Assessment Schedule – 2018

Physics: Demonstrate understanding of electrical systems (91526)

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	The battery has an internal resistance. Current flow creates a voltage across the resistance, lowering the voltage available to the circuit.	• Internal resistance linked to voltage drop when current flows (accept resistance inside the battery).		
(b)	EMF = 6.02 V $V_{\text{terminal}} = EMF - I \times R_{\text{internal}}$ $5.85\text{ V} = 6.02\text{ V} - 1.89\text{ A} \times R_{\text{i}}$ $R_{\text{i}} = 0.089947\ \Omega = 0.09\ \Omega$ OR $EMF = I(R + r)$ $6.02 = 1.89\ (3 + r)$ $r = 0.18\ \Omega$	• EMF = 6.02 V • Int Resistance = 0.0899 Ω • Int Resistance = 0.18 Ω • Int Resistance = 0.095 Ω (if stated that emf = 5.85) (**SHOW question**)	• EMF = 6.02 V AND r = 0.0899 **or** 0.18 Ω (**SHOW question**)	
(c)	Voltage after 1 time constant = $0.63 \times V_{\text{max}}$ $= 0.63 \times 6.02$ V = 3.79 V From graph: (time, 3.79 V) Time constant = 1.0×10^{-5} s Time constant = $R \times C$ $1.0 \times 10^{-5}\text{ s} = 3.09\ \Omega \times C$ $C = 3.24 \times 10^{-6}$ F (or 3.3×10^{-6} if used R = 3.00 Ω) (or 3.1×10^{-6} if used R = 3.175Ω)	• Voltage after one time constant = 3.79 V • Time constant = 0.9-1.0 × 10^{-5} s • Correct working for $\tau = RC$, but with incorrect T. (Accept working with V_{max} = 6.00 V.)	C = 0.28 – 0.33 × 10^{-5} (Accept with mistaken t =1.0 s if everything else is correct but not $\tau = \frac{5}{5} = 1.0$ s)	

(d)	The capacitor will charge more quickly because the circuit has less resistance and $T = RC$, so current is higher, delivering charge to the plates more quickly. (No energy would have been converted to light, but) more energy would be converted to heat passing through the (internal) resistance of the battery and coil since current is now higher. So the same amount of energy will be converted in the charging process (it just happens faster). The fully charged capacitor will store the same amount of energy as before. Energy stored is $E = \frac{1}{2}CV^2$ or $E = \frac{1}{2}QV$ and none of these values have changed.	• Capacitor will charge more quickly • Same amount of energy will be converted during charging. • Same amount of energy will be stored when capacitor is fully charged. • Less energy to light but more heat energy.	• Capacitor will charge more quickly BECAUSE: ○ $\tau = RC$ and R is lower OR ○ Current is higher, so Q is delivered more quickly. • Energy converted during charging will be the same (less light but more heat) BECAUSE ○ The reduced resistance will increase current, which will increase the lost voltage across the battery. OR ○ The capacitor always receives half of the energy supplied by the battery. • Energy stored will be equal because: ○ $E = \frac{1}{2}CV^2$ or $E = \frac{1}{2}QV$ or E does not depend on R of circuit. OR Plates will still hold the same Q and be at the same V.	Any two bullet points from Merit.

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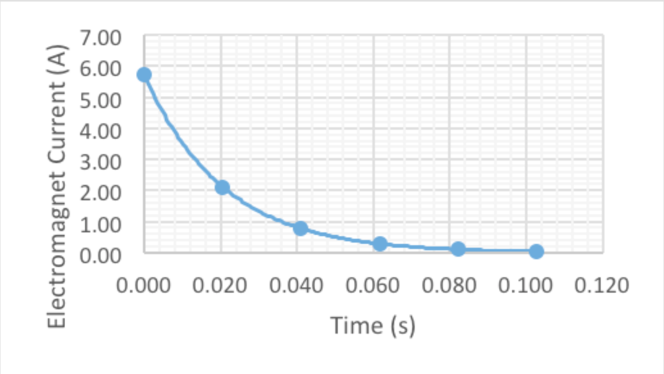
TWO (a)	$I = \dfrac{EMF}{\text{total } R}$ $= \dfrac{12.0\text{ V}}{(2.00\ \Omega + 0.09\ \Omega)}$ $= 5.74\text{ A}$	• $I = 5.74$ A		
(b)	When the switch is opened, the current / magnetic field collapse quickly creating a large rate of change of current / magnetic flux. Time constant = $\dfrac{L}{R}$ and the opening of the switch creates a very large R (theoretically infinite) so the rate of change becomes very high (theoretically infinite). And so, since EMF = $L\dfrac{\mathrm{d}I}{\mathrm{d}t}$, this produces very large EMF (theoretically infinite).	• Change of current / magnetic flux creates an EMF in coil. • Large R small τ • Not restricted to Kirchhoff's Law *na: if mention of an induced CURRENT produced by the inductor*	• The RAPID change in current / magnetic flux creates and EXTREMELY LARGE EMF in the coil.	
(c)	Kirchhoff Voltage loop around outside of circuit: $+V_{\text{battery}} - V_{0.9\ \Omega} - V_{2.0\ \Omega} - V_{\text{coil}} = 0$ $+12\text{ V} - 2.0\text{ A} \times 0.09\ \Omega - I_{\text{coil}} \times 2.00\ \Omega - 9.00\text{ V} = 0$ $I = 1.41$ A	• Decent attempt at a KVL equation (allow mistakes) • $V_{2.00\ \Omega} = 2.82$ V • Calculates I in left loop = 0.597A (SHOW question)	• Correct working and answer $I = 1.41$ A (SHOW question)	

