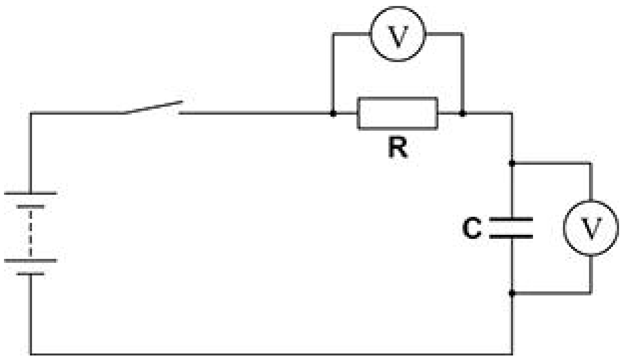
## Q1.

**Figure 1** shows a circuit used to charge capacitor **C**.
The battery has negligible internal resistance.

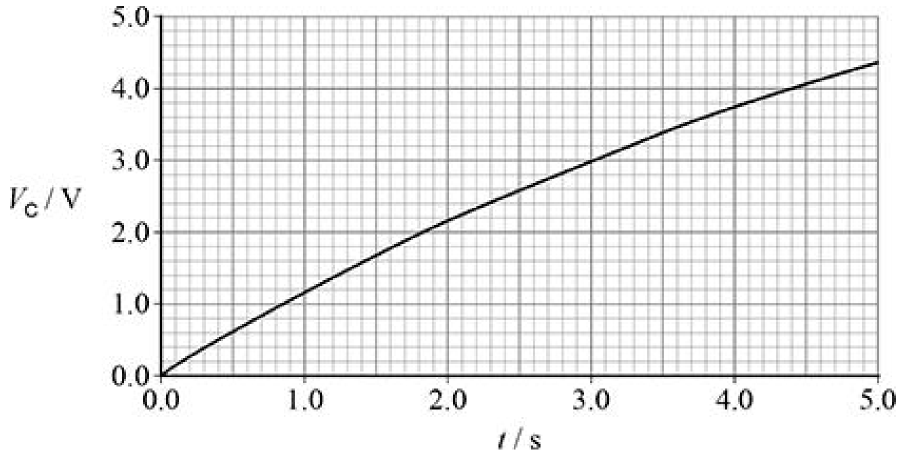
**Figure 1**




The capacitance of **C** is known.

(a) The switch is closed at time $t$ = 0 and the potential difference $V_C$ across **C** is recorded at different times $t$.
**Figure 2** shows the variation of $V_C$ with $t$.

**Figure 2**




Explain how a gradient of the graph in **Figure 2** can be used to determine the initial current $I_0$ in the circuit.

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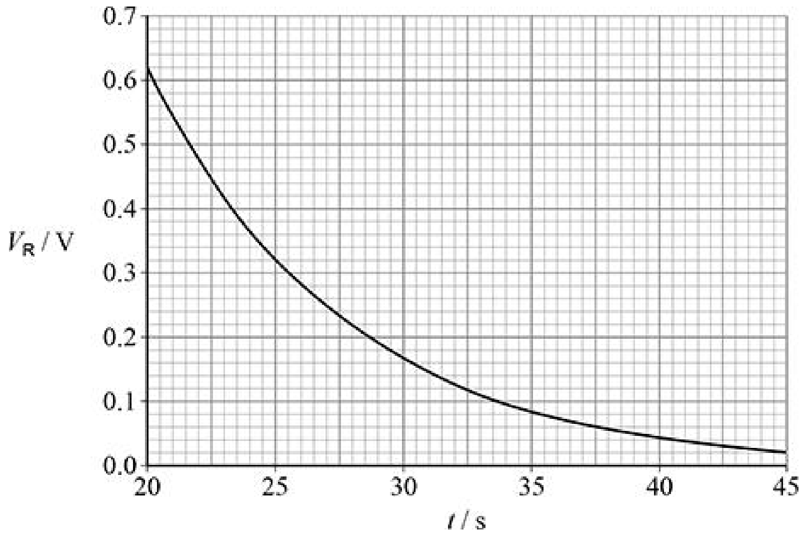
**(2)**

(b) The potential difference $V_R$ across **R** is also recorded.
**Figure 3** shows the variation of $V_R$ with $t$ between $t$ = 20 s and $t$ = 45 s.

**Figure 3**




The capacitance of **C** is 31.0 μF.

Determine, using **Figure 3**, the time constant of the circuit.
Go on to show that the resistance of **R** is about 2.4 × $10^5$ Ω.

time constant = ____________________ s

resistance = ____________________ Ω

**(2)**

(c) The current $I_0$ at time $t$ = 0 is 3.6 × $10^{-5}$ A.

