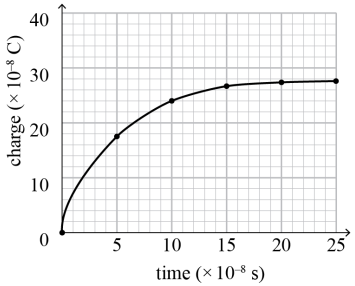
Assessment Schedule – 2023

Physics: Demonstrate understanding of electrical systems (91526)

Evidence

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}1.85\times10^{-7}\times1.5^2$ $= 2.08\times10^{-7}$ J	• Q = 2.78×10^{-7} C	• This is a SHOW question. $E = 2.081 \times 10^{-7}$ J	
(b)	$\tau = RC = 0.270\times1.85\times10^{-7}$ J $= 5.00\times10^{-8}$ s $Q = CV = 1.85\times10^{-9}\times1.50 = 2.78\times10^{-7}$ $Q = 2.78\times10^{-7}$ C $= 27.8\times10^{-8}$ C Graph should be roughly like that below. Obvious points to plot are: • At $t = 0$, $Q = 0$ • After τ charge has increased to 63% of max Q. • After 5τ charge is roughly equal to max Q. Other points are included in table below.  t / charge: 5 / 17.5; 10 / 24.0; 15 / 26.4; 20 / 27.3; 25 / 27.6	• $\tau = 5.00 \times 10^{-8}$ s Correct shape for graph Q at $\tau_1 = 1.75 \times 10^{-7}$ C	• Shows growth of charge from zero, reaching an asymptote at Q_{max} AND $\tau = 5.00 \times 10^{-8}$ s AND Q at $\tau_1 = 17.5 \times 10^{-8}$ C ONE error (check for use of C or V instead of Q)	• Complete graph, with at least four correct points for each plate.

(c)	$A = 3.2\times10^{-2}\times1.83 = 0.05856\ \text{m}^2$ $d = \varepsilon_0\varepsilon_r\dfrac{A}{C} = \dfrac{8.85\times10^{-12}\times2.1\times0.05856}{1.85\times10^{-7}}$ $d = 5.88\times10^{-6}$ m	• $d = 5.88 \times 10^{-6}$ m		
(d)	$E = \frac{1}{2}CV^2$, so with V increasing by $\times\frac{200}{1.5}$, the energy stored will be $\left(\frac{200}{1.5}\right)^2$ bigger (i.e. 18 000 times bigger) $\left[\left(\frac{200}{1.5}\right)^2\times2.08\times10^{-7} = 3.70\times10^{-3}\ \text{J}\right]$ OR Energy stored using 200 V $= \frac{1}{2}\times185\times10^{-9}\times200^2 = 3.7\times10^{-3}$ J Energy stored using 1.5 V $= \frac{1}{2}\times185\times10^{-9}\times1.5^2 = 2.08\times10^{-7}$ J I_0 will be much greater: $I = \frac{V}{R}$, so the increase in V causes a proportional increase in $I\times\frac{200}{1.5}$. Since there is a greater current and a higher voltage, the power output will be greater, causing a brighter flash. Or more energy spent per second.	• $E = 3.7 \times 10^{-3}$ J Compares energy Greater current due to increase in charges / energy / voltage. Much brighter due to greater V / I /P /energy / charges.	• Any **TWO** of: - Calculates /compares energy E increases 133^2x (18000x) - Explains why I increases **EITHER** more charges are released per second from the capacitor **OR** I increases because V increases $133\times\frac{200}{1.5}$. - Explains that P increases because V and I increase (or more energy released per second).	• ALL of: - Calculates /compares energy E increases 133^2x (18000x) - Explains why I increases **EITHER** more charges are released per second from the capacitor **OR** I increases because V increases $133\times\frac{200}{1.5}$. - Explains that P increases because V and I increase (or more energy released per second).

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No evidence	1a	2a 1m	3a 1a + 1m 1e	4a 2a + 1m 2a + 1e	2m 2e 1m + 1e	3m	1a + 2e 1a + 1m + 1e 2m + 1e	1m + 2e 2a + 2e

