Capacitors MS12

Question Number	Answer	Mark
1(a)	Charges **(1)** Movement of electrons from one plate to the other OR one plate becomes + the other – OR until pd across C equals V_{supply} **(1)**	**2**
1(b)(i)	Use of $Q = It$ (both 0.74 and 0.1/0.2) **(1)** Recognition of milli and Δt =0.1 **(1)** Eg $Q = 0.74 \times 10^{-3} \times 0.1 = 74 \times 10^{-6}$ C	**2**
1(b)(ii)	Use of $V = Q/C$ **(1)** Explains unit conversion **(1)** Eg $V = 278 \times 10^{-6} / 100 \times 10^{-6} = 2.78$ [accept μ/μ]	**2**
1(c)(i)	Recall of *RC* **(1)** Answer = 0.3 (s) **(1)** Eg $T = 3000 \times 0.0001$ **plus either** 1/e or 37% of initial **(1)** =0.23 - 0.27 (s) **(1)** **or** sub in formula $I = I_0 e^{-t/RC}$ **(1)** = 0.23 - 0.27 (s) **(1)** **or** Initial Tangent drawn **(1)** Time constant = 0.2-0.3 (s) **(1)**	**4**
1(c)(ii)	Plot Ln *I* **/** Log *I* **(1)** Against *t* **(1)** (dependent on first mark) or Gradients of graph (1) Against I (1) (dependent on first mark) should be straight line **(1)** (dependent on previous 2)	**3**
	Total for question	**13**

Question Number	Answer	Mark
2(a)(i)	Discharges / loses charge (1) Idea that discharge is not instantaneous (1) [e.g. over period of time, gradually, exponential]	**2**
2(a)(ii)	Decay curve starting on *y*-axis and not reaching x-axis (1) [no rise at the end] Initial current marked 2 mA (1) X-axis labelled such that $T_{½}$ = 0.02 to 0.06 s (1)	**3**
2(a)(iii)	<u>Same</u> graph (1) On negative side of current axis/current in the opposite direction (1)	**2**
2(b)	Use of $W = ½ CV^2$ / Use of $Q = CV$ and $W = ½ QV$ (1) $W = 5 \times 10^{-4}$ J (1) <u>Example of calculation</u> $W = ½ (10 \times 10^{-6}\ \text{F}) (10\ \text{V})^2$ $W = 5 \times 10^{-4}$ J	**2**
2(c)	Use of $\ln V/V_0 = (-)\ t/RC$ or $V = V_0\ e^{-t/RC}$ with V and V_0 correct (1) t = 0.13 s (1) <u>Example of calculation</u> $\ln(10\ \text{V}/0.7\ \text{V}) = t / 0.05$ s t = 0.13 s	**2**
	Total for question	**11**

Question Number	Answer	Mark
3(a)(i)	Capacitor charges up **Or** p.d. across capacitor becomes (equal to) p.d. of cell **(1)** Negative charge on one plate and positive charge on the other **Or** opposite charges on each plate **Or** movement of electrons from one plate and to the other (around the circuit) **(1)** (Reference to positive charges moving or to charge moving directly between the plates negates the second mark)	**2**
3(a)(ii)	As capacitor charges current decreases **Or** As capacitor charges current drops to zero **Or** p.d. across capacitor becomes (equal to) p.d. of cell **(1)** No current through R (means no p.d.) **Or** $V_{cell} = V_{capacitor} + V_{resistor}$ **(1)**	**2**
***3(b)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) See Q=CV **(1)** As C increased then charge flows (**Or** more charge stored) on capacitor **(1)** So p.d. across R **(1)** Charge flow / current /output signal reversed when plates move apart **(1)** **Or** See Q=CV **(1)** As C increased p.d. across capacitor decreased **(1)** So p.d. across R must increase **(1)** p.d. reverses when plates move apart **(1)**	**4**
3(c)	Use of time constant =*RC* **Or** attempt to find half life **(1)** Time constant = 0.005 (s) **Or** $t_{½}$ = 0.0035 (s) **(1)** Use of $T = 1/f$ (to give T = 0.05 s for the lowest audible frequency) **(1)** Capacitor completes discharging/charging during cycle of signal **(1)** (last mark can only be gained if supported by calculations) ($f = 1/CR$ may be used to find the 'frequency of the microphone', rather than time. In this case candidates may just calculate f =200 Hz rather than a time. Only first 3 marks are available) <u>Example of calculation</u> $RC = 10 \times 10^{6}\ \Omega \times 500 \times 10^{-12}$ F RC = 0.005 s $F = 1/T = 1/20 = 0.05$ s	**4**
	Total for question	**12**

