Question			Expected Answers	Marks	Additional Guidance
1	a		Capacitance = charge per (unit) potential difference	B1	Allow: capacitance = charge / potential difference, charge/pd, charge/voltage but not charge / volt, coulomb /pd (no mixture of quantities and units. Allow 'over' instead of per
	b	(i)	Q = CV = 4.5 μ x 6.3 = 28.(35) (μC)	B1	Allow: 28 (≥ 2 sf)
		(ii)	$E = ½ CV^2 = 0.5 \times 4.5 \times \mu \times (6.3)^2$ $= 8.9(3) \times 10^{-5}$ (J) / 89.3 μ(J)	C1 A1	Allow use of E = ½ QV and the Q value from **(b)(i)** Q=28 E= 8.82 and Q=28.4 E=8.946 Allow ecf from **(b)(i)** penalise power of ten error (-1)
	c	(i)	Electrons / they move in an anticlockwise direction Charge on plates decreases / electrons neutralise positive charge p.d. decreases <u>exponentially</u>	B1 B1 B1	Alternatives for anticlockwise: from / lower plate around the circuit, from / lower plate through the resistor to top plate implied Capacitor discharges / loses charge
		(ii)	(dissipated as heat) in the resistor / wires	B1	
	d	(i)	Total capacitance = 1.5 + 4.5 = 6(.0) (μF)	A1	Allow one SF
		(ii)	Original charge on 4.5 μF capacitor is conserved (28.35 μC) V = (28.35 μ) / (1.5 + 4.5) μ = 4.7 (V)	C1 A1	ecf from **(b)(i) and (d)(i)**
			Total	**[11]**	

Question			answer	Marks	Guidance
2	(a)	(i)	Any <u>two</u> from: Correct direction of movement of electrons Electrons deposited on **Y** / removed from **X** An equal number of electrons removed and deposited on plates (AW)	B1 × 2	
		(ii)1	$Q = 40 \times 10^{-6} \times 100$ (= 4.0×10^{-3} C) $4.0 \times 10^{-3} = 1.6 \times C$ $C = 2.5 \times 10^{-3}$ (F)	C1 C1 A1	**Allow**: 2 marks for 2.5×10^{n} (F), where $n \neq -3$ (POT error)
		(ii)2	Graph starts at <u>origin</u> and has positive gradient A straight line graph that passes between 1-2 V at 100 s	M1 A1	
	(b)	(i)	$CR = 4.7 \times 10^{-6} \times 220$ (= 1.03×10^{-3} s) $4.00 = 6.00e^{-\frac{t}{1.03\times10^{-3}}}$ $t = -\ln(4.00/6.00) \times 1.03 \times 10^{-3}$ time = 4.2×10^{-4} (s)	C1 C1 A1	**Note**: Answer to 3 sf is 4.19×10^{-4} (s) **Allow**: 2 marks for $t = -lg(4.00/6.00) \times 1.03 \times 10^{-3} = 1.8 \times 10^{-4}$ s
		(ii)	speed = $\frac{0.100}{4.2\times10^{-4}}$ speed = 240 (m s^{-1})	B1	Possible ecf from **(b)(i)**
			Total	**11**	

Question			Answers	Marks	Guidance
3	(a)		capacitance = charge/p.d. or capacitance = charge per (unit) p.d.	B1	**Allow**: voltage instead of p.d. **Note**: Do not allow mixture of quantity and unit, e.g. 'charge per (unit) volt'
	(b)	(i)	$C_{parallel}$ = 240 (μF) $C_T = (240 \times 120)/(240 + 120)$ or $C_T = (240^{-1} + 120^{-1})^{-1}$ total capacitance = 80 (μF)	C1 C1 A0	**Allow** :1 mark if C_T is not the subject, e.g: $\frac{1}{C_T} = \frac{1}{240} + \frac{1}{120}$
		(ii)	$E = \frac{1}{2}V^2C$ $E = \frac{1}{2} \times 6.0^2 \times 80 \times 10^{-6}$ energy = 1.4×10^{-3} (J) or 1.44×10^{-3} (J)	C1 A1	Possible ecf **Allow**: 1 mark for an answer 1.44×10^n ($n \neq -3$)
		(iii)	6.0/*e* = 2.2 (V) (as on graph) Or $6.0 \times 0.37 = 2.2$ (V) (as on graph) Or At 20 (s), *V* = 2.2 (V), 2.2/6.0 = 0.37 (or e^{-1})	B1	**Allow**: Graph reading within ± 0.2 V
		(iii)	*CR* = 20 $R = \frac{20}{80 \times 10^{-6}}$ $R = 2.5 \times 10^5$ (Ω)	C1 A1	**Allow**: Follow through with *CR* value from **(iii)1**
			Total	**8**	

Question			Expected Answer	Mark	Additional Guidance
4	(a)		coulomb <u>per</u> volt	B1	**Allow**: 1 F = 1 $\underline{CV^{-1}}$
	(b)	(i)	<u>Electrons</u> flow 'clockwise' / negative to positive These are deposited on (plate) **A** (and hence becomes negatively charged) or These are removed from (plate) **B** (and hence become positively charged)	B1 B1	**Not**: **A** becomes negative / **B** becomes positive
		(ii)	$Q = C \times V = 5.4 \times 10^{-9} \times 12$ charge = 6.48×10^{-8} (C)	B1	
		(ii)	energy = $\frac{1}{2}V^2C = \frac{1}{2} \times 12^2 \times 5.4 \times 10^{-9}$ energy = 3.89×10^{-7} (J)	B1	Possible ecf if Q used from **(ii)1**
	(c)	(i)	$R = \frac{12}{3.24 \times 10^{-6}}$ resistance = 3.7×10^6 (Ω)	M1 A0	**Allow**: 'R = 12/3.24μ' (= 3.7 MΩ)
		(ii)	time constant = CR = $5.4 \times 10^{-9} \times 3.7 \times 10^6$ or 0.02 (s) $I = I_0 e^{-t/CR} = 3.24 \times e^{-(0\,080\,/\,0\,020)}$ current = 0.059 (μA)	C1 A1	**Allow**: ecf for time constant **Allow**: 1 mark for 5.9×10^{-n}
	(d)		(Total) resistance of circuit <u>halved</u> / time constant is <u>halved</u> Rate of discharge is <u>doubled</u> / (initial) current is <u>doubled</u>	B1 B1	
			Total	10	