CAMBRIDGE INTERNATIONAL A LEVEL • PHYSICS 9702

Topical Questions

Unit 19: Capacitance

Past Papers 2021 – 2025

MARK SCHEME 13 Questions

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Question 1 — Mark Scheme

Question	Answer	Marks
6(a)	$Q = CV$ **and** $E = \frac{1}{2}CV^2$	**B1**
6(b)(i)	$C_N = CL / (L - D)$	**B1**
6(b)(ii)	(charge is unchanged by moving the plates so) $Q_N = CV$	**B1**
6(b)(iii)	$V_N = Q_N / C_N$ $= (CV) / [CL / (L - D)]$ $= V(L - D) / L$	**B1**
6(c)	oppositely charged plates attract, so energy stored decreases	**B1**

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Question 2 — Mark Scheme

Question	Answer	Marks
7(a)	charge / potential	**M1**
	charge is on one plate, potential is p.d. between the plates	**A1**
7(b)(i)	$I = Q / t$	**M1**
	charge = CV and time = $1 / f$ leading to $I = fCV$	**A1**
7(b)(ii)	$4.8 \times 10^{-6} = 150 \times 60 \times C$	**C1**
	$C = 530$ pF	**A1**
7(c)	(total) capacitance is halved	**B1**
	charge (for each cycle/discharge) is halved **or** since f and V are constant, current is proportional to capacitance	**B1**
	current = 2.4 μA	**B1**

Question 3 — Mark Scheme

9702/42 Cambridge International AS & A Level – Mark Scheme **PUBLISHED** May/June 2021

Question	Answer	Marks
6(a)	potential difference applied between the plates	**M1**
	causes charge separation (between the plates) **or** causes energy to be stored (between the plates)	**A1**
6(b)(i)	$I = Q / t$	**M1**
	clear substitution of $Q = CV$ and $f = 1 / t$, leading to $I = fCV$	**A1**
6(b)(ii)	$2.5 \times 10^{-6} = 50 \times C \times 180$	**C1**
	$C = 280$ pF	**A1**
6(c)	(total) capacitance increases	**B1**
	greater charge (for each cycle/discharge) so greater (average) current **or** V and f are constant so (average) current increases **or** I is (directly) proportional to C so (average) current increases	**B1**

Question 4 — Mark Scheme

9702/42 Cambridge International AS & A Level – Mark Scheme October/November 2021
PUBLISHED

Question	Answer	Marks
6(a)	work done per unit charge	B1
	(work done in) moving positive charge from infinity	B1
6(b)	$C = Q / V$	C1
	$V = Q / (4\pi\varepsilon_0 r)$ and so $C = Q / [Q / (4\pi\varepsilon_0 r)] = 4\pi\varepsilon_0 r$	A1
6(c)	$Q = 4\pi\varepsilon_0 rV \quad = 4\pi \times 8.85 \times 10^{-12} \times 0.13 \times 4500$ $(= 6.5 \times 10^{-8}\ \text{C})$	C1
	$(Q - q) / 13 = q / 5.2$	C1
	$5.2Q - 5.2q = 13q$, so $q = (5.2 / 18.2)Q$ $q \quad = (5.2 / 18.2) \times 6.5 \times 10^{-8}$ $= 1.9 \times 10^{-8}\ \text{C}$	A1
	or	
	$V_T = Q_T / C_T$ $= 6.5 \times 10^{-8} / [4\pi \times 8.85 \times 10^{-12} \times (0.13 + 0.052)]$ $(= 3210\ \text{V})$	(C1)
	$q \quad = 4\pi \times 8.85 \times 10^{-12} \times 0.052 \times 3210$ $= 1.9 \times 10^{-8}\ \text{C}$	(A1)

Question 6 — Mark Scheme

9702/42 Cambridge International AS & A Level – Mark Scheme **PUBLISHED** February/March 2022

Question	Answer	Marks
5(a)	(energy stored =) area under line or ½ QV = ½ × 8.0 × 1.2 × 10^{-4}	C1
	= **4.8 × 10^{-4}** J	A1
5(b)(i)	(τ=) RC	C1
	(τ=) 220 × 10^{3} × (1.2 × 10^{-4}/8.0) = **3.3** s	A1
5(b)(ii)	$E \propto V^2$	C1
	(so time to) V_o / 3 $V = V_o e^{-t/RC}$	C1
	$\frac{V_o}{3} = V_o e^{-t/3.3}$ $\frac{1}{3} = e^{-t/3.3}$	C1
	t = 3.6 s	A1
5(c)	(total) capacitance is doubled	M1
	time constant is doubled	A1

