**2** A student investigates an electrical circuit.

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

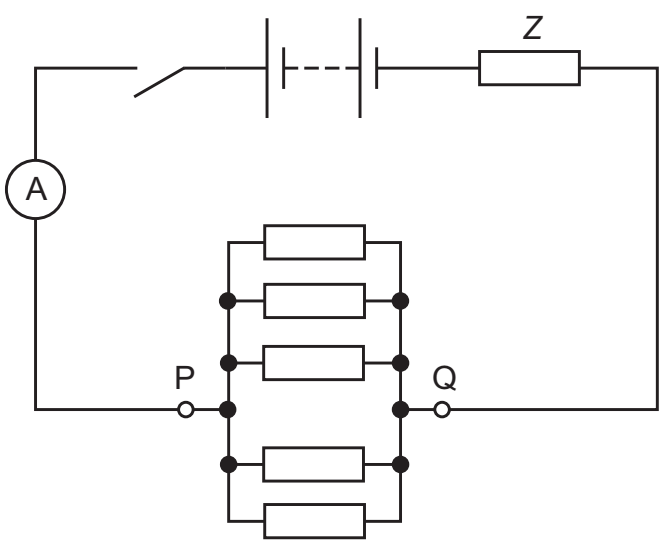



**Fig. 2.1**

A battery of negligible internal resistance is connected to a resistor of resistance $Z$. Five resistors, each of resistance $R$, are connected in parallel between P and Q.

The switch is closed. The total current $I$ in the circuit is measured using the ammeter.

The experiment is then repeated by changing the number $n$ of resistors, each of resistance $R$, connected in parallel between P and Q.

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

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

where $E$ is the electromotive force (e.m.f.) of the battery.

**(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 $y$-intercept.

gradient = .....

$y$-intercept = .....
[1]

**(b)** Values of $n$, $\frac{1}{n}$ and $I$ are given in Table 2.1.

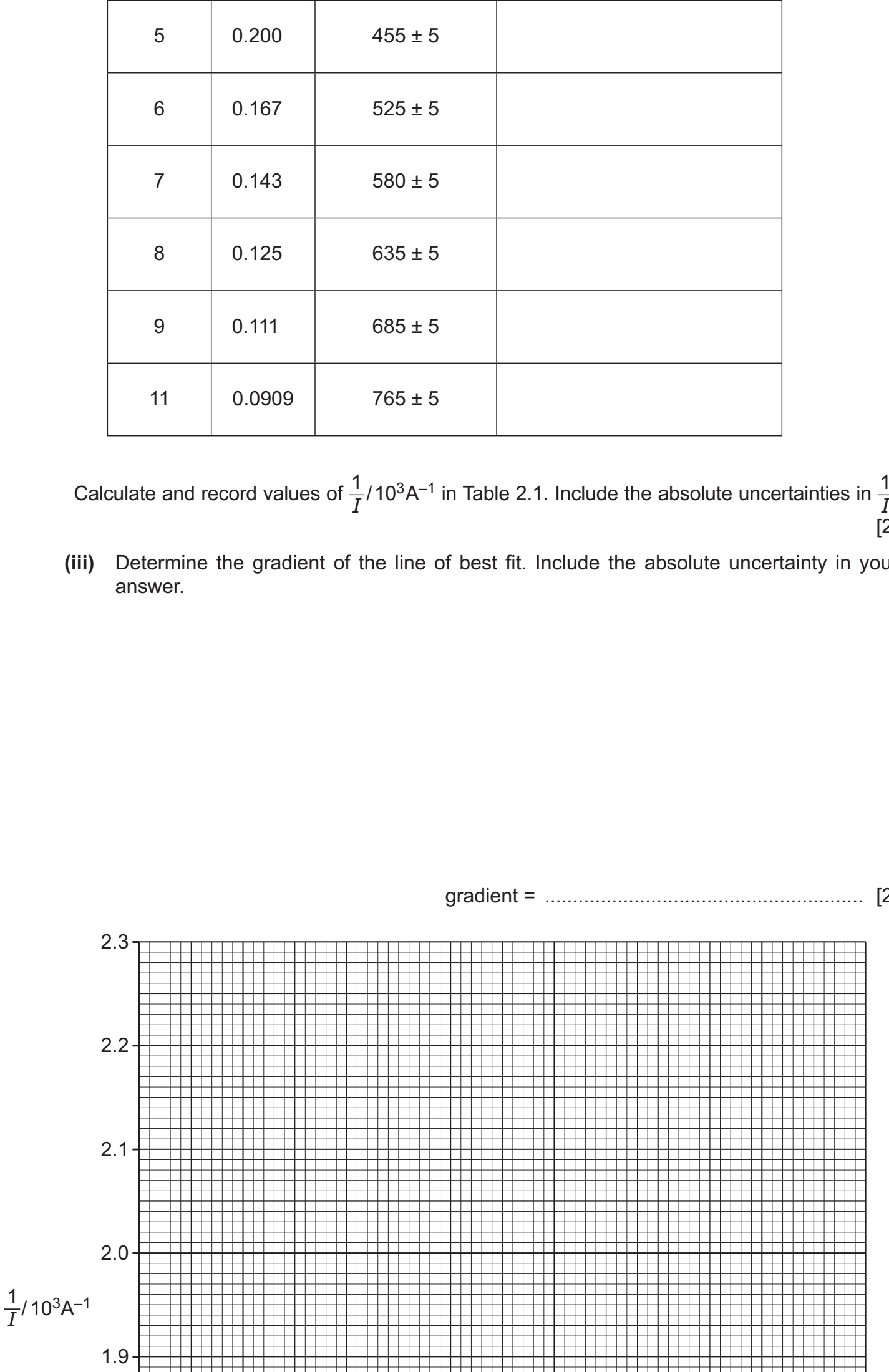
**Table 2.1**

| $n$ | $\frac{1}{n}$ | $I$/μA | $\frac{1}{I}/10^3\text{A}^{-1}$ |
|---|---|---|---|
| 5 | 0.200 | 455 ± 5 | |
| 6 | 0.167 | 525 ± 5 | |
| 7 | 0.143 | 580 ± 5 | |
| 8 | 0.125 | 635 ± 5 | |
| 9 | 0.111 | 685 ± 5 | |
| 11 | 0.0909 | 765 ± 5 | |

Calculate and record values of $\frac{1}{I}/10^3\text{A}^{-1}$ in Table 2.1. Include the absolute uncertainties in $\frac{1}{I}$.
[2]

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

gradient = ..... [2]




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

$y$-intercept = ..... [2]

**(d)** The e.m.f. $E$ of the battery is determined twice during the experiment. The values obtained are 5.6 V and 6.0 V.

**(i)** Using your answers to **(a)**, **(c)(iii)** and **(c)(iv)**, determine the values of $R$ and $Z$. Include appropriate units.

$R$ = .....

$Z$ = .....
[2]

**(ii)** Determine the percentage uncertainty in your value of $R$.

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

**(e)** The experiment is repeated with 20 resistors, each of resistance $R$, connected in parallel between P and Q. Determine the total current $I$ in the circuit.

$I$ = ..... A [1]

[Total: 15]