Question	Part	Answer	Marks	Total
1	(a)	$C = Q/V$ with symbols explained or charge per unit potential difference/voltage	1	[1]
	(b)	(i) (Electrons/negative) charge are/is moved from one plate of C to other plate (by the action of the battery) or battery sets up instantaneous current in circuit	1	
		(ii) $Q = CV = 500 \times 12 = 6000$ (μC)	1	[2]
	(c)	(i) Initial current = 6 mA; $R = V/I = 2 \times 10^3$ (Ω) or finding RC = 1.0 s; value of R	2	
		(ii) RC = 1.0 (s) ecf	1	
		(iii) $I = 6 \times (10^{-3})\, e^{-t}$ ecf	1	
		(iv) Area under curve (is the integral of current against time/sum of $I \times \Delta t$ at all t); charge = current x time / a mathematical link	2	
		(v) Initial current = 12 mA; curve with time constant = 0.5 s	2	[8]
		Total		**11**

Question	Part		Answer	Marks	Total
2	(a)	(i)	$E = V/d = 2000/4 \times 10^{-3} = 5 \times 10^5$; N C^{-1}/V m^{-1}	2	2
		(ii)	$Q = CV$;= $200 \times 10^{-12} \times 2000$; = $4 \times 10^{-7} = 0.40$ (μC) *taking p as 10^{-9} -1 mark/ correct conversion of any answer to μC gets final mark*	3	3
		(iii)	$W = ½ CV^2$ ecf possible = ½ QV;	1	
			= $0.5 \times 200 \times 10^{-12} \times 4 \times 10^6$;= 400 (μJ)	2	3
	(b)	(i)	4000 (V)	1	1
		(ii)	100 (pF) *ecf from (b)(i)*	1	1
		(iii)	800 (μJ) *ecf from (b)(i),(ii) also accept twice (a)(iii)*	1	1
	(c)		the mechanism pulling the plates apart/force working against attraction between charged plates/opposite charges/work done in separating plates/AW	1	1
			[Total		**12**

Question	Part		Answer	Marks
3	(a)	(i)	at least 3 parallel lines perpendicular to plates; arrows down	2
		(ii)	$V = Ed = 3 \times 10^5 \times 1.5 \times 10^3 = 450$ M/4.5×10^8 (V)	1
	(b)		battery acts as the (thermal) source of energy/models wind/AW;	1
			resistor required to model slow rate of charging of cloud (to 25 s)/AW;	1
			capacitor is the plates/cloud which become(s) charged;	1
	(c)	(i)	$I = Q/t$; = 20/25 = 0.8 (A)	2
		(ii)	$R = V/I$; = $4.5 \times 10^8/4.0$ = 110M/1.1×10^8 Ω *ecf from c(i)*	2
		(iii)	$C = Q/V$; = $20/4.5 \times 10^8 = 4.4 \times 10^{-8}$/44 n(F)	2
		(iv)	T = RC; = 1.1 x 4.4 = 4.95 or 5.0(s) *ecf from c(ii) & (iii)*	2
			Total	

4					
	a	i	$C_p = 2C + C = 3C$		1
		ii	$1/C_s = 1/2C + 1/C$; $= 3/2C$ giving $C_s = 2C/3$		2
	b	i	V		1
		ii	$Q = C_pV$; $= 3CV$ ecf from a(i)		2
	c		$E = ½\, C_sV^2$; $= {}^1/_3\, CV^2$ ecf from a(ii)		2
	d	i	discharge circuit made through voltmeter/plates connected through voltmeter/AW	1	
			voltmeter behaves as a (large) resistor so plates will discharge;	1	
			rate of discharge depends on size of voltmeter's resistance/AW/ similar suitable comment *max 2*	1	2
		ii	capacitors in series/Fig.4.2 as capacitance is smaller;	1	
			rate of discharge depends on value of RC/time constant	1	2
			Total		**12**

