1.	(a)	(i)	$C_p = 2 + 4 = 6\ \mu F$	A1
		(ii)	$1/C = 1/2 + ¼$ $Cs = 4/3 = 1.33\ \mu F$	C1 A1
	(b)	(i)	6.0 V	A1
		(ii)	$Q = C_pV$ $= 6 \times 6 = 36\ \mu C$	C1 A1
	(c)		$E = ½\ C_sV^2$ $= 24 \times 10^{-6}$	C1 A1
	(d)	(i)	The capacitors discharge <u>through</u> the voltmeter.	B1
		(ii)	$V = V_0e^{-t/CR}$ $1/4 = e^{-t/(6\times12)}$ $\ln 4 = t / 72$ $t = 72 \ln 4 \approx 100$ s	 C1 C1 A1

[12]

2.	(a)		$Q_o = CV = 1.2 \times 10^{-11} \times 5.0 \times 10^3$; $= 6.0 \times 10^{-8}$; C (3)	3
	(b)	(i)	$RC = 1.2 \times 10^{15} \times 1.2 \times 10^{-11}$ *or* $= 1.44 \times 10^4$ (s) (1)	1
		(ii)	$I = V/R = 5000/1.2 \times 10^{15}$ *or* $= 4.16 \times 10^{-12}$ (A) (1)	1
		(iii)	$t = Q_o/I$; $= 6 \times 10^{-8} / 4.16 \times 10^{-12} = 1.44 \times 10^4$ (s)	2
		(iv)	$Q = Q_oe^{-1}$; $Q = 0.37Q_o$ so Q lost $= 0.63Q_o$	2
	(c)	(i)	capacitors in parallel come to same voltage (1) so Q stored α C of capacitor (1) capacitors in ratio 10^3 so only 10^{-3} Q_o left on football (1)	3
		(ii)	$V = Q/C = 6.0 \times 10^{-8} / 1.2 \times 10^{-8}$ *or* $6.0 \times 10^{-11} / 1.2 \times 10^{-11}$ *or* only 10^{-3} Q left so 10^{-3} V left; $= 5.0$ (V)	2

[14]

3. (a) (i) $Q = VC$; $W = ½\ VC.V$ ($= ½\ CV^2$) (2)

(ii) parabolic shape passing through origin (1)
plotted accurately as $W = 1.1\ V^2$ (1) 4

(b) (i) $T = RC$; $= 6.8 \times 10^3 \times 2.2 = 1.5 \times 10^4$ s = 4.16 h 2

(ii) $\Delta W = ½\ C(V_1^2 - V_2^2) = 1.1(25 - 16)$; = 9.9 (J) 2

(iii) $4 = 5 \exp(-t/1.5 \times 10^4)$; giving $t = 1.5 \times 10^4 \times \ln 1.25 = 3.3 \times 10^3$ (s) 2

(iv) $P = \Delta W/\Delta t = 9.9/3.3 \times 10^3 = 3.0$ mW *ecf b(ii) and (iii)* 1
allow $P = V_{av}^2/R = 4.5^2/6.8 \times 10^3 = 2.98$ mW

[11]

4. (a) (i)

capacitor	capacitance / µF	charge / µC	p.d. / V	energy / µJ
X	5	30	= *Q/C* = 6 (V) (1)	= ½ *CV*^{2}(1) = ½ × 5 × 6^2 = 90 (1)
Y	25	= *CV* = 25 × 6 =150 (µC) (1)	= 6 (V) (1)	= 450 (1)
Z	10	30 + 150 = 180 (µC) (1)	= *Q/C* = 180/10 = 18 (V) (1)	= 1620 (1)

Each box correctly calculated scores (1) + (1) for ½ CV^2 9

(ii) **1** 18 V + 6 V = 24 (V) (1)

2 180 (µC) (1)

3 180 / 24 = 7.5 (1)

4 90 + 450 + 1620 = 2160 (µJ) (1) 4

(b) (i) Kirchhoff's second law OR conservation of energy (1) 1

(ii) Kirchhoff's first law OR conservation of charge (1) 1

(c) (i) time constant = *CR* (1)
$= 7.5 \times 10^{-6} \times 200\ 000 = 1.5$ (s) (1) 2

(ii) $Q = Q_o e^{-\frac{4CR}{CR}}$ (1)

$Q/Q_o = e^{-4} = 0.0183$ (1) 2

[19]

5. (i) $C_p = C + C = 6\ \mu F$; $1/C_s = 1/2C + 1/C$; $= 3/2C$ giving $Cs = 2C/3 = (2\ \mu F)$ 3

(ii) 2 sets of (3 in series) in parallel/ 3 sets of (2 in parallel) in series 2

[5]