<table>
<tr><th>Q</th><th>Evidence</th><th>Achievement</th><th>Merit</th><th>Excellence</th></tr>
<tr><td>TWO (a)</td><td>$\frac{N_p}{N_s} = \frac{V_p}{V_s}$
$V_s = \frac{V_p N_s}{N_p} = 240 \times \frac{600}{12000} = 12.0\ \text{V}$</td><td>• $V_s = 12.0$ V.</td><td></td><td></td></tr>
<tr><td>(b)</td><td>Current in the primary causes a magnetic field around the primary coil. Change in this current causes a change in flux.
Wherein the secondary coil voltage is induced by change in flux in the coil (Faraday's Law, $\varepsilon = -\frac{\Delta\phi}{\Delta t}$).
The magnetic field / flux is increased by the presence of the iron, which also directs it to cut the secondary coil.</td><td>• Changing I.
Changing flux
Fe increases efficiency
Fe increases inductance
Fe guides / directs flux.</td><td>• Change in voltage/current in primary causes change in flux, and therefore induced voltage in the secondary.
• Fe increases efficiency with reason (eg by guiding / directing flux or preventing eddy currents).
• Fe increases inductance with reason.</td><td>• Change in voltage / current in primary causes change in flux, and therefore induced voltage in the secondary.
AND
Fe increases efficiency / inductance/ guides / directs flux.</td></tr>
<tr><td>(c)</td><td>Change in current in the inductor produces a back emf, which limits the rate of increase in current, because the back emf cannot be bigger than the forwards voltage (minus the voltage dropped across the resistor).
OR
Time constant argument, with reasons that the inductor does this.</td><td>• Mention of back (opposing) emf
OR
Time constant for an inductor is $\tau = \frac{L}{R}$, so with a large inductor the time for the current to build up is increased.</td><td>• Links back emf to limited rate of change of current.
(Check Two (b)
(NOT induced current)</td><td></td></tr>
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(d)	$P = 50\,000$ W, $V = 220\,000$ V $I = \frac{P}{V} = \frac{50\,000}{220\,000} = 0.227$ A Power lost to heat = $I^2R = 0.227^2 \times 4.00 \times 300 = 61.98$ W This is not significant compared to 50 kW. Had the voltage been transmitted at 25 kV, the power loss would have been considerably more, as current would be larger, resulting in greater heat loss. $I = \frac{50\,000}{25\,000} = 2.0$ A Power loss = $2.00 \times 2.00 \times 4.00 \times 300 = 4800$ W	• $I = 0.227$ A $I = 2.0$ A Power loss not significant compared to 50 kW.	• $P = 61.98$ W $P = 4800$ W One error or omission in the answer.	• Both correct Power calculations AND Justification or comparison about heat loss with higher current / lower voltage transmission. • Explains that as V increases, I decreases, Power loss $\propto I^2$. AND Justification or comparison about heat loss with higher current / lower voltage transmission.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No evidence	1a	2a	3a	4a	2m 1m 1e	3m 1m + 1e	1a + 2e 2m + 1e	1m + 2e 2a + 2e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	$X_c = \frac{1}{\omega C} = \frac{1}{2\pi \times 200 \times 1.2 \times 10^{-6}} = 663\,\Omega$ $Z^2 = X_c{}^2 + R^2 = 663^2 + 15^2$ $Z = \sqrt{439\,794} = 663(0.2)\,\Omega$	• This is a SHOW question. $X_c = 663.15\ \Omega$ $Z = 663.32\ \Omega$	• Correct X_c **(by show)** AND Correct *Z*.	
(b)	At $f = 20\,000$ Hz $X_c = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 20\,000 \times 1.20 \times 10^{-6}}$ $= 6.63\,\Omega$ $Z = \sqrt{15^2 + 6.63^2} = 16.4\,\Omega$ When $f = 200\,000$ Hz, $X_c = \frac{1}{2\pi \times 200\,000 \times 1.20 \times 10^{-6}}$ $= 0.663\,\Omega$ $Z = \sqrt{15^2 + 0.663^2} = 15.01\,\Omega$ Changing the frequency to 20 kHz will result in the capacitor reactance decreasing (to 6.63 Ω) and the impedance reducing (to 16.4 Ω). So, circuit current will increase, causing the lamp to be brighter. Increasing the frequency to 200 kHz will mean the impedance is close to the value of the resistance = 15.01 Ω, which is not much different from 16.4 Ω. So the current will be more, and the brightness more, but not hugely different. *Accept commenting on the effect of increased frequency on the impedance. Candidate does not necessarily have to calculate it.*	• 20 kHz Xc = 6.63 Ω and Z = 16.4Ω 200kHz Xc = 0.663Ω and Z =15.01 As frequency increases, the reactance of the capacitor decreases. As frequency increases, the impedance decreases. As frequency increases, current increases. As frequency increases causing the lamp gets brighter.	• One correct justification for size of rms current and for brightness of lamp at 20 kHz **OR** 200 kHz. One aspect missing.	• Complete answer for 20 kHz and 200 kHz. (Calculations not necessary if justification is correct and shows in-depth understanding)
(c)	$f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.2 \times 1.2 \times 10^{-6}}} = 325\text{ Hz}$	• *f* = 325 Hz.		

(d)	$X_L = \omega L$, so $X_L \propto f$, and the high f means that the inductor causes a high impedance. Z is the vector sum of R, X_c, and X_L. At the high frequency, the high X_L causes low current. As the frequency is decreased, X_L decreases but X_C increases. When $X_L = X_c$, the inductor and capacitor produce identical voltages, which are in antiphase, so cancel at all times, leaving the impedance of the circuit minimum equal to the resistance. With minimum impedance, the bulb glows brightest (resonance).	• As f increases, X_L increases X_C = but opposite to X_L At resonance Z is minimum At resonance I is maximum At resonance $X_L - X_C = 0$.	• At resonance, minimum Z because $X_L = X_c$, because: They are out of phase so cancel out OR formula showing $X_L - X_C$. OR Vector diagram.	• $X_c = X_L$ because: they're opposite so cancel each other . OR Formula showing $X_L - X_C$. OR Vector diagram. AND Z is minimum and I is maximum.

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No evidence	1a	2a 1m	3a 1a + 1m 1e	4a 2a + 1m 2a + 1e	2m 2e 1m + 1e	3m	1a +2e 1a + 1m + 1e 2m + 1e	1m + 2e 2a + 2e

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 14	15 – 19	20 – 24