added to the circuit as shown.



Explain how this circuit can be used to determine a value for *r* using a graphical method.

(4)

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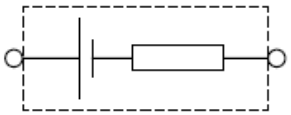
(Total for question = 11 marks)

Q4.

A student is asked to determine the e.m.f. and internal resistance of a cell using standard laboratory apparatus and a graphical method.

(a) The diagram below shows a cell with internal resistance. Add to the diagram to show the circuit she could use.

(2)



(b) Explain how she should determine the e.m.f. and internal resistance of the cell. Your answer should include a sketch of the graph.

(5)

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(Total for question = 7 marks)

Q5

A student is asked to determine the emf and internal resistance of a 1.5 V cell. Write a plan for an experiment which could be used to do this using standard laboratory apparatus and a graphical method.

You should:

(a) draw a diagram of the circuit to be used, **(2)**

(b) state the quantities to be measured, **(1)**

(c) for **two** of these quantities state and explain your choice of measuring instrument, **(4)**

(d) explain how the data collected will be used to find the emf and the internal resistance, **(3)**

(e) identify the main sources of uncertainty and/or systematic error, **(2)**

(f) comment on safety. **(1)**

(Total for Question 7 = 13 marks)

6 A student is investigating the current in a circuit. The circuit is set up as shown in Fig. 2.1
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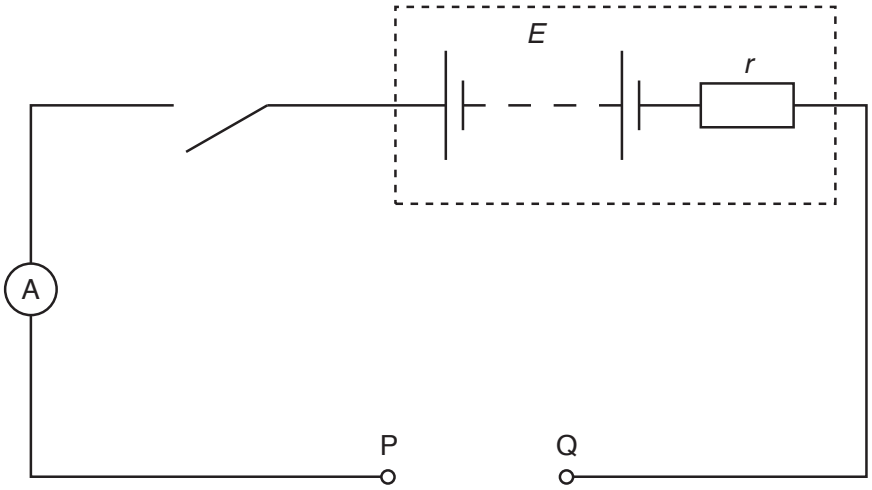


Fig. 2.1

Resistors, each of resistance R, are connected in parallel between P and Q. The current I is measured. The experiment is repeated for different numbers n of resistors between P and Q.

It is suggested that I and n are related by the equation

$$E = I\left(\frac{R}{n} + r\right)$$

where E is the electromotive force (e.m.f.) and r is the internal resistance of the power supply.

(a) A graph is plotted of $\frac{1}{I}$ on the y-axis against $\frac{1}{n}$ on the x-axis.

Determine expressions for the gradient and the y-intercept.

gradient = ...

y-intercept = ...
[1]

(b) Values of n, I and $\frac{1}{n}$ are given in Fig. 2.2.

n	I / mA	$\frac{1}{n}$	$\frac{1}{I}$ / A^{-1}
2	34 ± 2	0.50	
3	46 ± 2	0.33	
4	56 ± 2	0.25	
5	66 ± 2	0.20	
6	76 ± 2	0.17	
7	84 ± 2	0.14	

Fig. 2.2

Calculate and record values of $\frac{1}{I}$ / A^{-1} in Fig. 2.2.

