Sample Question Paper - 27
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. Draw a plot showing the variation of resistivity of a (i) conductor and (ii) semiconductor, with the increase in temperature.

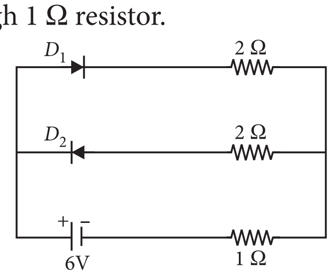
2. (a) Define the terms, (i) threshold frequency and (ii) stopping potential in photoelectric effect.

(b) Plot a graph of photocurrent versus anode potential for a radiation of frequency υ and intensities I_1 and I_2 ($I_1 < I_2$).

OR

Calculate the energy of a photon of wavelength 390 nm.

3. Assuming that the two diodes D_1 and D_2 used in the electric circuit shown in the figure are ideal, find out the value of the current flowing through 1 Ω resistor.



SECTION - B

4. State clearly how a microwave oven works to heat up a food item containing water molecules.
Why are microwaves found useful for the radar systems in aircraft navigation?

5. Draw a plot of potential energy of a pair of nucleons as a function of their separation. Write two important conclusions which you can draw regarding the nature of nuclear forces.

6. Derive the expression for the intensity at a point of the interference pattern in Young's double slit experiment.

7. (a) In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band? Explain.

(b) When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot in seen at the centre of the obstacle. Explain why.

8. (i) Define magnifying power of a telescope. Write its expression and what are its limitations.

(ii) A small telescope has an objective lens of focal length 150 cm and an eye piece of focal length 5 cm. If this telescope is used to view a 100 m high tower 3 km away, find the height of the final image when it is formed 25 cm away from the eye piece.

OR

(a) Draw a ray diagram for the formation of image by a compound microscope.

(b) You are given the following three lenses. Which two lenses will you use as an eyepiece and as an objective to construct a compound microscope?

Lenses	Power(D)	Aperture (cm)
L_1	3	8
L_2	6	1
L_3	10	1

9. Draw the circuit diagram of a half wave rectifier and explain its working.

10. Two particles A and B of same mass have their de Broglie wavelengths in the ratio $\lambda_A : \lambda_B = k : 1$. Their potential energies $U_A : U_B = 1 : k^2$. Find the ratio of total energies A and B.

11. Define ionization energy. How would the ionization energy change when electron in hydrogen atom is replaced by a particle of mass 200 times that of the electron but having the same charge?

OR

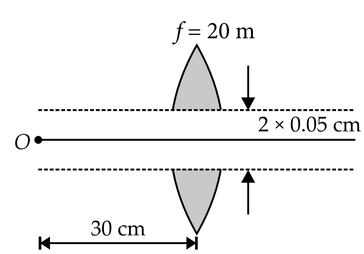
The ground state energy of hydrogen atom is –13.6 eV. If an electron makes a transition from an energy level – 0.85 eV to –3.4 eV, calculate the wavelength of the spectral line emitted. To which series of hydrogen spectrum does this wavelength belong?

SECTION - C

12. CASE STUDY : REFRACTION THROUGH LENS

A convex or converging lens is thicker at the centre than at the edges. It converges a parallel beam of light on refraction through it. It has a real focus. Convex lens is of three types : (i) Double convex lens (ii) Plano-convex lens (iii) Concavo-convex lens. Concave lens is thinner at the centre than at the edges. It diverges a parallel beam of light on refraction through it. It has a virtual focus.

(i) A point object O is placed at a distance of 0.3 m from a convex lens (focal length 0.2 m) cut into two halves each of which is displaced by 0.0005 m as shown in figure.



What will be the location of the image?

(a) 30 cm right of lens
(b) 60 cm right of lens
(c) 70 cm left of lens
(d) 40 cm left of lens

(ii) Two thin lenses are in contact and the focal length of the combination is 80 cm. If the focal length of one lens is 20 cm, the focal length of the other would be

(a) –26.7 cm (b) 60 cm (c) 80 cm (d) 20 cm

(iii) A spherical air bubble is embedded in a piece of glass. For a ray of light passing through the bubble, it behaves like a

(a) converging lens (b) diverging lens

(c) plano-converging lens (d) plano-diverging lens

(iv) Lens used in magnifying glass is

(a) concave lens (b) convex lens (c) both (a) and (b) (d) none of the above

(v) The magnification of an image by a convex lens is positive only when the object is placed

(a) at its focus *F* (b) between *F* and 2*F*

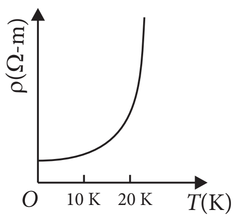
(c) at 2*F* (d) between *F* and optical centre

Solution

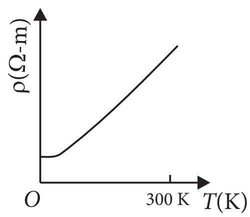
PHYSICS - 042

Class 12 - Physics

1. (i) The resistivity of a conductor increases non-linearly with increase in temperature.