5					
	a		C = Q/V with symbols explained or charge per unit potential difference/voltage		1
	b	i 1	$Q = CV$; $= 4.7 \times 10^{-7} \times 11 = 5.2 \times 10^{-6}$ (C) or 5.2 (μC)		2
		2	$E = ½\, QV$ or $½\, CV^2$; $= 2.8(4) \times 10^{-5}$ (J) or 28.4 μ(J) *possible ecf from b(i)*		2
		ii 1	$V = IR$; $I = 11/2200 = 5$ (mA) or 0.005 (A)		2
		2	$T = RC$; $= 2200 \times 4.7 \times 10^{-7} = 1.0 \times 10^{-3}$ (s)		2
	c	i	attempt constant ratio for equal time intervals or other suitable method;	1	
			achieved successfully	1	2
		ii	$\Delta Q = I \times \Delta t$; estimates area under graph between t = 1 ms and t = 2 ms;	2	
			$\Delta Q = 1.20 \pm 0.1 \times 10^{-6}$ (C) *accept analytical answer using exp. function*	1	3
			Total		**14**

6					
	a	i	C = Q/V or gradient of graph / $= 24\ \mu C/3V$; $= 8.0$ (μF)	2	
		ii	$E = ½\, CV^2$ / $= {}^1/_2 \times 8 \times 3^2$; $= 36$ (μJ) *ecf a(i)*	2	
			or $½\, QV$ / $= ½ \times 24 \times 3$; $= 36$ (μJ)		
		iii	$T = RC = (0.04)$; $R = 0.04/8.0\mu = 5.0 \times 10^3$ (Ω) *ecf a(i)*	2	
		iv	idea of exponential/constant ratio in equal times; which is independent of initial value/AW or argued mathematically in terms of $Q/Q_o = e^{-t/RC}$	2	8
			give 1 mark for statement that time depends only on time constant/RC		
	b	i	$C_p = C + C = 6\ \mu F$; $1/C_s = 1/2C + 1/C$; $= 3/2C$ giving $C_s = 2C/3 = (2\ \mu F)$	3	
		ii	2 sets of (3 in series) in parallel/ 3 sets of (2 in parallel) in series	2	5
			Total		**13**

7					
	a	i	5.0 (V)	1	
		ii	10.0 (V)	1	2
	b	i	$Q = CV := 1.0 \times 10^{-3}$ (C)	2	
	b	ii	The total capacitance of each circuit is the same (namely 100 μF) ;	1	
			because capacitors in series add as reciprocals/ in parallel add/ supply voltage is the same and Q = VC, etc. *max 2 marks*	1	2
	c	i	A1 will give the same reading as A2; because the two ammeters are connected in series /AW	1 1	
			answer only in terms of exponential decrease for a maximum of 1 mark		
		ii	A4 will show the same reading as A2 at all times;	1	
			A3 will show half the reading of A2 initially; and at <u>all</u> subsequent times	2	5
			Total		11

