Sample Question Paper - 20
Physics (042)
Class- XII, Session: 2021-22
TERM II

Time : 2 Hours | *Max. Marks : 35*

General Instructions :

(i) There are 12 questions in all. All questions are compulsory.

(ii) This question paper has three sections: Section A, Section B and Section C.

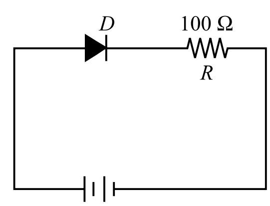
(iii) Section A contains three questions of two marks each, Section B contains eight questions of three marks each, Section C contains one case study-based question of five marks.

(iv) There is no overall choice. However, an internal choice has been provided in one question of two marks and two questions of three marks. You have to attempt only one of the choices in such questions.

(v) You may use log tables if necessary but use of calculator is not allowed.

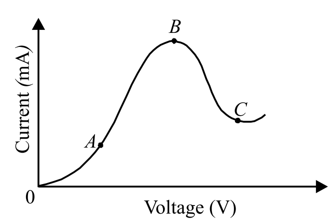
SECTION - A

1. In the given figure, a diode D is connected to an external resistance $R = 100\ \Omega$ and an emf of 3.5 V. If the barrier potential developed across the diode is 0.5 V, what is the current in the circuit?



2. (a) Why cannot we use Si and Ge in fabrication of visible LEDs?

(b) The graph shown in the figure represents a plot of current versus voltage for a given semiconductor. Identify the region, if any, over which the semiconductor has a negative resistance.



3. Two monochromatic radiations of frequencies υ_1 and $\upsilon_2 (\upsilon_1 > \upsilon_2)$ and having the same intensity are in turn, incident on a photosensitive surface to cause photoelectric emission. Explain, giving reason, in which case (i) more number of electrons will be emitted and (ii) maximum kinetic energy of the emitted photoelectrons will be more.

OR

Write three basic properties of photons which are used to obtain Einstein's photoelectric equation. Use this equation to draw a plot of maximum kinetic energy of the electrons emitted versus the frequency of incident radiation.

SECTION - B

4. A hydrogen atom initially in the ground state absorbs a photon which excites it to the $n = 4$ level. Estimate the frequency of the photon.

5. (a) A plane electromagnetic wave travels in vacuum along z-direction. What can you say about the direction of electric and magnetic field vectors?

(b) Gamma rays and radio waves travel with the same velocity in free space. Distinguish between them in terms of their origin and the main application.

6. Distinguish between the phenomena of nuclear fission and fusion.

7. In a single slit diffraction experiment, light of wavelength λ illuminates the slit of width 'a' and the diffraction pattern is observed on a screen.

(a) Show the intensity distribution in the pattern with the angular position θ.

(b) How are the intensity and angular width of central maxima affected when

(i) width of slit is increased, and

(ii) separation between slit and screen is decreased?

OR

(a) The ratio of the widths of two slits in Young's double slit experiment is 4 : 1. Evaluate the ratio of intensities at maxima and minima in the interference pattern.

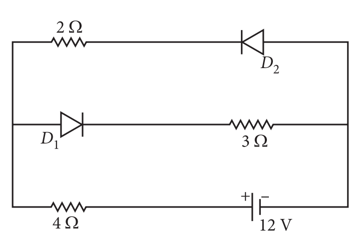
(b) Does the appearance of bright and dark fringes in the interference pattern violate, in any way, conservation of energy? Explain.

8. A convex lens made up of glass of refractive index 1.5 is dipped, in turn, in (i) a medium of refractive index 1.65, (ii) a medium of refractive index 1.33.

(a) Will it behave as a converging or a diverging lens in the two cases?

(b) How will its focal length change in the two media?

9. The circuit has two oppositely connected ideal diodes in parallel. What is the current flowing in the circuit?



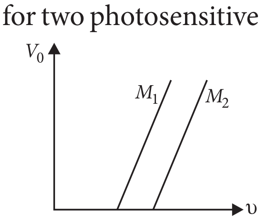
10. (a) Plot a graph for angle of deviation as a function of angle of incidence for a triangular prism.

(b) Derive the relation for the refractive index of the prism in terms of the angle of minimum deviation and angle of prism.

OR

Explain briefly how the phenomenon of total internal reflection is used in fibre optics.

11. Figure shows a plot of stopping potential (V_0) with frequency (υ) of incident radiation for two photosensitive material M_1 and M_2. Explain



(i) why the slope of both the lines is same

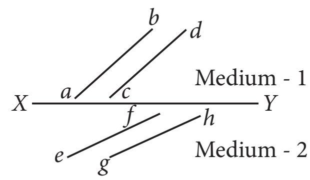
(ii) for which material emitted electrons have greater kinetic energy for the same frequency of incident radiation.

