



QUESTION WORKBOOK

The time constant and exponential decay

Capacitance · Year 13

AQA 3.7.4.4 · CIE 19.3.1, 19.3.2, 19.3.3 · OCR A 6.1.3(b), 6.1.3(c), 6.1.3(d), 6.1.3(e)

18 questions · 49 marks

PRINT EDITION

SECTION A · Warm-up

- A1** State the equation for the time constant of a capacitor-resistor circuit and explain what the time constant represents for a discharging capacitor. [2]

- A2** A $100\ \mu\text{F}$ capacitor discharges through a $10\ \text{k}\Omega$ resistor. Calculate the time constant of the circuit. [2]

- A3** Write down the equation for the charge remaining on a capacitor at time t as it discharges through a resistor. [1]

- A4** A capacitor charges through a resistor. State the percentage of its final charge that it has gained one time constant after charging begins. [1]

- A5** A $47\ \mu\text{F}$ capacitor discharges through a $2.2\ \text{M}\Omega$ resistor. Calculate the time constant of the circuit. [2]

SECTION B · Standard

- B1** A $470\ \mu\text{F}$ capacitor discharges through a $2.2\ \text{k}\Omega$ resistor. Calculate the time constant and state the fraction of the initial charge that remains after one time constant. [3]

- B2** A $100\ \mu\text{F}$ capacitor is charged to $12\ \text{V}$ and then discharged through a $47\ \text{k}\Omega$ resistor. Calculate the potential difference across the capacitor $5.0\ \text{s}$ after the discharge begins. [3]

- B3** For the circuit in the previous question, calculate the time taken for the potential difference to halve. [2]

- B4** A timing circuit requires a time constant of 2.0 s using a 220 μF capacitor. Calculate the resistance required. [2]

- B5** In required practical 9 a student discharges a capacitor through a resistor while logging the pd across it. The pd falls from 6.0 V to 2.2 V in 15 s. Show that the time constant of the circuit is about 15 s. [3]

- B6** A capacitor discharges through a 33 k Ω resistor. The pd across it halves every 4.6 s. Determine the capacitance of the capacitor. [3]

SECTION C · Stretch

- C1** A capacitor discharges through a resistor with a time constant of 3.0 s. Determine the time taken for the potential difference across it to fall from 20 V to 5.0 V. [3]

- C2** A 470 μF capacitor is charged from a 9.0 V supply through a 10 k Ω resistor. Calculate the potential difference across the capacitor 10 s after charging begins. [3]

- C3** A student plots $\ln(V)$ against time for a discharging capacitor. Explain how the time constant can be determined from this graph. [3]

- C4** A student uses required practical 9 to test a capacitor labelled $470\ \mu\text{F}$ with a tolerance of $\pm 20\%$. The capacitor is discharged through a $10\ \text{k}\Omega$ resistor, and the graph of $\ln(V)$ against t is a straight line of gradient $-0.185\ \text{s}^{-1}$. Deduce whether the capacitor is within its stated tolerance. [4]

- C5** A capacitor discharges through a resistor. Show that the energy stored falls to about 14% of its initial value after one time constant. [3]

- C6** The manual for a high-voltage supply states that its reservoir capacitor must be left to discharge until less than 1.0% of the initial charge remains before the case is opened. The discharge time constant is 4.0 s. Determine the minimum waiting time. [3]

- C7** Describe an experiment to determine the capacitance of an unmarked capacitor by discharging it through a resistor of known resistance. Include the measurements you would take and explain how you would analyse the data to obtain the capacitance. [6]
