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
<u>either</u> to separate charges, work must be done
<u>or</u> energy released when charges 'come together' A1 [2]

(ii) <u>either</u> energy = ½CV^2 <u>or</u> energy = ½QV and $C = Q/V$ C1
change = ½ × 1200 × 10^{-6} (50^2 - 15^2) C1
change = 1.4 J (1.37) A1 [3]
[allow 2 marks for ½C(ΔV)^2, giving energy = 0.74 J)

Q2.

5 (a) at t = 1.0 s, V = 2.5 V C1
energy = ½CV^2 C1
0.13 = ½ × C × ($8.0^2 - 2.5^2$) 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 = ½CV^2 *or* energy = ½QV <u>and</u> $C = Q/V$ C1
energy = ½ × 4 × 10^{-11} × {$(7.0 \times 10^5)^2 - (2.5 \times 10^5)^2$)} 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 × 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 <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 by <u>charge conservation</u>, charges are $-Q$, $+Q$, $-Q$, $+Q$, $-Q$	B1 B1	[2]
		(ii)	total p.d. $V = V_1 + V_2 + V_3$ $Q/C = Q/C_1 + Q/C_2 + Q/C_3$ $1/C = 1/C_1 + 1/C_2 + 1/C_3$	B1 B1 A0	[2]
	(c)	(i)	energy $= \frac{1}{2}CV^2$ or energy $= \frac{1}{2}QV$ and $C = Q/V$ $= \frac{1}{2} \times 12 \times 10^{-6} \times 9.0^2$ $= 4.9 \times 10^{-4}$ J	C1 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 <u>total</u> charge on capacitor is zero (so does not store charge) (+)ve and (-)ve charges to be separated work done to achieve this so stores energy	B1 B1 M1 A1	[4]
	(b)	(i)	capacitance of Y and Z together is 24 μF $1/C = 1/24 + 1/12$ $C = 8.0$ μF (*allow* 1 s.f.)	C1 A1	[2]
		(ii)	some discussion as to why all charge of one sign on one plate of X $Q = (CV =)$ <u>8.0×10^{-6}</u> $\times 9.0$ $= 72$ μC	B1 M1 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 charge = 36 μC *Must have correct voltage in* ***(iii)****1 if just quote of 36μC in* ***(iii)****2.*	C1 A1	[2]

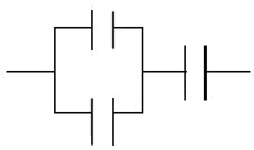
Q13.

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]

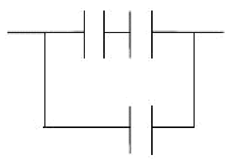
(ii) total charge $Q = Q_1 + Q_2 + Q_3$ — M1
$CV = C_1V + C_2V + C_3V$ — M1
(*allow* $Q = CV$ *here* or in (i))
so $C = C_1 + C_2 + C_3$ — A0 [2]

(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* $E = ½CV^2$ — 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, $1/C_T = 1/96 + 1/48$		
		$C_T = 32\mu F$	A1	[2]
	(b)	p.d. across parallel combination is one half p.d. across single capacitor	C1	
		total p.d. = 9 V	A1	[2]