SECTION - C

12. CASE STUDY : WAVEFRONT

Wavefront is a locus of points which vibrate in same phase. A ray of light is perpendicular to the wavefront. According to Huygens principle, each point of the wavefront is the source of a secondary disturbance and the wavelets connecting from these points spread out in all directions with the speed of wave.

The figure shows a surface XY separating two transparent media, medium-1 and medium-2. The lines ab and cd represent wavefronts of a light wave travelling in medium- 1 and incident on XY. The lines ef and gh represent wavefronts of the light wave in medium-2 after refraction.



(i) Light travels as a

(a) parallel beam in each medium

(b) convergent beam in each medium

(c) divergent beam in each medium

(d) divergent beam in one medium and convergent beam in the other medium.

(ii) The phases of the light wave at c, d, e and f are ϕ_c, ϕ_d, ϕ_e and ϕ_f respectively. It is given that $\phi_c \neq \phi_f$

(a) ϕ_c cannot be equal to ϕ_d

(b) ϕ_d can be equal to ϕ_e

(c) $(\phi_d - \phi_f)$is equal to $(\phi_c - \phi_e)$

(d) $(\phi_d - \phi_c)$ is not equal to $(\phi_f - \phi_e)$.

(iii) Wavefront is the locus of all points, where the particles of the medium vibrate with the same

(a) phase (b) amplitude (c) frequency (d) period

(iv) A point source that emits waves uniformly in all directions, produces wavefronts that are

(a) spherical (b) elliptical (c) cylindrical (d) planar

(v) What are the types of wavefronts ?

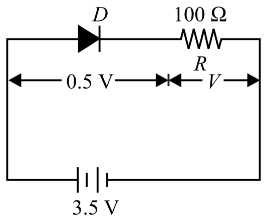
(a) Spherical (b) Cylindrical (c) Plane (d) All of these

Solution

PHYSICS - 042

Class 12 - Physics

1.



The potential difference across the resistance R is

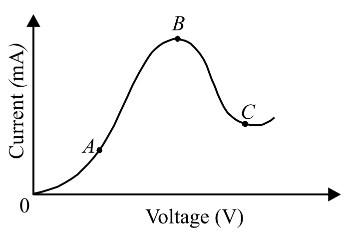
$V = 3.5\text{ V} - 0.5\text{ V} = 3\text{ V}$

By Ohm's law, the current in the circuit is

$$I = \frac{V}{R} = \frac{3\text{ V}}{100\ \Omega} = 3\times10^{-2}\text{ A} = 30\times10^{-3}\text{ A} = 30\text{ mA}$$

2. (a) LED's must have band gap in the order of 1.8 eV to 3 eV but Si and Ge have band gap less than 1.8 eV.

(b) Region BC of the graph has a negative slope, hence in region BC semiconductor has a negative resistance.



3. (i) Intensity = Number of photons per unit area per unit time

For unit area and unit time, $I_1 = I_2 \Rightarrow n_1\upsilon_1 = n_2\upsilon_2$

$$\frac{n_2}{n_1} = \frac{\upsilon_1}{\upsilon_2} > 1 \Rightarrow n_2 > n_1$$

For same intensity number of photons per unit area per unit time is large for υ_2 *i.e.* n_2. Hence, more electrons will be emitted corresponding to υ_2.

(ii) The maximum kinetic energy of emitted electrons is more for the light of greater frequency. Since $\upsilon_1 > \upsilon_2$, maximum kinetic energy of emitted photoelectrons will be correspond to υ_1.

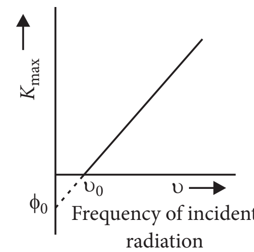
OR

Photons : According to Planck's quantum theory of radiation, an electromagnetic wave travels in the form of discrete packets of energy called quanta.

The main features of photons are as follows:

(i) In the interaction of photons with free electrons, the entire energy of photon is absorbed.

(ii) Energy of photon is directly proportional to frequency. Intensity of incident radiation depends on the number of photons falling per unit area per unit time for a given frequency.



(iii) In photon electron collision, the total energy and momentum remain constant.

Einstein's photoelectric equation is

$K_{max} = h\upsilon - \phi_0$

4. Energy of hydrogen atom in n^{th} state

$$E_n = -\frac{13.6\text{ eV}}{n^2}$$

According to question, $h\upsilon = E_4 - E_1$

$$h\upsilon = -13.6\left(\frac{1}{16} - 1\right)\text{eV} = 13.6\times\frac{15}{16}\text{eV}$$

$$\upsilon = 13.6\times\frac{15}{16}\times\frac{1.6\times10^{-19}}{6.63\times10^{-34}} = 3\times10^{15}\text{ Hz}$$

5. (a) The electric and magnetic field vectors $\vec{E}$ and $\vec{B}$ are perpendicular to each other and also perpendicular to the direction of propagation of the electromagnetic wave. If a plane electromagnetic wave is propagating along the z-direction, then the electric field is along x-axis, and magnetic field is along y-axis.