8	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**	
		ii	$I = V/R = 5000/1.2 \times 10^{15}$ *or* $= 4.16 \times 10^{-12}$ (A)	**1**	
		iii	$t = Q_o/I$; $= 6 \times 10^{-8} / 4.16 \times 10^{-12} = 1.44 \times 10^{4}$ (s)	**2**	
		iv	$Q = Q_o e^{-1}$; $Q = 0.37Q_o$ so Q lost $= 0.63Q_o$	**2**	**6**
	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**	
		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**	**5**
			Total		**14**
9	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)* *allow* $P = V_{av}^{2} / R = 4.5^{2}/6.8 \times 10^{3} = 2.98$ mW	**1**	**7**
			Total		**11**
10	a		The charge flows one way/onto capacitor deflecting ammeter one way;	**1**	
			at discharge charge flows other way/off capacitor deflecting ammeter other way; **or** equal deflections at equal times from start of process; but in opposite directions **or** time constants same; currents opposite /AW	**1**	**2**
	b		$I_0 = 6.0 \times 10^{-4}$; $V = I_0 R$ gives $12 = 6.0 \times 10^{-4} \times R$ and $R = 2 \times 10^{4}$ Ω	**2**	**2**
	c	i	current falls to 1/e (0.37) of initially chosen value in time constant;	**1**	
			indication on graph, e.g. $I = 2.2 \times 10^{-4}$ A at 5.0 s for initial current I_0	**1**	
		ii	$RC = 5.0$ s ;so $C = (5.0/2.0) \times 10^{-4}$ $(= 2.5 \times 10^{-4}$ F)	**2**	**4**
	d	i	$Q = CV$;$= 12 \times 250 \times 10^{-6} = 3.0 \times 10^{-3}$ C	**2**	
		ii	$I_0 t = 6.0 \times 10^{-4} \times 5.0 = 3.0 \times 10^{-3}$ C	**1**	
		iii	calculate the area under the graph (as Q = It)	**1**	**4**
			Total		**12**
11	a	i	9 V	**1**	
		ii	correct method, e.g same Q so V = Q/C so larger C has half V of smaller one/ratio of V's inverse to C values	**1**	
			3 V	**1**	**3**
	b	i	Q = CV ; = 150 x 9 = 1350 (μC)	**2**	
		ii	Q = CV = 150 x 6 = 900 (μC) *ecf (a)(ii)*	**1**	**3**
	c		$E = 1/2CV^{2}$	**1**	
			in Fig. 5.1 $½ \times 450 \times 9^{2}$	**1**	
			in Fig. 5.2 $½ \times 100 \times 9^{2}$; so ratio f = 4.5	**2**	**4**
			Total		**10**

12

a	i	No charge on capacitor so held at 0 V	1	
		0 V across R means no current in A_1	1	2
	ii	12 V across 4.0 kΩ ; gives A_2 reading 3.0 mA	2	2
b	i1	A_1 = 2.0 mA	1	
	2	A_2 = 0	1	2
	ii	potential divider argument **or** current in circuit is 2.0 mA so V across	1	
		2.0 kΩ is 4.0 V; capacitor in parallel **or** charged so draws no current/AW	1	2
	iii	Q = CV ; = 1 x 10^{-3} C	2	2
c	i	A_1 = A_2 = 2.0 mA	1	1
	ii	RC = 0.5 s	1	1
	iii	suitable scale and attempt at decay curve;	1	
		decay curve going through (0, 2); *ecf*	1	
		using RC = 0.5 s , e.g. passing through (0.5,0.735), (1.0,0.27), (1.5,0.1)	1	3
		Total		**15**

13

	(a)		Q_o= CV = 1.2 x 10^{-11} x 5.0 x 10^{3} ; = 6.0 x 10^{-8}; C	**3**	**3**	
	(b)	**(i)**	RC = 1.2 x 10^{15} x 1.2 x 10^{-11} *or* = 1.44 x 10^{4} (s)	**1**		
		(ii)	I = V/R = 5000/1.2 x 10^{15} *or* = 4.17 x 10^{-12} (A)	**1**		
		(iii)	t = Q_o/I; = 6 x 10^{-8} / 4.17 x 10^{-12} = 1.44 x 10^{4} (s)	**2**		
		(iv)	Q = $Q_o e^{-1}$; Q = 0.37Q_o so Q lost = 0.63Q_o	**2**	**6**	
	(c)	**(i)**	capacitors in parallel come to same voltage so Q stored α C of capacitor capacitors in ratio 10^{3} so only 10^{-3} Q_o left on plates	**1** **1** **1**		
		(ii)	V = Q/C = 6.0 x 10^{-8} /1.2 x 10^{-8} *or* 6.0 x 10^{-11} /1.2 x 10^{-11} *or* only 10^{-3} Q left so 10^{-3} V left; = 5.0 (V)	**2**	**5**	
			Total		**14**	