SOLUTIONS TO PREBOARD EXAM 2023

PHYSICS – XII SET 2

One mark for correct answer.

1.	(c)	2.	(a)	3.	(b)	4.	(d)
5.	(c)	6.	(a)	7.	(b)	8.	(d)
9.	(c)	10.	(c)	11.	(d)	12.	(a)
13.	(a)	14.	(d)	15.	(a)	16.	(c)

17. Definition of Depletion Region:

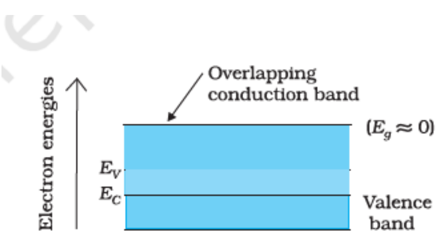
The small region on either side of the junction in p-n junction diode where the electrons and holes taking part in the initial movement across the junction *depleted* the region of its free charges is known as *depletion region*. ------------------------ **1**

Effect on depletion region

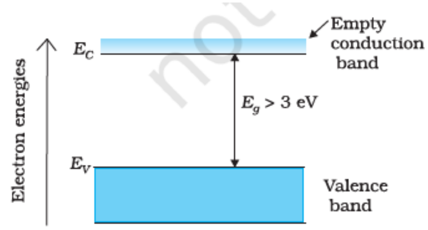
(i) Forward bias ---- decreases (ii) Reverse bias ---- Increases---- **½ each**

OR

Energy band diagrams



(ii)



(b)

------- **1**

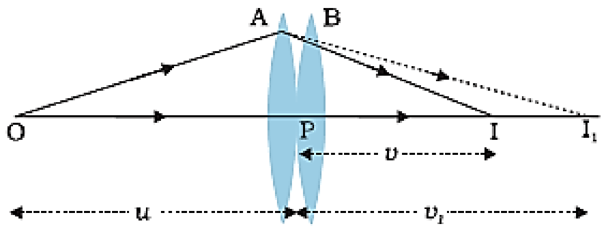
In conductors, the forbidden energy gap is almost zero and electrons can move from Valence band to conduction band easily. In insulators the gap is very high and no electron can reach the conduction band. --- **1**

18. As given $A_A : A_B = 1 : 6$

$$H = I^2R = I^2\frac{\rho l}{A}$$

-------------- **2**

$$\frac{H_A}{H_B} = \frac{A_B}{A_A} = \frac{6}{1}$$

19.  ---------- ½

For lens L_1

$$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u}$$

For lens L_2, image I_1 acts as a virtual object and distance v_1 is the object distance.

$$\frac{1}{f_2} = \frac{1}{v} - \frac{1}{v_1}$$

Adding the two equations $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$

20. (a) de-broglie wavelength is given by

$\lambda = \frac{h}{\sqrt{2mqV}}$ --------------------------------- ½

V is same, so $\lambda \,\alpha \frac{1}{\sqrt{mq}}$ ----------------------- ½

For α particle m = 4, q = 2

For proton m = 1, q = 1

$\frac{\lambda_\alpha}{\lambda_p} = \frac{1}{\sqrt{8}}$ --------------- ½

(b) K E = qV

$\frac{KE_\alpha}{KE_p} = 2$ -- ½

21. Angle of prism A = 60 °, angle of incidence = angle of emergence when angle of deviation is minimum.

$$i = e = \frac{3}{4}A = \frac{3}{4}\,60° = 45°$$

$$i + e = A + \delta$$

$$D_m = 2i - A = 90^\circ - 60^\circ = 30^\circ$$

Refractive index

$$n = \frac{\sin\left(\frac{A + D_m}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \sqrt{2}$$

22. Ground state energy of electron (n = 1) is $E_1 = -13.6$ eV

Energy of the first excited state (n= 2)

$$E_2 = -\frac{13.6}{2^2} = -3.4\ eV ---------1$$

Energy required to be given to electron $\Delta E = E_2 - E_1 = -3.4 - (-13.6) = 10.2$ eV

