Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		Horizontal line[s] with direction indicated from X to Y	1			1		
	(b)	(i)	Substitution into $F = \frac{Ve}{d}$ shown: $\frac{1800 \times 1.6 \times 10^{-19}}{3.2 \times 10^{-3}}$ (1) $F = 9.0 \times 10^{-14}$ [N] (1)	1	1		2	2	
		(ii)	[Gain in E_k = Work done by field] Gain in $E_k = 9.0 \times 10^{-14} \times 3.2 \times 10^{-3}$ (1) (**ecf** on F) Gain in $E_k = 2.88 \times 10^{-16}$ J **unit mark** (1) **Alternative:** $W = 1.6 \times 10^{-19} \times 1800$ (1) $W = 2.88 \times 10^{-16}$ J **unit mark** (1) [Accept 1 800 eV **unit mark**]	1	1		2	2	
		(iii)	$x = ut + \frac{1}{2}at^2$ and $u = 0$ (all possible by implication) (1) $a = \frac{F}{m}$ **and** substitution step: **ecf** on F e.g. $t^2 = \frac{2 \times 3.2 \times 10^{-3} \times 9.11 \times 10^{-31}}{9.0 \times 10^{-14}}$ (1) $t = 2.54 \times 10^{-10}$ [s] (1) **Alternative:** $\frac{1}{2}mv^2 = 2.88 \times 10^{-16}$ to calculate v (1) Application of $x = \frac{(u+v)t}{2}$ (1) **ecf** on v $t = 2.54 \times 10^{-10}$ [s] (1)	1	1 1		3	3	
	(c)		F doubled (explained from $\frac{Ve}{\frac{1}{2}d}$) (1) $W = 2F \times \frac{d}{2}$ so no change (1) **Accept:** $W = QV$ and Q stated to be constant (1) so W remains unchanged (1)			2	2		
			Question total	**4**	**4**	**2**	**10**	**7**	**0**

#2

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)		Statement that length of error bar = largest reading (of U) – smallest reading (of U) [1] Accept reference from mean point to max or min if clearly stated. Data from one plot to show this e.g. for 6.8 μF capacitor, length of error bar calculated as = $14 \times 10^{-4} - 13.2 \times 10^{-4}$ [1] [award 1st mark by implication if 2nd mark awarded]		2		2	1	2
		(ii)		Length of horizontal error bar for one data point taken and divided by 2. e.g. for 6.8 μF, (0.65 to 0.70 seen) [1] % tolerance calculated: 10% (Accept 6% to 12%) e.g. $0.68 \times \frac{100}{6.8}$ [1]		2		2	1	2
	(b)	(i)		$U = \frac{1}{2}CV^2$ used and V shown (by implication possibly) to $= (2 \times \text{gradient})^{1/2}$ [1] $V_{max} = 22.4$ [V] [1] $V_{min} = 18.0$ [V] [1]		3		3	3	3
		(ii)		Mean $V = \frac{(22.4+18.0)}{2} = 20.2$ [V] (any sig fig.) [1] Uncertainty = $\frac{(22.4-18.0)}{2} = 2.2$ [V] (any sig fig) [1] or candidate answers to (i) used correctly (**ecf**) 2 or 3 sig figs seen for mean V and 1or 2 sig figs for uncertainty [1]		3		3	3	3
	(c)			Substitution into $V = V_0 e^{-\frac{t}{CR}}$ [1] Algebra to show either V = 8 V or V_0 = 20 V or t = 35 s or CR value [1] Relevant statement: e.g. value confirmed [1]			3	3	2	3
				Question total	**0**	**10**	**3**	**13**	**10**	**13**

#3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	(a)		Plates of X are closer together (than plates of Y) or vice-versa [1] X contains dielectric (or space between plates of X contains material of higher permittivity) or vice-versa [1] **Accept:** Overlap of plates in X > overlap of plates in Y	2			2		
	(b)	(i)	Series combination: Substitution - $\frac{1}{C_{series}} = \frac{1}{20\,[\mu\text{F}]} + \frac{1}{30\,[\mu\text{F}]}$ or $C_{series} = \frac{20 \times 30}{20 + 30}$ [μF] [1] C_{series} = 12 μ[F] [1] Total capacitance = 52 μ[F] [1]	1 1	1		3	2	
		(ii)	Idea that Q is same on both capacitors, either stated or e.g. $C \propto \frac{1}{V}$ [1] 20 [× 10^{-6}] × pd across C_2 = 30 [× 10^{-6}] × pd across C_3 [1] [Both marks can be awarded if this seen]	1	1		2	1	
		(iii)	40 [V]		1		1	1	
		(iv)	C_1 stores the greatest charge with explanation: Largest capacitance and greatest pd across it [1] Q = 40 × 10^{-6} × 100 = 0.004 [C] [1]	1	1		2	1	
	(c)		Substitution: E = ½ × 1.6 × 10^{-3} × $(300)^2$ [1] E = 72 [J] [1] Energy gained by Al block = $mc\Delta\theta$ or substitution seen i.e. E = 0.1 × 910 × 0.6 [1] E = 54.6 [J] [1] Efficiency (%) = $\frac{54.6\text{ecf} \times 100}{72\text{ecf}}$ = 75.8 % ∴ Not justified / criteria not met [1]			5	5	3	
			Question 3 total	**6**	**4**	**5**	**15**	**8**	**0**

