Section A Part 2

Follow the instructions given below.

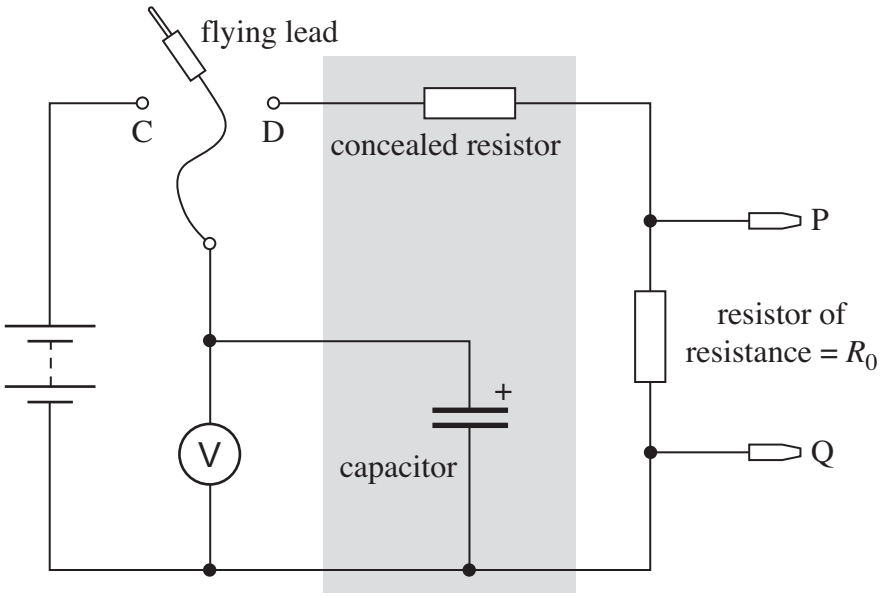
Answer **all** the questions in the spaces provided.

No description of the experiment is required.

1 In this experiment you are to investigate the discharge of a capacitor through different combinations of resistors.

You are provided with the circuit shown in **Figure 4**, part of which is concealed, as shown by the shaded region on the diagram.

Figure 4



concealed part of the
circuit shown shaded

1 (a) Charge the capacitor by connecting the flying lead to terminal C.
The voltmeter will show a steady reading.

Connect the flying lead to terminal D so that the capacitor discharges through the concealed resistor and the resistance R_0.
The voltmeter reading will be seen to fall exponentially.

Make suitable measurements to determine T_0, the time for the voltmeter reading to decrease by 50%.

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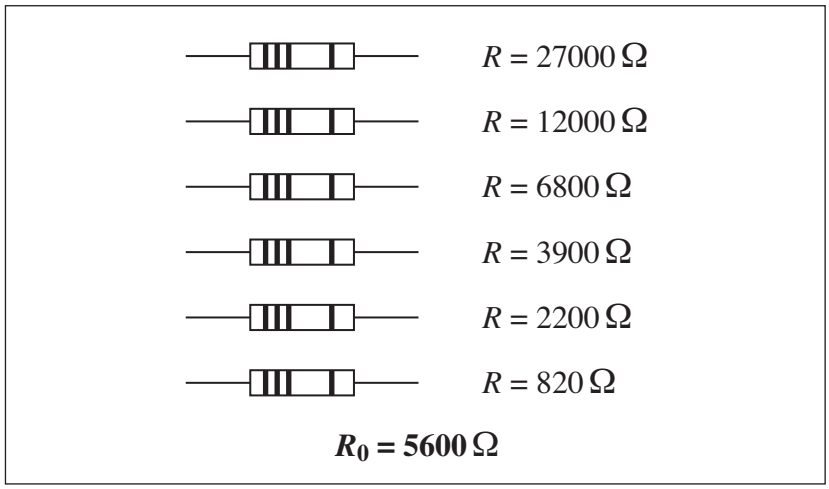
T_0 = ...

(1 mark)

1 (b) You are provided with a postcard to which six resistors have been attached; the resistance, R, of each of these is printed on the card, as shown in **Figure 5**.

Figure 5



Connect the resistor with $R = 27000\,\Omega$ between clip P and clip Q so that it is in parallel with resistor R_0.

Using the same procedure for charging and then discharging the capacitor as before, make suitable measurements to obtain T, the time for the voltmeter reading to decrease by 50%.

Repeat the procedure using each resistor, in turn, between P and Q, until you have obtained values of T for all six resistors.

Record your measurements and observations below.

(4 marks)

1 (c) Use the value of R_0 printed on the postcard to calculate values of $\frac{R}{R+R_0}$ that correspond to each of your values for T.

