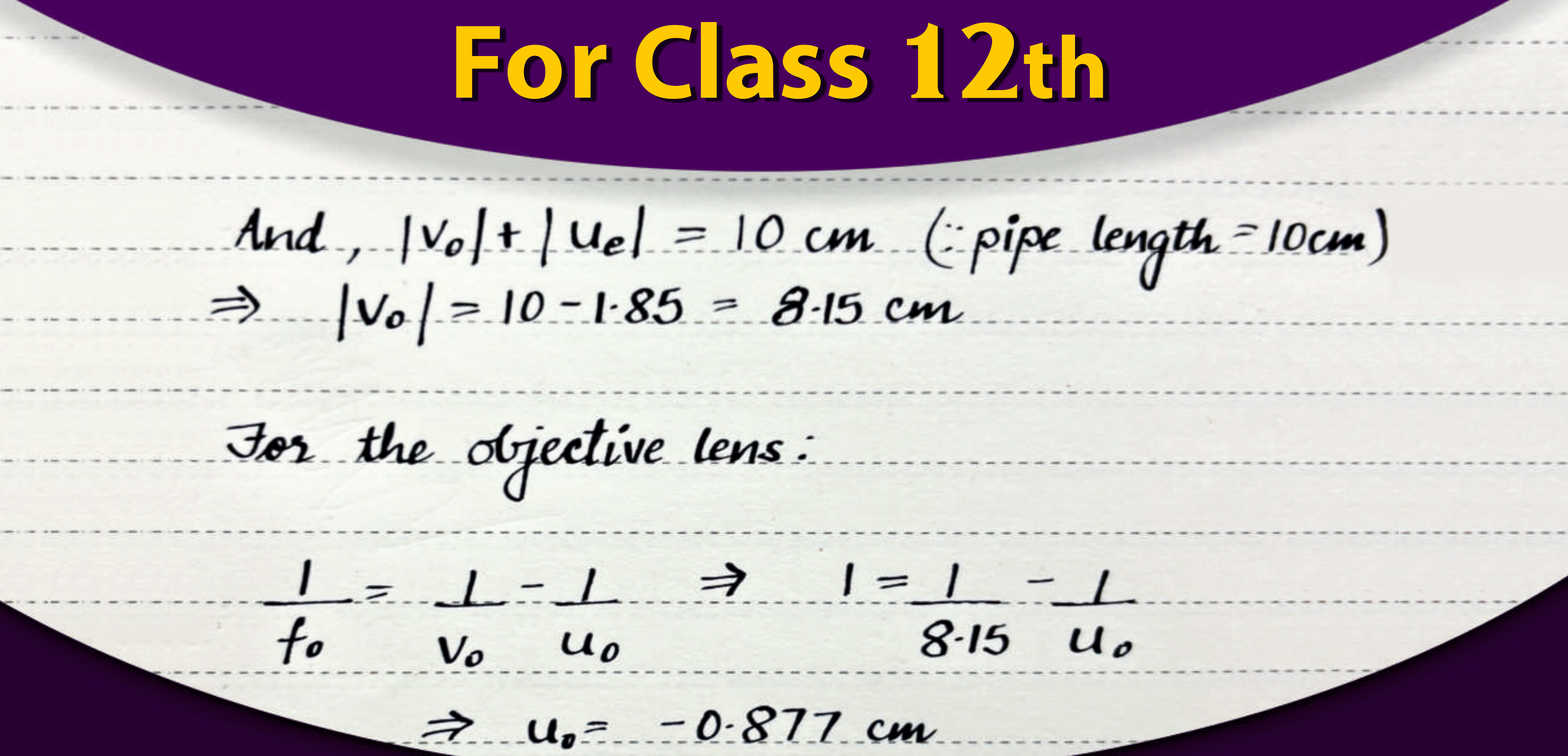
CBSE

TOPPER'S ANSWER SHEET

For Class 12th



PHYSICS

CHEMISTRY

BIOLOGY

MATHEMATICS

2026
EXAMINATION

2023 and 2024 Papers

PHYSICS

SECTION-A

***MCQ* (1 to 16)**

(16×1=16 Marks)

1. A battery supplies 0.9 A current through a 2Ω resistor and 0.3 A current through a 7Ω resistor when connected one by one. The internal resistance of the battery is

(a) 2
(b) 1.5
(c) 1
(d) 0.5

1) (d)
For 2 Ω, $E = 0.9(r+2)$ —①
For 7 Ω, $E = 0.3(r+7)$ —②
From equations ① and ②
$0.9(r+2) = 0.3(r+7)$
$\Rightarrow r = 0.5\,\Omega$

2. A particle of mass m and charge q describes a circular path of radius R in a magnetic field. If its mass and charge were 2m and $\frac{q}{2}$ respectively, the radius of its path would be

(a) $\frac{R}{4}$
(b) $\frac{R}{2}$
(c) 2 R
(d) 4 R

2) (d)
Magnetic force = Centripetal force
$\Rightarrow qVB = \frac{mV^2}{R} \Rightarrow R = \frac{mV}{qB}$

for $m' = 2m$ and $q' = q/2$
$R' = \frac{2mV}{\frac{q}{2} \times B} \Rightarrow \frac{4mV}{qB} = 4R$

3. Which of the following pairs is that of paramagnetic materials?

(a) Copper Aluminium
(b) Sodium and Calcium
(c) Lead and Iron
(d) Nickel and Cobalt

3) (b)
Paramagnetic materials are the materials which have unpaired e^- and are weakly attracted to an external magnetic field. Sodium and Calcium are paramagnetic materials.

