1)

(a) Define the *farad*.

.... **[1]**

(b) Fig. 2.1 shows a capacitor **C** of capacitance 5.4 nF connected to a battery. The switch $\mathbf{S_1}$ is closed and the capacitor is charged to a p.d. of 12 V.

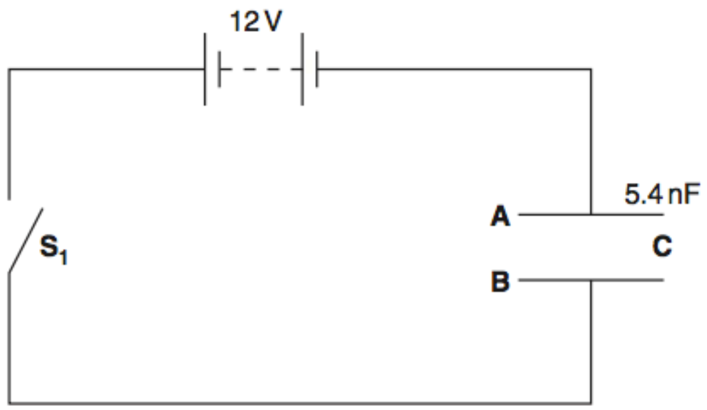

Fig. 2.1

The plates of the capacitor are labelled **A** and **B**.

(i) Explain how the plates of the capacitor become charged in terms of the movement of charged particles in the circuit.

....

....

....

.... **[2]**

(ii) Calculate

1 the charge stored by the capacitor

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

2 the energy transferred to the capacitor.

energy = ... J **[1]**

(c) Fig. 2.2 shows the capacitor **C** connected to a resistor **R**.

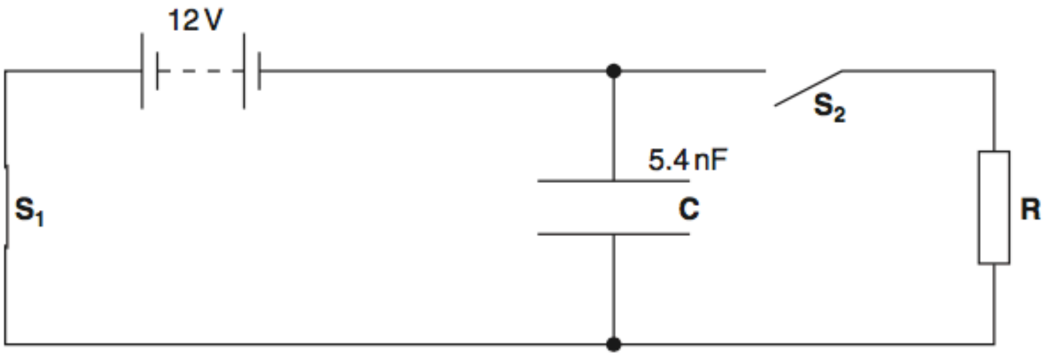

Fig. 2.2

The switch $\mathbf{S_1}$ is now opened and switch $\mathbf{S_2}$ is closed. The current in the resistor **R** is monitored. The initial current through **R** is 3.24 μA.

(i) Show that the resistance of the resistor **R** is 3.7 MΩ.

[1]

(ii) Calculate the current through **R** after a time t = 0.080 s.

current = ... μA **[2]**

(d) Explain the effect on the initial rate of discharge of the capacitor when a second resistor of resistance 3.7 MΩ is connected in parallel with the resistor **R**.

....

....

....

.... **[2]**

Total: [10]

2)

(a) Define *capacitance*.

....

.... **[1]**

(b) Fig. 4.1 shows an arrangement of three identical capacitors connected to a 6.0V battery.

