CAMBRIDGE INTERNATIONAL AS & A LEVEL PHYSICS · 9702

PHYSICS



MARK SCHEME

19 CAPACITANCE

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196. 9702_m21_MS_42 Q: 6

	Answer	Marks
(a)	(both have) radial field lines	B1
(b)(i)	**2.1** cm	B1
(b)(ii)	$E = \frac{Q}{4\pi\varepsilon_o r^2}$ e.g. r = 2.1 cm, $E = 1.30 \times 10^5$ V m^{-1} $Q = 4\pi\varepsilon_o r^2 E$ $= 4\times\pi\times 8.85\times10^{-12}\times0.021^2\times1.30\times10^5$	C1
	$= 6.4\times10^{-9} C$	A1

	Answer	Marks
(c)	$C = \frac{Q}{V}$ *either* $V = \frac{Q}{4\pi\varepsilon_o r}$ leading to $C = 4\pi\varepsilon_o r$	C1
	$C = 4\times\pi\times8.85\times10^{-12}\times0.021$	C1
	$(C =) 2.3\times10^{-12}$ F	A1
	or $V = \frac{Q}{4\pi\varepsilon_o r}$ $= \frac{6.4\times10^{-9}}{4\times\pi\times8.85\times10^{-12}\times0.021}$ $= 2740 V$ $C = \frac{6.4\times10^{-9}}{2740}$	(C1)
	$= 2.3\times10^{-12}$F	(A1)

197. 9702_s21_MS_41 Q: 7

	Answer	Marks
(a)	charge / potential	M1
	charge is on one plate, potential is p.d. between the plates	A1
(b)(i)	$I = Q / t$	M1
	charge = CV and time = $1 / f$ leading to $I = fCV$	A1
(b)(ii)	$4.8 \times 10^{-6} = 150 \times 60 \times C$	C1
	C = 530 pF	A1
(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

198. 9702_s21_MS_42 Q: 6

	Answer	Marks
(a)	potential difference applied between the plates	M1
	causes charge separation (between the plates) **or** causes energy to be stored (between the plates)	A1
(b)(i)	$I = Q / t$	M1
	clear substitution of $Q = CV$ and $f = 1 / t$, leading to $I = fCV$	A1
(b)(ii)	$2.5 \times 10^{-6} = 50 \times C \times 180$	C1
	$C = 280$ pF	A1
(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

199. 9702_s21_MS_43 Q: 7

	Answer	Marks
(a)	charge / potential	M1
	charge is on one plate, potential is p.d. between the plates	A1
(b)(i)	$I = Q / t$	M1
	charge = CV and time = $1 / f$ leading to $I = fCV$	A1
(b)(ii)	$4.8 \times 10^{-6} = 150 \times 60 \times C$	C1
	$C = 530$ pF	A1
(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

200. 9702_w21_MS_42 Q: 6

	Answer	Marks
(a)	work done per unit charge	B1
	(work done in) moving positive charge from infinity	B1
(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
(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)

201. 9702_m20_MS_42 Q: 6

	Answer	Marks
(a)	**2.0** cm	B1
(b)	At 16 (cm) from A the electric fields are equal or $E_A = E_B$	B1
	$E = Q / 4\pi\varepsilon_o r^2$ $Q_A / (4\pi\varepsilon_o r_A^2) = Q_B / (4\pi\varepsilon_o r_B^2)$ $3.6 \times 10^{-9} / 0.16^2 = Q_B / 0.08^2$	C1
	$Q_B = \mathbf{9.0 \times 10^{-10}}\ \text{C}$	A1
(c)(i)	$V = Q / 4\pi\varepsilon_o r_A$ $V = 3.6 \times 10^{-9} / (4 \times \pi \times 8.85 \times 10^{-12} \times 0.020)$	C1
	$V = \mathbf{1600}\ \text{V}$	A1
(c)(ii)	$C = Q / V$ $= 3.6 \times 10^{-9} / 1600$	C1
	$= \mathbf{2.3 \times 10^{-12}}\ \text{F}$	A1

202. 9702_s19_MS_41 Q: 6

	Answer	Marks
(a)	Any valid two points e.g.: • to store (electrical) energy • smoothing/reduce ripple (on direct voltages/currents) • to block d.c. • timing/time delay (circuits) • in oscillator (circuits) • in tuning (circuits) • to prevent arcing/sparks	**B2**
(b)	clear indication of equal charge on each capacitor	**B1**
	$E = V_1 + V_2 + V_3$ **and** $V = Q / C$	**M1**
	completion of algebra leading to $1 / C = 1 / C_1 + 1 / C_2 + 1 / C_3$	**A1**
(c)(i)	three capacitors connected in parallel	**B1**
(c)(ii)	parallel combination of three capacitors connected in series with one capacitor	**B1**

