

## Solution

### ALTERNATING CURRENT WS 1

#### Class 12 - Physics

#### Section A

- (b) 220 V, 50 Hz  
**Explanation:** In India, we use electricity at 220 volt and 50 hertz.
- (a) Assertion and reason both are correct statements and reason is correct explanation for assertion.  
**Explanation:** Assertion and reason both are correct statements and reason is correct explanation for assertion.
- (a) Both A and R are true and R is the correct explanation of A.  
**Explanation:** The effect of ac on the body depends largely on the frequency. Low-frequency currents of 50 to 60 Hz (cycles/sec), which are commonly used, are usually more dangerous than high-frequency currents and are 3 to 5 times more dangerous than dc of the same voltage and amperage (current). The usual frequency of 50 cps (or 60 cps) is extremely dangerous as it corresponds to the fibrillation frequency of the myocardium. This results in ventricular fibrillation and instant death.
- (b) Both A and R are true but R is not the correct explanation of A.  
**Explanation:** The mean average value of alternating current (or emf) during a half, cycle is given by  $I_m = 0.636 I_0$  (or  $E_m = 0.636 E_0$ ) During the next half cycle, the mean value of ac will be equal in magnitude but opposite in direction. For this reason the average value of ac over a complete cycle is always zero. So the average value is always defined over a half cycle of ac.
- (d) A is false but R is true.  
**Explanation:** Like direct current, an alternating current also produces a magnetic field. But the magnitude and direction of the field go on changing continuously with time.
- (c) A is true but R is false.  
**Explanation:** Faraday's laws of electromagnetic induction are consequences of the conservation of energy. It involves only the transformation of energy into electrical energy. In a purely resistive circuit, current and voltage are in the same phase.
- (a) Assertion and reason both are correct statements and reason is correct explanation for assertion.  
**Explanation:** Assertion and reason both are correct statements and reason is correct explanation for assertion.
8. Here  $\varepsilon_{rms} = 220$  V,  $f = 50$  Hz  
Instantaneous voltage is given by  
$$\varepsilon = \varepsilon_0 \sin \omega t = \sqrt{2} \varepsilon_{rms} \sin 2\pi f t$$
$$= 1.414 \times 220 \sin(2 \times 3.14 \times 50t)$$
$$= 311 \sin 314 t \text{ volt.}$$
9. Here  $E_0 = 350$  V,  $R = 100 \Omega$ ,  $I_v = ?$   
$$I_v = \frac{E_v}{R} = \frac{E_0}{\sqrt{2}R} = \frac{350}{1.414 \times 100} = 2.47 \text{ A}$$
10. Here  $R = 50 \Omega$ ,  $\varepsilon_0 = 10$  V,  $f = 100$  Hz  
$$I_0 = \frac{\varepsilon_0}{R} = \frac{10}{50} = \frac{1}{5} \text{ A} = 200 \text{ mA}$$
$$I_{rms} = 0.707 I_0 = 0.707 \times 200 = 141.4 \text{ mA}$$
The instantaneous current is given by  
$$I = I_0 \sin 2\pi f t = 200 \sin 200\pi t \text{ mA}$$
11. The mean square current for the rms current for the period  $t = 0$  to  $t = \tau$  is given by  
$$i^2 = \frac{1}{\tau} \int_0^\tau i_0^2 \left(\frac{t}{\tau}\right)^2 dt$$
$$= \frac{i_0^2}{\tau^3} \int_0^\tau t^2 dt = \frac{i_0^2}{\tau^3} \left[\frac{t^3}{3}\right]_0^\tau = \frac{i_0^2}{\tau^3} \cdot \frac{\tau^3}{3} = \frac{i_0^2}{3}$$
$$\therefore i_{rms} = \sqrt{i^2} = \sqrt{\frac{i_0^2}{3}} = \frac{i_0}{\sqrt{3}}$$

12.  $P = 100 \text{ W}$ ,  $V_{\text{rms}} = 220 \text{ V}$ ,  $f = 50 \text{ Hz}$ ,  $R = ?$ ,  $I_{\text{rms}} = ?$

$$\text{i. } R = \frac{V_{\text{rms}}^2}{P} = \frac{(220)^2}{100} = 484 \Omega$$

$$\text{ii. } I_{\text{rms}} = \frac{V_{\text{rms}}}{R} = \frac{220}{484} = 0.45 \text{ A}$$

13. The choke coil is used to reduce the current. As its power factor is zero, it reduces the current without wasting the power. If an ordinary resistor is used instead of the choke coil, it will waste power in the form of heat.