½

Kinetic energy of electron in the first excited state = – (E) = 3.4 eV ½

Radius of first excited state $r_2 = n^2 a_0 = (2)^2\ 0.53\ A^\circ = 2.12\ A^\circ$ **1**

23. Let the charges on the spheres be q_1 and q_2.

$q_1 + q_2 = q$

Let σ = surface charge density

$q_1 = 4\pi a^2 \sigma$ and $q_2 = 4\pi b^2 \sigma$

$q = 4\pi\sigma(a^2 + b^2)$

$$\sigma = \frac{q}{4\pi(a^2 + b^2)}$$

Potential at the common center V = V1 + V2

$$V = \frac{1}{4\pi\epsilon_0}\frac{q_1}{a} + \frac{1}{4\pi\epsilon_0}\frac{q_2}{b}$$

$$V = \frac{1}{4\pi\epsilon_0}\frac{4\pi a^2\sigma}{a} + \frac{1}{4\pi\epsilon_0}\frac{4\pi b^2\sigma}{b}$$

Solving

$$V = \frac{q(a+b)}{4\pi\epsilon_0(a^2 + b^2)}$$

OR

Energy stored in the capacitor $E_i = \frac{1}{2}CV^2$

On inserting the dielectric, capacitance C' = KC and potential V' = V/K

On connecting with uncharged capacitor

Common potential

$$V" = \frac{C'V'}{C(1+K)} = \frac{CV}{C(1+K)} = \frac{V}{1+K}$$

Energy stored in the combination

$$E_f = \frac{1}{2}C(1+K)V"^2 = \frac{E_i}{1+K}$$

$$\frac{E_f}{E_i} = \frac{1}{1+K}$$

24. The process is called Nuclear Fission. ------ **1**

Mass of Fe_{26}^{56}= 55.93494 u
Mass of Al_{13}^{28} nucleus = 27.98191 u

Fe ------------- 2 Al

Mass defect = (55.93494 – 2(27.98191)) = – 0.02888

Energy released Q value = – 0.02888 × 931 = – 26.88728 MeV 1½

Since the Q value is coming out to be negative this nuclear fission is not possible.½

25. When only key K_1 is closed --- ½

$$I = \frac{E}{R+X}$$

When both K_1 and K_2 are closed -------------------- ½

$$I' = \frac{E}{R + \frac{XS}{S+X}}$$

Reading of ammeter ---- ½

$$\frac{S}{S+X} I' = \frac{I}{2} \; given$$

$$\frac{S}{S+X}\left(\frac{E}{R + \frac{XS}{S+X}}\right) = \frac{1}{2}\left(\frac{E}{R+X}\right)$$

Solving we get --------- **1½**

$$X = \frac{RS}{R-S}$$

26. Principal of Transformer – Mutual Induction -------------------------- ½

Windings shown in diagram (b) is more efficient because the extent of mutual induction will be more since the coils are wound on each other. --------------- **1**

Secondary voltage = 22 V, resistance = 440 Ω

Current in secondary = 22/440 = 0.05 A

Output power = P = $V_s I_s$ = 22 × 0.05 = 1.1 W

$efficiency = \frac{P_{out}}{P_{in}}$

$0.9 = \frac{1.1}{P_{in}}$ ---------------------- **1½**

P_{in} = 1.22 W

$P_{in} = V_p I_p$

$I_p = \frac{P_{in}}{V_p} = \frac{1.22}{220} = 5.5\, mA$

27. Wavelengths: (1each)

λ_1 – X – rays --- X-ray tubes or inner shell electrons

λ_2 - UV rays --- Inner shell electrons in atoms moving from one energy level to a lower level

λ_3 – Infra red --- Vibration of atoms and molecules

28. Expression for the Force **F** = q(**v** × **B**) ---------------------------- ½

Helical Path : If **v** is making an angle with **B**. ------------------- ½

Circular Path: If **v** is perpendicular to **B**. --------------------- ½

Since F is perpendicular to v, power F.v = 0.

