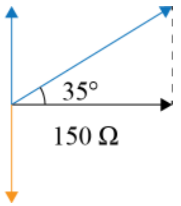
Assessment Schedule – 2020

Physics: Demonstrate understanding of electrical systems (91526)

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	$V_{peak} = \sqrt{2} \times 65.0 = 91.9 \text{ V}$	• Vector diagram labelled correctly. • $Z = 183\ \Omega$	• Correct vector diagram. AND $Z = 183\ \Omega$	
(b)	 $Z = \dfrac{150}{\cos 35°} = 183\,\Omega$	• Vector diagram labelled correctly. • $Z = 183\ \Omega$	• Correct vector diagram AND $Z = 183\ \Omega$	
(c)	$X_T = 150 \tan 35 = 105\,\Omega$ $X_L = 2\pi f L = 119.4\,\Omega$ $X_c = 119.4 - 105 = 14.4\,\Omega$ $C = \dfrac{1}{2\pi f X_c} = \dfrac{1}{2\pi \times 50 \times 14.4}$ $= 2.21 \times 10^{-4} \text{ F}$	• $X = 105\ \Omega$ • $X_L = 119\ \Omega$ • $C = 2.67 \times 10^{-5}$	• $X_C = 14.4\ \Omega$ • Correct C using incorrect X_C • $C = 1.42 \times 10^{-5}$	• C = 2.21 x 10^{-4} F
(d)	At resonance, $X_c = X_L$ Since in the above circuit, the reactance of the inductor is greater than the reactance of the capacitor, the frequency of the supply will have to be reduced so as to reduce inductor reactance and increase capacitor reactance. This is because the reactance of the capacitor is inversely proportional to frequency, whereas the reactance of the inductor is directly proportional to frequency.	• At resonance $X_L = X_C$ f must decrease X_L decreases X_C increases.	• f must decrease because $X_L > X_C$ and for resonance $X_L = X_C$ • f decreases, X_L decreases, X_C increases • $f_0 = 17.4$ Hz, f must decrease • Correct explanation or calculation for incorrect answer from 1c (i.e. consequential error).	

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TWO (a)	Voltage across resistor = 0 V Voltage across inductor = 12.0 V	• V_R = 0 V AND $_L$ = 12 V		
(b)	With the inductor in the circuit, there is a changing current at switch on. This causes a back emf across the inductor that opposes the changing current and it slows its increase to its max value.	• ΔI • ΔB • $\Delta \Phi$ • Induced V	• ΔI results in opposing induced V **(***If induced I mentioned, NO m grade.)*	
(c)	$I_{\max} = \frac{12}{22} = 0.545$ A After 1 time constant: $I = 0.55\left(1 - e^{-1}\right) = 0.345$ A OR $0.63 \times 0.545 = 0.345$ A	• I = 0.55 A • 0.63 × incorrect I • Other correct method • τ = 0.23 s	• I = 0.345 A	
(d)	• When the switch is closed, the voltage across the spark plug will only be 12 V, which is equal to the battery voltage. • When the switch is open, there is an air gap, and the current falls rapidly, so there is a high rate of change of flux, which induces a very high voltage. • Also the time constant is very short, since the value of resistance is very high. • Kirchhoff's law is no longer obeyed, since it is no longer a closed circuit.	• When switch closed max V = 12 V • $\frac{\Delta I}{t}$ is large. • I decreases quickly. • $\frac{\Delta \Phi}{t}$ is large. • Small τ. • Large R. • Open circuit, no Kirchhoff's law.	• $\frac{\Delta I}{t}$ is large. • I decreases quickly. • $\frac{\Delta \Phi}{t}$ is large AND • Small τ because R is large. OR • Reference to Kirchhoff's law (ie not restricted to 12 V.) (explain why I drops quickly)	• $\frac{\Delta I}{t}$ is large • I decreases quickly • $\frac{\Delta \Phi}{t}$ is large AND • Small τ because R is large. AND • Reference to Kirchhoff's law.

