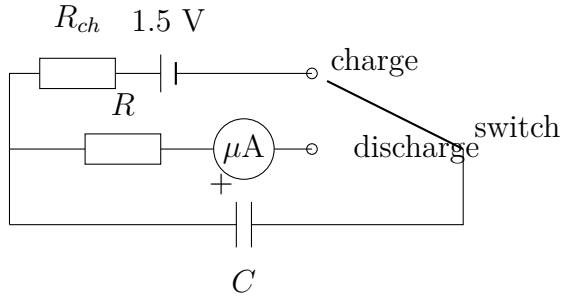
Capacitor discharge and stored charge

Name: _____ Class: _____ Date: _____

Aim Test exponential decay and estimate the initial stored charge. Allow 70–90 minutes.

Model During discharge, $I = I_0 e^{-t/(RC)}$. The **time constant** is $\tau = RC$. Plot $\ln(I/I_*)$ against t, with the fixed reference $I_* = 1\,\mu\text{A}$, so the logarithm has no unit. Its gradient is $s = -1/\tau$.

Apparatus 1.5 V cell, labelled 1000 μF capacitor, 100 kΩ discharge resistor, 1 kΩ charging resistor, break-before-make changeover switch, sensitive microammeter, leads and stopwatch; shared capacitance/resistance meter if available.



Safety Match capacitor polarity and voltage rating. Use low voltage only. Change connections with the supply disconnected. Discharge through the resistor; never short the capacitor directly. Have the circuit checked.

1 Plan, then measure

1. Record nominal R, C, their tolerances and instrument resolutions. Measure R, C if suitable meters are available. Estimate RC to choose a time interval.
2. Charge through R_{ch} for at least $5R_{ch}C$ (about 5 s for 1 kΩ and 1000 μF). Keep the charging voltage the same in each run.
3. Change to discharge and start timing together. A pilot should establish a visible, positive current and at least eight useful readings before the current approaches meter resolution.
4. Use fixed intervals (about 10–20 s for nominal $RC = 100$ s). Repeat a full discharge after recharging. Record raw currents; stop logarithmic analysis before readings are zero or dominated by resolution.

Processing check (synthetic data) A log-current gradient is $s = -0.0100 \pm 0.0010\,\text{s}^{-1}$. Calculate τ and its approximate uncertainty. Then invert both endpoint gradients: is the exact interval symmetric?

2 Record and process

$R =$ _____ kΩ $C =$ _____ μF $V_0 =$ _____ V.

Current resolution: _____ Timing uncertainty: _____.

