InkPhysics

ANSWER BOOK

Capacitors and energy stored

Capacitance · Year 13

AQA 3.7.4.1, 3.7.4.2, 3.7.4.3 · CIE 19.1, 19.2 · OCR A 6.1.1, 6.1.2, 6.2.3

10 questions · 30 marks

NAVY EDITION

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SECTION A · Warm-up

A1 Capacitance is the charge stored per unit potential difference, $C = Q/V$. Its unit is the farad (F), equal to one coulomb per volt. [2]

A2 $C = Q/V = (6.0 \times 10^{-3})/12 = 5.0 \times 10^{-4}$ F (500 μF). [2]

A3 $E = \tfrac{1}{2}QV = \tfrac{1}{2}CV^2 = \tfrac{1}{2}Q^2/C$. [2]

SECTION B · Standard

B1 (a) $Q = CV = 100 \times 10^{-6} \times 20 = 2.0 \times 10^{-3}$ C. (b) $E = \tfrac{1}{2}CV^2 = \tfrac{1}{2} \times 100 \times 10^{-6} \times 20^2 = 0.020$ J. [3]

B2 $E = \tfrac{1}{2}QV = \tfrac{1}{2} \times 5.0 \times 10^{-3} \times 8.0 = 0.020$ J. [3]

B3 $C = \varepsilon_0 A/d = (8.85 \times 10^{-12} \times 0.020)/(1.0 \times 10^{-3}) = 1.77 \times 10^{-10}$ F (177 pF). [4]

B4 $Q = CV = 470 \times 10^{-6} \times 9.0 = 4.23 \times 10^{-3}$ C. $E = \tfrac{1}{2}CV^2 = \tfrac{1}{2} \times 470 \times 10^{-6} \times 9.0^2 = 0.019$ J. [3]

SECTION C · Stretch

C1 $C = \varepsilon_0 \varepsilon_r A/d$, which is 4.0 times the vacuum value: $C = 4.0 \times 177 = 708$ pF. At a fixed voltage $E = \tfrac{1}{2}CV^2$, so the energy stored also increases by a factor of 4. [4]

C2 (a) $E = \tfrac{1}{2}Q^2/C = \tfrac{1}{2} \times (3.3 \times 10^{-3})^2/(220 \times 10^{-6}) = 0.0247$ J. (b) $V = Q/C = (3.3 \times 10^{-3})/(220 \times 10^{-6}) = 15$ V. [4]

C3 The field polarises the dielectric: its polar molecules rotate to line up with the field, producing their own opposing field. This reduces the net field (and so the voltage) for a given stored charge, so more charge can be held per volt, raising the capacitance. [3]