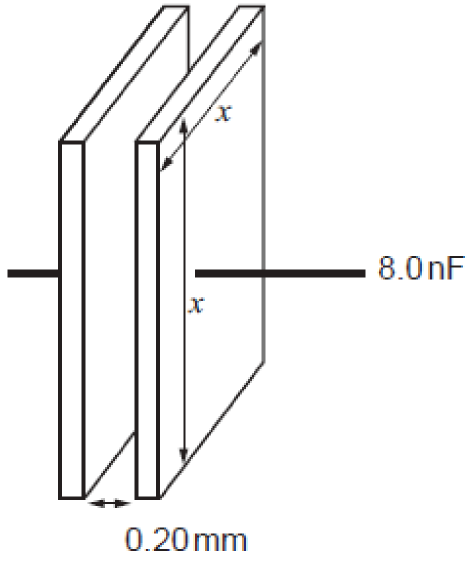
#1

(a) (i) An 8.0 nF capacitor has square plates separated by 0.20 mm of air. Calculate the length (x) of the sides of the plates. [3]



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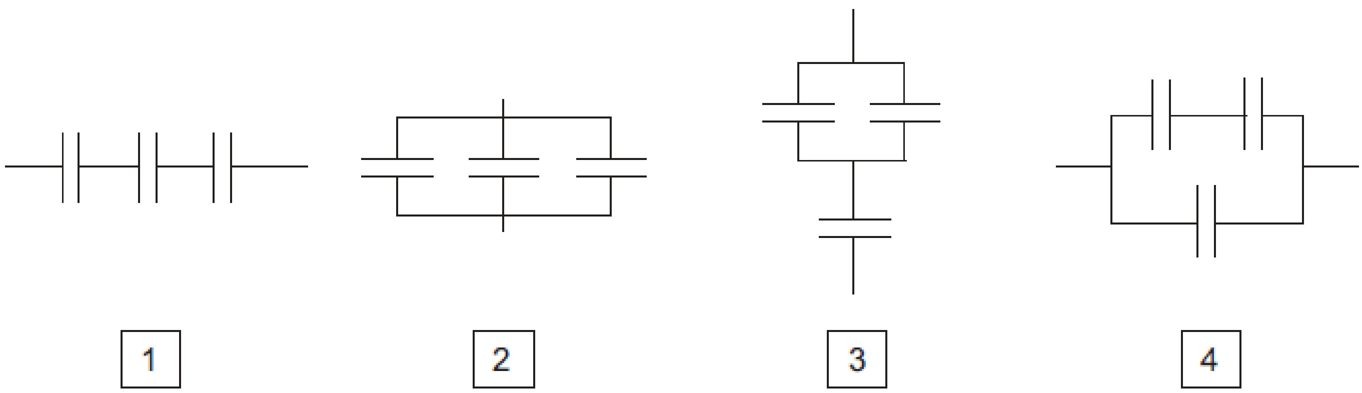
(ii) Which of the following combinations of 8.0 nF capacitors has a capacitance of 12.0 nF? Justify your answer. [4]

All individual capacitors shown are 8.0 nF.



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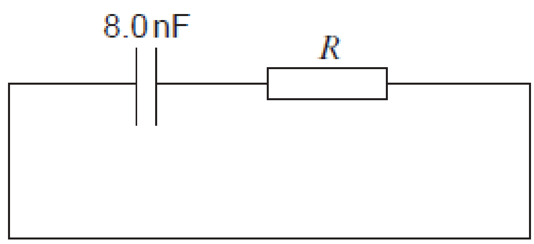
(iii) State how the capacitance of the capacitor can be increased without changing its dimensions. [1]

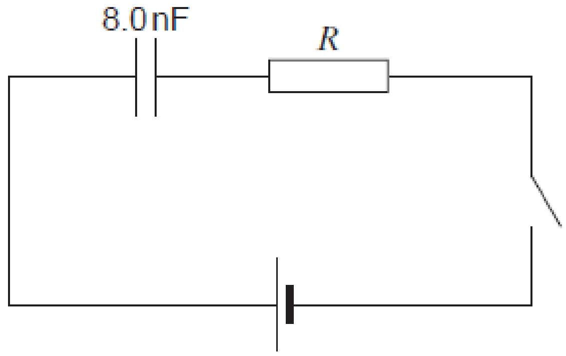
(iv) Calculate the charge on the plates of the 8.0 nF capacitor when it stores an energy of 0.62 μJ. [3]

