2023 Ph H2 Q13

Section: Electricity

Topic: Capacitors

Summary of Question:

A student charges a capacitor and measures potential difference and charge. (a)(i) Calculate capacitance. (a)(ii) Determine absolute uncertainty. (b) Use time constant to estimate charging time with given resistor and supply voltage.

(a)(i) Capacitance

$Q = CV \Rightarrow C = Q/V$

$Q = 136.8\ \text{mC} = 136.8 \times 10^{-3}\ \text{C} = 0.1368\ \text{C}$

$V = 5.7\ \text{V}$

$C = 0.1368 / 5.7 = 0.0240\ \text{F}\ (24.0\ \text{mF})$

(a)(ii) Absolute uncertainty

Uncertainty in $Q = \pm 0.1\ \text{mC} = \pm 0.0001\ \text{C}$

Uncertainty in $V = \pm 0.1\ \text{V}$

Fractional uncertainty in $Q = 0.0001 / 0.1368 \approx 7.3 \times 10^{-4}$ ($\approx 0.073\%$)

Fractional uncertainty in $V = 0.1 / 5.7 \approx 0.0175$ (1.75%)

Total fractional uncertainty $\approx 0.073\% + 1.75\% \approx 1.82\%$

Absolute uncertainty = $0.0240 \times 0.0182 \approx 0.00044$ F (0.44 mF)

(b) Charging time

Time constant $\tau = RC$

$R = 15\ k\Omega = 1.5 \times 10^4\ \Omega$

$C = 0.0240$ F

$\tau = 1.5 \times 10^4 \times 0.0240 = 360$ s

Full charge time $\approx 5\tau = 5 \times 360 = 1800$ s (30.0 min)

Final Answers

(a)(i) $C = 0.0240$ F (24.0 mF)

(a)(ii) Absolute uncertainty = 0.00044 F (0.44 mF)

(b) Time to charge ≈ 1800 s (30.0 minutes)

Revision Tips

• Capacitance $C = Q/V$; ensure consistent SI units (C, V, F).

• Combine fractional uncertainties when dividing/multiplying.

• A capacitor is effectively fully charged after about 5τ.