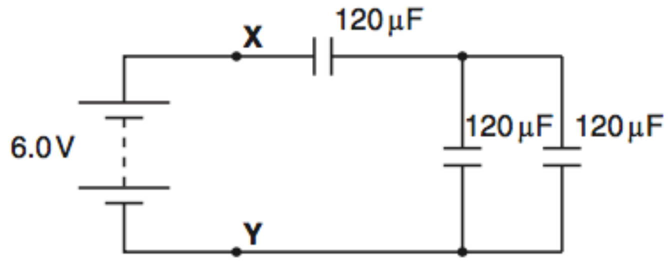

Fig. 4.1

Each capacitor has a capacitance of 120 μF.

(i) Show that the total capacitance of the circuit is 80 μF.

[2]

(ii) Calculate the total energy stored by the capacitors.

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

(iii) The battery is disconnected from the circuit shown in Fig. 4.1. The p.d. between points **X** and **Y** remains at 6.0 V. A fixed resistor of resistance *R* is now connected between **X** and **Y**. Fig. 4.2 shows the variation of the p.d. *V* across the resistor with time *t*.

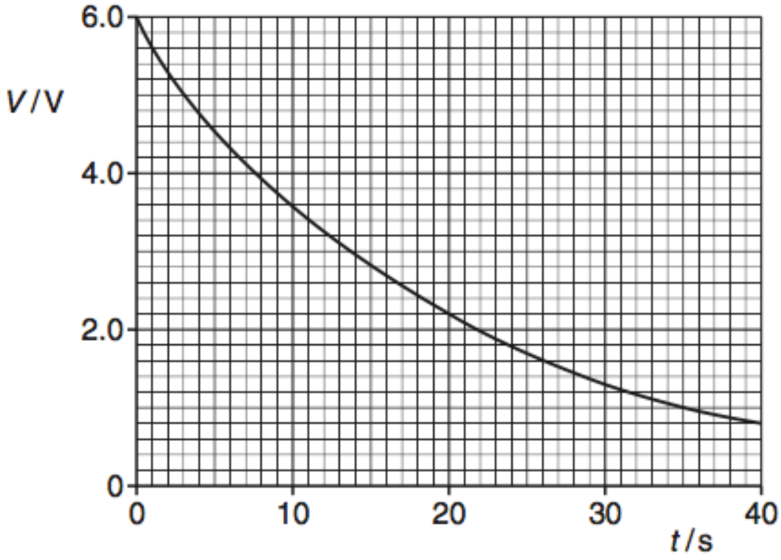

Fig. 4.2

1 Use Fig. 4.2 to show that the circuit has a time constant of 20 s.

[1]

2 Hence, calculate the resistance *R* of the resistor.

R = ... Ω **[2]**

[Total: 8]

3)

(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.

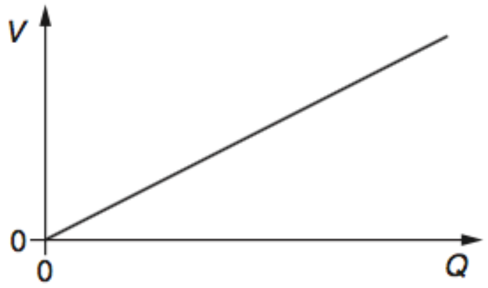

Fig. 1.1

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]

4)

(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.

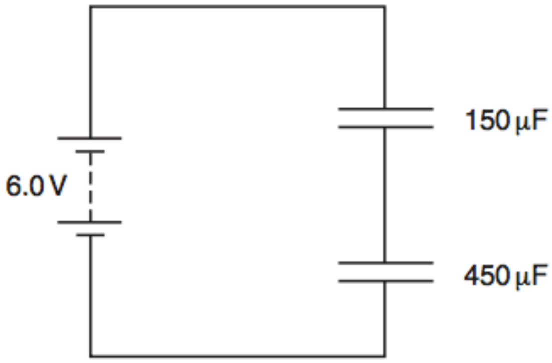

Fig. 2.1

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.

