1 **(a)** A charged capacitor is connected across the ends of a negative temperature coefficient (NTC) thermistor kept at a fixed temperature. The capacitor discharges through the thermistor. The potential difference V across the capacitor is maximum at time $t = 0$.

(i) On the axes of Fig. 4.1, carefully sketch a graph to show how the potential difference V across the capacitor varies with time t. Label this graph **L**.

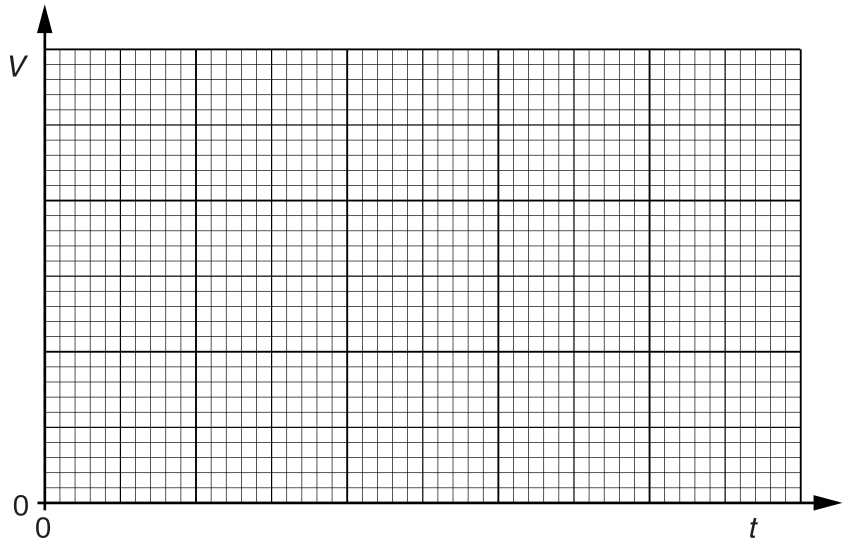

Fig. 4.1 **[1]**

(ii) The temperature of the thermistor is increased to a higher fixed value. On Fig. 4.1, sketch another graph to show the variation of V with t when the same charged capacitor is discharged across the ends of the hotter thermistor. Label this graph **H**. **[1]**

(iii) Explain how you can show that the graph sketched in **(i)** has a constant-ratio property (exponential decay).

....

....

.... **[1]**

(b) Fig. 4.2 shows an electrical circuit.

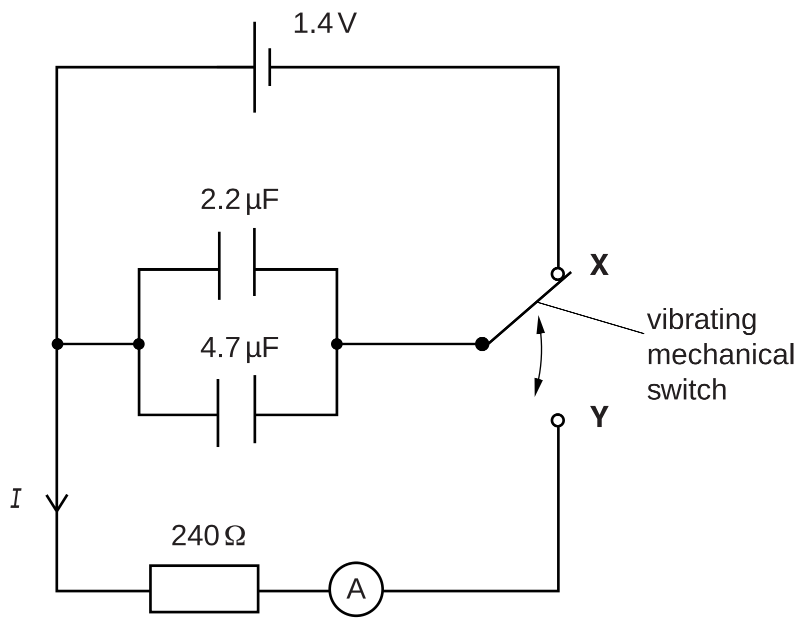

Fig. 4.2

The cell has e.m.f. 1.4 V and negligible internal resistance. The values of the capacitors and the resistor are shown in Fig. 4.2. A mechanical switch vibrates between contacts **X** and **Y** at a frequency of 120 Hz.