203. 9702_s19_MS_43 Q: 6

	Answer	Marks
(a)	Any valid two points e.g.: • to store (electrical) energy • smoothing/reduce ripple (on direct voltages/currents) • to block d.c. • timing/time delay (circuits) • in oscillator (circuits) • in tuning (circuits) • to prevent arcing/sparks	**B2**
(b)	clear indication of equal charge on each capacitor	**B1**
	$E = V_1 + V_2 + V_3$ **and** $V = Q / C$	**M1**
	completion of algebra leading to $1 / C = 1 / C_1 + 1 / C_2 + 1 / C_3$	**A1**
(c)(i)	three capacitors connected in parallel	**B1**
(c)(ii)	parallel combination of three capacitors connected in series with one capacitor	**B1**

204. 9702_s18_MS_41 Q: 7

	Answer	Marks
(a)	(capacitance =) charge / potential	**M1**
	charge is (numerically equal to) charge on one plate	**A1**
	potential is potential difference between plates	**A1**
(b)(i)	4.5×10^{-6} C	**A1**
(b)(ii)	9.0×10^{-8} C	**A1**
(b)(iii)	capacitance = $(9.0 \times 10^{-8}) / 120$	**C1**
	$= 7.5 \times 10^{-10}$ F	**A1**
(c)	total capacitance is halved	**B1**
	current is halved	**B1**

205. 9702_s18_MS_43 Q: 7

	Answer	Marks
(a)	(capacitance =) charge / potential	M1
	charge is (numerically equal to) charge on one plate	A1
	potential is potential difference between plates	A1
(b)(i)	4.5×10^{-6} C	A1
(b)(ii)	9.0×10^{-8} C	A1
(b)(iii)	capacitance = $(9.0 \times 10^{-8}) / 120$	C1
	$= 7.5 \times 10^{-10}$ F	A1
(c)	total capacitance is halved	B1
	current is halved	B1

206. 9702_w17_MS_41 Q: 6

	Answer	Marks
(a)(i)	$1/T = 1/(2C) + 1/C$	C1
	$T = \frac{2}{3}C$ **or** $0.67C$	A1
(a)(ii)	same charge on Q as on combination	B1
	so p.d. is 6.0 V	B1
(b)	P: p.d. will decrease (from 3.0 V)	B1
	to zero	B1
	Q: p.d. will increase (from 6.0 V)	B1
	to 9.0 V	B1

207. 9702_w17_MS_43 Q: 6

	Answer	Marks
(a)(i)	$1/T = 1/(2C) + 1/C$	C1
	$T = \frac{2}{3}C$ **or** $0.67C$	A1
(a)(ii)	same charge on Q as on combination	B1
	so p.d. is 6.0 V	B1
(b)	P: p.d. will decrease (from 3.0 V)	B1
	to zero	B1
	Q: p.d. will increase (from 6.0 V)	B1
	to 9.0 V	B1

208. 9702_w16_MS_42 Q: 7

(a) (i) charge / potential (difference) or charge per (unit) potential (difference) B1 [1]

(ii) ($V = Q/4\pi\varepsilon_0 r$ and $C = Q/V$)

for sphere, $C\ (= Q/V) = 4\pi\varepsilon_0 r$ C1

$C = 4\pi \times 8.85 \times 10^{-12} \times 12.5 \times 10^{-2} = 1.4 \times 10^{-11}$ F A1 [2]

(b) (i) $1/C_T = 1/3.0 + 1/6.0$

$C_T = 2.0\,\mu$F A1 [1]

(ii) total charge = charge on 3.0 μF capacitor = 2.0 (μ) × 9.0 = 18 (μC) C1

potential difference = Q/C = 18 (μ)C / 3.0 (μ)F = 6.0 V A1 [2]

or

argument based on equal charges:

$3.0 \times V = 6.0 \times (9.0 - V)$ (C1)

$V = 6.0$ V (A1)

(iii) potential difference (= 9.0 – 6.0) = 3.0 V C1

charge (= 3.0 × 2.0 (μ)) = 6.0 μC A1 [2]

