1 (a) Define *capacitance*.

....

.... **[1]**

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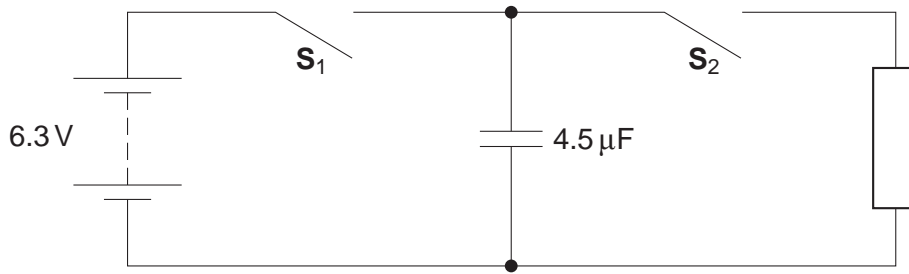

Fig. 1.1

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 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.
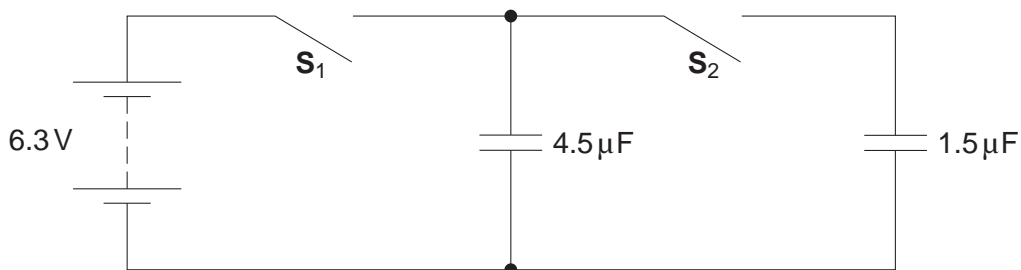

Fig. 1.2

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]

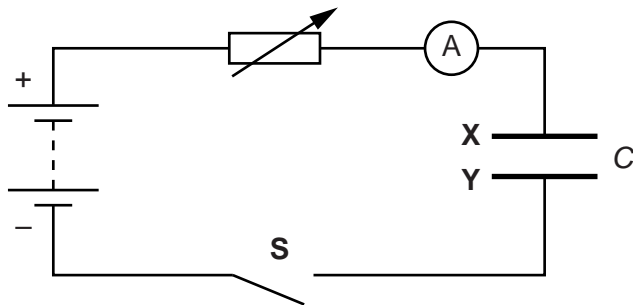**2** **(a)** Fig. 1.1 shows a circuit with a capacitor of capacitance C.

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.
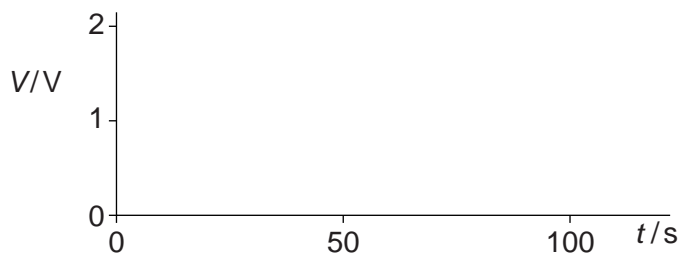

Fig. 1.2 [2]

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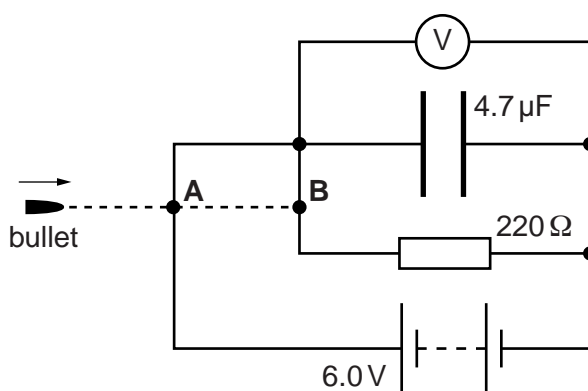

Fig. 1.3

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 6.0V. 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 4.0V.

(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 0.10m. Calculate the speed of the bullet.

speed = ...ms^{-1} **[1]**

[Total: 11]

3 **(a)** Define *capacitance*.

....

.... **[1]**

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

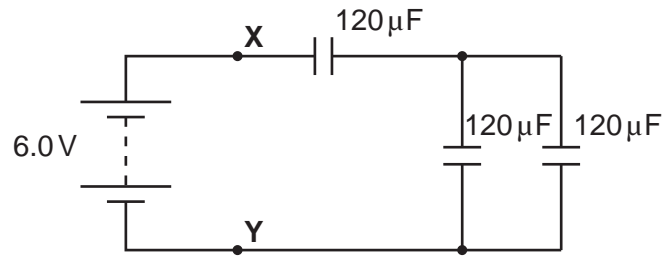**Fig. 4.1**

Each capacitor has a capacitance of 120µF.