Record these data below.

(2 marks)

1 (d) Plot, on the grid opposite, a graph with $\frac{R}{R+R_0}$ on the vertical axis and T on the horizontal axis.

(9 marks)

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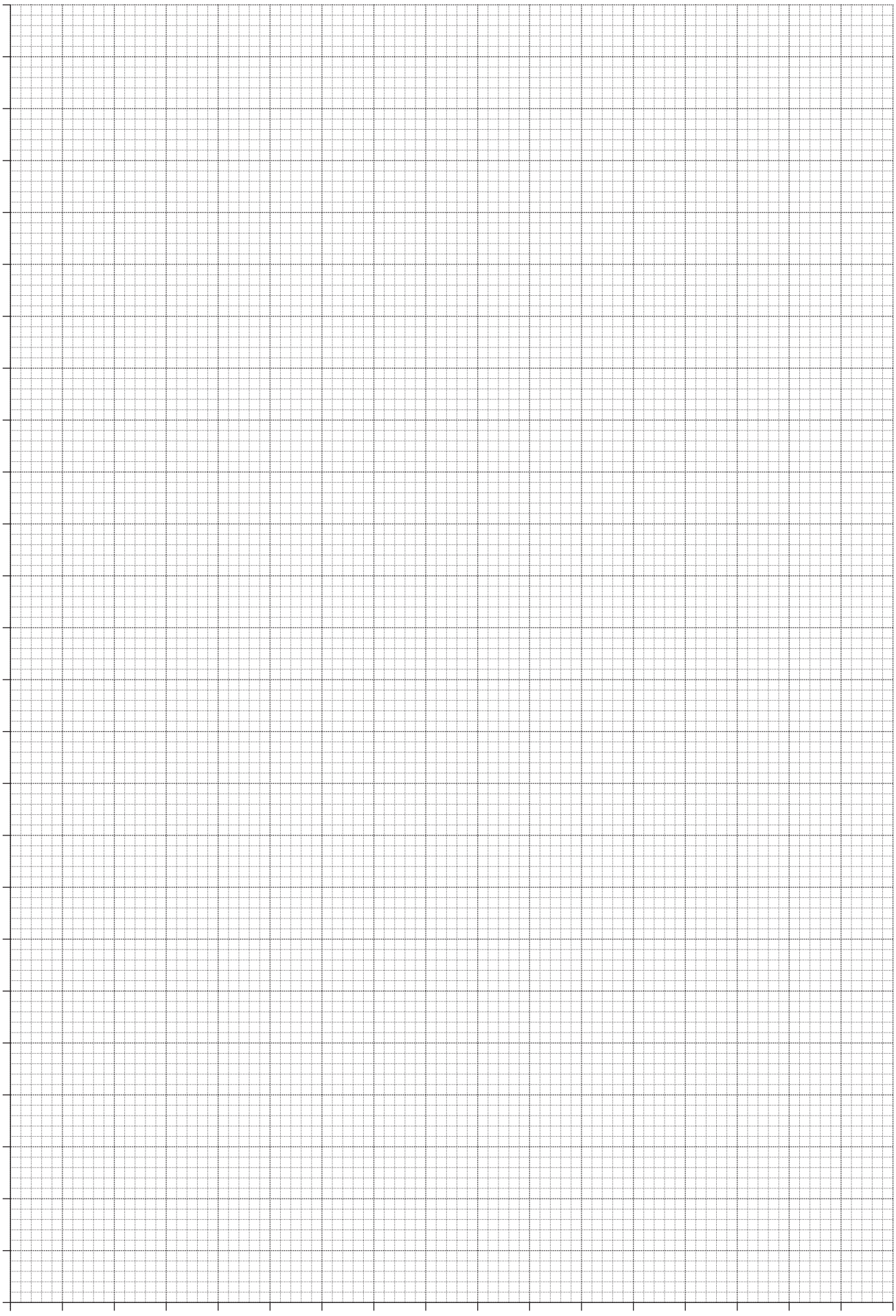
END OF QUESTIONS



Section B

Answer **all** the questions in the spaces provided.

You will need to refer to the work you did in Section A Part 2 when answering these questions.

1 (a) (i) Determine the gradient, G, of your graph of $\frac{R}{R+R_0}$ against T.

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G = ...

(2 marks)

1 (a) (ii) Calculate GT_0.

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GT_0 = ...

(2 marks)

1 (b) When no resistor is connected between clip P and clip Q, the time, T, for the voltmeter reading to fall by 50% = T_0.