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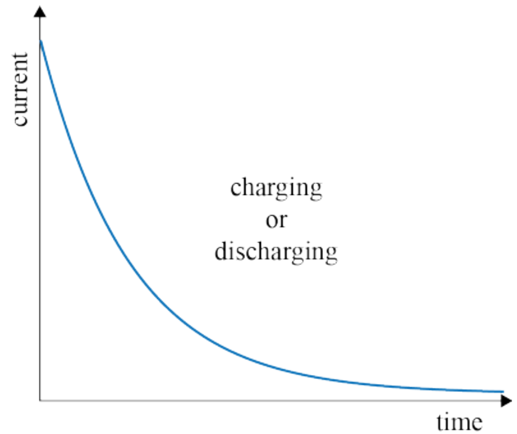
THREE (a)	 Maximum current is determined by the battery voltage and the resistance of the resistor.	• Correct graph. • Battery voltage. • Resistance.	• Correct graph. **AND** Voltage and Resistance.	
(b)	Energy stored in the capacitor = $\frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2} \times 1.20 \times 10^{-6} \times 3.0^2 = 5.40 \times 10^{-4}$ J Energy supplied by the cell = $QV = CV^2 = 1.20 \times 10^{-4} \times 3.0^2 = 1.08 \times 10^{-3}$ J When current flows through the wires, electrical energy is converted to heat energy in the wires. So, only half the energy is stored in the capacitor.	• $E_{cap} = 5.4 \times 10^{-4}$ J • $E_{cell} = 1.08 \times 10^{-3}$ J • $E_{cap} = \frac{1}{2} E_{cell}$ • $E_{cap} < E_{cell}$ • Difference due to heat energy	• $E_{cap} = 5.4 \times 10^{-4}$ J AND • Ecell = 1.08×10^{-3} J • $E_{cap} = \frac{1}{2} E_{cell}$ • $E_{cap} < E_{cell}$ AND • $\Delta E = 1.08 \times 10^{-3}$ J OR Due to heat energy. OR • Resistance.	
(c)	$A = \frac{Cd}{\varepsilon_r \varepsilon_0} = \frac{120 \times 10^{-6} \times 2 \times 10^{-3}}{8.85 \times 10^{-12} \times 10} = 2711.86 \text{ m}^2$	• $A = 2711.9 \text{ m}^2$		

(d)	Charge moves from higher potential to lower; will go from A to B. $Q_A = C_A V_A = 1.20\times10^{-4}\times50.0 = 6.00\times10^{-3}$ C $Q_B = C_B V_B = 1.00\times10^{-4}\times40.0 = 4.00\times10^{-3}$ C $\text{common voltage} = \frac{\text{total charge}}{\text{total capacitance}}$ $V = \frac{10.0\times10^{-3}}{2.20\times10^{-4}} = 45.45$ V New charge on A $= 1.20\times10^{-4}\times45.45 = 5.45\times10^{-3}$ C	• A to B • Left to right • High to low • 50 to 40 • I – clockwise • Q – anticlockwise • $Q_A = 6\times10^{-3}$ C • $Q_B = 4\times10^{-3}$ C • $C_T = 2.2\times10^{-4}$ F • $Q_A = 5.45\times10^{-3}$ C	• $Q_T = 1\times10^{-2}$ F AND $C_T = 2.2\times10^{-4}$ F AND $V = 45.45$ x$\times10^{-3}$ V OR $Q_A = 5.45$x $\times10^{-3}$ C SHOW THAT Q Direction not needed	$Q_T = 1$ x 10^{-2} F AND $C_T = 2.2\times10^{-4}$ F AND $V = 45.4\times10^{-3}$ V AND $Q_A = 5.45\times10^{-3}$ C Direction not needed

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a 1a + 1m	4a 2a + 1m	1a + 2m 3a + 1m	2a + 2m 1a + 1m + 1e	2m + 1e 2a + 1m + 1e	1a + 2m + 1e

a = 1 m = 2 e = 3

Cut Scores

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