4. A galvanometer of resistance 50Ω is converted into a voltmeter of range (0-2V) using a resistor of 1.0 kΩ. If it is to be converted into a voltmeter of range (0-10V), the resistance required will be

(a) 4.8 kΩ (b) 5.0 kΩ
(c) 5.2 kΩ (d) 5.4 kΩ

4) (c) $\because V = I_g(G+R)$

Case 1, $2 = I_g(50+1000) \Rightarrow I_g = \frac{2}{1050}$ A

Case 2, $10 = I_g(50+R)$

$10 = \frac{2}{1050}(50+R)$

$\Rightarrow R = \frac{10 \times 1050}{2} - 50 = 5.2\,k\Omega$

5. Two coils are placed near each other. When the current in one coil is changed at the rate of 5A/s, an emf of 2mV is induced in the other. The mutual inductance of the two coils is

(a) 0.4 mH (b) 2.5 mH
(c) 10 mH (d) 2.5 H

5) (a)

$\varepsilon_2 = \left|-M\frac{dI}{dt}\right|$

$\Rightarrow 2 \times 10^{-3} = M(5) \Rightarrow M = 0.4\,mH$

6. The electromagnetic waves used to purify water are

(a) Infrared rays (b) Ultraviolet rays
(c) X-rays (d) Gamma rays

6) (b)

Ultraviolet rays are used to purify water because they have ability to kill/inactivate micro organisms.

7. The focal lengths of the objective and the eyepiece of a compound microscope are 1 cm and 2 cm respectively. If the tube length of the microscope is 10 cm, the magnification obtained by the microscope for most suitable viewing by relaxed eye is

(a) 250 (b) 200
(c) 150 (d) 125

7) (d)

For the eyepiece

$\frac{1}{f_e} = \frac{1}{v_e} - \frac{1}{u_e}$

$\Rightarrow \frac{1}{2} = \frac{1}{-25} - \frac{1}{u_e} \Rightarrow u_e = -1.85$ cm

And, $|v_o| + |u_e| = 10$ cm ($\because$ pipe Length = 10cm)

$\Rightarrow |v_o| = 10 - 1.85 = 8.15$ cm

For the objective lens:

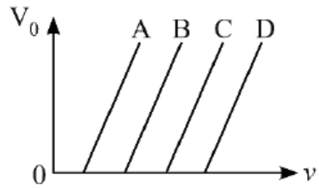
$\frac{1}{f_o} = \frac{1}{v_o} - \frac{1}{u_o} \Rightarrow 1 = \frac{1}{8.15} - \frac{1}{u_o}$

$\Rightarrow u_o = -0.877$ cm

Now, magnification, $m = \frac{v_o}{|u_o|}\left(1 + \frac{D}{f_e}\right)$

$\Rightarrow m = \frac{8.15}{0.877}\left(1 + \frac{25}{2}\right) = 125$

8. The variation of the stopping potential (V_0) with the frequency (ν) of the incident radiation for four metals A,B,C and D is shown in the figure. For the same frequency of incident radiation producing photo-electrons in all metals, the kinetic energy of photo-electrons will be maximum for metal



(a) A (b) B
(c) C (d) D

8) (a)
Since the threshold frequency (ν_0) is least for A. Therefore, for the same frequency of incident radiation producing photoelectrons in the metals, the KE ($h\nu - h\nu_0$) will be maximum for metal A.

9. The energy of an electron in the ground state of hydrogen atom is –13.6 eV. The kinetic and potential energy of the electron in the first excited state will be

(a) –13.6 eV, 27.2 eV (b) –6.8 eV, 13.6 eV
(c) 3.4 eV, –6.8 eV (d) 6.8 eV, –3.4 eV

9) (c)
For the first excited state, n=2

$E_2 = -\frac{13.6}{n^2} = \frac{-13.6}{(2)^2} = -3.4\,eV$

Now, $K = -E = 3.4\,eV$

$U = 2E = -6.8\,eV$

10. A Young's double-slit experimental set up is kept in a medium of refractive index $\left(\frac{4}{3}\right)$. Which maximum in this case will coincide with the 6[th] maximum obtained if the medium is replaced by air?