Question Number	Answer		Mark
4(a)	Use of $Q = CV$ $Q = 0.18$ C <u>Example of calculation</u> $Q = 150 \times 10^{-6}$ F $\times$ 1200 V $Q = 0.18$ C	**(1)** **(1)**	**2**
4(b)	Use of $W = ½\,CV^2$ **Or** of $W = ½\,QV$ **Or** of $W = ½\,Q^2/C$ $W = 110$ J Allow ecf from (a) if $½\,QV$ or $½\,Q^2/C$ used <u>Example of calculation</u> $W = ½ \times 150 \times 10^{-6}$ F $\times$ (1200 V)^2 $W = 108$ J	**(1)** **(1)**	**2**
4(c)(i)	$R = 86$ (Ω) <u>Example of calculation</u> $R = V/I$ = 1200 V / 14 A $R = 85.7$ Ω	**(1)**	**1**
4(c)(ii)	$Q = 0.25\,Q_0$ **Or** $Q = 0.045$ C Use of RC (0.013 s) Use of $Q = Q_0\,e^{-t/RC}$ to give $t = 0.018$ s (show that value will give $t = 0.019$ s) [Use of ln 4 gives the correct answer if the − sign is ignored , scores 1 for use of RC use of ¾Q →3.7 × 10^{-3} s scores 1 mark] **Or** Use of RC Use of 2 × 0.69 × RC $t = 0.018$ s <u>Example of calculation</u> $Q = 0.25\,Q_0$ $Q = Q_0\,e^{-t/RC}$ $0.25\,Q_0 = Q_0\,e^{-t/RC}$ ln (0.25) = - t/ (86 Ω × 150 × 10^{-6} F) $t = 0.0178$ s	**(1)** **(1)** **(1)**	**3**
4(c)(iii)	Same charge (flows for shorter time) **OR** (Same charge flows for) shorter time	**(1)**	**1**
	Total for question 15		**9**

Question Number	Answer		Mark
5(a)(i)	t = 0, capacitor uncharged therefore 12V across R **Or** at t = 0, the capacitor begins to charge [accept 'when the switch is closed' for t = 0] (capacitor and resistor in series so) V_R decreases as V_C increases **Or** $V_R + V_C$ = constant **Or** as charge on capacitor increases, current decreases so V_R decreases. **Or** numerical justification of exponential decrease	**(1)** **(1)**	**2**
5(a)(ii)	Exponentially increasing graph with decreasing gradient Max value 10.4 – 11.2 V at t = 50 s	**(1)** **(1)**	**2**
5(b)(i)	Indicates that t 37% of initial V_R **Or** $1/e$ of initial V_R read time off graph **Or** Uses graph to find time for p.d.to half Equates this to 0.69RC where RC equals the time constant **Or** draw a tangent at t = 0 value is where tangent cuts x-axis. **Or** draws a tangent at any time value is difference between where tangent cuts x-axis and time where tangent was drawn. **Or** plot a graph of ln V against t Time constant is gradient of graph **Or** take a pair of values from graph and sub into exponential equation calculate RC which is time constant	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**2**
5(b)(ii)	Use of $V = IR$ R = 48 kΩ Use of t and their value of R to find C in $t = RC$ C = 520 μF (consistent with their values) **Or** Use $C=It/V$ with V =12 V and t = 25s C = 520 μF Use of t and their value of C to find R **Or** use of $V = IR$ to find R R = 48 kΩ <u>Example of calculation</u> $R = 12\text{ V} / 0.25 \times 10^{-3}\text{ A} = 48\text{ k}\Omega$ $t = 48 \times 10^3\ \Omega \times C$ $C = 25\text{ s} / 48 \times 10^3\ \Omega$ C = 520 μF	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**4**
	Total for Question		**10**

Question Number	Answer		Mark
6(a)	Use of $T = RC$ T = 0.3 s <u>Example of calculation</u> $T = RC$ = 1500 Ω × 200 × 10^{-6} F T = 0.3 s	**(1)** **(1)**	 **2**
6(b)	B5 = (6V - E4)/1.5 (k Ω) **Or** I = (E−V)/R **Or** I = (6.0 – 3.33)/1.5 Correct units or comment about mA and kΩ (allow 1 mark for B5 =C5/(A5-A4) and 1 mark for use of exponential equation)	 **(1)** **(1)**	 **2**
6(c)(i)	3 points plotted accurately ± ½ small square Line of best fit drawn (smooth by eye)	**(1)** **(1)**	 **2**
6(c)(ii)	Initial tangent drawn t = 0.19 s −0.26 s **Or** 37% of initial current found t = 0.24 s −0.26 s **Or** half life determined and use of half life = 0.693RC t = 0.23 s −0.26 s **Or** uses a pair of points off the graph in exponential equation t = 0.24 s −0.26 s	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	 **2**
6(c)(iii)	Reduce the time interval	**(1)**	**1**
***6(d)**	Reference to $I = I_0 e^{-t/RC}$ **Or** ln I = ln I_0 –t/RC **Or** states that there is exponential relationship between I and t Plot ln I against t **Or** ln (I/I_0) against t The time constant = –1/gradient	 **(1)** **(1)** **(1)**	 **3**
	Total for Question		**12**