Include the absolute uncertainties in $\frac{1}{I}$. [2]

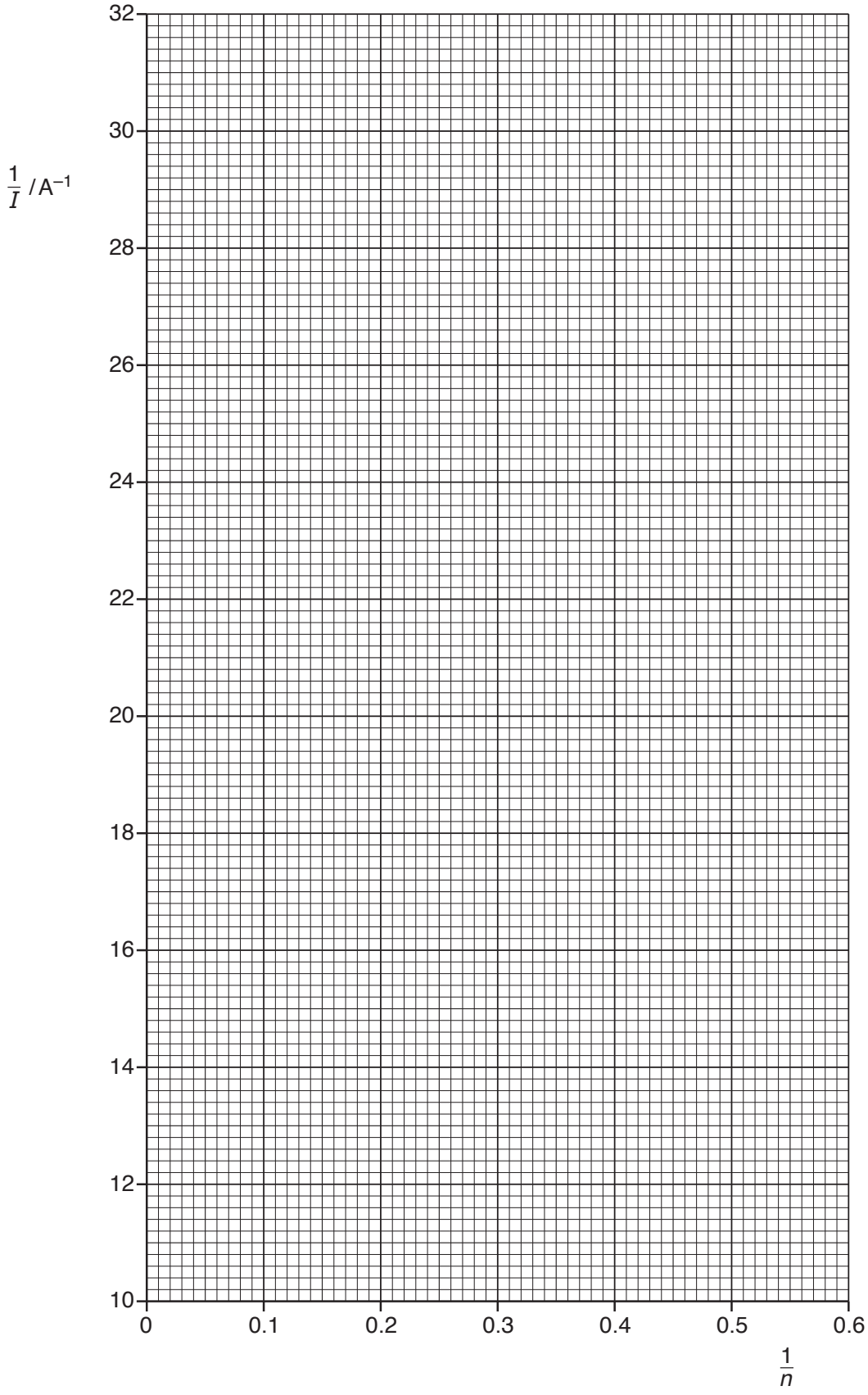
(c) **(i)** Plot a graph of $\frac{1}{I}$ / A^{-1} against $\frac{1}{n}$.