(a) 4[th] (b) 6[th]
(c) 8[th] (d) 10[th]

10) (c)
6th bright fringe in air ($\mu = 1$) $= \frac{n\lambda D}{\mu d} = \frac{6\lambda D}{d}$

nth bright fringe in medium ($\mu = 4/3$) $= \frac{3n\lambda D}{4d}$

So, $x'_n = x_6$

$\Rightarrow \frac{3n\lambda D}{4d} = \frac{6\lambda D}{d} \Rightarrow n = 8$

11. The potential energy between two nucleons inside a nucleus is minimum at a distance of about

(a) 0.8 fm (b) 1.6 fm

(c) 2.0 fm (d) 2.8 fm

11) (a) The potential energy inside a nucleus is minimum between two nucleus when they are at a distance of about 0·8 fm

12. A pure Si crystal having 5×10^{28} atoms m^{-3} is dopped with 1ppm concentration of antimony. If the concentration of holes in the doped crystal is found to be 4.5×10^{9} m^{-3}, the concentration (in m^{-3}) of intrinsic charge carriers in Si crystal is about

(a) 1.2×10^{15} (b) 1.5×10^{16}

(c) 3.0×10^{15} (d) 2.0×10^{16}

12) (b)

In 5×10^{28} atoms, net si doped $= \frac{5\times10^{28}}{10^6}$

$= 5\times10^{22}$ atoms

So, number of excess electrons

$n_e = 5\times10^{22}$

Also, $n_i^2 = n_e n_n = (5\times10^{22})(4.5\times10^{9})$

$\Rightarrow n_i = 1.5\times10^{16}$

For Questions 13 to 16, two statements are given - one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below.

(a) If both Assertion (A) and Reason (R) are true and Reason (R) is correct explanation of Assertion (A).

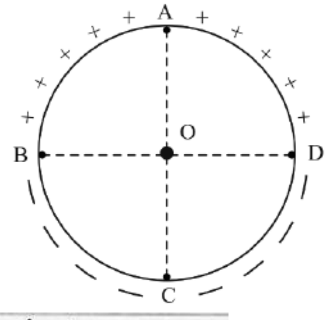
(b) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).

(c) If Assertion (A) is true but Reason (R) is false.

(d) If both Assertion (A) and Reason (R) are false.

13. **Assertion (A):** Equal amount of positive and negative charges are distributed uniformly on two halves of a thin circular ring as shown in figure. The resultant electric field at the centre O of the ring is along OC.

Reason (R): It is so because the net potential at O is not zero.



13) (C) Direction of electric field will be along OC (positive to negative). And net potential at O is zero.

14. **Assertion (A):** The energy of a charged particle moving in a magnetic field does not change.

Reason (R): It is because the work done by the magnetic force on the charge moving in a magnetic field is zero.

14) (a) Since velocity and applied magnetic field are perpendicular to each other, therefore the work done is zero. It means that energy of particle will not change.

15. **Assertion (A):** In a Young's double-slit experiment, interference pattern is not observed when two coherent sources are infinitely close to each other.

Reason (R): The fringe width is proportional to the separation between the two sources.

15) (c) fringe width $(w) = \frac{\lambda D}{d}$

Since, W(fringe width) $\propto \frac{1}{d}$

Therefore, there will be no pattern when the two sources are infinitely close to each other.

16. **Assertion (A):** An alpha particle is moving towards a gold nucleus. The impact parameter is maximum for the scattering angle of 180°.

Reason (R): The impact parameter in an alpha particle scattering experiment does not depend upon the atomic number of the target nucleus.

16) (d) Both statements are false

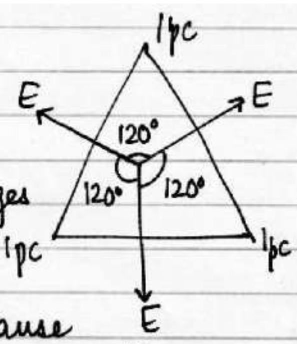
Impact parameter depends on the atomic number (Z) of target nucleus.

When scattering angle is 180° then impact parameter is 0.

SECTION-B **[5 × 2 = 10 Marks]**

17. Three point charges, 1pC each, are kept at the vertices of an equilateral triangle of side 10cm. Find the net electric field at the centroid of triangle.

(b) The electric field at the centre of triangle due to all the three equal charges placed at the vertices of the triangle is zero because it is balanced from all sides, due to symmetry.



18. Derive an expression for magnetic force $\vec{F}$ acting on a straight conductor of length L carrying current I in an external magnetic field $\vec{B}$. Is it valid when the conductor is in zig-zag form? Justify.

18) The force on an individual charge moving at the drift velocity v_d is

$F = qv_dB\sin\theta$

For N charge carriers, the force is

$F = Nqv_dB\sin\theta$

where, $N = nV = nAL$

so, $F = nALqv_dB\sin\theta$

$= ILB\sin\theta \quad [\because I = nqAv_d]$

$\Rightarrow \vec{F} = I(\vec{l} \times \vec{B})$

Yes, it is valid when the conductor is in zig zag form as the length of the wire will remain at the same angle with the magnetic field.

19. A telescope has an objective lens of focal length 150 cm and an eyepiece of focal length 5cm. Calculate its magnifying power in normal adjustment and the distance of the image formed by the objective.