$$P = \frac{dW}{dt} = 0$$

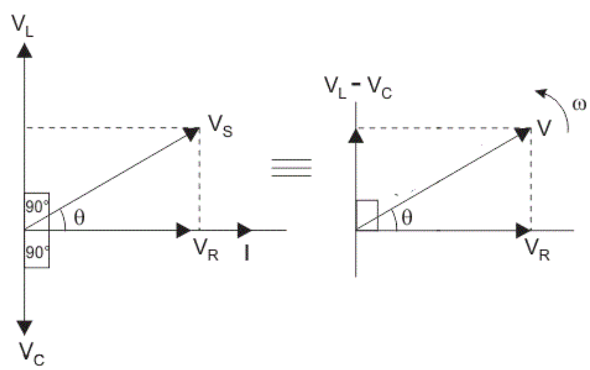
Or, W = 0 hence from work energy theorem, Change in KE = 0 or KE = constant ---

1½

29. (i) (c) (ii) (a) (iii) (a) (iv) (b)

30. (i) (b) (ii) (c) (iii) (c) (iv) (a)

31.



$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$V_R = IR, V_L = IX_L, V_C = IX_C$$

$$V = I\sqrt{R^2 + (X_L - X_C)^2}$$

Impedance

$$z = \frac{V}{I} = \sqrt{R^2 + (X_L - X_C)^2}$$

Phase difference

$$tan\emptyset = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{R}$$

The current and voltage will be in phase if $\phi = 0$ and $X_L = X_C$.

This condition of the circuit is called RESONANCE

(ii) For LR circuit Power factor

$$P_1 = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + X_L^2}} = \frac{R}{\sqrt{2R^2}} = \frac{1}{\sqrt{2}}$$

On connecting the capacitor it becomes LCR series circuit and since $X_L = X_C$, the circuit is in resonance and Power factor

$$P_2 = 1$$

$$\frac{P_1}{P_2} = \frac{1}{\sqrt{2}}$$

OR

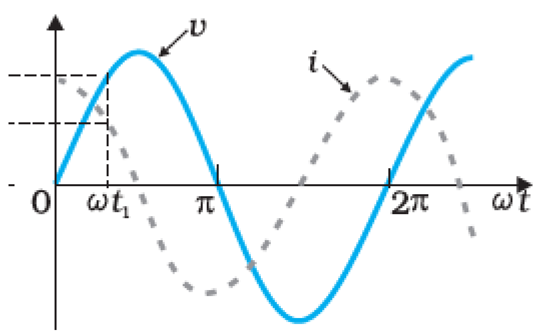
(i) The device is a pure Capacitor.

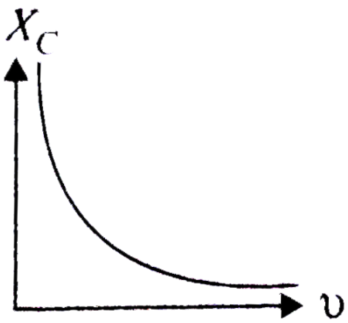
Reason; The current is leading the voltage by an angle of $\pi/2$.

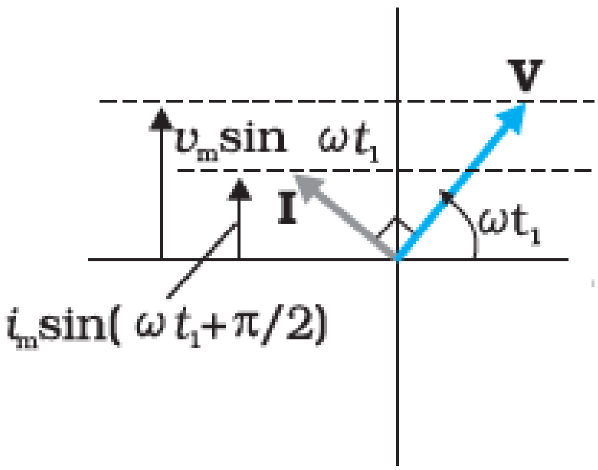
(ii) X = ratio of voltage to current is called Reactance

