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 *(do not allow reference to plates of a capacitor)*	B1	[1]
	(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 = 8 V *or* p.d. across combination = 12 V 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 $\times$ time ....B1 [1]

(ii) area is 21.2 cm^2 (*allow* $\pm 0.5\ cm^2$) C2
(*allow 1 mark if outside* $\pm 0.5\ cm^2$ *but within* $\pm 1.0\ cm^2$)
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 <u>$4\pi\varepsilon_0$ is constant</u>	M1	
		so $C \propto r$	A0	[1]
	(c) (i)	$r = C / 4\pi\varepsilon_0 r$	C1	
		$r = (6.8 \times 10^{-12}) / (4\pi \times 8.85 \times 10^{-12})$	C1	
		$= 6.1 \times 10^{-2}$ m	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 = $\frac{1}{2}CV^2$	C1	
		$\Delta E = \frac{1}{2} \times 6.8 \times 10^{-12} \times 220^2 - \frac{1}{2} \times 18 \times 10^{-12} \times 83^2$	C1	
		$= 1.65 \times 10^{-7} - 6.2 \times 10^{-8}$		
		$= 1.03 \times 10^{-7}$ J	A1	[3]
		or energy = $\frac{1}{2}QV$	(C1)	
		$\Delta E = \frac{1}{2} \times 1.5 \times 10^{-9} \times 220 - \frac{1}{2} \times 1.5 \times 10^{-9} \times 83$	(C1)	
		$= 1.03 \times 10^{-7}$ J	(A1)	

Q10.

4	**(a) (i)**	work done moving unit positive charge	M1	
		from infinity <u>to the point</u>	A1	[2]
	(ii)	charge / potential (difference) *(ratio must be clear)*	B1	[1]
	(b) (i)	capacitance = $(2.7 \times 10^{-6}) / (150 \times 10^3)$	C1	
		(*allow any appropriate values*)		
		capacitance = 1.8×10^{-11} *(allow 1.8 ±0.05)*	A1	[2]
	(ii)	*either* energy = $\frac{1}{2}CV^2$ *or* energy = $\frac{1}{2}QV$ *<u>and</u>* $Q = CV$	C1	
		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	A1	[2]
	(c)	*either* since energy $\propto V^2$, capacitor has $(\frac{1}{2})^2$ of its energy left		
		or full formula treatment	C1	
		energy lost = 0.15 J	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 <u>charge conservation</u>, 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 $= ½CV^2$ or energy $= ½\,QV$ and $C = Q/V$		C1	
	$= ½ \times 12 \times 10^{-6} \times 9.0^2$ $= 4.9 \times 10^{-4}$ 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	
	<u>total</u> 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	
	$Q = (CV =)$ <u>8.0×10^{-6}</u> $\times 9.0$	M1	
	$= 72$ μC	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 36μC in **(iii)**2.*		

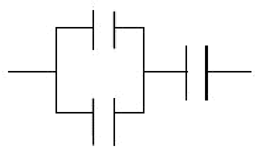
Q13.

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 <u>and</u> $Q = CV$ — B1 [1]

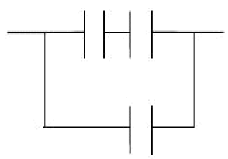
(ii) total charge $Q = Q_1 + Q_2 + Q_3$ — M1
$CV = C_1V + C_2V + C_3V$ — M1
(*allow* $Q = CV$ *here* or in **(i)**)
so $C = C_1 + C_2 + C_3$ — A0 [2]

(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* $E = ½CV^2$ — C1
$= ½ \times 4700 \times 10^{-6} \times 4.7^2$
$= 5.1 \times 10^{-2}$ J — A1 [2]

or $E = ½QV$ — (C1)
$= ½ \times 22 \times 10^{-3} \times 4.7$
$= 5.1 \times 10^{-2}$ J — (A1)

or $E = ½Q^2/C$ — (C1)
$= ½ \times (22 \times 10^{-3})^2/4700 \times 10^{-6}$
$= 5.1 \times 10^{-2}$ 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 μF	A1	[2]
	(b)	p.d. across parallel combination is one half p.d. across single capacitor	C1	
		total p.d. = 9 V	A1	[2]