(b) (i) A charged 8.0 nF capacitor is discharged through a large resistor. Calculate the resistance of the resistor if the time constant is 15.5 ms. [2]



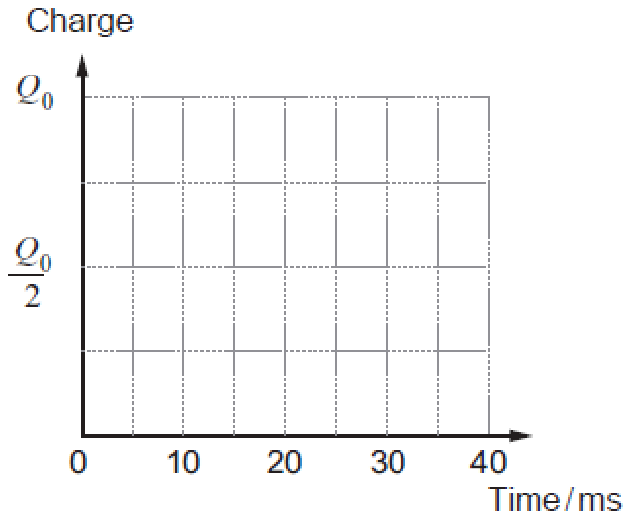
(ii) Calculate the fraction of the initial charge remaining on the capacitor after 31.0 ms. [3]

(c) An identical, uncharged 8.0 nF capacitor is **charged** in the following circuit, **using the same large resistor, *R***. The switch is closed and the capacitor is uncharged at time $t = 0$.

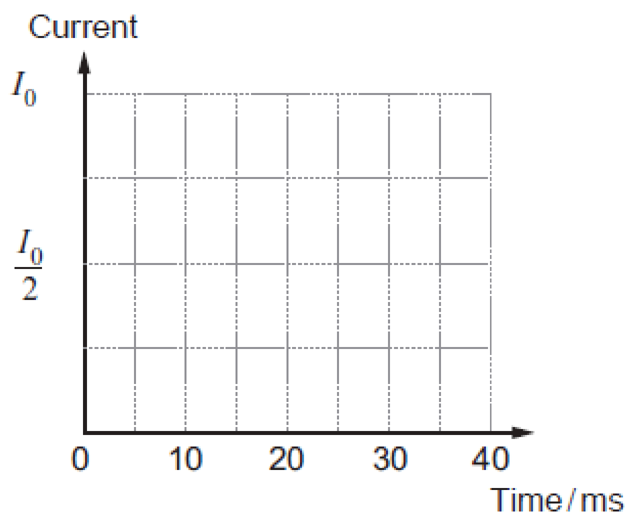


Without further calculations, sketch graphs of:

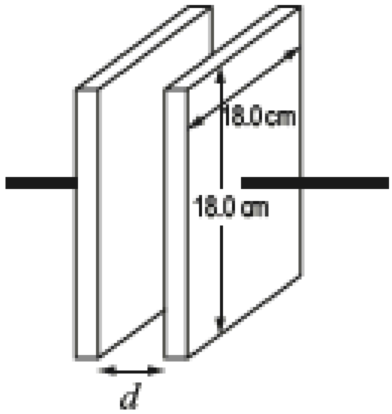
(i) the charge on the plates of the capacitor against time; [2]



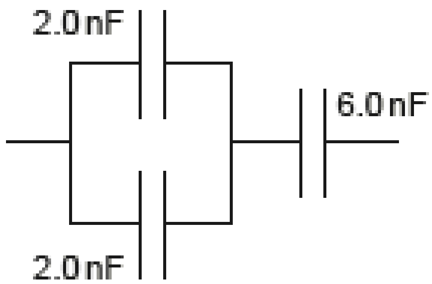
(ii) the current in the circuit against time. [2]