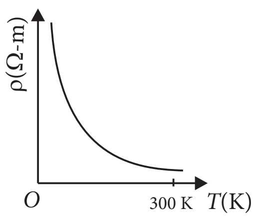


(For low temperature)



(For high temperature)

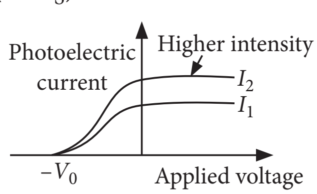
(ii) The resistivity of a semiconductor decreases with increase in temperature.



2. (a) (i) Threshold Frequency : The minimum frequency of incident light which is just capable of ejecting electrons from a metal is called the threshold frequency. It is denoted by υ_0.

(ii) Stopping Potential : The minimum retarding potential applied to anode of a photoelectric tube which is just capable of stopping photoelectric current is called the stopping potential. It is denoted by V_0 (or V_S).

(b)



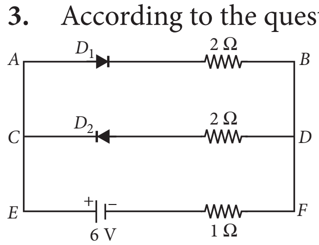
OR

Here, λ = 390 nm

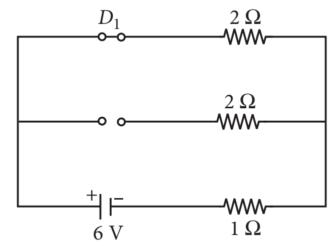
Energy of a photon, $E = \dfrac{hc}{\lambda}$

$$\therefore \quad E = \frac{1240 \text{ eV nm}}{390 \text{ nm}} = 3.2 \text{ eV}$$

3. According to the question



D_2 will be reversed biased and D_1 will be forward biased so equivalent circuit will be



So current in 1 Ω resistor

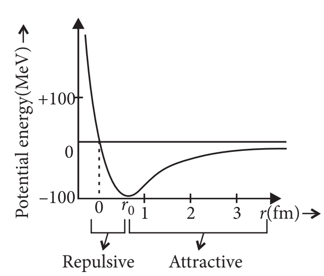
$$I = \frac{6}{1+2} = \frac{6V}{3\,\Omega}$$

I = 2A

4. In microwave oven, the frequency of the microwaves is selected to match the resonant frequency of water molecules so that energy from the waves get transferred efficiently to the kinetic energy of the molecules. This kinetic energy raises the temperature of any food containing water.

Microwaves are short wavelength radio waves, with frequency of order of GHz. Due to short wavelength, they have high penetrating power with respect to atmosphere and less diffraction in the atmospheric layers. So these waves are suitable for the radar systems used in aircraft navigation.

5. Plot of potential energy of a pair of nucleons as a function of their separation is given in the figure.



Conclusions: (i) The nuclear force is much stronger than the coulomb force acting between charges or the gravitational forces between masses.

(ii) The nuclear force between two nucleons falls rapidly to zero as their distance is more than a few fermies.

(iii) For a separation greater than r_0, the force is attractive and for separation less than r_0, the force is strongly repulsive.

6. Let the waves from two coherent sources of light be represented as

$y_1 = a\sin\omega t$

$y_2 = b\sin(\omega t + \phi)$

where a and b are the respective amplitudes of the two waves and ϕ is the constant phase angle by which second wave leads the first wave.

According to superposition principle, the displacement (y) of the resultant wave at time (t) would be given by

$y = y_1 + y_2 = a\sin\omega t + b\sin(\omega t + \phi)$

$= a\sin\omega t + b\sin\omega t\cos\phi + b\cos\omega t\sin\phi$

$y = \sin\omega t\,(a + b\cos\phi) + \cos\omega t . b\sin\phi$

Put $a + b\cos\phi = R\cos\theta$ ...(i)

$b\sin\phi = R\sin\theta$ ...(ii)

$y = \sin\omega t . R\cos\theta + \cos\omega t . R\sin\theta$

$= R[\sin\omega t\cos\theta + \cos\omega t\sin\theta]$

$y = R\sin(\omega t + \theta)$

Thus the resultant wave is a harmonic wave of amplitude R.