19) Given, $f_o = 150$ cm, $f_e = 5$cm

For normal adjustment, $m = -\frac{f_o}{f_e}$

$= -\frac{150}{5} = -30$

For objective lens, $\frac{1}{f_o} = \frac{1}{v_o} - \frac{1}{u_o}$

$\Rightarrow \frac{1}{150} = \frac{1}{v_o} - \frac{1}{\infty} \quad [\because u_o = \infty$, object at $\infty)$

$\Rightarrow v_o = 150$ cm

20. (a) Two energy levels of an electron in hydrogen atom are separated by 2.55 eV. Find the wavelength of radiation emitted when the electron makes transition from the higher energy level to the lower energy level.

(b) In which series of hydrogen spectrum this line shall fall?

20)

(a) Given that, $E = 2.55\ eV = 2.55 \times 1.6 \times 10^{-19}$ J

$= 4.08 \times 10^{-19}$ J

$\because E = \frac{hc}{\lambda}$

$\therefore 4.08 \times 10^{-19} = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{\lambda}$

$\Rightarrow \lambda = 4872$ Å

(b) $\lambda = 4872$ Å falls in Balmer series of hydrogen spectrum.

21. The earth revolves around the sun in an orbit of radius 1.5×10^{11}m with orbital speed 30km / s. Find the quantum number that characterises its revolution using Bohr's model in this case (mass of earth = 6.0×10^{24}kg).

21) We have,

$r = 1.5\times10^{11}$ m, $v = 3\times10^{4}$ m/s

$m = 6.0\times10^{24}$ kg

As per the Bohr's model, angular momentum is given as,

$$mvr = \frac{nh}{2\pi}$$

$$\Rightarrow n = \frac{2\pi mvr}{h} = \frac{2\times3.14\times6\times10^{24}\times3\times10^{4}\times1.5\times10^{11}}{6.626\times10^{-34}}$$

$$\Rightarrow n = 3\times10^{74}$$

SECTION-C **[7 × 3 = 21 Marks]**

22. (a) Write Einstein's photoelectric equation. How did Millikan prove the validity of this equation?

(b) Explain the existence of threshold frequency of incident radiation for photoelectric emission from a given surface.

22)

(a) Einstein's photoelectric equation is,

$$h\nu - h\nu_0 = KE$$

After doing a series of experiments, Millikan found the slope h/e, of the V_0-ν graph. He calculated the value of Planck's constant, $h = 6.626\times10^{-34}$ Js, using the slope and electron charge values

Millikan did an experiment using a variety of alkali metal and verified the photoelectric equation.

(b) The threshold frequency is the minimum frequency of incident radiation required to emit electrons from a given surface in the photoelectric effect. Below this frequency no electrons are emitted regardless of the intensity of the radiation. This is because the energy of the photon is insufficient to overcome the work function of the material.

28. Explain the following, giving reasons:

(a) A doped semiconductor is electrically neutral.

(b) In a $p - n$ junction under equilibrium, there is no net current.

(c) In a diode, the reverse current is practically not dependent on the applied voltage.

28)

(a) A doped semiconductor is electrically neutral because the number of added impurity atoms (dopants) matches the number of charge carriers they provide, maintaining overall electrical neutrality.

(b) In a p-n junction under equilibrium, there is no current because the diffusion of electrons and holes is balanced by the drift current due to the electric field of the depletion region.

(c) The reverse current is limited by minority carriers, which are few and unaffected by changes in reverse voltage, hence remaining nearly constant.

SECTION-D **[2 × 4 = 8 Marks]**

29. Dielectrics play an important role in design of capacitors. The molecules of a dielectric may be polar or non-polar. When a dielectric slab is placed in an external electric field, opposite charges appear on the two surfaces of the slab perpendicular to electric field. Due to this an electric field is established inside the dielectric.

The capacitance of a capacitor is determined by the dielectric constant of the material that fills the space between the plates.

Consequently, the energy storage capacity of a capacitor is also affected. Like resistors, capacitors can also be arranged in series and/or parallel.

(i) Which of the following is a polar molecule?

(a) O_2 (b) H_2

(c) N_2 (d) HCl

(ii) Which of the following statements about dielectrics is correct?

(a) A polar dielectric has a net dipole moment in absence of an external electric field which gets modified due to the induced dipoles.

(b) The net dipole moments of induced dipoles is along the direction of the applied electric field.

(c) Dielectrics contain free charges.

(d) The electric field produced due to induced surface charges inside a dielectric is along the external electric field.

(iii) When a dielectric slab is inserted between the plates of an isolated charged capacitor, the energy stored in it

(a) increases and the electric field inside it also increases.

(b) decreases and the electric field also decreases.
(c) decreases and the electric field increases.
(d) increases and the electric field decreases.

