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# A Level Physics A

**H556/02** Exploring physics

# Question Set 19

**1** A student wishes to determine the permittivity $\varepsilon$ of paper using a capacitor made in the laboratory.

The capacitor consists of two large parallel aluminium plates separated by a very thin sheet of paper.

The capacitor is initially charged to a potential difference $V_0$ using a battery. The capacitor is then discharged through a fixed resistor of resistance 1.0 MΩ.

The potential difference $V$ across the capacitor after a time $t$ is recorded by a data-logger. The student uses the data to draw the ln$V$ against $t$ graph shown in Fig. 22.

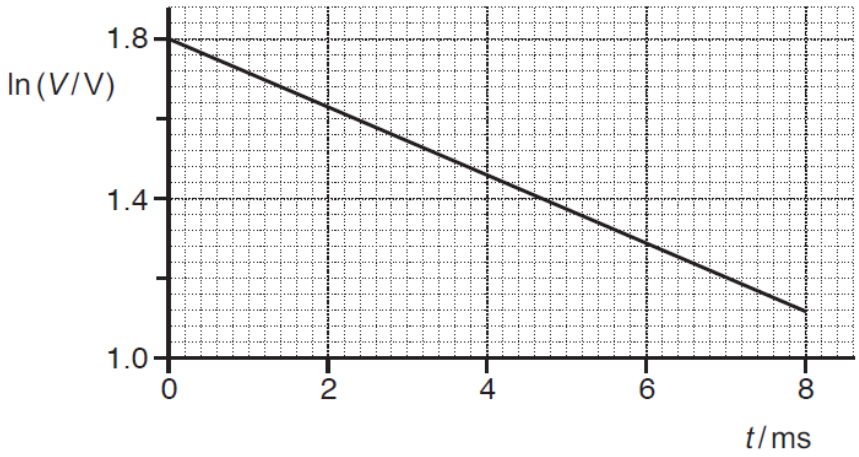


**Fig. 22**

**(a)** Show that the magnitude of the gradient of the line shown in Fig. 22 is equal to

$$\frac{1}{CR}$$

where $C$ is the capacitance of the capacitor and $R$ is the resistance of the resistor.

$V = V_0 e^{-t/CR} \Rightarrow \ln V = \ln V_0 - t/CR \Rightarrow$ in form $y = mx + c$ with gradient $m = \frac{-1}{CR}$ **[2]**

**(b)*** Use Fig. 22 to determine the capacitance $C$ of the capacitor. Describe how the student can then use this value of $C$ to determine a value for $\varepsilon$.
In your description, mention any additional measurements required on the capacitor.

**[6]**

- gradient of line $= \frac{-1.8 + 1.12}{8 \times 10^{-3}} = -85$
- $85 = \frac{1}{CR}$ where $R = 1 \times 10^6 \Rightarrow C = \frac{1}{85 \times 1 \times 10^6} = 1.2 \times 10^{-8}$ F
- $C = \frac{\varepsilon A}{d}$ where A is area of overlap between plates, and d is seperation between plates
- A ruler could be used to measure side length of plates, and ensure total overlap to find A.
- Measure d (equal to thickness of paper) using micrometer and take several readings to get an average.

**Total Marks for Question Set 19: 8**

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