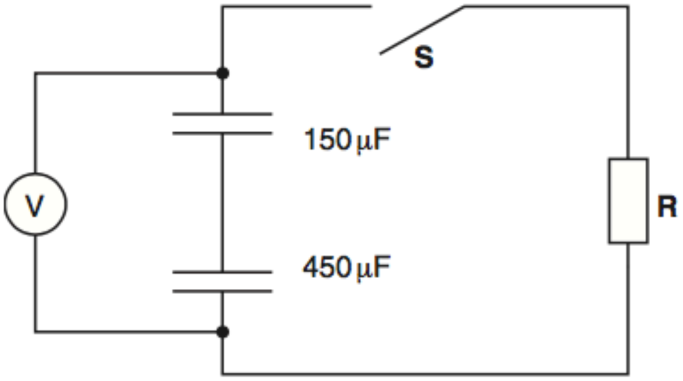

Fig. 2.2

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.

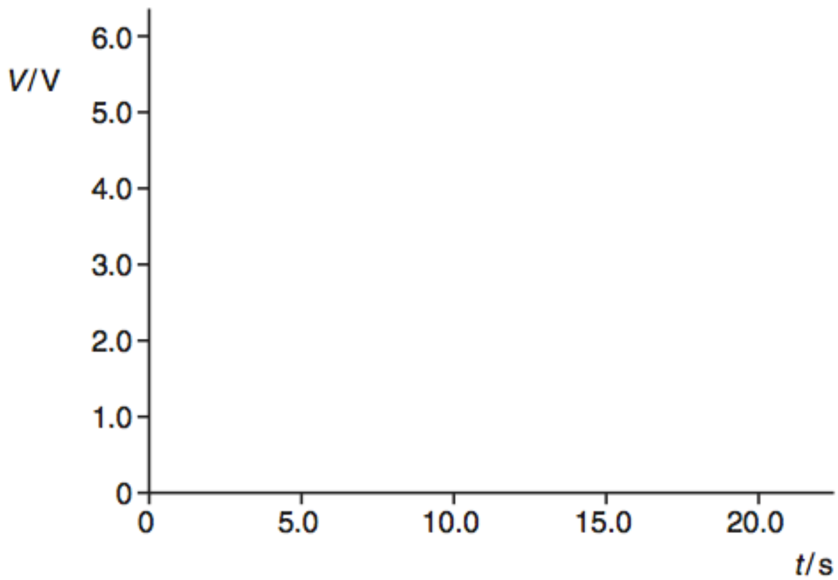

Fig. 2.3

[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]

5)

(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.

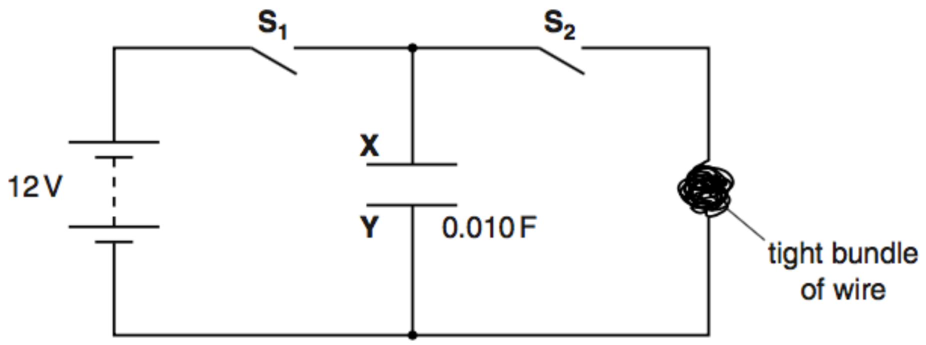

Fig. 4.1

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 S_2 is open. Switch S_1 is closed. Explain in terms of the movement of electrons how **X** and **Y** acquire equal but opposite charge.

....

....

....

....

....

....

....

.... **[3]**

(iii) Switch S_1 is opened. The potential difference across the capacitor is 12 V. Switch 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 24 V power supply is used to carry out the experiment.

....

....

....

.... **[2]**

[Total: 14]

6)

(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**.

