Mock Board Exam

Physics

Solutions

SECTION-A

1. (a) Since the speed of EM waves in free space is $c = \dfrac{1}{\sqrt{\mu_0 \varepsilon_0}}$

$$\therefore \left[\frac{1}{\sqrt{\mu_0 \varepsilon_0}}\right] = [c] = [LT^{-1}]$$

[1]

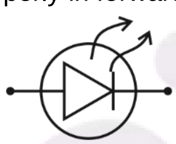
(b) Plane electromagnetic wave travels in direction of $\vec{E} \times \vec{B}$ **[1]**

2. • **Advantages of LED**

(i) LEDs have long life and ruggedness **[½]**

(ii) Low operational voltage and low power consumption **[½]**

• LED operates properly in forward biasing **[½]**

• Symbol of LED is  **[½]**

OR

Given E_g = 2 eV

□ $h\nu \geq E_g$ **[½]**

$\therefore$ $h\nu_{min} = E_g$ **[½]**

$$\nu_{min} = \frac{E_g}{h} = \frac{2 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}}$$ **[½]**

$\nu_{min} = 4.85 \times 10^{14}$ Hz **[½]**

3. From Einstein's photoelectric equation

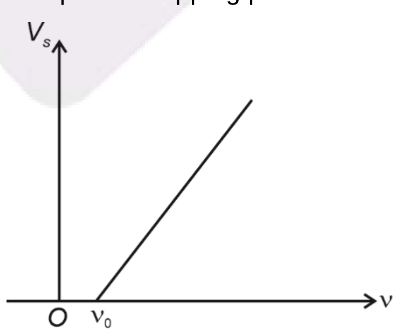
$KE_{max} = h\nu - \phi$ **[½]**

Since, stopping potential is related with KE as

$eV_s = KE_{max} = h\nu - h\nu_0$ **[½]**

$$V_s = \frac{h}{e}(\nu - \nu_0)$$ **[½]**

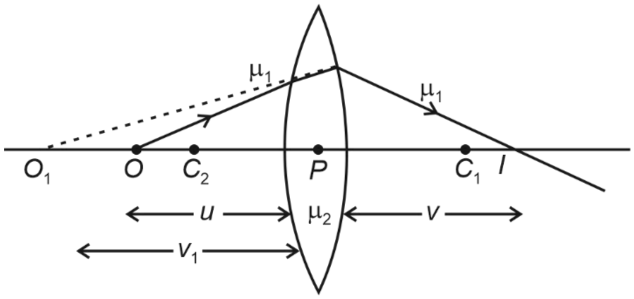
The plot of stopping potential with frequency ν is



[½]

SECTION-B

4. Let us consider the situation shown in the figure



Here C_1 and C_2 are centres of curvature of two spherical surfaces of the thin lens. O is the object and O_1 is the image due to the first refraction. Let radii of curvature be R_1 and R_2 **[1]**

For first refraction

$$\frac{\mu_2}{v_1}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R_1} \quad \ldots(1)$$ **[½]**

O_1 acts as an object for second refraction

$$\frac{\mu_1}{v}-\frac{\mu_2}{v_1}=\frac{\mu_1-\mu_2}{R_2} \quad \ldots(2)$$ **[½]**

Adding equation (1) and (2), we get

$$\mu_1\left(\frac{1}{v}-\frac{1}{u}\right)=(\mu_2-\mu_1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{v}-\frac{1}{u}=\left(\frac{\mu_2}{\mu_1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$ **[½]**

Where $\frac{1}{f}=\left(\frac{\mu_2}{\mu_1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ **[½]**

5. (a) Width of central maxima in single slit diffraction pattern $W=\frac{2\lambda D}{a}$