#4

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
6	(a)		capacitance = $\frac{\text{charge (on either plate)}}{\text{pd (between the plates)}}$ Accept charge per unit pd / voltage [between plates] (1) Accept $C = \frac{Q}{V}$ if Q and V defined	1			1		
	(b)	(i)	Q = - 75 nC, R = + 75 nC, S = - 75 nC All numerical values stated as 75 [nC] (1) Correct signs and unit, i.e. nC (1) One of: (1) • Capacitors in series carry equal charges when joined to common pd • Conservation of charge applies for series circuit [hence if +75 μC moves from A to plate P, the same moves from Q → R etc] • Opposite charge to P (accept R), since connected to negative potential [Accept: battery transfers electrons from P to Q]	3			3		
		(ii)	Total capacitance = 7.5 nF (1) $V = \frac{75 \times 10^{-9}}{7.5 \times 10^{-9}}$ **(ecf on total C)** V = 10 V (1) **Alternative:** Application and substitution into $\frac{Q}{C_1} + \frac{Q}{C_2}$ i.e. $\frac{75 \times 10^{-9}}{30 \times 10^{-9}} + \frac{75 \times 10^{-9}}{10 \times 10^{-9}}$ (1) V = 10 V (1)		2		2	2	
		(iii)	**Either:** Q same on both capacitors (1) $\frac{1}{2}\frac{Q^2}{C}$ is bigger on smaller capacitor (1) (Award 2 marks for correct numerical analysis) **Or:** $V \propto \frac{1}{C}$ so V bigger across smaller capacitor (1) ½ CV^2 bigger across smaller capacitor (V^2 factor) (1) (Award 2 marks for correct numerical analysis) **Or** Q same on both capacitors and $V \propto \frac{1}{C}$ so V bigger across smaller capacitor (1) ½ QV is bigger on smaller capacitor (1) (Award 2 marks for correct numerical analysis			2	2		
	(c)		New C = 0.47 pF (1) New $d = 3.0 \times 10^{-3}$ m (1) $\Delta d = 5.2 \times 10^{-3} - 3.0 \times 10^{-3} = 2.2 \times 10^{-3}$ m (1) (**ecf** from new d) Application of $F = k\Delta d$ ecf $k = 91$ N m^{-1} so spring of $k = 90$ N m^{-1} suitable [conclusion consistent with value of F](1) **Alternative 'Trial and Error' :** Application of $x = \frac{F}{k}$ for each spring constant, showing that for: $k = 120$ N m^{-1}, $x = 1.67 \times 10^{-3}$ m $k = 150$ N m^{-1}, $x = 1.33 \times 10^{-3}$ m $k = 90$ N m^{-1}, $x = 2.22 \times 10^{-3}$ m (All required for1) New C = 0.47 pF (1) Application of $C = \frac{\varepsilon_0 A}{d}$ for each value of x above to show that, for $x = 2.22 \times 10^{-3}$ m, $C = 0.475 \times 10^{-12}$ F, so $k = 90$ N m^{-1} suitable. (1)			4	4	3	
			Question 6 total	**4**	**2**	**6**	**12**	**5**	**0**

#5

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
	(a)		Electrons (or negative charges) are deposited on Z [and this plate becomes negatively charged] (1) Electrons (or negative charges) are removed from Y [and this plate becomes positively charged] (1)		2		2		2
	(b)	(i)	Initial pd across capacitor = pd of cell (by implication) **and** correct application to show R or I		1		1		1
		(ii)	Reference to **resolution of voltmeter** (1) which is **too small to be plotted** (1) (on given scale)			2	2		2
		(iii)	Error bars [are ±1 s]		1		1		1
		(iv)	Appropriate (corresponding) values from graph e.g. $V_0 = 6\text{ V}$, $V = 4\text{ V}$, $t = 13\text{ s}$ (1) Correct algebra [$V = V_0 e^{-\frac{t}{CR}}$] to show $t = 32$ [s] (1) **Alternative:** Time constant = 0.37 V_0 stated or implied or $V = 2.2[2]$ V (1) Time constant = 32 [s] (1) **Alternative:** $T_{½} = 0.69RC$ (1) $RC = 31$ [s] (1) **Alternative:** Initial gradient = $-\frac{V_0}{RC} = -\frac{6}{33}$ (tangent at $t = 0$ intercepts time axis at $t = 33\text{ s}$) (1) $RC = \frac{6 \times 33}{6} = 33$ [s] (1)		2		2	2	2
		(v)	Application of time constant = CR (1) $C = \frac{32}{68\,000} = 471\ \mu\text{F}$ (**ecf** in t or candidate value used) (1) % uncertainty calculated as 3% + 3.2% = 6.2% (1) Absolute uncertainty = ± 30 μF So: 470 ± 30 μF (or 0.47 ± 0.03 mF) (1) consistency of sig figs	1	1 1 1		4	4	4
		(vi)	Correct substitution into $V = V_0 e^{-\frac{t}{CR}}$ (1) V shown = 1.1 [V] (1) Reference to continued graph line going through this point (1)			3	3	2	3
			Question total	**1**	**9**	**5**	**15**	**8**	**15**