14. Heat produced by DC is  $H = I^2 RT$  ....(i)

Heat produced by AC is

$$H = I_V^2 RT \quad \text{or} \quad H = \left(\frac{I_0}{\sqrt{2}}\right)^2 RT \quad \dots(\text{ii})$$

where  $I_V = I_0/\sqrt{2} = \text{rms value of the AC current}$

From Eqs. (i) and (ii), we get,

$$I^2 RT = \frac{I_0^2 RT}{2} \quad \text{or} \quad I = I_0/\sqrt{2}$$

where I stands for DC and  $I_0$  is the peak value of AC current.

15. The rate of heat produced in ac and dc is resistance dependent which has the same behaviour for ac and dc. Thus, the rate of heat production in both cases will be the same.

16. Zero, because a.c is positive during one-half cycle and equally negative during another half cycle.

17. A starter is a variable resistance R connected in series with the armature circuit of the motor during starting to reduce the starting current.

18.  $Z = R$

Impedance = Resistance

19. For a steady state d.c., the lamp has no effect even if it is increased by an iron core. For a.c., the lamp will shine dimly because of additional impedance of the choke. It will dim further when the iron core is inserted which increases the choke's impedance.

20. An alternating current is a current that changes continuously in magnitude and periodically in direction. The value of a.c. at any instant is given by

$$I = I_0 \sin \omega t = I_0 \sin 2\pi ft$$

where  $I_0$  is the peak value of current and

$$\omega = 2\pi f = \frac{2\pi}{T},$$

is the angular frequency of a.c.

21. For normal brightness of the bulb

$$\varepsilon_{\text{rms}} = 12 \text{ V}$$

$$\therefore \varepsilon_0 = \sqrt{2}\varepsilon_{\text{rms}}$$

$$= 1.414 \times 12 = 17 \text{ V.}$$

### Section B

22. As ac voltage can be represented by  $V = V_0 \sin \omega t$ .

i. from the equation  $V = 70 \sin 100 \pi t$

$$2\pi\nu = 100\pi$$

$$\nu = 50 \text{ Hz}$$

ii. Peak voltage = 70 V

$$\text{peak current} = 70/25 = 2.8 \text{ A}$$

$$\text{rms Current} = 0.707 \times \text{peak current} = 0.707 \times 2.8 = 1.98 \text{ A}$$

23. i.  $V = 140 \sin 314 t$

Comparing it with  $V = V_0 \sin \omega t$ ,

$$\text{Here, } \omega = 314 \text{ rad/s}$$

$$\text{i.e. } 2\pi f = 314$$

$$\Rightarrow f = 314/2\pi$$

$$f = \frac{314}{2 \times 3.14} = 50 \text{ Hz}$$

ii. We know,  $I_{\text{rms}} = \frac{V_{\text{rms}}}{R}$  and  $V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$

$$\text{Here, } V_0 = 140 \text{ V}$$

$$V_{\text{rms}} = \frac{140}{\sqrt{2}} = 70\sqrt{2} \text{ V}$$

$$\therefore I_{\text{rms}} = \frac{70\sqrt{2}}{R} = \frac{70\sqrt{2}}{50} = 1.9 \text{ A}$$

24. a. We are given  $P = 100 \text{ W}$  and  $V = 220 \text{ V}$ . The resistance of the bulb is

$$R = \frac{V^2}{P} = \frac{(220\text{V})^2}{100\text{W}} = 484\Omega$$

b. The peak voltage of the source is

$$v_m = \sqrt{2}V = 311\text{V}$$

c. Since,  $P = IV$  thus rms current is given by,

$$I = \frac{P}{V} = \frac{100\text{W}}{220\text{V}} = 0.454 \text{ A}$$

25. i. Power dissipation is maximum across a resistance.

ii. Power dissipation is zero across reactance  $X_L$  or  $X_C$ .