Include error bars for $\frac{1}{I}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

gradient = ... [2]


$\frac{1}{I}$ / A^{-1}
32
30
28
26
24
22
20
18
16
14
12
10
0
0.1
0.2
0.3
0.4
0.5
0.6
$\frac{1}{n}$

(iv) Determine the *y*-intercept of the line of best fit. Include the absolute uncertainty in your answer.

y-intercept = ... [2]

(d) (i) Using your answers to **(a)**, **(c)(iii)** and **(c)(iv)**, determine the values of E and r. Include appropriate units.

Data: $R = 470 \pm 5\,\Omega$.

E = ...

r = ...
[3]

(ii) Determine the percentage uncertainty in r.

percentage uncertainty in r = ...% [1]

[Total: 15]

7 A student is investigating an electrical circuit containing a length of nichrome wire

. The circuit is set up as shown in Fig. 2.1.

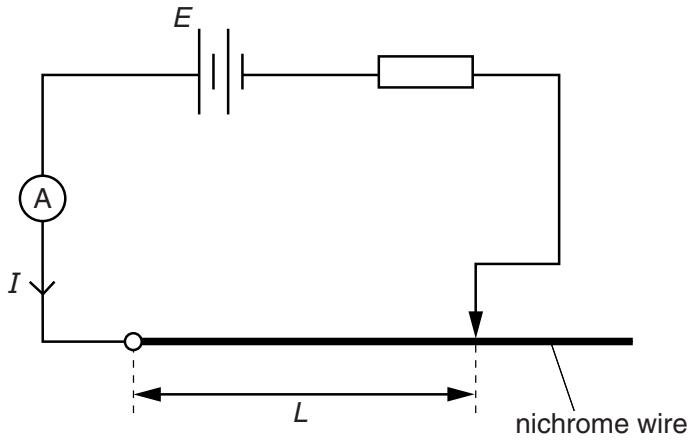


Fig. 2.1

The length L of the wire in the circuit is varied and the current I is measured.

It is suggested that I and L are related by the equation

$$\frac{1}{I} = \frac{4\rho L}{\pi E d^2} + \frac{r}{E}$$

where E is the e.m.f. of the battery, d is the diameter of the wire and ρ and r are constants.

(a) A graph is plotted of $\frac{1}{I}$ on the y-axis against L on the x-axis.

Determine expressions for the gradient and y-intercept.

gradient = ...

y-intercept = ...

[1]

(b) Values of L and I are given in Fig. 2.2.

$L/10^{-2}$ m	I/A	
40.0	0.24 ± 0.01	
48.0	0.20 ± 0.01	
60.0	0.17 ± 0.01	
70.0	0.15 ± 0.01	
80.0	0.13 ± 0.01	
92.0	0.12 ± 0.01	

Fig. 2.2

Calculate and record values of $\frac{1}{I}$/A^{-1} in Fig. 2.2.

Include the absolute uncertainties in $\frac{1}{I}$/A^{-1}. [3]