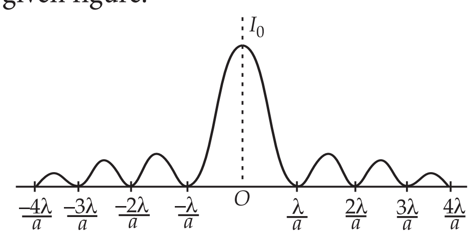
(b) Gamma rays : These rays are of nuclear origin and are produced in the disintegration of radioactive atomic nuclei and in the decay of certain subatomic particles. They are used in the treatment of cancer and tumours.

Radio waves : These waves are produced by the accelerated motion of charges in conducting wires or oscillating electric circuits having inductor and capacitor. These are used in satellite, radio and television communication

6.

	Nuclear Fission		Nuclear Fusion
1.	The process of splitting of a heavy nucleus into two nuclei of nearly comparable masses with liberation of energy is called nuclear fission. Example: $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n + Q$	1.	When two or more than two light nuclei fuse together to form heavy nucleus with the liberation of energy, the process is called nuclear fusion. Example: $^{2}_{1}H + ^{2}_{1}H \rightarrow ^{4}_{2}He + 24\text{ MeV}$
2.	A suitable bullet or projectile like neutron is needed.	2.	The lighter nuclei have to be brought very close to each other against electrostatic repulsion.
3.	The products of nuclear fission reaction are radioactive.	3.	The products of nuclear fusion are not radioactive.

7. (a) The intensity pattern on the screen is shown in the given figure.



Width of central maximum $= \frac{2D\lambda}{a}$

(b) The angular width of central maximum is given by

$2\theta_0 = \frac{2\lambda}{a}$, ...(i)

where a is the slit width and λ is the wavelength of light.

(i) From equation (i), it follows that $2\theta_0 \propto \frac{1}{a}$.

Therefore, as the slit width is increased, the width of the central maximum will decrease and the intensity of central maxima will increase.

(ii) From equation (i), it follows that $2\theta_0$ is independent of D. So the angular width and intensity will remain same when the separation between slit and screen is decreased.

OR

(a) The intensity of light due to slit is directly proportional to width of slit.

$\therefore \quad \frac{I_1}{I_2} = \frac{w_1}{w_2} = \frac{4}{1}$

$\Rightarrow \quad \frac{a_1^2}{a_2^2} = \frac{4}{1}$ or $\frac{a_1}{a_2} = \frac{2}{1}$ or $a_1 = 2a_2$

$$\frac{I_{\max}}{I_{\min}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2} = \frac{(2a_2+a_2)^2}{(2a_2-a_2)^2} = \frac{9a_2^2}{a_2^2} = 9:1$$

(b) No, the appearance of bright and dark fringes in the interference pattern does not violate the law of conservation of energy.

When interference takes place, the light energy which disappears at the regions of destructive interference appears at regions of constructive interference so that the average intensity of light remains the same. Hence, the law of conservation of energy is obeyed in the phenomenon of interference of light.

8. Here, $^a\mu_g = 1.5$

Let f_{air} be the focal length of the lens in air.

Then, $\frac{1}{f_{air}} = (^a\mu_g - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

or $\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = \frac{1}{f_{air}(^a\mu_g - 1)} = \frac{1}{f_{air}(1.5-1)}$

or $\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = \frac{2}{f_{air}}$ ... (i)

(i) When lens is dipped in medium A :

Here, $^a\mu_A = 1.65$

Let f_A be the focal length of the lens, when dipped in medium A. Then,

$$\frac{1}{f_A} = (^A\mu_g - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = \left(\frac{^a\mu_g}{^a\mu_A} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Using the equation (i), we have

$$\frac{1}{f_A} = \left(\frac{1.5}{1.65} - 1\right) \times \frac{2}{f_{air}} = -\frac{1}{5.5 f_{air}}$$

or $f_A = -5.5 f_{air}$

As the sign of f_A is opposite to that of f_{air}; the lens will behave as a diverging lens.

(ii) When lens is dipped in medium B :

Here, $^a\mu_B = 1.33$

Let f_B be the focal length of the lens, when dipped in medium B. Then,

$$\frac{1}{f_B} = (^B\mu_g - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = \left(\frac{^a\mu_g}{^a\mu_B} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

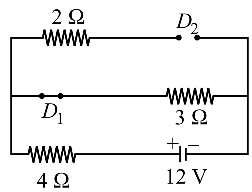
Using the equation (i), we have

$$\frac{1}{f_B} = \left(\frac{1.5}{1.33} - 1\right) \times \frac{2}{f_{air}} = \frac{0.34}{1.33 f_{air}}$$

or $f_B = 3.91 f_{air}$

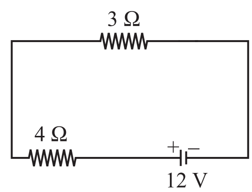
As the sign of f_B is same as that of f_{air}, the lens will behave as a converging lens.