(d)(i)	$T = \frac{L}{R} = \frac{0.450\text{ H}}{22.0\ \Omega}$ $= 0.0205$ s [Accept with 20 Ω also $t = 0.225$]. $I_{\text{after }1\tau} = 0.37\ (5.72\text{ A}) = 2.12$ A $I_{\text{after }2\tau} = 0.37\ (2.1164\text{ A}) = 0.783$ A $I_{\text{after }3\tau} = 0.37\ (0.783068\text{ A}) = 0.290$ A $I_{\text{after }4\tau} = 0.37\ (0.2897\text{ A}) = 0.107$ A $I_{\text{after }5\tau} = 0.37\ (0.107\text{ A}) = 0.0397$ A  	• τ = 0.0205 or 0.225 s • I after 1 time constant = 2.12 A • Draws roughly correct shape of graph (exponential decay). • Small R slows the change in current. • Small R, therefore τ increases. • Provides alternate route for the current.	• TWO points calculated and plotted correctly. • Explains resistor's role in slowing the rate of change of current / reducing size of EMF induced.	Correct graph. AND Explanation about R.
(ii)	The 20 Ω resistor provides a low resistance pathway for current to travel through. Low resistance means a large Time constant / slows the decrease in current. Since the rate of change of current is less, the EMF induced is smaller.			

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THREE (a)	$C = \varepsilon_0 \varepsilon_r \frac{A}{d}$ $= 8.85 \times 10^{-12}\,\text{F m}^{-1} \times \frac{8.90 \times 1.20\ \text{m}^2}{1.00 \times 10^{-4}\ \text{m}}$ $= 9.4518 \times 10^{-7}\ \text{F} = 9.45 \times 10^{-7}\ \text{F}$	• Correct working and answer. (SHOW question)		
(b)	$I_{\text{lamp}} = \frac{V_{\text{lamp}}}{R_{\text{lamp}}}$ $= \frac{4.64\ \text{V}}{5.00\ \Omega} = 0.928\ \text{A}$ $X_L = \frac{V_L}{I} = \frac{11.1\ \text{V}}{0.928\ \text{A}}$ $= 11.96\ \Omega$ $X_L = 2\pi f L$ $11.96\ \Omega = 2\pi \times 50\ \text{Hz} \times L$ $L = 0.0380698\ \text{H} = 0.0381\ \text{H}$	• $X_L = 12.0\ \Omega$ • $I = 0.928$ A • $I_{max} = 1.31$ A • $\Theta = 67.3^{\circ}$	• $L = 0.0381$ H with correct working shown. (SHOW question)	
(c)	Vector Diagram $X_c = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 400\ \text{Hz} \times 9.45 \times 10^{-7}\,\text{F}}$ $= 421.0448\ \Omega$ $X_L = 2\pi f L = 2\pi \times 400 H \times 0.0381\ \text{H}$ $= 95.72853\ \Omega$ $Z^2 = X_{\text{total}}{}^2 + R^2$ $Z^2 = (421.0448\ \Omega - 95.72853\ \Omega)^2 + (5.00\ \Omega)^2$ $Z = 325\ \Omega$	• $X_{total} = 325\ \Omega$ ($X_C - X_L$) • $X_L = 96\ \Omega$ • $X_C = 421\ \Omega$ • $Z = 3368\ \Omega$	• $Z = 325\ \Omega$ with correct working shown.	

(d)(i) (ii)	$f_o = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(3.81\times10^{-2}\text{ Hz})(9.45\times10^{-7}\text{ F})}}$ $= 838.768\text{ Hz} = 839\text{ Hz}$ This is higher than the 400 Hz of the power supply. Resonant frequency can be lowered by increasing *L* and / or increasing *C*. *C* can be increased by: • pushing the plates closer together / using a thinner piece of rubber (lower *d*) • larger copper plates (larger *A*) • using a higher dieletric material (larger ε_r). *L* can be increased by: • adding more coils • using a core with higher permittivity • larger core / coil area • reduce the length of the coil whilst keeping the number of coils the same.	• $f_o = 839$ Hz • Recognizes resonant frequency can be lowered by increasing *L* and / or *C*. • Suggests one change that would increase *L* or *C*. • Decrease Z • $X_L = X_C$	• $f_o = 839$ Hz AND Suggests any physical change that results in higher *C* OR higher *L*. AND Links it to raising *C* OR *L* to lower f_o. • Incorrect resonant frequency is calculated. AND At least one change is suggested that would raise/decrease *L* AND *C* (depending whether incorrect f is too small or too large). • $f_o = 839$ Hz AND Suggests that both Land C must increase.	• Correct resonant frequency is calculated. AND At least one change is suggested that would raise *L* AND *C*.

Marking convention:

a = 1 m = 2 e = 3

For E at least one e is required

For M at least one m is required

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 13	14 – 18	19 – 24