Assessment Schedule – 2006

Physics: Demonstrate understanding of electrical systems (90523)

Evidence Statement

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
1(a)	When the switch is closed, the capacitor will charge and current will flow through the circuit resistance.	[1] Idea of charge flowing on to the capacitor plates **and** around the circuit.		
1(b)	When the bounce breaks the circuit and isolates $R_{circuit}$ from the supply, the charged capacitor discharges through the circuit.	[1] Idea that the capacitor acts as the voltage source.		
1(c)	$\tau = RC \quad \Rightarrow C = \frac{\tau}{R}$ $C = \frac{0.11}{1450} \quad = 7.5862 \times 10^{-5}$ = 76 μF (2 sf)	[2] Correct working. [1] Answer rounded to 2 sf plus correct units given in 4 answers.		
1(d)	$Q = VC \quad = 5.50 \times 7.5862 \times 10^{-5}$ $= 4.17241 \times 10^{-4} \quad = 4.2 \times 10^{-4}$ C	[2] Correct answer.		
1(e)	For the capacitor to be able to act as the voltage supply, the capacitor must be charged to maximum voltage when the first break happens. As it takes several time constants before full charge is reached the time before the break must be longer than one time constant.	[1] Some idea that the capacitor needs to be charged when the first break comes.	[1] Link made between the requirement for the capacitor to be fully charged and the short period of time for this to happen.	[1] Clear, accurate and complete.
1(f)	Supply voltage will divide in the ratio of the resistances $V_C = 9.00 \times \frac{1450}{(1450 + 22)}$ $= 8.86549 \quad = 8.87$ V OR $9.00 - 22.0 \times I - V_C = 0$ $9.00 = (22.0 + 1450) \times I$ $I = 6.11413 \times 10^{-3}$ A $\Rightarrow V_C = 9.00 - 22.0 \times 6.11413 \times 10^{-3}$ $= 8.86549 \quad = 8.87$ V	[1] Correct voltage ratio / correct application of Kirchhoff	[2] Correct I / correct answer from incorrect *I*	[2] Correct answer.
2(a)	$\varepsilon = -L\frac{\Delta I}{\Delta t}$ $\Delta I = \frac{25}{220} \quad = 0.113636$ $\varepsilon = 0.35 \times \frac{0.113636}{5 \times 1.59091 \times 10^{-3}}$ $= 5.00000$ $= 5.0$ V	[1] Recognition that when the current is steady the inductor offers no impedance.	[2] Correct working for V using incorrect ΔI OR Correct ΔI.	[2] Correct working.

2(b)	$\varepsilon = -\frac{\Delta\phi}{\Delta t}$ $\Delta\phi = 5.00000 \times 5 \times 1.59091 \times 10^{-3}$ $= 0.039773$ $= 0.040$ Wb		[2] Correct answer (Accept if $\phi = LI$ used).	
2(c)	When the switch is closed, the inductor is in a closed loop and so the voltages around the circuit must sum to zero (Kirchhoff's Law). This means the maximum voltage across the inductor is limited to 25 V. (Or: When the switch is closed the time constant of the circuit means the current will rise fairly slowly, meaning that the rate of change of current, and hence induced voltage, will be low.) When the switch is opened the broken circuit causes the current to collapse very quickly and this high rate of change of current induces a high voltage in the inductor.	[1] One correct and relevant statement.	[1] Induced voltage linked to higher **rate** of change of current / flux when switch opened compared to when switch closed. Or: Difference in induced voltage explained in terms of Kirchhoff's Law.	[1] Merit **plus** a reason given for the high rate of change of current / flux when switch is opened.
2(d)	When all transient effects have ceased the current will be zero, and so the only voltages in the circuit will be the source and the capacitor. As voltages must sum to zero they must be equal and opposite to each other.	[1] One correct and relevant statement.	[1] Link made between zero current and voltages being equal.	[1] Equal voltages linked to zero voltage across resistor / no rate of change of current in inductor.
2(e)	$Q = CV \quad = 0.47 \times 10^{-6} \times 25$ $= 1.175 \times 10^{-5}$ C $E = \frac{1}{2}QV$ $= 0.5 \times 1.175 \times 10^{-5} \times 25$ $= 1.46875 \times 10^{-4}$ $= 1.5 \times 10^{-4}$ J		[2] Correct answer.	
2(f)	It will be converted to heat by the resistor as the capacitor discharges through the switch.	[1] One correct and relevant statement.	[1] . Converted to heat by the resistor.	
2(g)	If there were no resistor in the discharge circuit, the transient current through the switch would be high and could damage the contacts.	[1] Answer relates a lower current to the presence of resistance.	[1] Answer relates a high capacitor discharge current through the switch to potential damage.	
3(a)	$\omega = 2\pi f \quad = 2 \times \pi \times 50$ $= 314.159$ $= 310$ rad s^{-1}	[2] Correct answer.		
3(b)	$X_L = \omega L \quad = 314.159 \times 8.3 \times 10^{-2}$ $= 26.0752 \quad = 26\ \Omega$	[2] Correct working.		

3(c)	$X_C = X_{tot} + X_L$ or $X_L - X_{tot}$ $X_{tot} = \sqrt{Z^2 - R^2}$ $Z = \frac{V}{I} = \frac{12}{0.42} = 28.5714$ $X_{tot} = \sqrt{28.5714^2 - 8.5^2}$ $= 27.2778$ $\therefore X_C = X_{tot} + X_L$ (X_C must be +ve) $= 27.2778 + 26 = 53.2778$ $= 53\ \Omega$	[2] Correct Z. [1] Recognition of the phasor relationship between reactance, resistance and impedance.	[2] Correct X_{tot} or correct X_C consistent with incorrect X_{tot}.	[2] Correct answer.
3(d)	The current in the circuit depends on the total impedance. Total impedance is the combination of resistance and total reactance. Total reactance is the difference between the inductor reactance and the capacitor reactance. Changing the capacitance of the capacitor will change the reactance of the capacitor, and hence the total impedance, and hence the current.	[1] Change in capacitance causes a change in reactance / impedance.	[1] Change in capacitance causes a change in capacitor reactance and therefore a change in total reactance / impedance.	[1] Recognition that current depends on impedance, and a change in capacitance causes a change in capacitor reactance, causing a change in total reactance, and hence impedance.
3(e)	$I = \frac{V}{R} = \frac{12}{8.5} = 1.41176$ $= 1.4$ A		[2] Correct answer.	

Judgement Statement

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Criterion One

Achievement	Achievement with Merit	Achievement with Excellence
FOUR opportunities answered at Achievement level or higher. 4 × A1	FOUR opportunities answered with TWO at Merit level or higher. 2 × M1 *plus* 2 × A1	FIVE opportunities answered with ONE at Excellence level and at least TWO at Merit level or higher. 1 × E1 *plus* 2 × M1 *plus* 2 × A1

Criterion Two

Achievement	Achievement with Merit	Achievement with Excellence
THREE opportunities answered at Achievement level or higher. 3 × A2	FIVE opportunities answered with TWO at Merit level or higher. 2 × M2 *plus* 3 × A2	SEVEN opportunities answered with TWO at Excellence level and at least TWO at Merit level or higher. 2 × E2 *plus* 2 × M2 *plus* 3 × A2