1 (b) (i) State the value of R when $T = T_0$.

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(1 mark)

1 (b) (ii) Explain how T_0 could be obtained from your graph of $\frac{R}{R+R_0}$ against T.

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(1 mark)

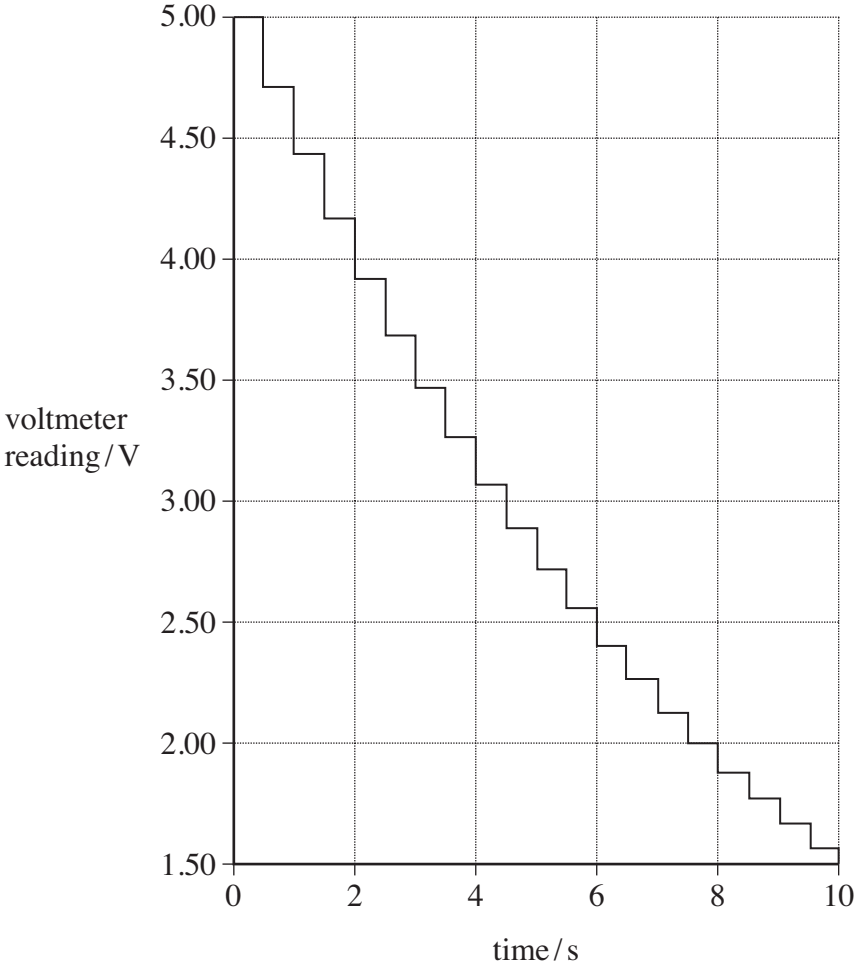
Turn over for the next question

6

2 A student carried out the experiment on Section A Part 2, making measurements to determine the time, T, for the voltmeter reading to fall by 50% for different values of R, including smaller values than you used.
The digital voltmeter used by the student had certain characteristics that may have introduced uncertainty in the measurements of T.

2 (a) The first characteristic is the *sample rate*; this is the rate at which readings are transferred to the display of the meter. For the type of digital voltmeter used, a typical sample rate is 2 Hz.
Figure 6 shows how the voltmeter reading varied with time as the capacitor was discharged.

Figure 6



2 (a) (i) Explain how **Figure 6** shows that the sample rate of the voltmeter is 2 Hz.

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(1 mark)

2 (a) (ii) With reference to **Figure 6**, outline **one** difficulty that the student would find when measuring *T* using the readings displayed on the voltmeter.

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(2 marks)

2 (a) (iii) A teacher suggests that the student should wait until the voltmeter reading has fallen by 75% before stopping the watch.
Explain how the value of *T* can be obtained using this method and explain why the uncertainty in the result would be reduced.