(i) Calculate the time constant of the circuit.

time constant = ... s **[1]**

(ii) Calculate the value of the average current I in the resistor. Assume that the capacitors are fully discharged between each throw of the switch.

I = ... A **[3]**

(iii) The frequency of vibration of the mechanical switch is doubled. Explain why the average current in the circuit is not doubled.

....

....

....

.... **[2]**

2 **(a)** Define the *time constant* of a capacitor-resistor discharge circuit.

....

....

.... **[1]**

(b) A student designs a circuit with a time constant of 5.0 s. State suitable values for resistance R and capacitance C for this circuit.

R = ... C = ... **[1]**

(c) Fig. 4.1 shows a circuit with a capacitor of capacitance 0.010 F.

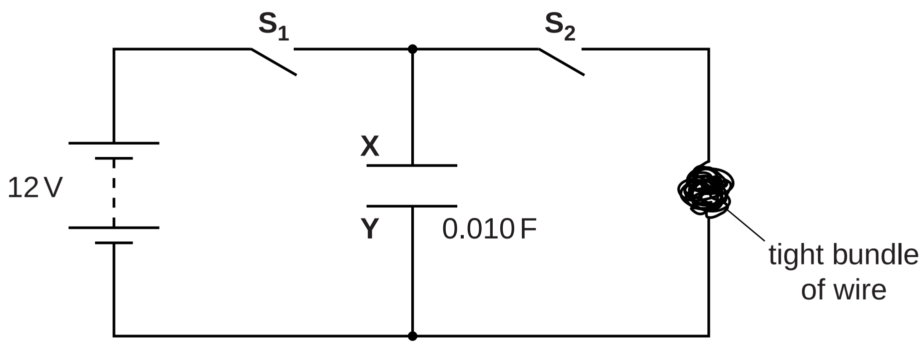

Fig. 4.1

A tight bundle of wire is made from 5.0 m of insulated wire of diameter 0.12 mm and resistivity $4.9 \times 10^{-7}\,\Omega\,m$. The material of the wire has density $8900\,kg\,m^{-3}$ and specific heat capacity $420\,J\,kg^{-1}\,K^{-1}$.

(i) Calculate the time constant of the circuit.

time constant = ... s **[3]**

(ii) Switch $\mathbf{S_2}$ is open. Switch $\mathbf{S_1}$ is closed. Explain in terms of the movement of electrons how **X** and **Y** acquire equal but opposite charge.

....

....

....

....

....

....

....

.... **[3]**

(iii) Switch $\mathbf{S_1}$ is opened. The potential difference across the capacitor is 12V. Switch $\mathbf{S_2}$ is now closed. Assume that all the energy stored by the capacitor is used to heat up the bundle of wire. Calculate the increase in the temperature of the bundle of wire.

increase in temperature = ... °C **[4]**

(iv) State and explain how your answer to **(iii)** would change when a 24V power supply is used to carry out the experiment.

....

....

....

.... **[2]**

[Total: 14]

3 **(a)** Fig. 1.1 shows an arrangement of capacitors.

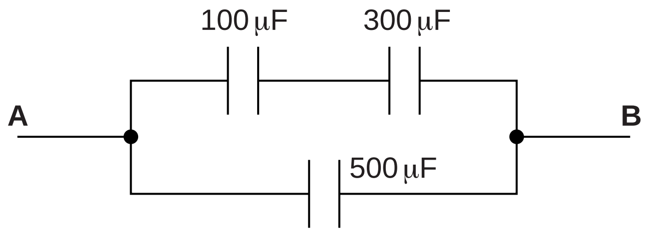

Fig. 1.1

Determine the total capacitance between **A** and **B**.

capacitance = ... μF **[2]**

(b) A capacitor of capacitance 500 μF is charged to 6.0 V. A student places her thumb and first finger across the terminals of the capacitor as shown in Fig. 1.2. This provides a high resistance path across the terminals of the capacitor causing it to discharge.