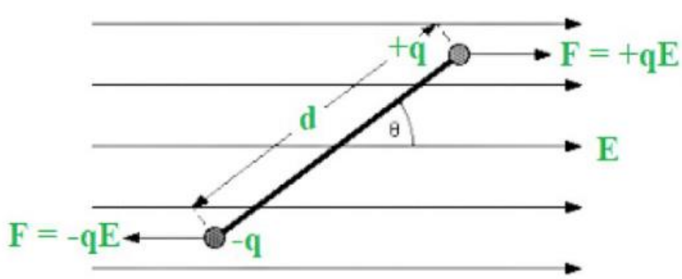
$X = \frac{1}{\omega C}$

(iii)



(iv) 

(v) 

32. 

Electric Dipole in External Field

Let θ be angle between the electric field E and dipolemoment p, then

Torque on the dipole is $\tau = pE\sin\theta$

If dipole is rotated by small angle dθ, work done

$dW = \tau \, d\theta$

Work done in rotating the dipole from angle θ_1 to θ_2 is

$$W = \int_{\theta_1}^{\theta_2} pE\sin\theta d\theta$$

$W = -pE(\cos\theta_2 - \cos\theta_1)$

Taking $\theta_1 = 90°$ as zero of potential and $\theta_2 = \theta$

$W = -pE\cos\theta$

This work done is stored in the dipole as potential energy

$U = -pE\cos\theta = -\mathbf{p.E}$

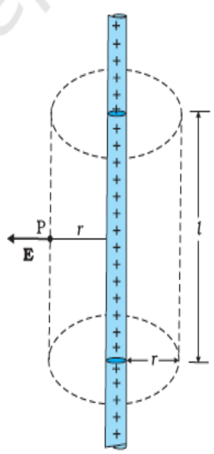
Stable equilibrium -- $\theta = 0°$ Unstable equilibrium -- $\theta = 180°$

$\tau = pE\sin\theta$

$= 4 \times 10^{-9} \times (5 \times 10^4)\sin 30°$

$= 10^{-4}$ Nm

OR



Flux through the Gaussian surface

= flux through the curved cylindrical part of the surface

= $E \times 2\pi rl$

The surface includes charge equal to λl. Gauss's law then give

$E \times 2\pi rl = \lambda l/\varepsilon_0$

i.e., $E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$

Vectorially, **E** at any point is given by

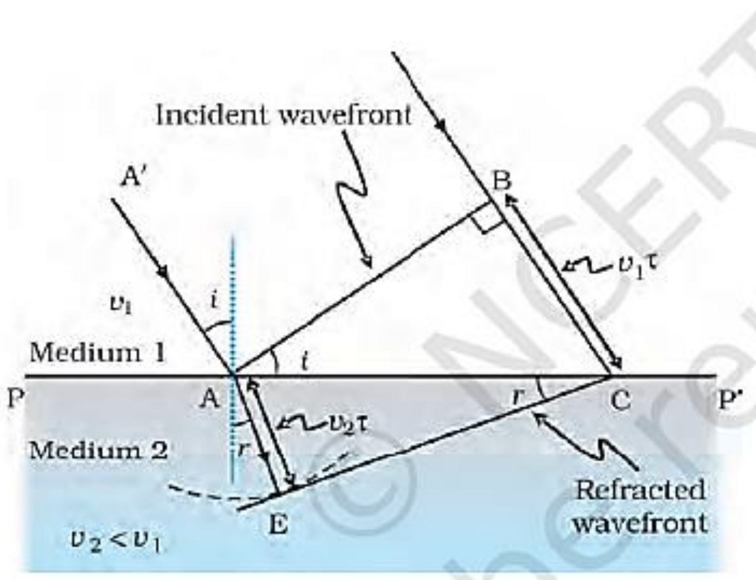
$$\mathbf{E} = \frac{\lambda}{2\pi\varepsilon_0 r}\hat{\mathbf{n}}$$

3

(a) There is no effect on the flux because the result is independent of the shape and size of the Gaussian surface.