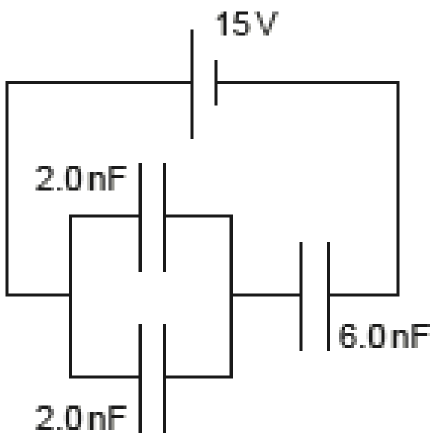
1. *(a)* (i) A laboratory technician has two square aluminium plates with sides of length 18.0 cm. Calculate the separation, d, of the plates that produces a capacitance of 2.0 nF. [3]



(ii) Calculate the capacitance of the capacitor combination shown. [3]



(iii) Show that the charge stored on a 2.0 nF capacitor in the following circuit is 18 nC. [3]



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(iv) Calculate the total energy stored by the capacitor combination. [2]

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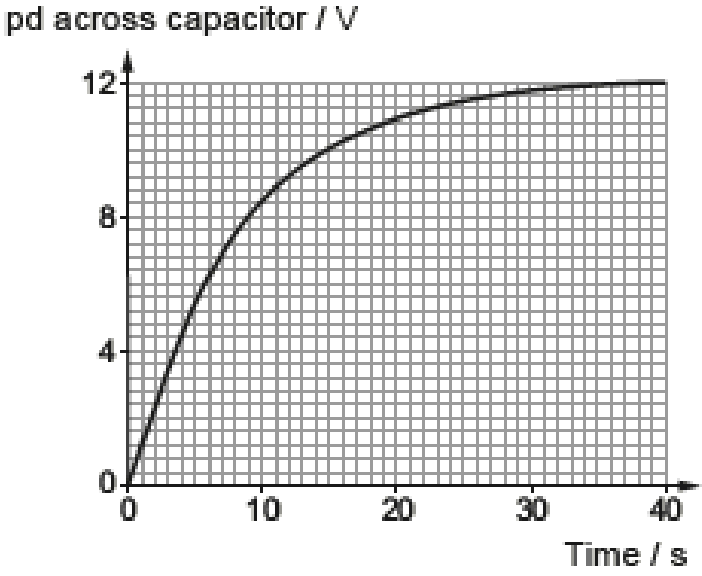
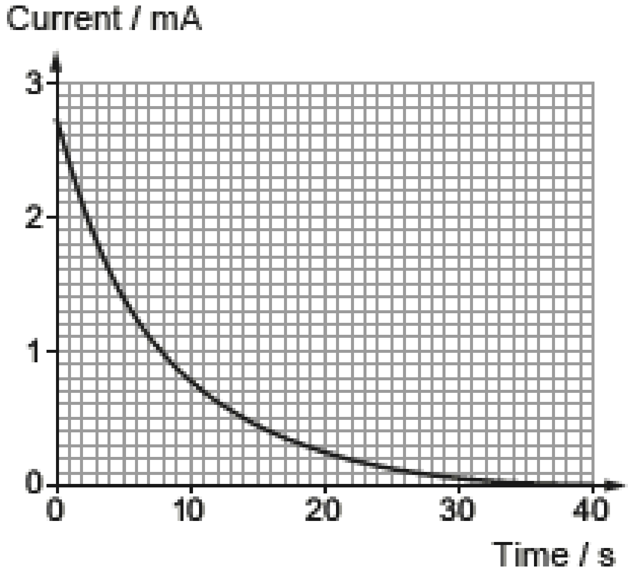
(b) A group of students investigated the charging of a capacitor through a resistor and obtained the following data.