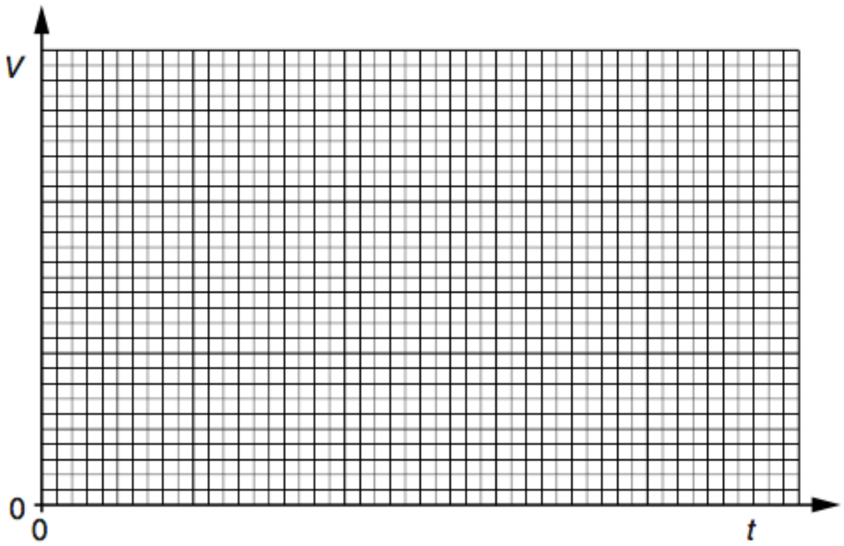

Fig. 4.1 **[1]**

(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.

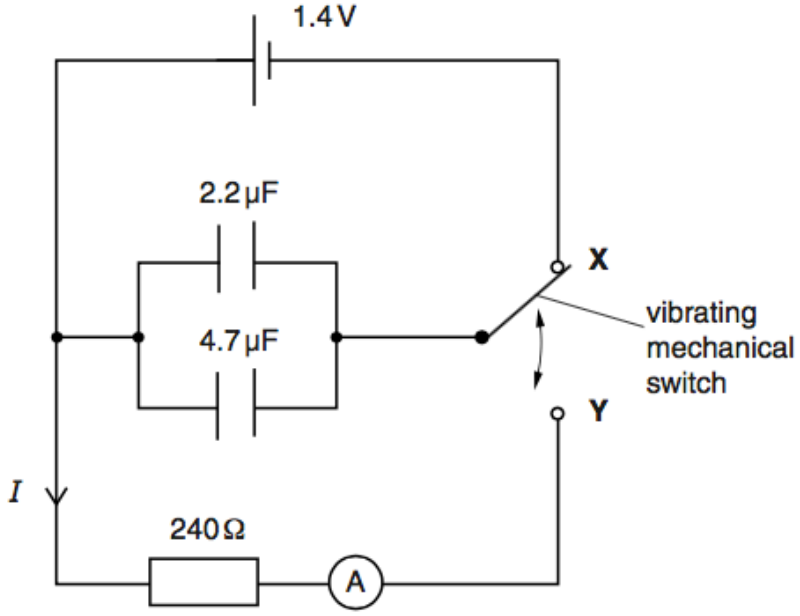

Fig. 4.2

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]**

7)

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

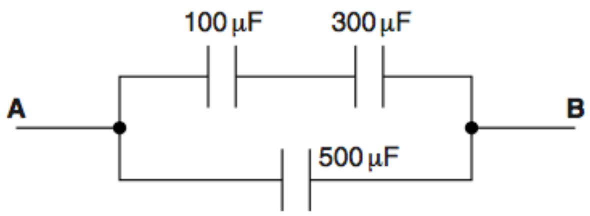

Fig. 1.1

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.