Squaring equation (i) and (ii) and adding, we get

$R^2(\cos^2\theta + \sin^2\theta) = (a + b\cos\phi)^2 + (b\sin\phi)^2$

$R^2 \times 1 = a^2 + b^2\cos^2\phi + 2ab\cos\phi + b^2\sin^2\phi$

$= a^2 + b^2(\cos^2\phi + \sin^2\phi) + 2ab\cos\phi$

$R = \sqrt{a^2 + b^2 + 2ab\cos\phi}$

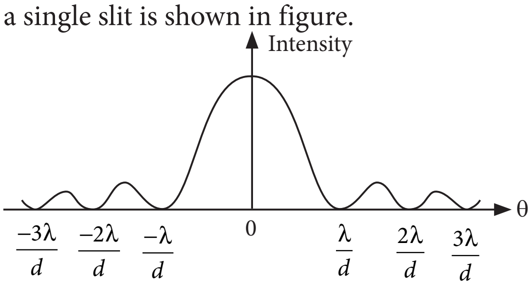
As intensity is directly proportional to the square of the amplitude of the wave

$\therefore \quad I_1 = Ka^2, I_2 = Kb^2,$

and $I_R = KR^2 = K(a^2 + b^2 + 2ab\cos\phi)$

$\therefore \quad I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

7. (a) Intensity distribution of light in diffraction at a single slit is shown in figure.



Width of central maximum is given by

$$\beta_0 = \frac{2D\lambda}{d}$$

When width (d) of the slit is increased, the width of central maximum decreases and the intensity increases.

(b) The bright spot is produced due to constructive interference of waves diffracted from the edge of the circular obstacle.

8. (i) Magnifying power of refracting telescope (M) is defined as the ratio of the angle subtended by the image (β) at the eye to the angle subtended by the distant object at the unaided eye (α).

$$M = \frac{\beta}{\alpha}$$

We can increase the magnifying power of telescope by

1. Increasing the focal length of the objective.
2. Decreasing the focal length of eyepiece.

Two limitations of refractive telescope are:

1. The lenses used in refractive telescope are expensive.
2. The lenses used for making refracting telescope have chromatic aberration and distortions.

They can be minimised by using reflecting type telescope, which use concave mirror rather than a lens for the objective.

(ii) Here, $f_o = 150$ cm, $f_e = 5$ cm

Angle subtended by 100 m tall tower at 3 km is

$$\alpha = \frac{100}{3 \times 1000} = \frac{1}{30} \text{ rad}$$

If h is the height of image formed by the objective, then

$$\alpha = \frac{h}{f_o} = \frac{h}{150}$$

$$\therefore \quad \frac{h}{150} = \frac{1}{30} \quad \text{or} \quad h = \frac{150}{30} \text{ cm} = 5 \text{ cm}$$

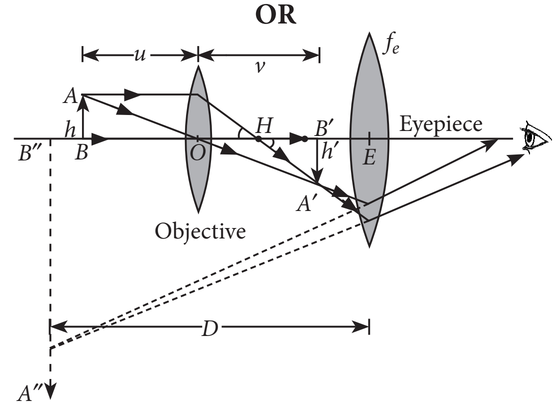
Magnification produced by eyepiece

$$m_e = \left(1 + \frac{D}{f_e}\right) = \left(1 + \frac{25}{5}\right) = 6$$

$\therefore$ Height of final image $= h \times m_e = 5 \times 6 = 30$ cm

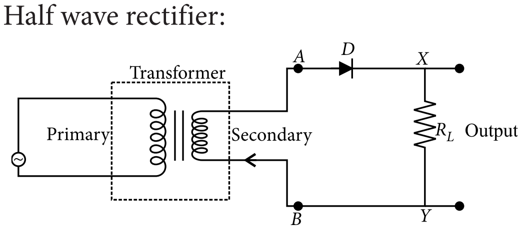
OR

(a)

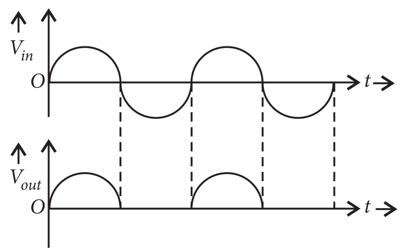


(b) For constructing compound microscope, L_3 should be used as objective and L_2 as eyepiece because both the lenses of microscope have short focal lengths and the focal length of objective lens should be smaller than the eyepiece lens.