(i) Draw a circuit diagram of the apparatus that might have been used to obtain the data. [2]

(ii) Use the graphs to determine:

- the emf of the power supply;
- the resistance of the resistor;
- the capacitance of the capacitor. [5]

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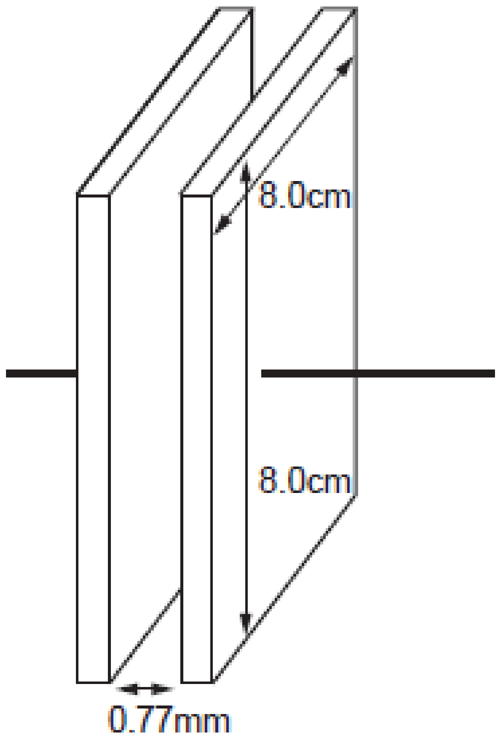
#3

1. *(a)* (i) For the air-spaced parallel plate capacitor shown, calculate the pd applied when it stores 25.5 μJ of energy. [4]



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(ii) Explain why the capacitor stores energy when a pd is applied to the plates. [2]

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(iii) A group of scientists claim that they have developed a new dielectric that enables the above capacitor to store a million times more charge and energy for a given pd. Explain what further steps must be taken by the scientific community and industry before this new dielectric can be used in devices and sold to the public. [3]

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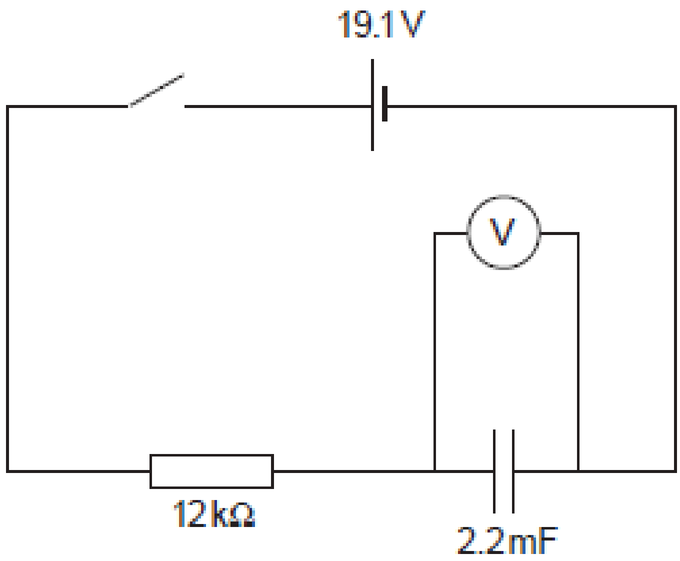
(b) Bethan investigates the charging of a capacitor using the following circuit.



The results she obtains are then tabulated.

Time / s	pd across capacitor / V ± 0.5 V	Charge on capacitor / mC ± 1.1 mC
10.0	6.1	13.4
20.0	10.0	22.0
30.0	12.8	....
40.0	15.1	33.2
50.0	16.2	35.6
60.0	17.1	....
70.0	17.7	38.9
80.0	18.3	40.3

(i) Confirm that the uncertainty in the charge is 1.1 mC (you may assume that the uncertainty in the 2.2 mF capacitor is negligible). [1]