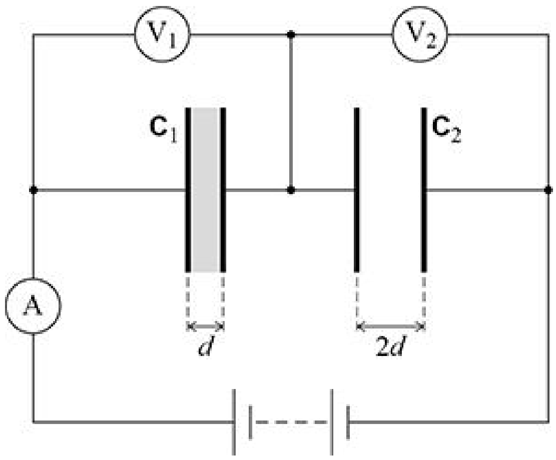
Determine the time at which $V_C$ is 6.0 V.

time = ____________________ s

**(3)**

(d) **Figure 4** shows two fully charged parallel-plate capacitors **$C_1$** and **$C_2$** in a circuit.
A dielectric fills the space between the plates of **$C_1$** and air fills the space between the plates of **$C_2$**.

**Figure 4**




The table below gives information about **$C_1$** and **$C_2$**.

| | **$C_1$** | **$C_2$** |
|---|---|---|
| charge | $Q$ | $Q$ |
| surface area | $S$ | $S$ |
| potential difference | $V_1$ | $V_2$ |
| plate separation | $d$ | $2d$ |
| dielectric constant | 4.0 | 1.0 |

Determine $\frac{V_1}{V_2}$

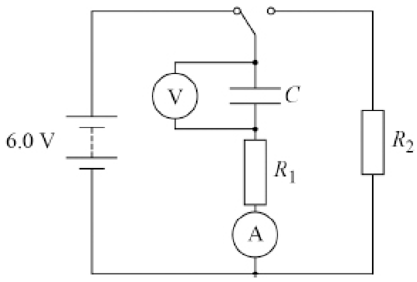
$\frac{V_1}{V_2}$ = ____________________

**(2)**
**(Total 9 marks)**

## Q2.

**Figure 1** shows a circuit used to investigate the charge and discharge of a capacitor of capacitance $C$ using resistors of resistances $R_1$ and $R_2$.

**Figure 1**



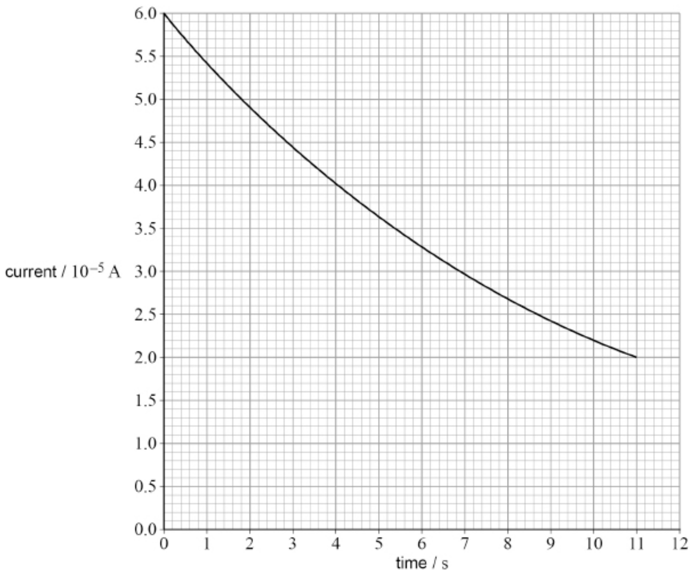

The battery has an emf of 6.0 V and negligible internal resistance.

(a) Show that the time taken for the capacitor to charge from 2.0 V to 4.0 V is approximately $0.7R_1C$.

**(3)**

The capacitor is fully discharged.
The capacitor is then charged until the potential difference (pd) across it is 4.0 V.
**Figure 2** shows the variation with time of the ammeter reading as the capacitor is charged.

