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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

NAVY SCREEN EDITION

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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 μF capacitor discharges through a 10 kΩ 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 μF capacitor discharges through a 2.2 MΩ resistor. Calculate the time constant of the circuit. [2]

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SECTION B · Standard

B1 A 470 µF capacitor discharges through a 2.2 kΩ resistor. Calculate the time constant and state the fraction of the initial charge that remains after one time constant. [3]

B2 A 100 µF capacitor is charged to 12 V and then discharged through a 47 kΩ resistor. Calculate the potential difference across the capacitor 5.0 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]

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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 kΩ resistor. The pd across it halves every 4.6 s. Determine the capacitance of the capacitor. [3]

SECTION C · Stretch

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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 kΩ 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]

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C4 A student uses required practical 9 to test a capacitor labelled 470 μF with a tolerance of ±20%. The capacitor is discharged through a 10 kΩ resistor, and the graph of ln(V) against t is a straight line of gradient -0.185 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]

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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]

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