(iv) (a) An air-filled capacitor with plate area A and plate separation d has capacitance C_0. A slab of dielectric constant K, area A and thickness $\left(\frac{d}{5}\right)$ is inserted between the plates. The capacitance of the capacitor will become

(a) $\left[\frac{4K}{5K+1}\right]C_0$ (b) $\left[\frac{K+5}{4}\right]C_0$

(c) $\left[\frac{5K}{4K+1}\right]C_0$ (d) $\left[\frac{K+4}{5K}\right]C_0$

29)
(i) (d) is correct
HCl is a polar molecule because there is a significant difference in electronegativity between H and Cl.

(ii) (b) is correct
The net effect of dipole moment produces a field that opposes the external field. So dipole moment is in the same direction as the external field.

(iii) (b) is correct
The energy stored in a capacitor $U=\frac{Q^2}{2C}$ decreases because the capacitance increases.
The electric field $E=\frac{V}{d}$ also decrease as $V=\frac{Q}{C}$ decreases.

(iv) a) (c) is correct

$C_0 = \frac{A\varepsilon_0}{d}$

$C = \frac{\varepsilon_0 A}{d-t+\frac{t}{K}} = \frac{A\varepsilon_0}{d}\left[\frac{1}{1-\frac{1}{5}+\frac{1}{5K}}\right]$ $\left[\because t=\frac{d}{5}\right]$

$= \left[\frac{5K}{1+4K}\right]C_0$

OR

(b) Two capacitors of capacitances $2C_0$ and $6C_0$ are first connected in series and then in parallel across the same battery. The ratio of energies stored in series combination to that in parallel is

(a) $\frac{1}{4}$ (b) $\frac{1}{6}$

(c) $\frac{2}{12}$ (d) $\frac{3}{16}$

b) (d) is correct

$$\frac{1}{C_{series}} = \frac{1}{2C_0} + \frac{1}{6C_0} = \frac{2}{3C_0}$$

$$\Rightarrow C_{series} = \frac{3C_0}{2}$$

$$U_{series} = \frac{1}{2}CV^2 = \frac{1}{2} \times \frac{3}{2} C_0 \times V^2 = \frac{3}{4} C_0 V^2$$

$$C_{parallel} = 2C_0 + 6C_0 = 8C_0$$

$$U_{parallel} = \frac{1}{2}CV^2 = \frac{1}{2} \times 8C_0V^2 = 4C_0V^2$$

Required ratio $= \dfrac{3/4\, C_0V^2}{4C_0V^2} = \dfrac{3C_0V^2}{16C_0V^2} = \dfrac{3}{16}$

30. A prism is an optical medium bounded by three refracting plane surfaces. A ray of light suffers successive refractions on passing through its two surfaces and deviates by a certain angle from its original path. The refractive index of the material of the prism is given by $\mu = \sin\left(\frac{A+\delta_m}{2}\right) / \sin\frac{A}{2}$. If the angle of incidence on the second surface is greater than an angle called critical angle, the ray will not be refracted from the second surface and is totally internally reflected.

(i) The critical angle for glass is θ_1 and that for water is θ_2. The critical angle for glass-water surface would be (given ${}_a\mu_g = 1.5$, ${}_a\mu_w = 1.33$)

(a) less than θ_2 (b) between θ_1 and θ_2

(c) greater than θ_2 (d) less than θ_1

(ii) When a ray of light of wavelength λ and frequency v is refracted into a denser medium

(a) λ and v both increase. (b) λ increases but *v* is unchanged.

(c) λ decreases but v is unchanged. (d) λ and *v* both decrease.

(iii) (a) The critical angle for a ray of light passing from glass to water is minimum for

(a) red colour (b) blue colour

(c) yellow colour (d) violet colour

30)

i) (c) is correct

critical angle (θ) is given by

$$\sin\theta = \frac{\mu_w}{\mu_g}$$

Also, $\sin\theta_1 = \frac{1}{\mu_g}$ and $\sin\theta_2 = \frac{1}{\mu_w}$

$\because \mu_g > \mu_w \quad \therefore \theta_1 < \theta_2$

$\Rightarrow \theta > \theta_2$

ii) (c) is correct

Frequency is determined by source of the light, so it remains unchanged. The wavelength ($\lambda = \frac{c}{\nu}$) decreases because speed (c) of the wave decreases in denser medium.

iii) a) (d) is correct

Violet colour has highest refractive index therefore critical angle is minimum

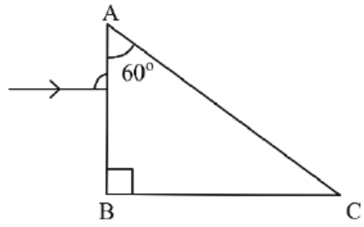
OR

(b) Three beams of red, yellow and violet colours are passed through a prism, one by one under the same condition. When the prism is in the position of minimum deviation, the angles of refraction from the second surface are r_R, r_Y and r_V respectively. Then

(a) $r_V < r_Y < r_R$ (b) $r_Y < r_R < r_V$

(c) $r_R < r_Y < r_V$ (d) $r_R = r_Y = r_V$

(iv) A ray of light is incident normally on a prism ABC of refractive index 2, as shown in figure. After it strikes face AC, it will