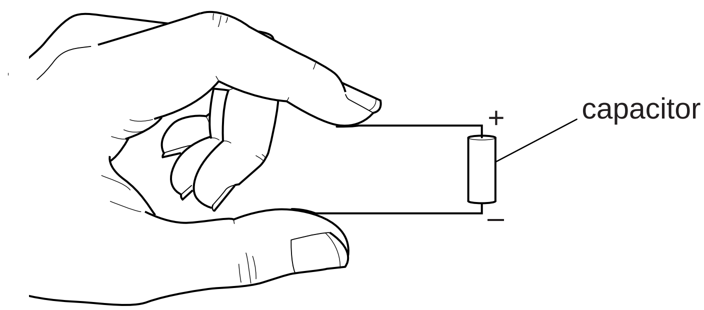

Fig. 1.2

Fig. 1.3 shows the variation of potential difference V across the capacitor with time t.

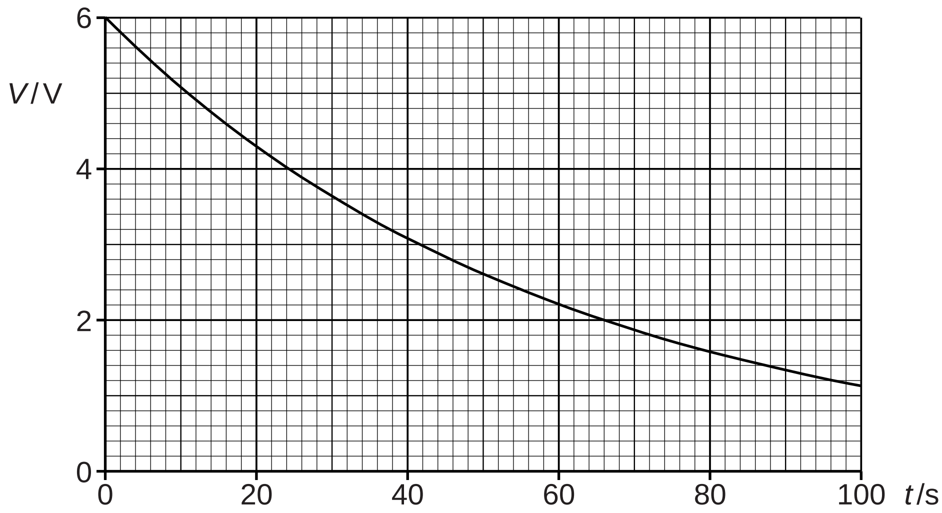

Fig. 1.3

(i) Use Fig. 1.3 to calculate the resistance across the terminals of the capacitor.

resistance = ... Ω **[3]**

(ii) Calculate the energy lost by the capacitor from time t = 0 to t = 30 s.

energy lost = ... J **[3]**

[Total: 8]

4 **(a)** Capacitance is measured in farads. Define the *farad*.

....

.... **[1]**

(b) Fig. 1.1 shows the graph of potential difference V against charge Q stored for a capacitor of capacitance C.

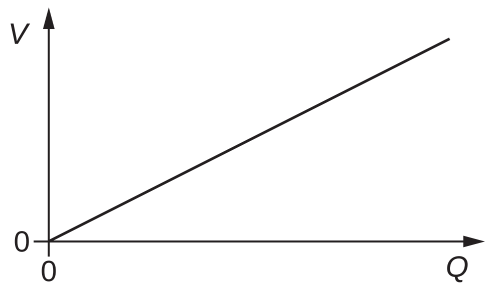

Fig. 1.1

State the quantity represented by the

(i) gradient of the graph

.... **[1]**

(ii) area under the graph.

.... **[1]**

(c) You are given three capacitors of capacitances 100 μF, 200 μF and 500 μF. Calculate the **minimum** total capacitance of these three capacitors in a combination. Show how the capacitors are connected.

capacitance = ... μF **[3]**

(d) A 0.10 F capacitor is charged at a constant rate with a **steady current** of 40 mA for a time of 60 s. Calculate the final

(i) charge stored by the capacitor

charge = ... C **[2]**

(ii) energy stored by the capacitor.

energy = ... J **[2]**

[Total: 10]

5 **(a)** Define *capacitance*.

....

.... **[1]**

(b) Fig. 2.1 shows two capacitors of capacitance 150 μF and 450 μF connected in series with a battery of e.m.f. 6.0 V. The battery has negligible internal resistance.