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

[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 6.0V. 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.
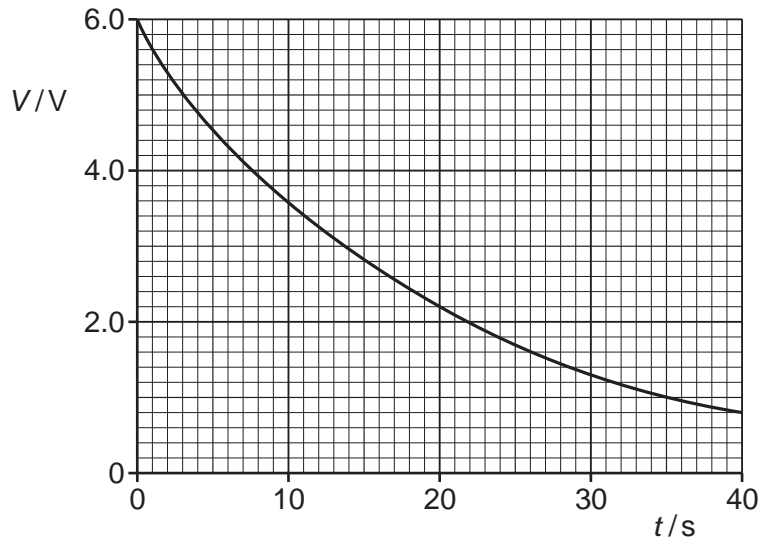

Fig. 4.2

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

[1]

2 Hence, calculate the resistance R of the resistor.

$R =$ .... Ω **[2]**

[Total: 8]

4 **(a)** Define the *farad*.

.... **[1]**

(b) Fig. 2.1 shows a capacitor **C** of capacitance 5.4 nF connected to a battery. The switch **S₁** is closed and the capacitor is charged to a p.d. of 12V.
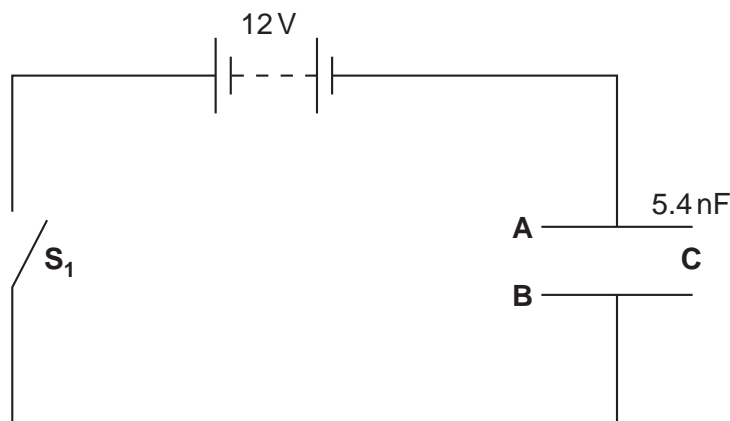

Fig. 2.1

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]**

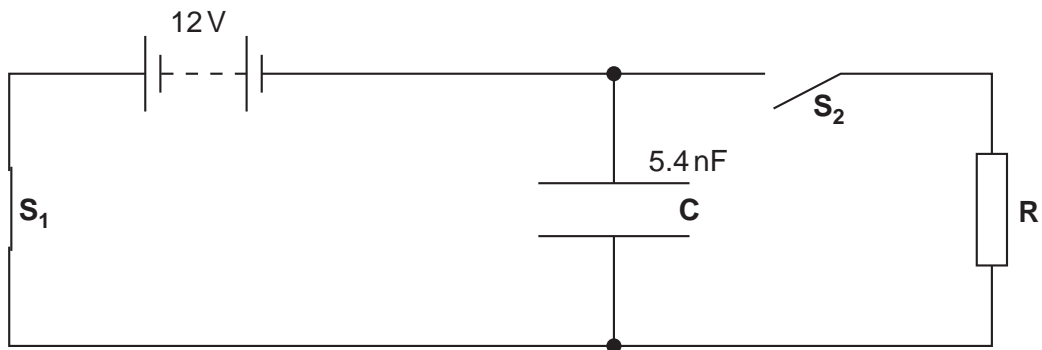**(c)** Fig. 2.2 shows the capacitor **C** connected to a resistor **R**.

Fig. 2.2

The switch **S₁** is now opened and switch **S₂** 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]