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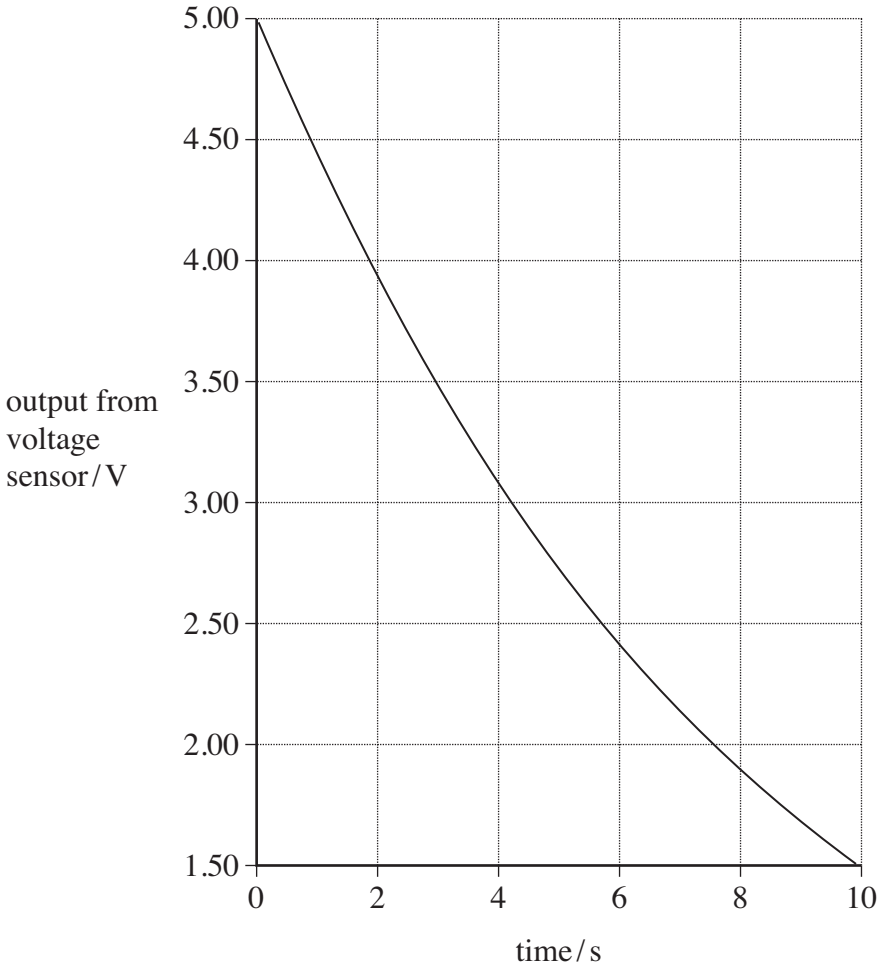
(2 marks)

Question 2 continues on the next page

A different student replaced the digital voltmeter with a voltage sensor connected to a data logger. The results of this experiment are shown in **Figure 7**.

Figure 7



2 (a) (iv) Explain why the results displayed in **Figure 7** show a continuous curve whereas those represented in **Figure 6** show a stepped line.

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(1 mark)

2 (b) The second characteristic of the meter that affects the measurements of T is the *resistance of the voltmeter*. The voltmeter provides another conducting route through which the capacitor can discharge, effectively lowering the resistance of the circuit. This causes all the readings of T to be less than they should have been.

2 (b) (i) What type of error does this cause in your measurements for T?

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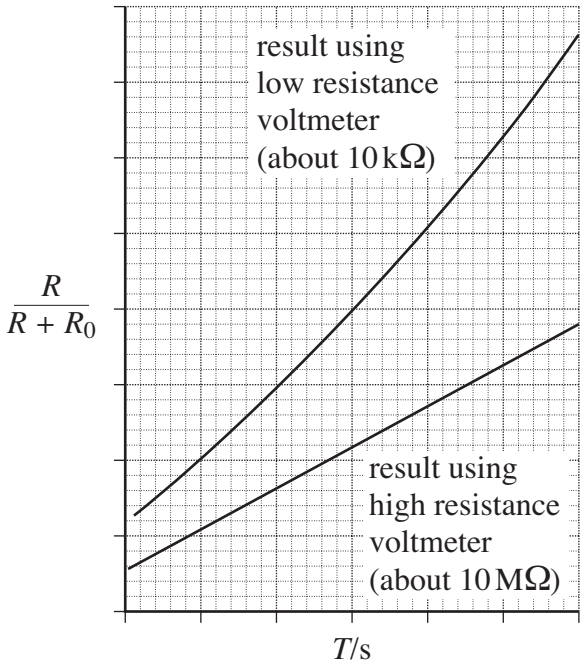
(1 mark)

Figure 8 illustrates how the resistance of the voltmeter affects the experiment.

Figure 8



2 (b) (ii) Explain with reference to **Figure 8** whether the results of your experiment indicate that the resistance of the voltmeter you used was small enough to cause an error of this type.

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(1 mark)

8

Turn over for next question