Where λ is wavelength

D is distance of screen from the slit

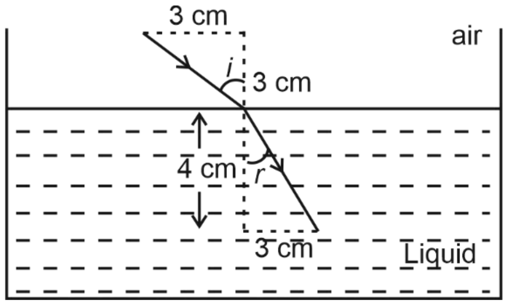
a is width of the slit **[1]**

(b) Width of central maxima in single slit diffraction pattern

$$W=\frac{2\lambda D}{a}$$ **[1]**

$$=\frac{2\times 630\times 10^{-9}\times 2}{2.0\times 10^{-4}}$$

= 1.26 cm **[1]**

6. (a) 

$$\sin i = \frac{3}{3\sqrt{2}} = \frac{1}{\sqrt{2}}$$

$$\sin r = \frac{3}{5}$$

From Snell's law $$\mu = \frac{\sin i}{\sin r} = \frac{\frac{1}{\sqrt{2}}}{\left(\frac{3}{5}\right)}$$ **[½]**

$$\mu = \frac{5}{3\sqrt{2}}$$

$$v = \frac{c}{\mu} = \frac{3\times10^8}{\frac{5}{3\sqrt{2}}} = \frac{9\sqrt{2}}{5}\times10^8 \text{ m/s}$$ **[½]**

$v \approx 2.5 \times 10^8$ m/s **[½]**

(b) (i) $$\sin\theta_C = \frac{1}{\mu} = \frac{1}{\sqrt{2}}$$ **[½]**

$$\theta_C = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45^\circ$$ **[½]**

(ii) For thin prism, minimum deviation $\delta = (\mu - 1)A$ **[½]**

Where $\mu \rightarrow$ refractive index of Prism material

$A \rightarrow$ Prism angle

7. Given $\lambda = 5 \times 10^{-7}$ m

$y_2 = 1 \times 10^{-2}$ m

$D = 2$ m

$d = ?$

From relation $y_n = \frac{n\lambda D}{d}$ **[1]**

$$y_2 = \frac{2\lambda D}{d}$$

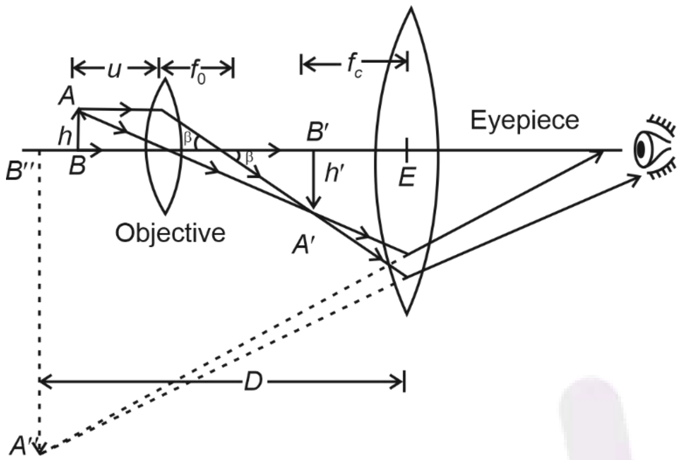
$$d = \frac{2\lambda D}{y_2}$$ **[1]**

$$d = \frac{2 \times 5 \times 10^{-7} \times 2}{1 \times 10^{-2}}$$

$d = 2 \times 10^{-4}$ m

$d = 0.2$ mm **[1]**

8. Compound microscope



[1]

The lens near an object is called an objective, and forms a real inverted and magnified image of the object. This serves as an object for eyepieces. Here the shown ray diagram is for the final image at the near point.

As magnifying power (m) = $m_0 m_e$….(1)

where m_e is angular magnification of eyepiece **[½]**

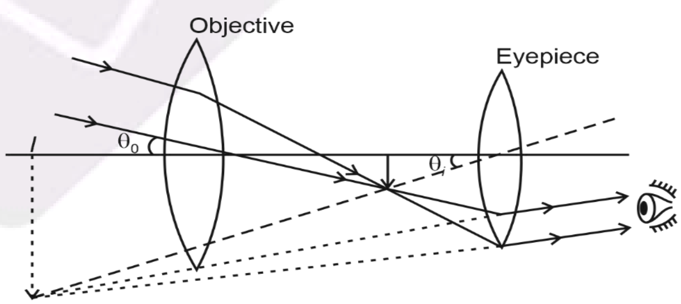
The magnifying power of objective $m_0 = \frac{v_0}{u_0}$ …(2)