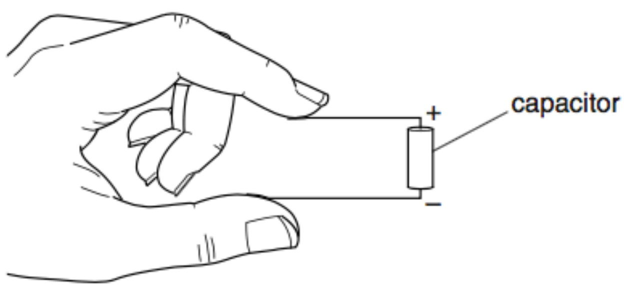

Fig. 1.2

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

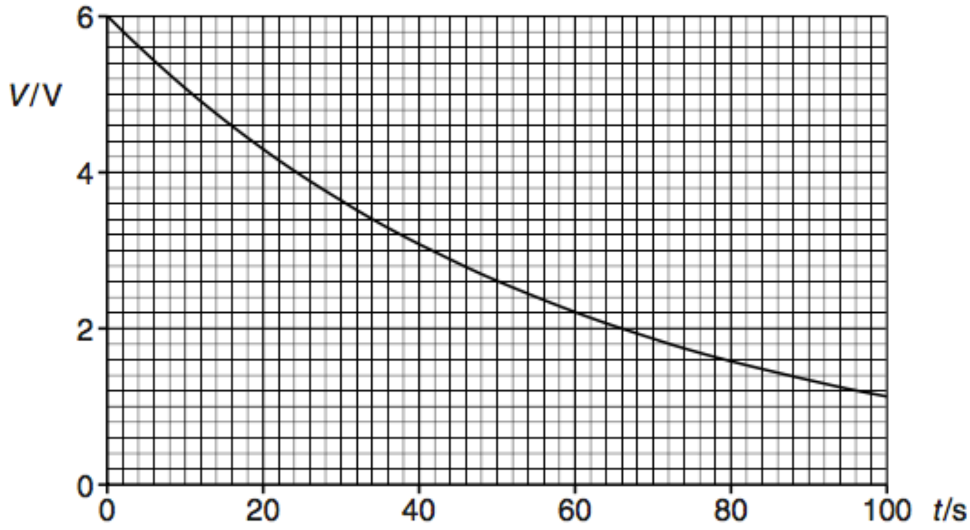

Fig. 1.3

(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]

8)

(a) Define *capacitance.*

....

.... **[1]**

(b) Fig. 1.1 shows a circuit consisting of a resistor and a capacitor of capacitance 4.5 μF.

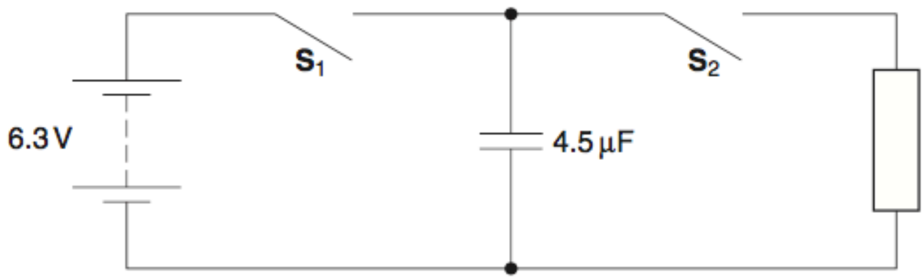

Fig. 1.1

Switch S_1 is closed and switch S_2 is left open. The potential difference across the capacitor is 6.3 V.

Calculate

(i) the charge stored by the capacitor

charge = ... μC **[1]**

(ii) the energy stored by the capacitor.

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

(c) Switch $\mathbf{S_1}$ is opened and switch $\mathbf{S_2}$ is closed.

(i) Describe and explain in terms of the movement of electrons how the potential difference across the capacitor changes.

....

....

....

.... **[3]**

(ii) The energy stored in the capacitor decreases to zero. State where the initial energy stored in the capacitor is dissipated.

....

.... **[1]**

(d) Fig.1.2 shows the 4.5 μF capacitor now connected in parallel with a capacitor of capacitance 1.5 μF. Both switches are open and both capacitors are uncharged.