9. In the given circuit diode, D_1 is forward biased and D_2 is reverse biased.



The resistance of D_1 is zero and that of D_2 is infinite as the diodes D_1 and D_2 are ideal. No current flows through D_2.

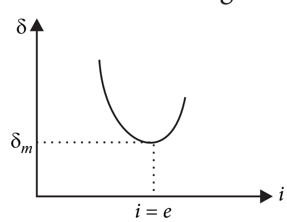
Thus D_1 can be replaced by a resistanceless wire and D_2 can be replaced by a broken wire. The equivalent circuit is shown in the figure.



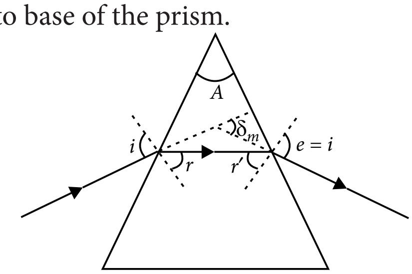
The current in the circuit is

$$I = \frac{12\text{ V}}{4\,\Omega + 3\,\Omega} = \frac{12\text{ V}}{7\,\Omega} = 1.71\text{ A}$$

10. (a) If graph is plotted between angle of incidence i and angle of deviation δ, it is found that the angle of deviation δ first decreases with increase in angle of incidence i and then becomes minimum 'δ_m' when $i = e$ and then increases with increase in angle of incidence i. Figure shows the path of a ray of light suffering refraction through a prism of refracting angle 'A'.



(b) At minimum deviation, the inside beam travels parallel to base of the prism.



$i = e$

$r = r'$

$\delta_m = (i + e) - (r + r')$

$\delta_m = 2i - 2r$ ...(i)

Also $r + r' = A = 2r$ ...(ii)

Using equation (i), angle of incidence

$i = \dfrac{A + \delta_m}{2}$, angle of refraction $r = \dfrac{A}{2}$

Now refractive index of the material of prism

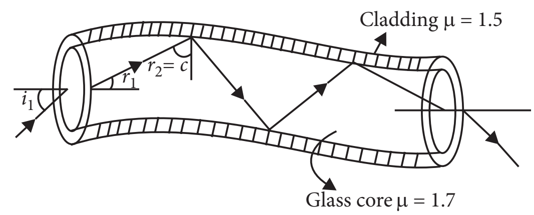
$$^{a}\mu_g = \frac{\sin i}{\sin r} = \frac{\sin\left(\dfrac{A + \delta_m}{2}\right)}{\sin \dfrac{A}{2}}$$

where A is the "refracting angle" of the prism and $A = 60°$ for an equiangular prism.

OR

Optical fibre is made up of very fine quality glass or quartz of refractive index about 1.7. A light beam incident on one end of an optical fibre at appropriate angle refracts into the fibre and undergoes repeated total internal reflection.

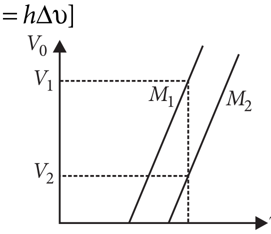
This is because the angle of incidence is greater than critical angle. The beam of light is received at other end of fibre with nearly no loss in intensity. To send a complete image, the image of different portion is send through separate fibres and thus a complete image can be transmitted through an optical fibre.



11. (i) Slope of line $= \dfrac{\Delta V}{\Delta \upsilon}$

Slope of line $= \dfrac{h}{e}$ $[\because e\Delta V = h\Delta\upsilon]$

$\Rightarrow$ It is a constant quantity and does not depend on nature of metal surface.



(ii) Maximum kinetic energy of emitted photoelectron,

$KE = eV_0 = h\upsilon - h\upsilon_0$, ...(i)

For a given frequency $V_1 > V_2$ (from the graph)

So from equation (i),

$(KE)_1 > (KE)_2$

Since the metal M_1 has smaller threshold frequency *i.e.*, smaller work function. It emits electrons having a larger kinetic energy.

12. (i) **(a) :** Since the path difference between two waveform is equal, light traves as parallel beam in each medium.

(ii) **(c) :** Since all points on the wavefront are in the same phase,

$\phi_d = \phi_c$ and $\phi_f = \phi_e$

$\therefore\ \phi_d - \phi_f = \phi_c - \phi_e$.

(iii) **(a) :** Wavefront is the locus of all points, where the particles of the medium vibrate with the same phase.

(iv) **(a)**

(v) **(d)**