**Figure 2**



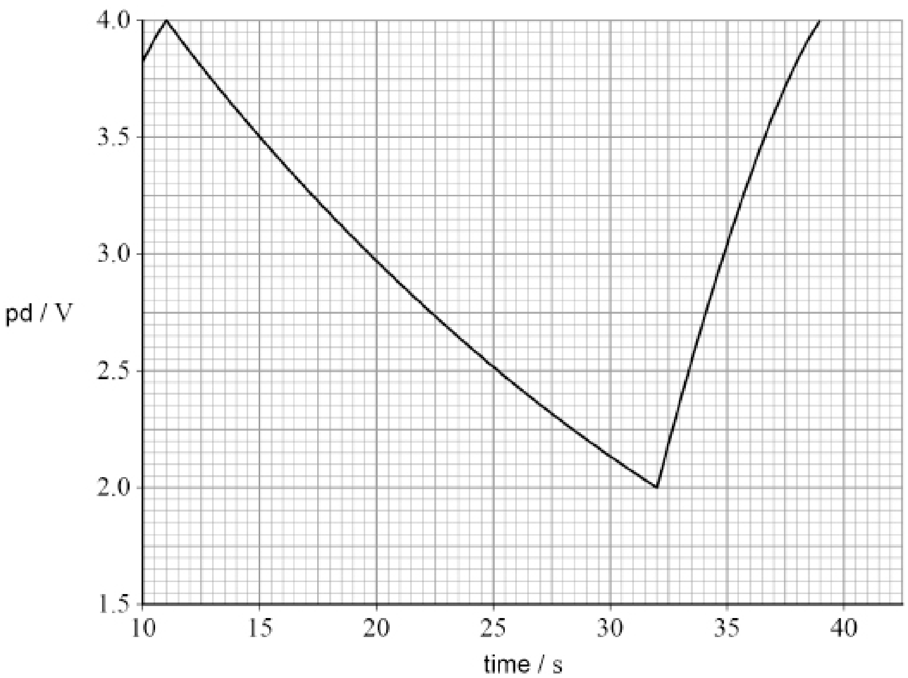
(b) Show that the capacitance of the capacitor is about $1 \times 10^{-4}$ F.

**(4)**

(c) When the pd reaches 4.0 V the switch is immediately set to discharge the capacitor.
When the pd reaches 2.0 V the switch is immediately set to charge the capacitor.

**Figure 3** shows how the pd across the capacitor varies with time.

**Figure 3**




Determine the value of $R_2$.

$R_2$ = ____________________ Ω

**(3)**

**(Total 10 marks)**

## Q3.

An isolated solid conducting sphere is initially uncharged.
Electrons are then transferred to the sphere.

(a) State and explain the location of the excess electrons.

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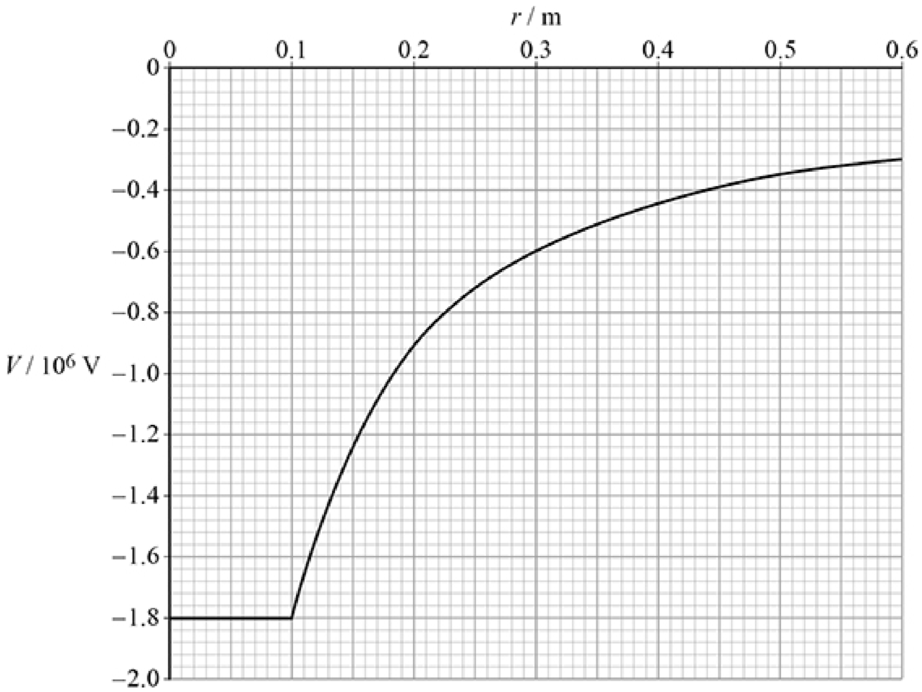
**(2)**

The figure below shows how the electric potential $V$ varies with distance $r$ from the centre of the sphere.
The radius of the sphere is $0.10$ m.




(b) The magnitude of the electric field strength $E$ is related to $V$ by $E = \frac{\Delta V}{\Delta r}$.

Determine, using this relationship, the magnitude of the electric field strength at a distance $0.30$ m from the centre of the sphere.

State an appropriate SI unit for your answer.

electric field strength = ____________________ unit __________

**(4)**

(c) The sphere acts as a capacitor because it stores charge at an electric potential.

Show that the capacitance of the sphere is approximately $1 \times 10^{-11}$ F.

**(3)**

(d) Electrons leak away from the sphere with time and the amount of energy stored by the sphere decreases. At one instant, the magnitude of the electric potential of the sphere has fallen to $1.0 \times 10^{6}$ V.

Calculate, for this instant, the change in the energy stored by the sphere.

change in energy = _______________ J

**(3)**

**(Total 12 marks)**