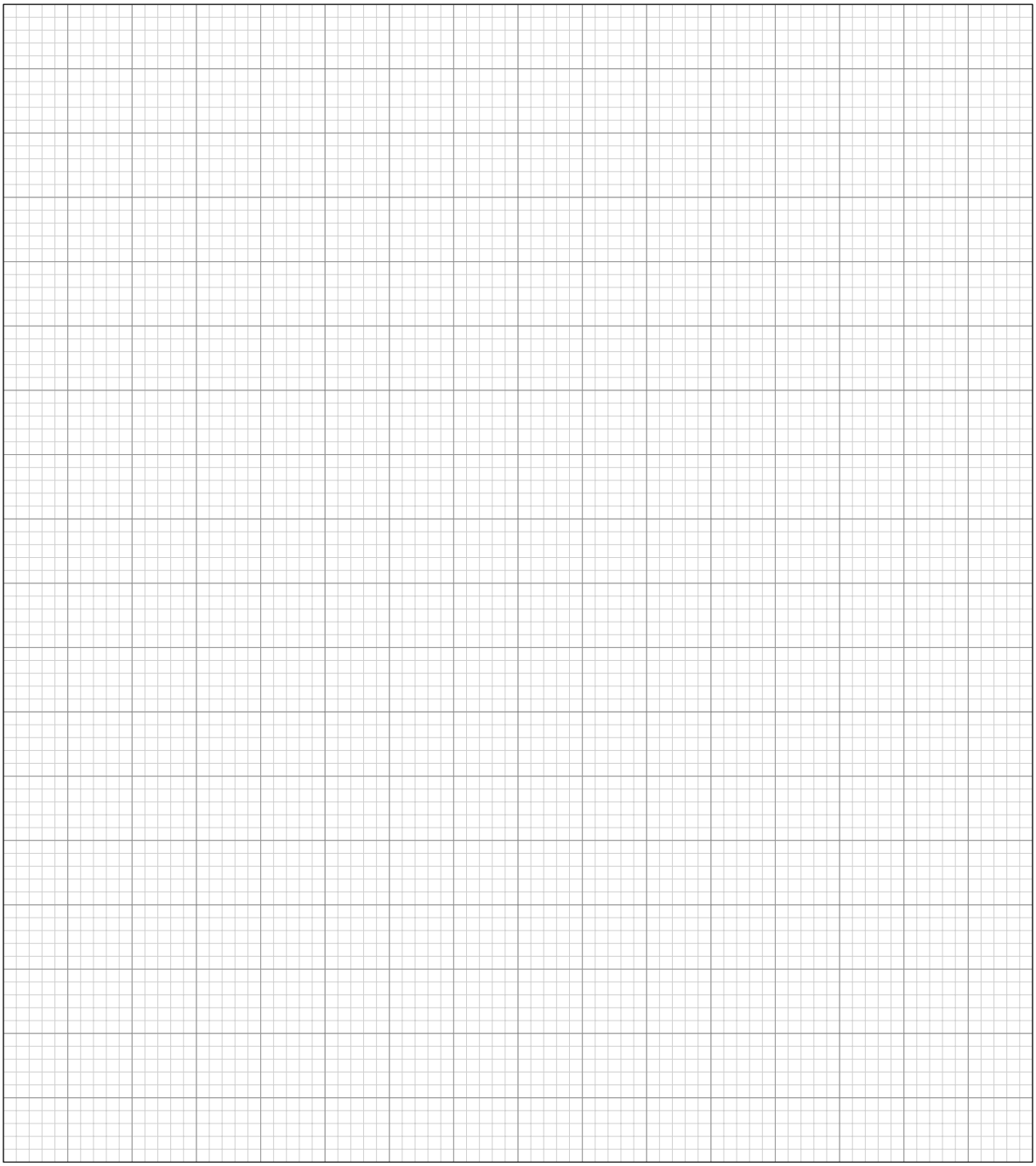
t/s	I_1/μA	I_2/μA	$\bar{I}/\mu$A	$\ln(\bar{I}/I_*)$

Planning record Justify your time interval and stopping current. State how you kept the starting charge consistent.

Uncertainty For positive current, $\Delta \ln I \simeq \Delta I / I$. Why do the last readings have larger logarithmic uncertainty?

3 Graph

Plot $\ln(\bar{I}/I_*)$ against t. Add justified vertical error bars. Draw the best-fit line and the steepest or shallowest acceptable line.



Choose scales and label both axes with quantities and units. Mark a large gradient triangle on the best-fit line where appropriate.

4 Analyse and evaluate

1. Find s, its unit and Δs from an extreme acceptable line. Calculate $\tau = -1/s$ and $\Delta\tau/\tau \simeq \Delta s/|s|$. Compare with measured or nominal RC, including component tolerances.

2. Find the intercept b, then $I_0 = I_* e^b$. Convert I_0 to amperes and calculate $Q_\infty = I_0\tau$. Compare with CV_0, giving charge in coulombs.

3. Use the table to estimate charge by the trapezoidal sum $Q_{\text{measured}} = \sum \frac{1}{2}(I_j + I_{j+1})(t_{j+1} - t_j)$, with currents in A. Estimate the unmeasured tail as $I(t_{\text{last}})\tau$. Explain any early-time gap.

4. Predict how replacing 100 kΩ by 47 kΩ changes I_0, τ and total charge at fixed C, V_0. Identify two limitations and matched improvements; consider switching delay, leakage and meter loading.

Before you leave Return the apparatus, clear the bench and submit your recorded data.