Answer key and Marking Scheme

Answers	Marks
D. The voltage across the LC combination will remain the same.	1
C. 5 A	1
A. I/6	1
A. Lower cost	1
D. 920	1
B. 3	1
B. B	1
A. Both A and R are true and R is the correct explanation of A	1
C. A is true but R is false	1
C. A is true but R is false	1
(a) Yes. (0.5 marks) (b) No. (0.5 marks) (c) Since both the speakers are connected to an inductor, the current in an inductive circuit decreases with increasing frequency. Thus, an inductor connected in series with a speaker blocks high-frequency signals and allows low-frequency signals. So both speaker 1 and 2 will deliver low-frequency signals. (1 mark) Correction: If speaker 2 is connected to a capacitor instead of an inductor, the capacitor blocks low-frequency signals and passes high-frequency signals. This is because the current in a capacitive circuit increases with increasing frequency. So speaker 2 connected to a capacitor in series will deliver high-frequency signals, as desired. (1 mark)	3
(a) Radio P will allow the person to hear the radio channel of frequency f_o, without the interference of other frequencies. (0.5 marks)	3

Both f_1 and f_2 do not lie in the bandwidth of the radio P while frequency f_1 lies in the bandwidth of radio Q. (0.5 marks) (b) The maximum current at resonance in an LCR circuit is given by i_{max} = V/R Since $i_P > i_Q$, the resistance of circuit used in radio P is less than the resistance of the circuit used in radio Q. (*0.5 marks for correct answer and 0.5 marks for correct reason*) The resonance frequency $f_o = 1/(2\pi\sqrt{LC})$ As L and f_o is the same for both circuits the capacitance of both circuits will be the same. *(0.5 marks for correct answer and 0.5 marks for correct reason.)*	
a. For angular frequency v = 50 Hz Inductive reactance $X_L = \omega L = 2\pi \times 50 \times 10 \times 10^{-3} = \pi$ ohm $I_{rms} = V_{rms}/X_L = 100/\pi$ A [0.5 mark for correct value of I_{rms}] For angular frequency v = 50 kHz Inductive reactance $X'_L = \omega L = 2\pi \times 50 \times 10^3 \times 10 \times 10^{-3} = 1000\pi$ ohm $I'_{rms} = V_{rms}/X_L = 1/10\pi$ A [0.5 mark for correct value of I'_{rms}] % decrease in I_{rms} $= \|\Delta I_{rms}\|/I_{rms} \times 100$ $= 999\pi/(10\pi \times 100) \times 100$ = 99.9 % [1 mark for correct calculation of % decrease of I_{rms}] b. Bulb glows dimmer. [0.5 mark for correct conclusion]	3

Increase in angular frequency increases the inductive reactance that further results in the decrease in I_{rms} current flowing through the bulb. Hence the bulb glows dimmer. [0.5 mark for correct reason explanation]	
a. 100 ohm Resistor: Voltage across R = 10sin100πt Current i = V/R = 10sin100πt /100 = 0.1 sin100πt [0.5 mark for voltage & 0.5 mark for correct expression of current] b. 10μF Capacitor: Voltage across C = 10sin100πt Current i = 10sin100πt /X_c Here $X_c = 1/C\omega = 1000/\pi$ ohm Current through C = i = V/X_c = 10sin(100πt + π/2) / (1000/π) $= \frac{10\sin\left(100\pi t + \frac{\pi}{2}\right)}{\left(\frac{1000}{\pi}\right)} = \frac{\pi}{100}\sin\left(100\pi t + \frac{\pi}{2}\right)$ [0.5 mark for voltage & 1 mark for correct expression of current] c. 10mH Inductor : Voltage across L = 10sin100πt Inductive reactance, $X_L = L\omega = 10 \times 10^{-3} \times 100\pi = \pi$ ohm Current through an inductor, i = V/X_L $= \frac{10}{\pi}\sin\left(100\pi t - \frac{\pi}{2}\right)$ [0.5 mark for voltage & 1 mark for correct expression of current]	4
In circuit (i):	3

$$I = \frac{V}{Z} = \frac{V}{\sqrt{R^2 + \left(\frac{1}{C\omega}\right)^2}}$$

$$I/2 = \frac{V}{Z'} = \frac{V}{\sqrt{R^2 + \left(\frac{3}{C\omega}\right)^2}}$$

Substituting for I,

$$\frac{V}{\sqrt{R^2 + \left(\frac{1}{c\omega}\right)^2}} = \frac{2V}{\sqrt{R^2 + \left(\frac{3}{c\omega}\right)^2}}$$

[1 mark for expression for currents]

Transposing and solving:

$3R^2 = 5\ (1/C\omega)^2 = 5X_C^2$

$X_C/R = \sqrt{3}/\sqrt{5}$

[0.5 mark for correct ratio X_C/R]

In circuit (ii):

$$I = \frac{V}{Z} = \frac{V}{\sqrt{R^2 + (L\omega)^2}}$$

$$2I = \frac{V}{Z} = \frac{V}{\sqrt{R^2 + L^2\omega^2/9}}$$

Substituting for I,

$$\frac{2V}{\sqrt{R^2 + (L\omega)^2}} = \frac{V}{\sqrt{R^2 + L^2\omega^2/9}}$$

[1 mark for expression for currents]

Transposing and solving,

$X_L/R = 3\sqrt{3}/\sqrt{5}$

So the ratio:

$X_C / X_L = 1/3$

[0.5 mark for correct final ratio]