209. 9702_w21_MS_41 Q: 6

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

210. 9702_w21_MS_43 Q: 6

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

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211. 9702_m19_MS_42 Q: 6

	Answer	Marks
(a)	charge / potential (difference)	M1
	charge on one plate, p.d. between the plates	A1
(b)(i)	all three capacitors connected in series	B1
(b)(ii)	8 (μF) in parallel with the two 4 (μF) capacitors connected in series	B1
(c)	discharge from 7.0 V to 4.0 V	C1
	Either energy = ½CV^2 *or* energy = ½ QV and $C = Q / V$	C1
	energy = ½ × 47 × 10^{-6} × ($7^2 - 4^2$) = 7.8 × 10^{-4} J	A1

212. 9702_s18_MS_42 Q: 6

	Answer	Marks
(a)	capacitance = charge / potential	M1
	charge is (numerically equal to) charge on one plate	A1
	potential is potential difference between plates	A1
(b)(i)	two in series, in parallel with the other (correct symbols)	A1
(b)(ii)	two in parallel connected to one in series (correct symbols)	A1
(c)(i)	capacitance = 1.2 μF	A1
(c)(ii)	**1.** $Q = CV$	C1
	= 1.2 × 8.0 = 9.6 μC	A1
	2. E = ½QV **and** $V = Q/C$ **or** E = ½CV^2 **and** $V = Q/C$ **or** E = ½Q^2/C	C1
	E = ½ (9.6 × 10^{-6})^2 / (3.0 × 10^{-6}) = 1.5 × 10^{-5} J	A1

213. 9702_s17_MS_42 Q: 7

	Answer	Marks
(a)	equal and opposite charges on the plates so no resultant charge	B1
	+ve and –ve charges separated so energy stored	B1
(b)	charge / potential difference	M1
	reference to charge on one plate and p.d. between plates	A1
(c)	energy = ½ CV^2 **or** energy = ½ QV **and** $C = Q / V$	C1
	(1 / 16) × ½ CV_0^2 = ½ CV^2 V = ¼ V_0	A1

214. 9702_m16_MS_42 Q: 7

(a) (capacitance =) charge / potential (difference) B1 [1]

(b) $V = V_1 + V_2 + V_3$ B1
either $Q/C = Q/C_1 + Q/C_2 + Q/C_3$ *or* $V/Q = V_1/Q + V_2/Q + V_3/Q$
and so $1/C = 1/C_1 + 1/C_2 + 1/C_3$ B1 [2]

(c) (i) 1. $1/C_T = (1/200) + (1/600)$
$C_T = 150\ \mu F$ A1 [1]

2. $Q = CV$
$= 150 \times 10^{-6} \times 12$ *or* $600 \times 10^{-6} \times 3.0$ *or* $200 \times 10^{-6} \times 9.0$
$= 1.8 \times 10^{-3}\,C$ A1 [1]

3. $V = Q/C = 1.8 \times 10^{-3} / 600 \times 10^{-6}$ *or* $V = [200/(200 + 600)] \times 12$
$= 3(.0)\,V$ A1 [1]

(ii) energy = $\frac{1}{2}CV^2$ or energy = $\frac{1}{2}QV$ and $C = Q/V$ C1
$^1/_2 \times C \times 3^2 = 2 \times {}^1/_2 \times C \times V^2$ C1
$V = 2.1\,V$ A1 [3]

215. 9702_m20_MS_42 Q: 7

	Answer	Marks
(a)	axes labelled with resistance and temperature	**M0**
	concave curve not touching temperature axis	**A1**
	line with negative gradient throughout	**A1**
(b)	resistance of thermistor decreases	**B1**
	total circuit resistance decreases so voltmeter reading increases *or* current increases so voltmeter reading increases *or* greater proportion of resistance in fixed resistor so voltmeter reading increases *or* p.d. across thermistor decreases so voltmeter reading increases	**B1**
(c)	(0.020 strain means) $\Delta R / R = 0.090$	**C1**
	$\Delta R = 0.090 \times 120 = 10.8\ \Omega$	**C1**
	resistance = 120 + 10.8 = **130** Ω	**A1**

Q1.