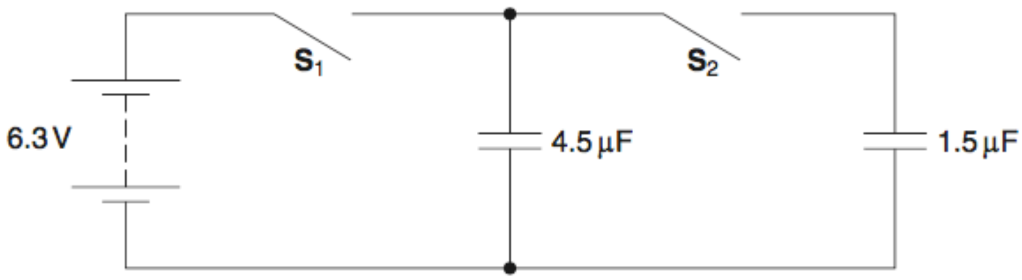

Fig. 1.2

Switch $\mathbf{S_1}$ is closed. The potential difference across the 4.5 μF capacitor is now 6.3V. Switch $\mathbf{S_1}$ is opened and then switch $\mathbf{S_2}$ is closed.

(i) Calculate the total capacitance of the circuit when $\mathbf{S_2}$ is closed.

capacitance = ... μF **[1]**

(ii) Calculate the final potential difference across the capacitors.

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

[Total: 11]

9)

(a) Fig. 1.1 shows a circuit with a capacitor of capacitance *C*.

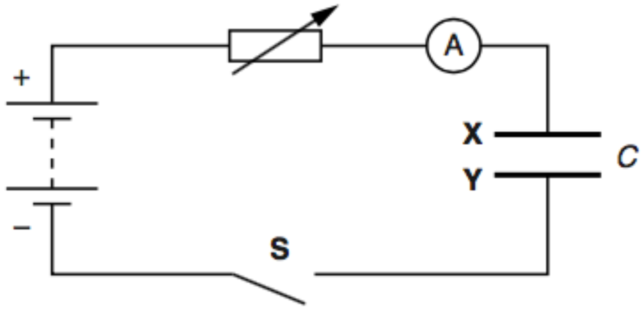

Fig. 1.1

The switch **S** is closed. The resistance of the variable resistor is manually adjusted so that the current in the circuit is kept **constant**.

(i) Explain in terms of movement of electrons how the capacitor plates **X** and **Y** acquire an equal but opposite charge.

....

....

....

....

.... **[2]**

(ii) The initial charge on the capacitor is zero. After 100 s, the potential difference across the capacitor is 1.6 V. The constant current in the circuit is 40 μA.

1 Calculate the capacitance *C* of the capacitor.

C = ... F **[3]**

2 On Fig. 1.2, sketch a graph to show the variation of potential difference V across the capacitor with time t.

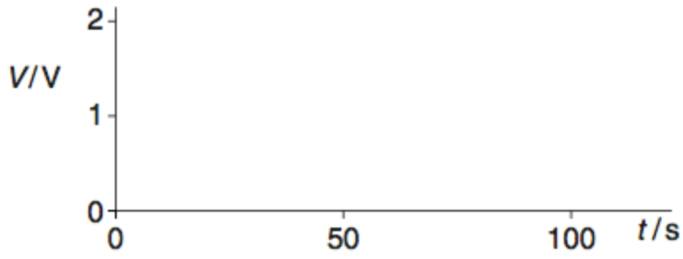

Fig. 1.2 **[2]**

(b) Fig. 1.3 shows an arrangement used to determine the speed of a bullet.

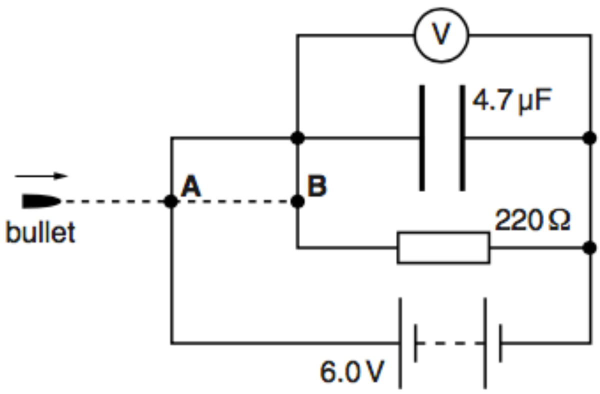

Fig. 1.3

The value of the resistance of the resistor and the value of the capacitance of the capacitor are shown in Fig. 1.3. The voltmeter reading is initially 6.0 V. The bullet first breaks the circuit at **A**. The capacitor starts to discharge **exponentially** through the resistor. The capacitor stops discharging when the bullet breaks the circuit at **B**. The final voltmeter reading is 4.0 V.