iii. Power dissipation across impedance  $Z$  depends on power factor  $\cos \phi$  in accordance with the relation

$$P_{av} = V_{rms} \cdot I_{rms} \cdot \cos \phi$$

26. The equation of ac voltage is  $V = V_0 \sin 2\pi\nu t$

i. Comparing with the equation  $V = 280 \sin 100\pi t$

$$\text{Peak voltage } V_0 = 280 \text{ V,}$$

$$2\nu = 100 \text{ and } \nu = 50 \text{ Hz}$$

ii. Peak voltage = 280 V

$$\text{peak current} = \frac{280}{40} = 7 \text{ A}$$

$$\text{rms current} = 0.707 \times 7 = 4.9 \text{ A}$$

27. The major differences between Alternating Current and Direct Current are given in the table below:

Alternating Current	Direct Current
AC is safe to transfer longer distance even between two cities, and maintain the electric power.	DC cannot travel for a very long distance. It loses electric power.
The rotating magnets cause the change in direction of electric flow.	The steady magnetism makes DC flow in a single direction.
The frequency of AC is depended upon the country. But, generally, the frequency is 50 Hz or 60 Hz.	DC has no frequency of zero frequency.
In AC the flow of current changes its direction backwards periodically.	It flows in a single direction steadily.
Electrons in AC keep changing its directions – backward and forward	Electrons only move in one direction – that is forward.

### Section C

28. 1.  $I_0 = V_0/R$

$$= 10/10$$

$$= 1 \text{ A}$$

$$\omega_r = 1/\sqrt{LC} = 1/\sqrt{(1 \times 1 \times 10^{-6})}$$

$$= 10^3 \text{ rad/s}$$

$$V_0 = I_0 X_L = I_0 \omega_r L = 1 \times 10^3 \times 1 = 10^3 \text{ V}$$

2.  $Q = \omega_r L/R$

$$= (10^3 \times 1)/10 = 100$$

29. Here  $I_{\text{eff}} = 5 \text{ A}$ ,  $f = 50 \text{ Hz}$

$$\text{i. } I_0 = \sqrt{2}I_{\text{eff}} = \sqrt{2} \times 5 = 7.07 \text{ A}$$

$$\text{ii. } I_m = \frac{2}{\pi}I_0 = 0.637 \times 7.07 = 4.5 \text{ A}$$

iii. At  $t = 1/300 \text{ s}$ ,

$$I = I_0 \sin 2\pi ft = 7.07 \sin \left( 2\pi \times 50 \times \frac{1}{300} \right)$$

$$= 7.07 \sin \frac{\pi}{3} = 7.07 \times \frac{\sqrt{3}}{2} = 6.12 \text{ A}$$

30. Comparing the equation:

$$\varepsilon_t = 140 \sin 300 t$$

with the standard equation :  $\varepsilon = \varepsilon_0 \sin \omega t$ , we get

i. Peak voltage,  $\varepsilon_0 = 140 \text{ V}$

ii. rms value of voltage,

$$\varepsilon_{\text{rms}} = \frac{\varepsilon_0}{\sqrt{2}} = \frac{140}{1.4} = 100 \text{ V}$$

iii. Angular frequency,  $\omega = 300$

$$\therefore \text{Frequency, } f = \frac{\omega}{2\pi} = \frac{300}{2 \times 3} = 50 \text{ Hz}$$

31. i.  $\varepsilon_{\text{rms}} = 220 \text{ V}$ ,  $R = 40 \Omega$

$$\therefore I_{\text{rms}} = \frac{\varepsilon_{\text{rms}}}{R} = \frac{220}{40} = 5.5 \text{ A}$$

ii. Maximum instantaneous current,

$$I_0 = \sqrt{2} I_{\text{rms}} = 1.414 \times 5.5 = 7.8 \text{ A}$$

iii. Let the alternating current be given by

$$I = I_0 \sin \omega t$$

Let the a.c. take its maximum and rms values at instants  $t_1$  and  $t_2$  respectively. Then

$$I_0 = I_0 \sin \omega t_1,$$

$$\text{which implies } \omega t_1 = \frac{\pi}{2} \text{ and } I_{\text{rms}} = \frac{I_0}{\sqrt{2}} = I_0 \sin \omega t_2,$$

$$\text{which implies } \omega t_2 = \frac{\pi}{2} + \frac{\pi}{4}$$

$$\begin{aligned} \therefore t_2 - t_1 &= \frac{\pi}{4\omega} = \frac{\pi}{4 \times 2\pi f} \\ &= \frac{\pi}{4 \times 2\pi \times 50} = \frac{1}{400} \text{ s} = 2.5 \text{ ms} \end{aligned}$$