8	(a)	Q/V, with symbols explained [do not allow in terms of units]	**B1**	**[1]**
	(b) (i)	on a capacitor, there is charge separation/there are + and - charges	**M1**	
		either to separate charges, work must be done		
		or energy released when charges 'come together'	**A1**	**[2]**
	(ii)	either energy = $\frac{1}{2}CV^2$ or energy = $\frac{1}{2}QV$ and $C = Q/V$	**C1**	
		change = $\frac{1}{2} \times 1200 \times 10^{-6} (50^2 - 15^2)$	**C1**	
		change = 1.4 J (1.37)	**A1**	**[3]**
		[allow 2 marks for $\frac{1}{2}C(\Delta V)^2$, giving energy = 0.74 J)		

Q2.

5	(a)	at t = 1.0 s, V = 2.5 V	C1	
		energy = $\frac{1}{2}CV^2$	C1	
		$0.13 = \frac{1}{2} \times C \times (8.0^2 - 2.5^2)$	M1	
		C = 4500 μF	A0	[3]
	(b)	use of two capacitors in series in all branches of combination	M1	
		connected into correct parallel arrangement	A1	[2]

Q3.

5	(a) (i)	ratio of charge (on body) and its potential	B1	[1]
		(do not allow reference to plates of a capacitor)		
	(ii)	(potential at surface of sphere =) $V = Q / 4\pi\varepsilon_0 r$	M1	
		$C = Q / V = 4\pi\varepsilon_0 r$	A0	[1]
	(b) (i)	$C = 4 \times \pi \times 8.85 \times 10^{-12} \times 0.36$		
		$= 4.0 \times 10^{-11}$ F *(allow 1 s.f.)*	A1	[1]
	(ii)	$Q = CV$		
		$= 4.0 \times 10^{-11} \times 7.0 \times 10^5$		
		$= 2.8 \times 10^{-5}$ C	A1	[1]
	(c)	plastic is an insulator / not a conductor / has no free electrons	B1	
		charges do not move (on an insulator)	B1	
		either so no single value for the potential		
		or charge cannot be considered to be at centre	B1	[3]
	(d)	*either* energy = $\frac{1}{2}CV^2$ *or* energy = $\frac{1}{2}QV$ and $C = Q/V$	C1	
		energy = $\frac{1}{2} \times 4 \times 10^{-11} \times \{(7.0 \times 10^5)^2 - (2.5 \times 10^5)^2)\}$	C1	
		= 8.6 J	A1	[3]

Q4.

5 (a) e.g. 'storage of charge' / storage of energy
blocking of direct current
producing of electrical oscillations
smoothing
(any two, 1 mark each) B2 [2]

(b) (i) capacitance of parallel combination = 60 μF C1
total capacitance = 20 μF A1 [2]

(ii) p.d. across parallel combination = ½ × p.d. across single capacitor C1
maximum is 9V A1 [2]

(c) *either* energy = $\frac{1}{2}CV^2$ *or* energy = $\frac{1}{2}QV$ and $Q = CV$ C1
energy = $\frac{1}{2} \times 4700 \times 10^{-6} \times (18^2 - 12^2)$ C1
= 0.42 J A1 [3]

Q5.

3 (a) charges on plates are equal and opposite M1
so no resultant charge A1
energy stored because there is charge separation B1 [3]

(b) (i) capacitance = Q / V C1
$= (18 \times 10^{-3}) / 10$
= 1800 μF A1 [2]

(ii) use of area under graph *or* energy = $\frac{1}{2}CV^2$ C1
energy = $2.5 \times 15.7 \times 10^{-3}$ *or* energy = $\frac{1}{2} \times 1800 \times 10^{-6} \times (10^2 - 7.5^2)$
= 39 mJ A1 [2]

(c) combined capacitance of Y & Z = 20 μF *or* total capacitance = 6.67 μF C1
p.d. across capacitor X = 8V *or* p.d. across combination = 12V C1
charge = $10 \times 10^{-6} \times 8$ *or* $6.67 \times 10^{-6} \times 12$
= 80 μC A1 [3]

Q6.

5 (a) two capacitors in series
or any circuit such that $V \leq 25$ V across any C B1
in parallel with second series pair or any correct combination ..... B1 [2]

(b) two capacitors in series in parallel with a single capacitor
or other correct combination ..... B2 [2]
(leads not shown, then –1 overall)

Q7.