(i) Calculate the time taken for the bullet to travel from **A** to **B**.

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

(ii) The separation between **A** and **B** is 0.10 m. Calculate the speed of the bullet.

speed = ... m s^{-1} **[1]**

[Total: 11]

10)

(a) Define *capacitance.*

....

.... **[1]**

(b) Fig. 1.1 shows a circuit consisting of a resistor and a capacitor of capacitance 4.5 μF.

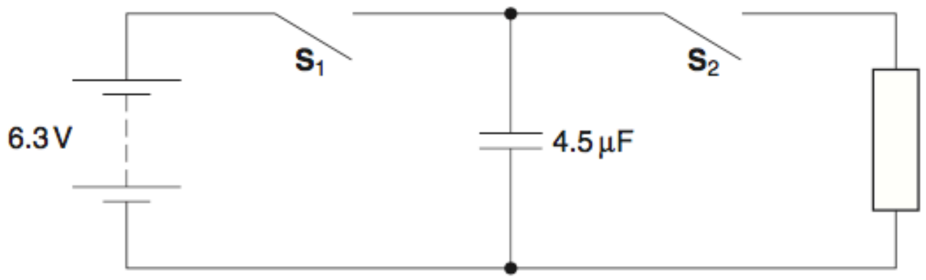

Fig. 1.1

Switch $\mathbf{S_1}$ is closed and switch $\mathbf{S_2}$ is left open. The potential difference across the capacitor is 6.3 V.

Calculate

(i) the charge stored by the capacitor

charge = ... μC **[1]**

(ii) the energy stored by the capacitor.

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

(c) Switch S_1 is opened and switch S_2 is closed.

(i) Describe and explain in terms of the movement of electrons how the potential difference across the capacitor changes.

....

....

....

.... **[3]**

(ii) The energy stored in the capacitor decreases to zero. State where the initial energy stored in the capacitor is dissipated.

....

.... **[1]**

(d) Fig.1.2 shows the 4.5 μF capacitor now connected in parallel with a capacitor of capacitance 1.5 μF. Both switches are open and both capacitors are uncharged.

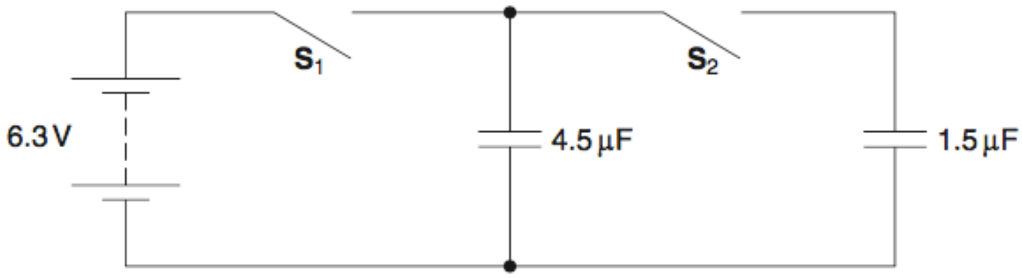

Fig. 1.2

Switch S_1 is closed. The potential difference across the 4.5 μF capacitor is now 6.3 V. Switch S_1 is opened and then switch S_2 is closed.

(i) Calculate the total capacitance of the circuit when S_2 is closed.

capacitance = ... μF **[1]**

(ii) Calculate the final potential difference across the capacitors.

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

[Total: 11]

11)
12)
13)
14)
15)
16)
17)
18)
19)
20)