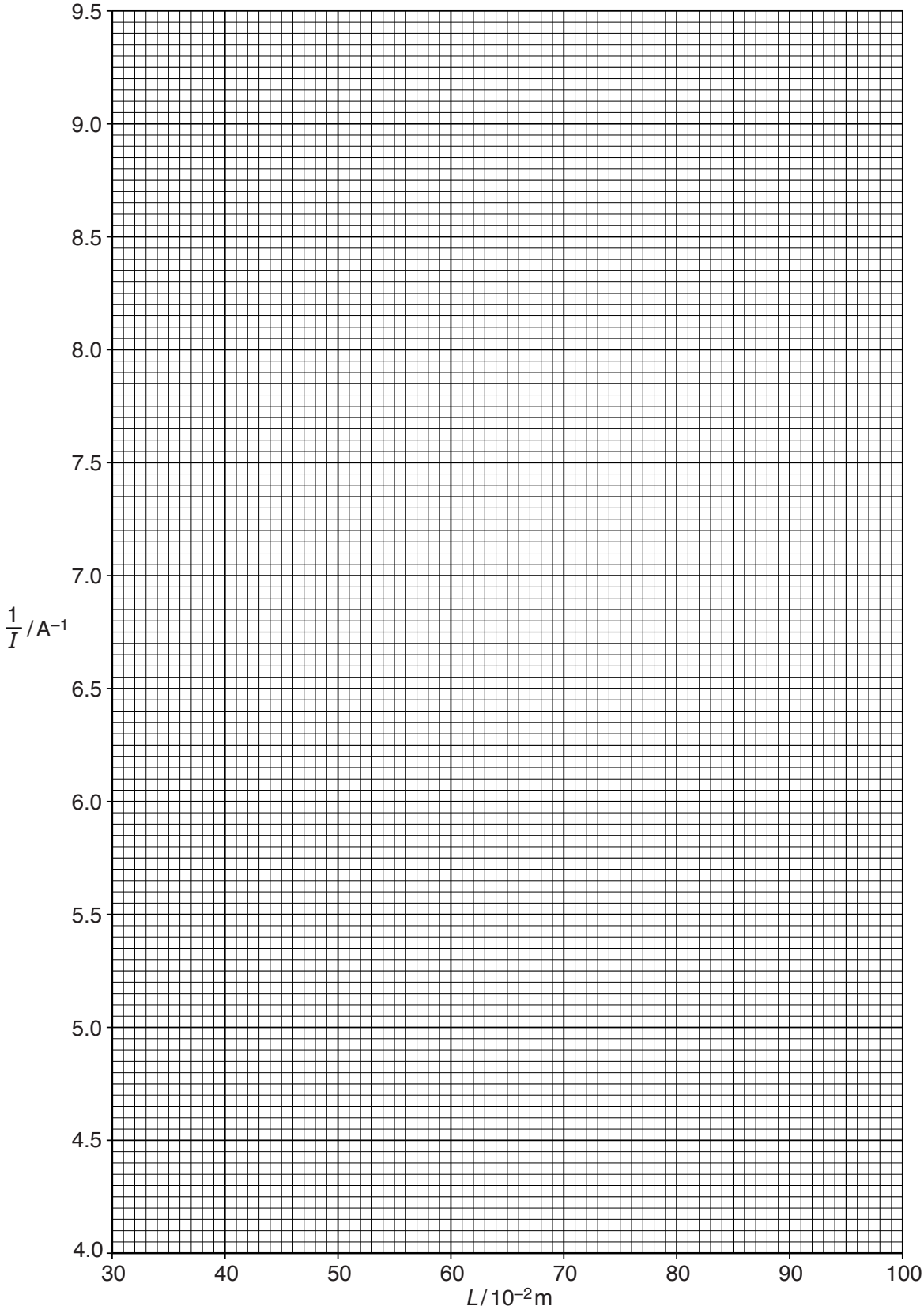
(c) **(i)** Plot a graph of $\frac{1}{I}$/A^{-1} against $L/10^{-2}$ m.

Include error bars for $\frac{1}{I}$/A^{-1}. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

gradient = ... [2]


9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
$\frac{1}{I}$ / A^{-1}
30
40
50
60
70
80
90
100
L / 10^{-2} m

(iv) Determine the *y*-intercept of the line of best fit. Include the absolute uncertainty in your answer.

y-intercept = ... [2]

(d) (i) Using your answers to **(a)**, **(c)(iii)** and **(c)(iv)**, determine the values of ρ and r. Include appropriate units.

Data: $E = 3.2 \pm 0.1\,\text{V}$ and $d = 0.31 \pm 0.01\,\text{mm}$.

ρ = ...

r = ...

[2]

(ii) Determine the percentage uncertainty in ρ.

percentage uncertainty in ρ = ... % [1]