5 (a) e.g. separate charges, store energy, smoothing circuit. etc. .....B1 [1]
(*allow 'stores charge'*)

(b) (i) charge = current × time .....B1 [1]

(ii) area is 21.2 cm^2 (*allow ±0.5 cm^2*) C2
(*allow 1 mark if outside ±0.5 cm^2 but within ±1.0 cm^2*)
1.0 cm^2 represents ($0.125 \times 10^{-3} \times 1.25$ =) 156 μC C1
charge = 3300 μC .....A1 [4]

(iii) capacitance = Q/V C1
= $(3300 \times 10^{-6}) / 15$
= 220 μF .....A1 [2]

(c) *either* energy = $\frac{1}{2}CV^2$ or energy = $\frac{1}{2}QV$ and $C = Q/V$ C1
$\frac{1}{2} \times C \times 15^2 = 2 \times \frac{1}{2} \times C \times V^2$ C1
V = 10.6 V .....A1 [3]

Q8.

4 (a) charge / potential .....(*ratio must be clear*) .....B1 [1]

(b) potential (at surface of sphere) = $Q / 4\pi\varepsilon_0 R$ M1
$C = Q / V = 4\pi\varepsilon_0 R$ .....A0 [1]

(c) (i) $C = 4\pi \times 8.85 \times 10^{-12} \times 0.63$ C1
$= 7.0 \times 10^{-11}$ A1
farad / F .....B1 [3]

(ii) energy = $\frac{1}{2}CV^2$ C1
$0.25 \times \frac{1}{2}C \times (1.2 \times 10^6)^2 = \frac{1}{2}CV^2$ C1
$V = 6.0 \times 10^5$ V .....A1 [3]
(*use of 0.75 rather than 0.25, allow max 2 marks*)

[Total: 8]

Q9.

4	(a)	charge / potential (difference) (*ratio must be clear*)	B1	[1]
	(b) (i)	$V = Q / 4\pi\varepsilon_0 r$	B1	[1]
	(ii)	$C = Q / V = 4\pi\varepsilon_0 r$ and $4\pi\varepsilon_0$ is constant so $C \propto r$	M1 A0	[1]
	(c) (i)	$r = C / 4\pi\varepsilon_0 r$ $r = (6.8 \times 10^{-12}) / (4\pi \times 8.85 \times 10^{-12})$ $= 6.1 \times 10^{-2}$ m	C1 C1 A1	[3]
	(ii)	$Q = CV = 6.8 \times 10^{-12} \times 220$ $= 1.5 \times 10^{-9}$ C	A1	[1]
	(d) (i)	$V = Q/C = (1.5 \times 10^{-9}) / (18 \times 10^{-12})$ $= 83$ V	A1	[1]
	(ii)	*either* energy = $\frac{1}{2}CV^2$ $\Delta E = \frac{1}{2} \times 6.8 \times 10^{-12} \times 220^2 - \frac{1}{2} \times 18 \times 10^{-12} \times 83^2$ $= 1.65 \times 10^{-7} - 6.2 \times 10^{-8}$ $= 1.03 \times 10^{-7}$ J *or* energy = $\frac{1}{2}QV$ $\Delta E = \frac{1}{2} \times 1.5 \times 10^{-9} \times 220 - \frac{1}{2} \times 1.5 \times 10^{-9} \times 83$ $= 1.03 \times 10^{-7}$ J	C1 C1 A1 (C1) (C1) (A1)	[3]

Q10.

4	(a) (i)	work done moving unit positive charge from infinity to the point	M1 A1	[2]
	(ii)	charge / potential (difference) (*ratio must be clear*)	B1	[1]
	(b) (i)	capacitance = $(2.7 \times 10^{-6}) / (150 \times 10^3)$ (*allow any appropriate values*) capacitance = 1.8×10^{-11} (*allow 1.8 ±0.05)*	C1 A1	[2]
	(ii)	*either* energy = $\frac{1}{2}CV^2$ *or* energy = $\frac{1}{2}QV$ *and* $Q = CV$ energy = $\frac{1}{2} \times 1.8 \times 10^{-11} \times (150 \times 10^3)^2$ *or* $\frac{1}{2} \times 2.7 \times 10^{-6} \times 150 \times 10^3$ = 0.20 J	C1 A1	[2]
	(c)	*either* since energy $\propto V^2$, capacitor has $(\frac{1}{2})^2$ of its energy left *or* full formula treatment energy lost = 0.15 J	C1 A1	[2]

Q11.