Question 7 — Mark Scheme

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Question	Answer	Marks
5(a)(i)	$Q = CV$	C1
	$Q_0 = 24 \times 470 \times 10^{-6}$ $= 0.011$ C	A1
5(a)(ii)	$I_0 = 24 / 5600$ $= 4.3 \times 10^{-3}$ A	A1
5(a)(iii)	$\tau = RC$	C1
	$= 5600 \times 470 \times 10^{-6}$ $= 2.6$ s	A1
5(a)(iv)	line with negative gradient throughout passing through $(0, I_0)$	B1
	exponential decay curve asymptotic to *t*-axis	B1
5(b)(i)	current in wire P gives rise to a magnetic field	B1
	as current (in P) changes, wire Q cuts (magnetic) flux (of wire P)	B1
	cutting magnetic flux causes induced e.m.f. (across Q)	B1
5(b)(ii)	sketch shows line with a negative gradient throughout	B1

Question 8 — Mark Scheme

Question	Answer	Marks
5(a)(i)	$Q_A = CV$	A1
5(a)(ii)	$E_A = \frac{1}{2}CV^2$	A1
5(b)(i)	some of the charge transfers to (the plates of) capacitor B	B1
	transfer is because the p.d.s across the capacitors are not equal **or** transfer stops when the p.d.s across the capacitors become equal	B1
5(b)(ii)	$V_A = V_B$	M1
	charge on A + charge on B = CV	M1
	$CV_B + 3CV_B = CV$ leading to $V_B = V/4$	A1
	or	
	$C_T = 4C$	(M1)
	$Q_T = CV$	(M1)
	$V_B = CV/4C = V/4$	(A1)
5(b)(iii)	$\Delta E = \frac{1}{2}CV^2 - nCV^2$, where n is a multiple that is less than $\frac{1}{2}$ **or** total final energy $= \frac{1}{2} \times 4C \times (V/4)^2$ $= \frac{1}{8}CV^2$	C1
	$\Delta E = \frac{1}{2}CV^2 - \frac{1}{8}CV^2$ $= \frac{3}{8}CV^2$	A1

Question 9 — Mark Scheme

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Question	Answer	Marks
5(a)	from graph ln Q = 2.9 (so Q = 18.2 μC)	B1
	$C = Q / V$	C1
	= 18.2 / 12 = 1.5 μF	A1
5(b)	gradient = –0.25	C1
	gradient = $-1 / RC$	C1
	$R = 1 / (0.25 \times 1.5 \times 10^{-6})$ $= 2.7 \times 10^{6}\ \Omega$	A1
	or $\frac{Q}{Q_0} = e^{-t/CR}$ **or** ln Q – ln $Q_0 = \frac{-t}{CR}$	(C1)
	e.g. $\frac{4.95}{18.2} = e^{-5.2/(1.5\times10^{-6}R)}$ **or** 1.6 – 2.9 = 5.2 / (1.5 × $10^{-6}R$)	(C1)
	$R = 2.7 \times 10^{6}\ \Omega$	(A1)

Question	Answer	Marks
5(c)	$W = ½ QV$	C1
	$= ½ \times 18.2 \times 10^{-6} \times 12$ $= 1.1 \times 10^{-}4$ J	A1
	or $W = ½ CV^2$	(C1)
	$= ½ \times 1.5 \times 10^{-6} \times 12^2$ $= 1.1 \times 10^{-}4$ J	(A1)
	or $W = ½ Q^2 / C$	(C1)
	$= ½ \times (18.2 \times 10^{-6})^2 / 1.5 \times 10^{-6}$ $= 1.1 \times 10^{-}4$ J	(A1)
5(d)	straight line with different negative gradient starting from (0, 2.9)	M1
	straight line between $t = 0$ and at least $t = 5.0$ s with twice the gradient of the original line	A1

Question 10 — Mark Scheme

Question	Answer	Marks
6(a)(i)	energy stored = area under graph	C1
	= ½ × 450 × 10^{-6} × 8.0 = 1.8 × 10^{-3} J **or** 1.8 mJ	A1
6(a)(ii)	$C = Q / V$ **or** $E = ½CV^2$	C1
	C = (450 × 10^{-6}) / 8.0 **or** (2 × 1.8 × 10^{-3}) / 8.0^2 = 5.6 × 10^{-5} F	A1
6(b)(i)	$V = V_0 \exp(-t/RC)$ **and** $\tau = RC$	C1
	$V = V_0 \exp(-t/\tau)$ V_0 = 8.0 V, and at one time constant, $t = \tau$ $V/8.0 = \exp(-\tau/\tau)$, so ln (V/8.0) = –1.0 **or** –ln (V/8.0) = 1.0	A1
6(b)(ii)	[t read from graph at –ln (V/8.0) = 1.0]: τ = 3.2 s	A1
6(b)(iii)	$\tau = RC$	C1
	R = 3.2 / (5.6 × 10^{-5}) = 5.7 × 10^4 Ω	A1