For image at far point $m_e = \left(1 + \frac{D}{f_e}\right)$, so

$$m = \frac{v_0}{u_0}\left[\frac{D}{f_e}\right]$$ **[1]**

For an image at a far point, $m_e = \frac{D}{f_e}$, so **[½]**

OR



(a) **[1]**

(b) Given $f_0 = 60$ cm, $f_e = 5$ cm

(i) For image in normal adjustment mode

$$m=\frac{f_0}{f_e}$$ **[½]**

$$m=\frac{60}{5}=12$$ **[½]**

(ii) For image at near point

$$m=\frac{f_0}{f_e}\left[1+\frac{f_e}{D}\right]$$ **[½]**

$$m=\frac{60}{5}\left[1+\frac{5}{25}\right]$$

$$m=12\left[1+\frac{1}{5}\right]$$

= 14.4 **[½]**

9. • **Ionisation energy:** The minimum energy needed to ionize an atom is called "ionisation energy" **[1]**
   • Energy of first orbit of hydrogen atom E_1 = –13.6 eV **[½]**
   Potential energy of electrons in 1st orbit is $PE_1 = 2E_1$
   PE_1 = –27.2 eV **[½]**
   Ionisation energy of an electron in ground state (1st orbit) is $E = -E_1$ **[½]**
   = –(–13.6)eV = 13.6 eV **[½]**

10. The fusion reaction is written as ${}_{2}^{4}\text{He}+{}_{2}^{4}\text{He}+{}_{2}^{4}\text{He}\rightarrow{}_{6}^{12}\text{C}+Q$ **[½]**

Given $m\left({}_{2}^{4}\text{He}\right)=4.002603\,\text{u}$

Now Q-value of reaction will be

$$Q=\left\{3\left[m\left({}_{2}^{4}\text{He}\right)\right]-m\left({}_{6}^{12}\text{C}\right)\right\}c^2$$ **[1]**

= [3(4.002603 u) – 12 u]c^2

= [12.007809 u – 12 u]c^2 **[½]**

= [0.007809 × 931.5] MeV **[½]**

= 7.274 MeV **[½]**

11. Bohr's three postulates are as follows
   (1) In a hydrogen atom, an electron revolves in certain stable orbits, called stationary orbits without the emission of radiant energy. **[1]**
   (2) The stationary orbit are those for which the angular momentum is some integral of $\frac{h}{2\pi}$, *i.e.* $L=\frac{nh}{2\pi}$, where n is an integer called a quantum number **[1]**
   (3) The third postulate states that an electron might make a transition from one of its specified non-radiating orbits to another of lower energy. When this transition takes place, a photon is emitted having energy equal to the energy difference between the initial and final states. The frequency (ν) of the emitted photon is then given by

$$h\nu = E_i - E_f$$ **[1]**

OR

Since transition A has minimum energy difference therefore photons emitted have longest wavelength **[1]**

For transition A, $\Delta E_A = [-0.85 - (-1.51)\text{eV}]$

$\Delta E_A = 0.66$ eV **[½]**

$$\frac{hc}{\lambda_A} = \Delta E_A$$

$$\lambda_A = \frac{12400}{0.66}\ \text{Å} \approx 18788\ \text{Å}$$ **[½]**

For transition C, $\Delta E_C = [-1.51\ \text{eV} - (-13.6\ \text{eV})]$

$\Delta E_C = 12.09$ eV **[½]**

$$\frac{hc}{\lambda_C} = \Delta E_C$$

$$\lambda_C = \frac{12400}{12.09}\ \text{Å} = 1025.6\ \text{Å}$$ **[½]**

SECTION-C

12. (a) Answer (i) Conductors have positive temperature coefficient of resistance while semiconductor and insulator have negative temperature coefficient of resistance **[1]**

(b) Answer (i)
For semiconductor $E_g < 3$ eV while
For insulator $E_g > 3$ eV
Hence material having band gap 1.4 eV is semiconductor **[1]**

(c) Answer (ii)
When silicon is doped with phosphorus, then semiconductor becomes of n-type because phosphorus is pentavalent **[1]**

(d) Answer (ii)
When silicon is doped with trivalent atoms then the number of holes increases and the semiconductor becomes of p-type. *i.e.* $n_e << n_h$ **[1]**

(e) Answer (iii)
Since all types of semiconductors are electrically neutral i.e. total negative charge is equal to total positive charge i.e. $N_a + n_e = N_d + n_h$ **[1]**

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