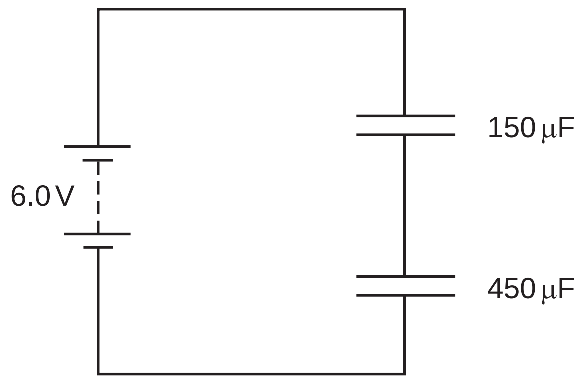

Fig. 2.1

For the circuit shown in Fig. 2.1, calculate

(i) the potential difference across the 150 μF capacitor

potential difference = ... V **[2]**

(ii) the charge stored by the 150 μF capacitor

charge = ... C **[1]**

(iii) the total capacitance of the circuit.

capacitance = ... F **[1]**

(c) The fully charged capacitors shown in **(b)** are disconnected from the battery. The capacitors are then connected in series with a resistor **R** of resistance 45 kΩ and an open switch **S** as shown in Fig. 2.2.

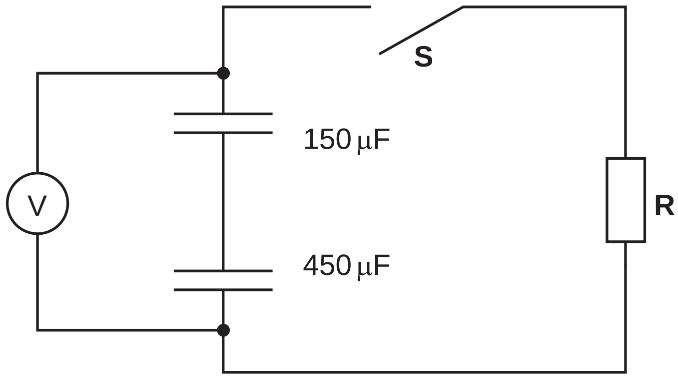

Fig. 2.2

The p.d. *V* across the capacitors is measured with a voltmeter of infinite resistance.
The switch **S** is closed at time t = 0 and measurements of *V* are made at regular time intervals.

(i) Show that the time constant for the circuit is about 5 s.

[1]

(ii) On Fig. 2.3 sketch the variation of p.d. *V* with time *t*.

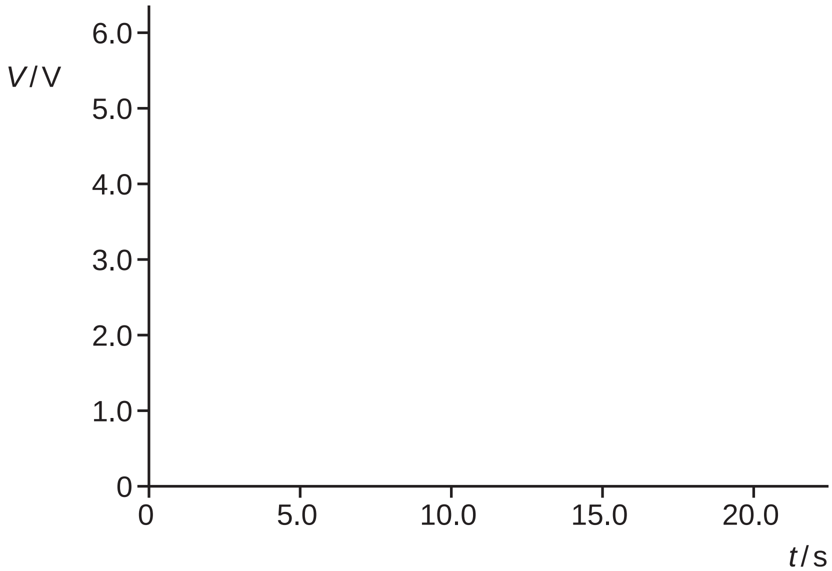

Fig. 2.3

[3]

(iii) At time $t = 0$ calculate the ratio

$$\frac{\text{energy stored by the } 150\,\mu\text{F capacitor}}{\text{energy stored by the } 450\,\mu\text{F capacitor}}.$$

ratio = ... **[2]**

(iv) State and explain how the ratio varies with time.

....

....

.... **[2]**

[Total: 13]