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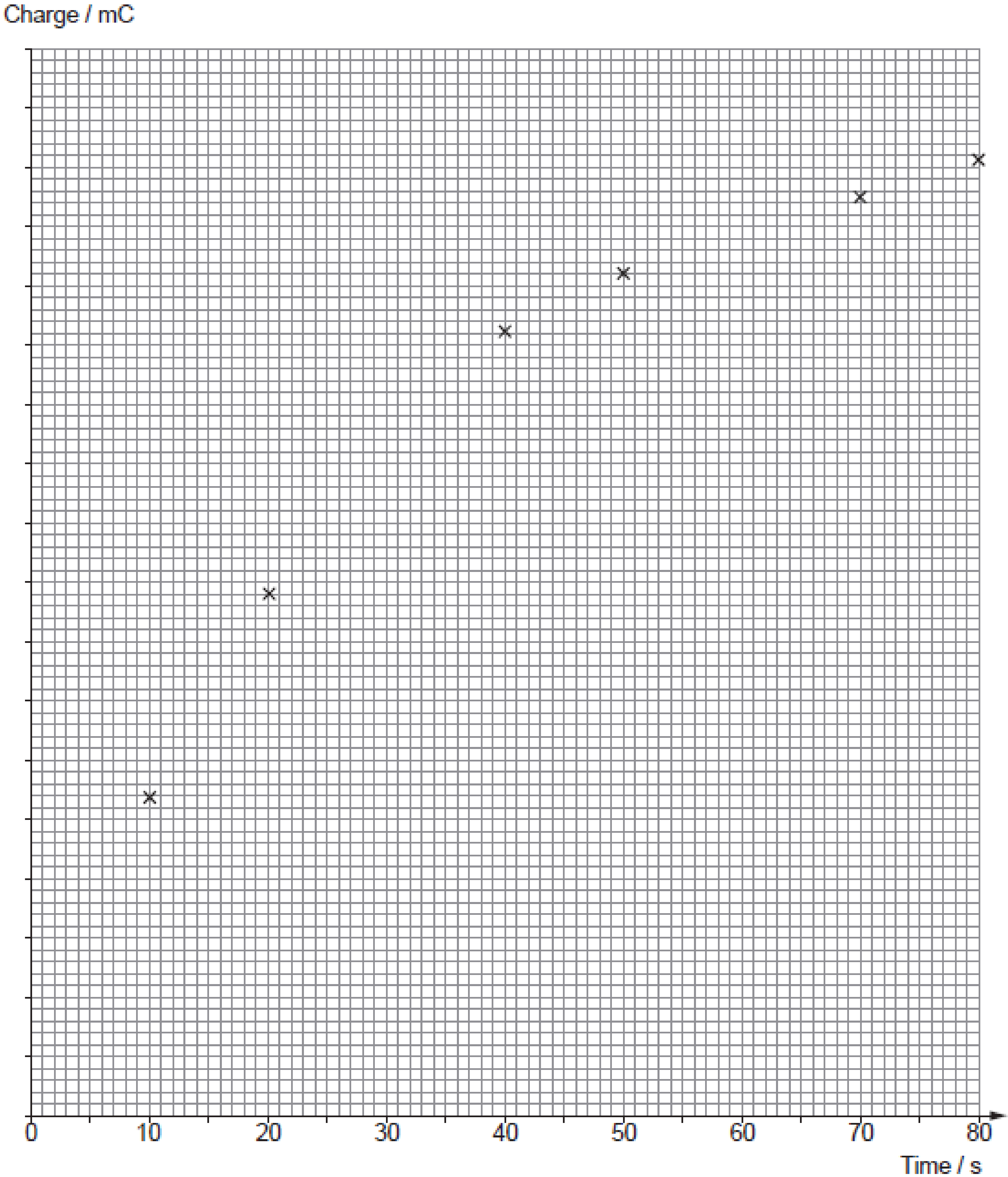
(ii) Complete the table. [2]

(iii) Complete the graph by labelling the y-axis scale, plotting the remaining two points, adding error bars for charge and drawing a curve of best fit. [5]



(iv) **Use the curve of best fit** to obtain the time constant of the charging circuit (show your working and do not simply multiply the resistance by the capacitance). [3]

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(v) By drawing a suitable tangent, calculate the current in the circuit at 45 s. [2]

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(c) Use the graph on page 5 and your answers to *(b)*(iv) and *(b)*(v) to evaluate whether or not the data obtained in this experiment are in good agreement with the equations: [5]

$$Q = Q_0\left(1 - e^{-\frac{t}{RC}}\right) \text{ and } I = I_0 e^{-\frac{t}{RC}}$$

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