(a) go straight undeviated (b) just graze along the face AC

(c) refract and go out of the prism (d) undergo total internal reflection

b) (d) is correct

wavelengths of all three are same in air. Therefore, $r_R = r_Y = r_V$

iv) (d) is correct

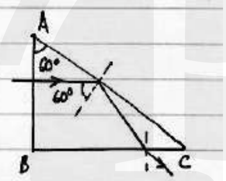
$\mu = \sqrt{2}$

$\sin i_c = \frac{1}{\mu} = \frac{1}{\sqrt{2}}$

$i_c = 45°$

$\because$ incident angle is $> i_c$

$\therefore$ Total internal reflection will happen



SECTION-E [3 × 5 = 15 Marks]

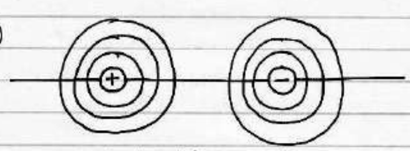
31. (a) (i) Draw equipotential surfaces for an electric dipole.

(ii) Two point charges q_1 and q_2 are located at $\vec{r_1}$ and $\vec{r_2}$ respectively in an external electric field $\vec{E}$. Obtain an expression for the potential energy of the system.

(iii) The dipole moment of a molecule is 10^{-30} Cm. It is placed in an electric field $\vec{E}$ of 105 V/m such that its axis is along the electric field. The direction of $\vec{E}$ is suddenly changed by 60° at an instant. Find the change in the potential energy of the dipole, at that instant.

31)

a) i)



Equipotential surface

ii) Work done in bringing q_1 from ∞ to r_1

$W_1 = q_1 V(r_1)$

Work done in bringing q_2 from ∞ to r_2

$$W_2 = q_2 (V)(r_2) + \frac{q_1 q_2}{4\pi\varepsilon_0 r_2}$$

Thus total PE = $W_1 + W_2$

$$\Rightarrow U = q_1 V(r_1) + q_2 V(r_2) + \frac{q_1 q_2}{4\pi\varepsilon_0 r_2}$$

iii) $p = 10^{-30}$ C-m, $E = 10^5$ V/m

$$\Delta V = -PE\ (\cos\theta_2 - \cos\theta_1)$$
$$= -10^{-30} \times 10^5 (\cos 60^\circ - \cos 0^\circ)$$
$$= 10^{-25}\ J$$

OR

(b) (i) A thin spherical shell of radius R has a uniform surface charge density σ. Using Gauss' law, deduce an expression for electric field (i) outside and (ii) inside the shell.

(ii) Two long straight thin wires AB and CD have linear charge densities 10μC/m and –20μC/m, respectively. They are kept parallel to each other at a distance 1 m. Find magnitude and direction of the net electric field at a point midway between them.

b) i) Electric field outside the shell.
For a point at a distance r from center, (r>R) :-
Gauss' law states:

$$\oint E \cdot dA = \frac{Q_{enc}}{\varepsilon_0}$$

Total charge, $Q = \sigma \cdot 4\pi R^2$

So,

$$\oint E \cdot dA = \frac{\sigma 4\pi R^2}{\varepsilon_0}$$

$$\Rightarrow E \cdot 4\pi r^2 = \frac{\sigma 4\pi R^2}{\varepsilon_0}$$

$$\Rightarrow E = \frac{\sigma R^2}{\varepsilon_0 r^2}$$

So,

$$\oint E \cdot dA = \frac{\sigma 4\pi R^2}{\varepsilon_0}$$

$$\Rightarrow E \cdot 4\pi r^2 = \frac{\sigma 4\pi R^2}{\varepsilon_0}$$

$$\Rightarrow E = \frac{\sigma R^2}{\varepsilon_0 r^2}$$

ii) Electric field inside the shell:-
For a point at a distance of r < R :
Consider a Gaussian surface inside the shell.
Since there is no charge enclosed, the Q_{enc} is zero.

$$\therefore \oint E \cdot dA = \frac{Q_{enc}}{\varepsilon_0} = 0$$

$$\Rightarrow E = 0$$

b) ii) For a point at a distance r from linear charge,

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

Total electric field,

$$E = \frac{\lambda_1}{2\pi\varepsilon_0 r} + \frac{\lambda_2}{2\pi\varepsilon_0 r} = \frac{2}{4\pi\varepsilon_0 r}(\lambda_1+\lambda_2)$$

$$= \frac{2\times 9\times 10^9}{0.5}(10\times 10^{-6} - 20\times 10^{-6})$$

$$= -3.6\times 10^5\ N/C$$

The direction is towards wire CD.

32. (a) (i) You are given three circuit elements X,Y and Z. They are connected one by one across a given ac source. It is found that V and I are in phase for element X. V leads I by $\left(\frac{\pi}{4}\right)$ for element Y while I leads V by $\left(\frac{\pi}{4}\right)$ for element Z. Identify elements X,Y and Z.

