InkPhysics

QUESTION WORKBOOK

Capacitors and energy stored

Capacitance · Year 13

AQA 3.7.4.1, 3.7.4.2, 3.7.4.3 · CIE 19.1.1, 19.1.2, 19.1.3, 19.1.4, 19.2.1, 19.2.2
OCR A 6.1.1(a), 6.1.1(c), 6.1.1(d), 6.1.1(e)(i), 6.1.2(a), 6.1.2(b), 6.1.2(c), 6.2.3(b)

19 questions · 56 marks

NAVY SCREEN EDITION

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SECTION A · Warm-up

A1 Define capacitance and state its unit. [2]

A2 A capacitor stores a charge of 6.0×10^{-3} C when the potential difference across it is 12 V. Calculate its capacitance. [2]

A3 Write down three equivalent expressions for the energy stored by a charged capacitor. [3]

A4 A capacitor is charged in stages and a graph of charge stored against potential difference is plotted. State what is represented by the gradient of this graph. [1]

A5 The capacitor in a defibrillator stores a charge of 0.36 C when charged to a potential difference of 1.8 kV. Calculate its capacitance. [2]

A6 A 50 µF capacitor is used in a signal filter. Calculate the potential difference needed for it to store a charge of 4.0 mC. [2]

SECTION B · Standard

B1 A 100 µF capacitor is charged to a potential difference of 20 V. Calculate the charge stored and the energy stored. [3]

B2 A capacitor stores a charge of 5.0×10^{-3} C at a potential difference of 8.0 V. Calculate the energy stored. [2]

B3 A parallel-plate capacitor has plates of area 0.020 m^2 separated by a 1.0 mm vacuum gap. Calculate its capacitance.
$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1} [2]

B4 A 470 µF capacitor in a camera flash unit is charged to 9.0 V. Calculate the charge stored and the energy stored. [3]

B5 The sensing pad of a touch screen behaves as a parallel-plate capacitor. The pad has an area of 4.0 cm^2 and the plates are separated by a 0.10 mm layer of glass with relative permittivity 5.0. Calculate the capacitance of the pad.
$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1} [3]

B6 A student charges a capacitor from a variable supply and plots the potential difference across it against the charge stored. The graph is a straight line through the origin that passes through Q = 3.6 mC at V = 12 V. Determine the capacitance of the capacitor, and use the graph to determine the energy stored at 12 V. [4]

B7 A 1500 µF capacitor in a bicycle rear light is charged to 6.0 V. Show that the energy stored is about 27 mJ. Go on to calculate the average power delivered when the capacitor discharges completely through the LED in 0.30 s. [3]

SECTION C · Stretch

C1 The capacitor in the earlier question (177 pF with a vacuum gap) has the gap filled with a dielectric of relative permittivity 4.0. Calculate the new capacitance and state the effect on the energy stored if the capacitor remains connected to the same supply voltage. [3]

C2 A 220 μF capacitor stores a charge of 3.3×10^{-3} C. Calculate the energy stored and the potential difference across the capacitor. [4]

C3 Explain how inserting a polar dielectric between the plates of a capacitor increases its capacitance. [3]

C4 A designer needs a capacitor for a memory back-up circuit. It must store at least 2.5 J when charged to its maximum rated potential difference. Two capacitors are available:
capacitor P: capacitance 0.10 F, maximum rated pd 6.3 V
capacitor Q: capacitance 0.022 F, maximum rated pd 16 V
Deduce which capacitor, if either, meets the requirement. [4]

C5 A parallel-plate capacitor containing a polymer dielectric sheet of relative permittivity 2.5 is charged and then disconnected from the supply. The sheet is then withdrawn from between the plates. State and explain what happens to the capacitance, the charge stored, the potential difference across the plates and the energy stored. [4]

C6 A camera flash unit uses a capacitor, charged by a small battery, to supply a xenon flash tube. Explain why the energy stored by the charged capacitor is ½QV rather than QV, and explain why a capacitor, rather than the battery alone, is used to supply the flash tube. [6]