

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
 $C = 4500 \mu\text{F}$ 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 $\Rightarrow V = Q / 4\pi\epsilon_0 r$ M1
 $C = Q / V = 4\pi\epsilon_0 r$ 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 = $\frac{1}{2}$ \times 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 B1
 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 B2
 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 $\pm 0.5 \text{ cm}^2$) C2
 (allow 1 mark if outside $\pm 0.5 \text{ cm}^2$ but within $\pm 1.0 \text{ cm}^2$)
 1.0 cm^2 represents $(0.125 \times 10^{-3} \times 1.25 =) 156 \mu\text{C}$ C1
 charge = $3300 \mu\text{C}$ A1 [4]
- (iii) capacitance = Q/V C1
 $= (3300 \times 10^{-6}) / 15$
 $= 220 \mu\text{F}$ 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
 $V = 10.6 \text{ V}$ A1 [3]

Q8.

- 4 (a) charge / potential(ratio must be clear) B1 [1]
- (b) potential (at surface of sphere) = $Q / 4\pi\epsilon_0 R$ M1
 $C = Q / V = 4\pi\epsilon_0 R$ 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
 $V = 6.0 \times 10^5 \text{ V}$ A1 [3]
 (use of 0.75 rather than 0.25, allow max 2 marks)

[Total: 8]

Q9.

- 4 (a) (i) charge / potential (difference) (*ratio must be clear*) B1 [1]
- (b) (i) $V = Q / 4\pi\epsilon_0 r$ B1 [1]
- (ii) $C = Q / V = 4\pi\epsilon_0 r$ and $4\pi\epsilon_0$ is constant M1
so $C \propto r$ A0 [1]
- (c) (i) $r = C / 4\pi\epsilon_0$ C1
 $r = (6.8 \times 10^{-12}) / (4\pi \times 8.85 \times 10^{-12})$ C1
 $= 6.1 \times 10^{-2} \text{m}$ A1 [3]
- (ii) $Q = CV = 6.8 \times 10^{-12} \times 220$
 $= 1.5 \times 10^{-9} \text{C}$ A1 [1]
- (d) (i) $V = Q/C = (1.5 \times 10^{-9}) / (18 \times 10^{-12})$
 $= 83 \text{V}$ 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
 $= 1.65 \times 10^{-7} - 6.2 \times 10^{-8}$
 $= 1.03 \times 10^{-7} \text{J}$ 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)
 $= 1.03 \times 10^{-7} \text{J}$ (A1)

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 = $(2.7 \times 10^{-6}) / (150 \times 10^3)$ 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 = $\frac{1}{2}QV$ and $Q = CV$ C1
energy = $\frac{1}{2} \times 1.8 \times 10^{-11} \times (150 \times 10^3)^2$ or $\frac{1}{2} \times 2.7 \times 10^{-6} \times 150 \times 10^3$
 $= 0.20 \text{J}$ 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 charge conservation, charges are $-Q, +Q, -Q, +Q, -Q$ B1
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
= $\frac{1}{2} \times 12 \times 10^{-6} \times 9.0^2$
= 4.9×10^{-4} J A1 [2]
- (ii) energy dissipated in (resistance of) wire/as a spark B1 [1]

Q12.

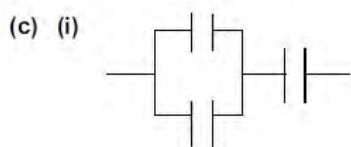
- 5 (a) (i) ratio of charge and potential (difference)/voltage
(ratio must be clear) B1 [1]
- (ii) capacitor has equal magnitudes of (+)ve and (-)ve charge B1
total charge on capacitor is zero (so does not store charge) B1
(+)ve and (-)ve charges to be separated M1
work done to achieve this so stores energy A1 [4]
- (b) (i) capacitance of Y and Z together is $24 \mu\text{F}$ C1
 $1/C = 1/24 + 1/12$
 $C = 8.0 \mu\text{F}$ (allow 1 s.f.) A1 [2]
- (ii) some discussion as to why all charge of one sign on one plate of X B1
 $Q = (CV) = 8.0 \times 10^{-6} \times 9.0$ M1
= $72 \mu\text{C}$ 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 = $36 \mu\text{C}$ A1 [2]
Must have correct voltage in (iii)1 if just quote of $36 \mu\text{C}$ in (iii)2.

Q13.

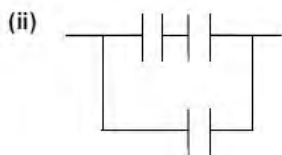
4 (a) e.g. store energy (do not allow 'store charge')
 in smoothing circuits
 blocking d.c.
 in oscillators
any sensible suggestions, one each, max. 2 B2 [2]

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

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



A1 [1]



A1 [1]

Q14.

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

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

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

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

or $E = \frac{1}{2}Q^2/C$
 $= \frac{1}{2} \times (22 \times 10^{-3})^2 / 4700 \times 10^{-6}$
 $= 5.1 \times 10^{-2} \text{ J}$ (C1)
 (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 = $96 \mu\text{F}$
for complete arrangement, $1/C_T = 1/96 + 1/48$
 $C_T = 32 \mu\text{F}$

C1

A1 [2]

- (b) p.d. across parallel combination is one half p.d. across single capacitor
total p.d. = 9V

C1

A1 [2]