(ii) Establish the expression for impedance of circuit when elements X,Y and Z are connected in series to an ac source. Show the variation of current in the circuit with the frequency of the applied ac source.

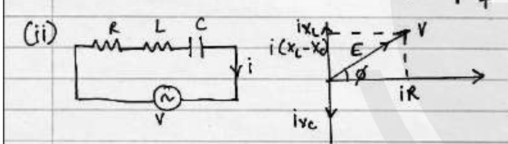
(iii) In a series LCR circuit, obtain the conditions under which (i) impedance is minimum and (ii) wattless current flows in the circuit.

32) a)(i) The element X is a resistor because phase difference between V and I is zero

The element Y is an inductor because voltage leads the current by $\frac{\pi}{4}$.

The element Z is a capacitor because the current leads the voltage by $\frac{\pi}{4}$

(ii)



Circuit diagram   Phasor diagram

$V^2 = V_R^2 + (V_L - V_C)^2$ $V = V_0 \sin\omega t$

$V^2 = i^2(R^2 + (X_L - X_C)^2)$ $i = \frac{V_0}{Z}\sin(\omega t - \phi)$

$i = \frac{V}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{V}{Z}$ $\tan\phi = \frac{X_L - X_C}{R}$

$\Rightarrow Z = \sqrt{R^2 + (X_L - X_C)^2}$

when $X_L = X_C$

$\omega_r L = \frac{1}{\omega_r C}$

$\Rightarrow \omega_r = \frac{1}{\sqrt{LC}} = 2\pi\nu_r$

$\Rightarrow \nu_r = \frac{1}{2\pi\sqrt{LC}}$

At this frequency $Z = R \rightarrow$ minimum value

Thus, for frequency greater or less than ω_r current will be lesser than the maximum value (I_0)

iii) (i) When $X_L = X_C$ then $Z = R$ which is minimum

(ii) $P = VI\cos\phi$ when $\phi = \pi/2$

then $P = 0$

$\therefore$ wattless current flows when circuit is purely inductive or purely capacitive

OR

(b) (i) Describe the construction and working of a transformer and hence obtain the relation for $\left(\frac{v_s}{v_p}\right)$ in terms of number of turns of primary and secondary.

(ii) Discuss four main causes of energy loss in a real transformer.

b) (i) A transformer is an electrical device used to transfer electrical energy between two or more circuits through EMI.

Construction :

1) Core : It is made of laminated soft iron to minimize eddy current losses.

2) Primary winding : This is the coil to which the input voltage is applied.

3) Secondary winding : This is the coil from which output voltage is taken.

Working :

When an alternating voltage V_p is applied to the primary winding, an AC flows through it, creating a time varying magnetic field in the core. According to Faraday's law of EMI, this changing magnetic field induces an emf in the secondary winding. The emf induced in the primary winding are proportional to the rate of change of magnetic flux.

$$\therefore \frac{V_S}{V_P} = \frac{N_S}{N_P}$$

where, V_S and V_P are secondary and primary voltages respectively. N_P, N_S represents number of turns in primary and secondary winding.

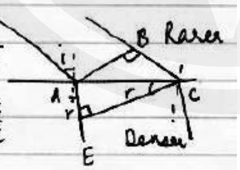
(ii) The four main causes of energy loss in real transformer are:
1) Copper losses: Due to resistance of the windings
2) Iron losses: Including hysteresis and eddy current losses in the core.
3) Magnetic leakage losses: Due to incomplete coupling of the magnetic flux.
4) Dielectric losses: Due to energy dissipation in the insulating material

33. (a) (i) A plane light wave propagating from a rarer into a denser medium, is incident at an angle *i* on the surface separating two media. Using Huygen's principle, draw the refracted wave and hence verify Snell's law of refraction.

(ii) In a Young's double slit experiment, the slits are separated by 0.30 mm and the screen is kept 1.5 m away. The wavelength of light used is 600 nm. Calculate the distance between the central bright fringe and the 4th dark fringe.

33) a)(i) Huygen's principle states that every point on a wavefront acts as a source of secondary spherical wavelets. The wavefront in the denser medium bends towards the normal due to slower speed of light in the denser medium.

In ΔABC, $\sin i = \frac{BC}{AC} = \frac{v_1 t}{AC}$



In ΔAEC, $\sin r = \frac{AE}{AC} = \frac{v_2 t}{AC}$

$\Rightarrow \frac{v_1}{v_2} = \frac{\sin i}{\sin r}$ —(1)

And, $\frac{\mu_2}{\mu_1} = \frac{v_1}{v_2}$ —(2) $\left[\because \mu = \frac{c}{v}\right]$

From (i) and (ii)

$\frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1}$

This is known as Snell's law.

(ii) Distance of nth dark fringe from central fringe $(x_n) = \frac{(2n-1)}{2}\frac{\lambda D}{d}$

when $n = 4$

$x_4 = \frac{(8-1) \times 600 \times 10^{-9} \times 1.5}{2 \times 0.30 \times 10^{-3}} = 1.05$ cm

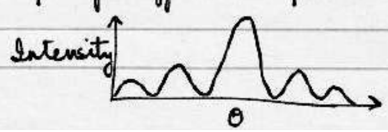
OR

(b) (i) Discuss briefly diffraction of light from a single slit and draw the shape of the diffraction pattern.