(b) Charge enclosed = $q = \phi\varepsilon_0 = -8.85$ nC **2**

33. Wave front: The locus of all points of the medium oscillating in same phase is called wave front. --- **1**



----------- **½**

$$\sin i = \frac{BC}{AC} = \frac{v_1\tau}{AC}$$

$$\sin i = \frac{AE}{AC} = \frac{v_2\tau}{AC}$$

$$\frac{sini}{sinr} = \frac{v_1}{v_2} = \mu$$

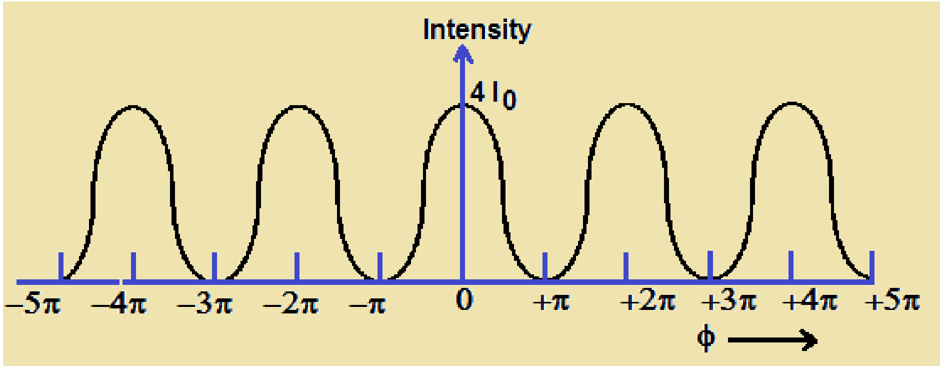
-------------------- **1½**

For diffraction, central maxima is given by

$$\beta = 2\frac{\lambda D}{d}$$

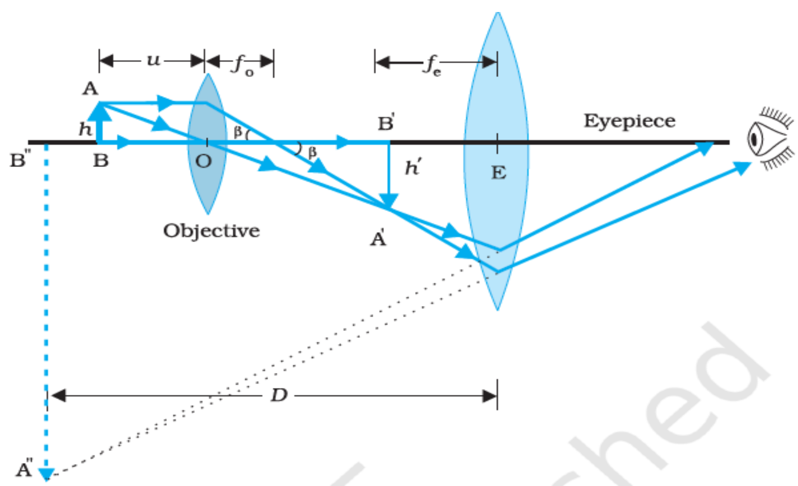
$$d = 2\frac{\lambda D}{\beta} = \frac{2 \times 6 \times 10^{-7} \times 0.8}{4.8 \times 10^{-3}} = 0.2\ mm$$

-------------- **1**



1 mark for diagram

OR



1½

Magnifying power

$$m = \frac{L}{f_0}\left(1 + \frac{D}{f_e}\right)$$

----------- ½

For the telescope

$$\frac{D}{r} = \frac{h}{f_o}$$

$$h = f_o\frac{D}{r} = \frac{3.48 \times 10^6 \times 15}{3.8 \times 10^8} = 13.7\ cm$$

---------------------- **1½**

The objective of a telescope has a larger aperture so that sufficient light can be gathered to form a bright image of a distance object. ----------- --------------- **1**

The focal length of the objective is kept large to increase magnification. --------------- ½