Question 11 — Mark Scheme

Question	Answer	Marks
6(a)	• p.d. across capacitor proportional to charge on capacitor • p.d. across capacitor = p.d. across resistor • current in resistor proportional to p.d. across resistor • current in resistor = rate of decrease of charge on capacitor *Any two points, 1 mark each*	**B2**
	charge proportional to current so rate of decrease of current decreases as current decreases (therefore exponential shape)	**B1**
6(b)(i)	$R = V / I$ $= 12 / (0.13 \times 10^{-3})$	**C1**
	$= 9.2 \times 10^{4}\ \Omega$	**A1**
6(b)(ii)	correct read-off of at least one pair of values for I and t	**C1**
	attempted read-off of t when $I = 0.048$ mA **or** substitution of a correct pair of values of I and t into $I = 0.13 \exp(-t / \tau)$	**C1**
	$\tau = 4.3$ s	**A1**
6(c)	$\tau = RC$	**C1**
	$C = \tau / R = 4.3 / (9.2 \times 10^{4})$ $= 4.7 \times 10^{-5}$ F	**A1**

Question 12 — Mark Scheme

Question	Answer	Marks
6(a)	equal charge on both capacitors	B1
	$V_X + V_Y = V$	M1
	$(Q / C_X) + (Q / C_Y) = (Q / C_T)$ leading to $(1 / C_X) + (1 / C_Y) = (1 / C_T)$ **or** $(V_X / Q) + (V_Y / Q) = (V / Q)$ leading to $(1 / C_X) + (1 / C_Y) = (1 / C_T)$	A1
6(b)(i)	$E = ½CV^2$	C1
	$V = \sqrt{[(2 \times 2.5 \times 10^{-3}) / (200 \times 10^{-6})]} = 5.0\,V$	A1
6(b)(ii)	total capacitance = 600 μF	C1
	$E = ½ \times 600 \times 10^{-6} \times 5.0^2$ $(= 7.5 \times 10^{-3}\,J)$	C1
	$= 7.5\,mJ$	A1
6(b)(iii)	line with positive gradient starting at (0, 2.5)	B1
	straight line passing through (400, 7.5)	B1

Question 13 — Mark Scheme

Question	Answer	Marks
4(a)	combined capacitance of parallel capacitors = 30 (μF)	C1
	total capacitance = $(1/45 + 1/30)^{-1}$ = 18 μF	A1
4(b)	$E = \frac{1}{2}CV^2$	C1
	$\Delta E = \frac{1}{2} \times 45 \times 10^{-6} (9.6^2 - 8.0^2)$ $= 6.3 \times 10^{-4}$ J	A1
4(c)(i)	gaps in circuit closed and correct symbol for capacitor shown in parallel with load resistor	B1
4(c)(ii)	two correct pairs of values of t and V read off from within same discharge cycle, e.g. (5.0, 4.0) and (13.0, 3.2)	C1
	correct substitution of values of V, V_0 and Δt into $V = V_0 \exp(-\Delta t / \tau)$ e.g. $3.2 = 4.0 \exp(-8.0 / \tau)$	C1
	τ = 36 ms	A1

Question	Answer	Marks
4(d)(i)	8.0 W	A1
4(d)(ii)	4.0 W	A1

Question 14 — Mark Scheme

Question	Answer	Marks
7(a)	charge / potential (difference)	M1
	charge is charge on one plate, and potential is p.d. between the plates	A1
7(b)(i)	straight line starting at the origin	B1
	line with positive gradient ending at (V, Q)	B1
7(b)(ii)	work done is the area under the graph	B1
	$W = \frac{1}{2}QV$	A1
7(c)(i)	final p.d. shown as $V/4$ for both capacitors	B1
	final charges add together to give Q	B1
	charge on Y = 3 × charge on X (and both charges shown as a multiple of Q) Fully correct answer: X: final p.d. $V/4$, final charge $Q/4$ Y: final p.d. $V/4$, final charge $3Q/4$	B1
7(c)(ii)	less than	B1