(ii) An object is placed between the pole and the focus of a concave mirror. Using mirror formula, prove mathematically that it produces a virtual and an enlarged image.

b) (i) When monochromatic light passes through a single slit and is observed on a screen, the resulting pattern consists of a central fringe (maximum) with a series of alternating dark (minima) and bright (secondary maxima) fringes on either side.

Shape of diffraction pattern.



(ii) Apply mirror formula,

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

for concave mirror, $f<0$, $u<0$

$$\Rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

$$\Rightarrow \frac{1}{f} - \frac{1}{u} > 0, \quad \frac{1}{v} > 0$$

$$\Rightarrow v > 0$$

It means that image is on right side of concave mirror.

Now, $m = \frac{-v}{u}$

$\because v>0$ and $u<0$

$\Rightarrow m>0$

Therefore, virtual and enlarged image is formed.

■■■

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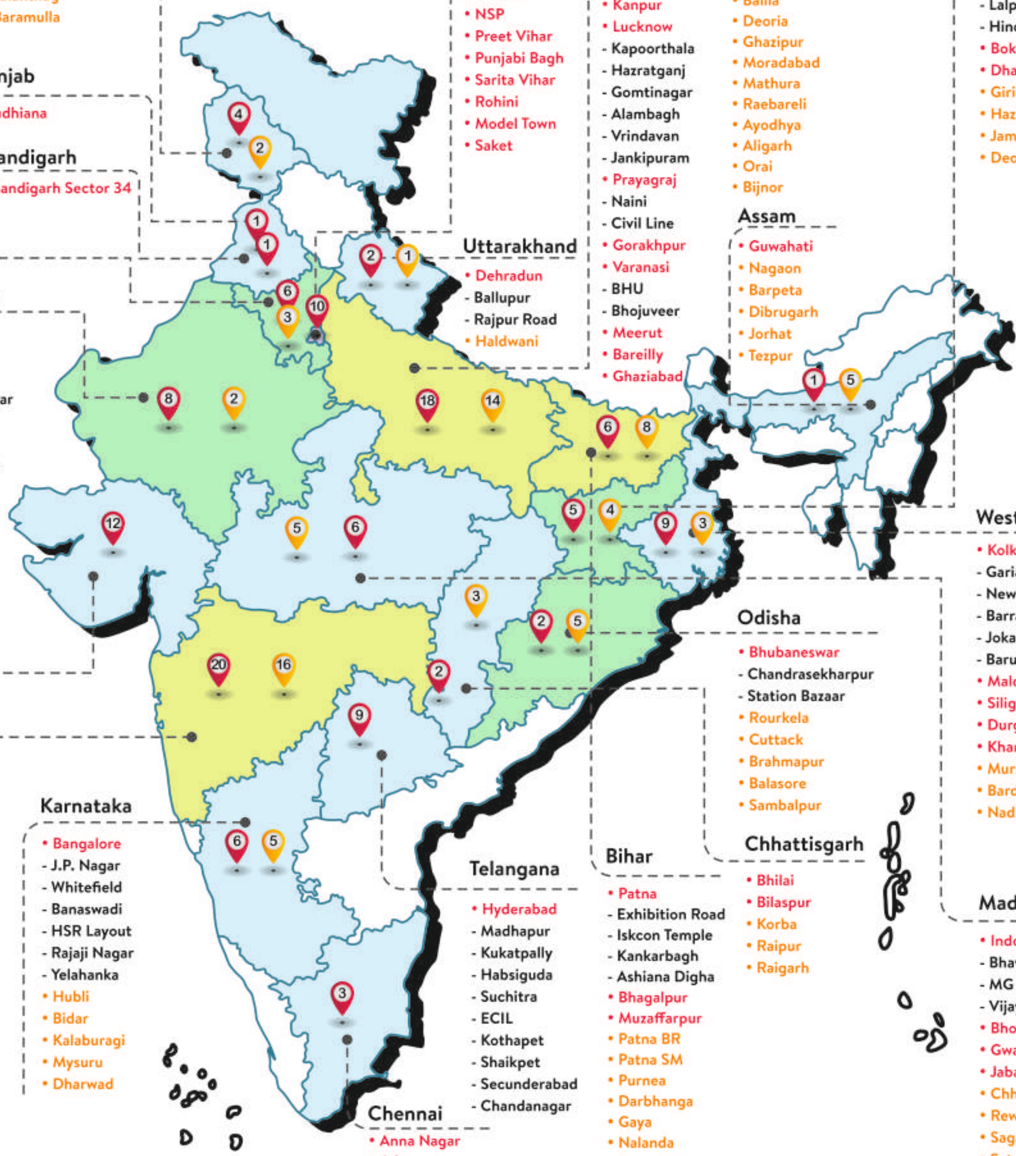

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