9. Half wave rectifier:



It consists of a diode D connected in series with load resistor R_L across the secondary windings of a step-down transformer. Primary of transformer is connected to a.c. supply. During positive half cycle of input a.c., end A of the secondary winding becomes positive and end B negative. Thus, diode D becomes forward biased and conducts the current through it. So, current in the circuit flows from A to B through load resistor R_L.



During negative half cycle of input a.c., end A of the secondary winding becomes negative and end B positive. Thus, diode D becomes reverse biased and does not conduct any current. So, no current flows in the circuit. Since electric current through load R_L flows only during positive half cycle, in one direction only *i.e.*, from A to B, so d.c. is obtained across R_L.

10. Let the mass of each particle be m.

If K_A and K_B are their kinetic energies, then

$$\lambda_A = \frac{h}{\sqrt{2mK_A}} \text{ and } \lambda_B = \frac{h}{\sqrt{2mK_B}}$$

$$\therefore \quad \frac{\lambda_A}{\lambda_B} = \frac{h/\sqrt{2mK_A}}{h/\sqrt{2mK_B}} = \sqrt{\frac{K_B}{K_A}}$$

$$\text{or} \quad \frac{K_B}{K_A} = \left(\frac{\lambda_A}{\lambda_B}\right)^2 = \left(\frac{k}{1}\right)^2 \quad \text{or} \quad \frac{K_A}{K_B} = \frac{1}{k^2}$$

As per question $\dfrac{U_A}{U_B} = \dfrac{1}{k^2}$

$$\therefore \quad \frac{K_A}{K_B} = \frac{U_A}{U_B} \quad \text{or} \quad \frac{K_A}{U_A} = \frac{K_B}{U_B}$$

Adding 1 on both sides, we get

$$\frac{K_A}{U_A} + 1 = \frac{K_B}{U_B} + 1 \quad \text{or} \quad \frac{K_A + U_A}{U_A} = \frac{K_B + U_B}{U_B}$$

$$\text{or} \quad \frac{E_A}{U_A} = \frac{E_B}{U_B} \quad \text{or} \quad \frac{E_A}{E_B} = \frac{U_A}{U_B} = \frac{1}{k^2}$$

or $E_A : E_B = 1 : k^2$

11. The minimum energy, required to free the electron from the ground state of the hydrogen atom, is known as ionization energy of that atom.

$E_0 = \dfrac{me^4}{8\varepsilon_0^2 h^2}$ *i.e,.* $E_0 \propto m$, so when electron in hydrogen atom is replaced by a particle of mass 200 times that of the electron, ionization energy increases by 200 times.

OR

$$h\upsilon = \frac{hc}{\lambda} = (E_2 - E_1) \text{ or } \lambda = \frac{hc}{(E_2 - E_1)}$$

$$\therefore \quad \lambda = \left[\frac{6.63 \times 10^{-34} \times 3 \times 10^8}{[-0.85 - (-3.4)] \times 1.6 \times 10^{-19}}\right] \text{m}$$

$= 4.875 \times 10^{-7}$ m = 4875 Å

This wavelength belongs to Balmer series.

12. (i) **(b) :** Each half lens will form an image in the same plane. The optic axes of the lenses are displaced,

$\dfrac{1}{v} - \dfrac{1}{(-30)} = \dfrac{1}{20}$; $v = 60$ cm

(ii) **(a)** : Here $f_1 = 20$ cm ; $f_2 = ?$

$F = 80$ cm

As $\dfrac{1}{f_1} + \dfrac{1}{f_2} = \dfrac{1}{F} \Rightarrow \dfrac{1}{f_2} = \dfrac{1}{F} - \dfrac{1}{f_1}$

$$\frac{1}{f_2} = \frac{1}{80} - \frac{1}{20} = \frac{-3}{80}$$

$$f_2 = \frac{-80}{3} = -26.7 \text{ cm}$$

(iii) **(b) :** The bubble behaves like a diverging lens.

(iv) **(b) :** Convex lens is used in magnifying glass.

(v) **(d)**