4 (a) e.g. storing energy
separating charge
blocking d.c.
producing electrical oscillations
tuning circuits
smoothing
preventing sparks
timing circuits
(any two sensible suggestions, 1 each, max 2) B2 [2]

(b) (i) $-Q$ (induced) on opposite plate of C_1 B1
by charge conservation, charges are $-Q$, $+Q$, $-Q$, $+Q$, $-Q$ B1 [2]

(ii) total p.d. $V = V_1 + V_2 + V_3$ B1
$Q/C = Q/C_1 + Q/C_2 + Q/C_3$ B1
$1/C = 1/C_1 + 1/C_2 + 1/C_3$ A0 [2]

(c) (i) energy $= \frac{1}{2}CV^2$ or energy $= \frac{1}{2}QV$ and $C = Q/V$ C1
$= \frac{1}{2} \times 12 \times 10^{-6} \times 9.0^2$
$= 4.9 \times 10^{-4}$ J A1 [2]

(ii) energy dissipated in (resistance of) wire/as a spark B1 [1]

Q12.

5 (a) (i) ratio of charge and potential (difference)/voltage
(*ratio must be clear*) B1 [1]

(ii) capacitor has equal magnitudes of (+)ve and (-)ve charge B1
total charge on capacitor is zero (so does not store charge) B1
(+)ve and (-)ve charges to be separated M1
work done to achieve this so stores energy A1 [4]

(b) (i) capacitance of Y and Z together is 24 μF C1
$1/C = 1/24 + 1/12$
$C = 8.0$ μF (*allow* 1 s.f.) A1 [2]

(ii) some discussion as to why all charge of one sign on one plate of X B1
$Q = (CV =) \underline{8.0 \times 10^{-6}} \times 9.0$ M1
$= 72\,\mu C$ A0 [2]

(iii) 1. $V = (72 \times 10^{-6})/(12 \times 10^{-6})$
$= 6.0$ V (*allow* 1 s.f.) (allow 72/12) A1 [1]

2. *either* $Q = 12 \times 10^{-6} \times 3.0$ *or* charge is shared between Y and Z C1
charge = 36 μC A1 [2]
Must have correct voltage in ***(iii)****1 if just quote of 36*μ*C in* ***(iii)****2.*

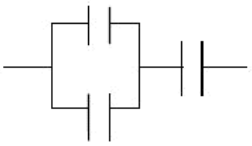
Q13.

4 (a) e.g. store energy (do not allow 'store charge')
in smoothing circuits
blocking d.c.
in oscillators
any sensible suggestions, one each, max. 2 B2 [2]

(b) (i) potential across each capacitor is the same and $Q = CV$ B1 [1]

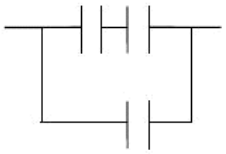
(ii) total charge $Q = Q_1 + Q_2 + Q_3$ M1
$CV = C_1V + C_2V + C_3V$ M1
(*allow* $Q = CV$ *here* or in (i))
so $C = C_1 + C_2 + C_3$ A0 [2]

(c) (i)



A1 [1]

(ii)



A1 [1]

Q14.

6 (a) (i) energy $= EQ$ C1
$= 9.0 \times 22 \times 10^{-3}$
$= 0.20$ J A1 [2]

(ii) 1. $C = Q/V$
$V = (22 \times 10^{-3})/(4700 \times 10^{-6})$ C1
$= 4.7$ V A1 [2]

2. *either* $E = \frac{1}{2}CV^2$ C1
$= \frac{1}{2} \times 4700 \times 10^{-6} \times 4.7^2$
$= 5.1 \times 10^{-2}$ J A1 [2]

or $E = \frac{1}{2}QV$ (C1)
$= \frac{1}{2} \times 22 \times 10^{-3} \times 4.7$
$= 5.1 \times 10^{-2}$ J (A1)

or $E = \frac{1}{2}Q^2/C$ (C1)
$= \frac{1}{2} \times (22 \times 10^{-3})^2/4700 \times 10^{-6}$
$= 5.1 \times 10^{-2}$ J (A1)

(b) energy lost (as thermal energy) in resistance/wires/battery/resistor B1 [1]
(award only if answer in ***(a)(i)*** *> answer in* ***(a)(ii)2****)*

Q15.

6	(a)	for the two capacitors in parallel, capacitance = 96 μF	C1	
		for complete arrangement, $1/C_T = 1/96 + 1/48$		
		$C_T = 32\,\mu F$	A1	[2]
	(b)	p.d. across parallel combination is one half p.d. across single capacitor	C1	
		total p.d. = 9 V	A1	[2]