ISC Solved Paper 2022 Semester -2

Physics

Class-XII

(Maximum Marks : 40)

(Time allowed : One and half hours)

*Candidates are allowed an additional **10 minutes** for **only** reading the paper.*
*They must **NOT** start writing during this time.*

All questions are compulsory.
*This question paper is divided in, **Section A, B** and **C.***
The intended marks for questions are given in brackets [].
All working, including rough work, should be done on the same sheet as and adjacent to the rest of the answer.
Answers to sub parts of the same question must be given in one place only.
A list of useful physical constants is given at the end of this paper.
A simple scientific calculator without a programmable memory may be used for calculations.

SECTION-A [7 Marks]

1. (i) Define coherent sources of light. **[1]**

(ii) State de Broglie hypothesis. **[1]**

(iii) What is an n-type semiconductor? **[1]**

(iv) Dispersive power of a prism depends upon: **[1]**

(a) Shape of the prism
(b) Height of the prism
(c) Material of the prism
(d) Angle of the prism

(v) If in Young's double slit interference experiment, the distance between the two slits is made three times, keeping all other conditions same, then the fringe width becomes

(a) one third **(b)** one ninth
(c) nine times **(d)** three times **[1]**

(vi) Angular momentum of an electron orbiting in the 3rd Bohr orbit of a hydrogen atom is:

(a) $h/2\pi$ **(b)** $2h/2\pi$
(c) $3h/2\pi$ **(d)** $4h/\pi$ **[1]**

(vii) In photoelectric effect, the graph of Stopping potential 'V_s' versus frequency 'f' of the incident radiation is a straight line. Then Slope 'm' of this line, Planck's constant 'h' and elementary charge 'e' are related as follows:

(a) $h = e\,m$ **(b)** $m = e\,h$
(c) $e = m\,h$ **(d)** $e = m\pi h$ **[1]**

Ans. (i) Coherent sources of light: Two sources are said to be coherent if they produce two waves having same frequency, identical waveform and have constant phase difference between them.

(ii) de Broglie hypothesis: All matter has both particle and wave nature. The wavelength associated with the wave nature of a particle is $\lambda = h/p$, where p = momentum of the particle, h =Planck's constant, and λ = wavelength.

(iii) *n*-type semiconductor: An n-type semiconductor is an intrinsic semiconductor doped with phosphorus (P), arsenic (As), or antimony (Sb) or similar group-V element as an impurity. Electrons are the majority carrier in n-type semiconductor.

(iv) Option (c) is correct.
Explanation: Dispersive power = $(\mu_V - \mu_R)/(\mu_Y - 1)$
So, it is totally material dependent.

(v) Option (a) is correct.
Explanation: Fringe width = $\beta = \lambda D/d$
The distance between the slits now becomes $3d$.
So, new fringe width = $\beta' = \lambda D/3d = \beta/3$

(vi) Option (c) is correct.
Explanation: The angular momentum of an electron in n^{th} Bohr orbit = $nh/2\pi$
Given $n = 3$
So, the angular momentum of an electron in 3rd Bohr orbit = $3h/2\pi$

(vii) Option (a) is correct.
Explanation: Slope of the graph = $m = h/e$
So, $h = me$

SECTION-B [10 Marks]

2. (i) What is meant by "diffraction of light"? [2]

(ii) State any one difference between diffraction of light and interference of light.

Ans. (i) Diffraction of light: Diffraction is the slight bending of light as it passes around the edge of an object and illuminating the areas where a shadow is expected. The amount of bending depends on the relative size of the wavelength of light to the sharpness of the edge.

(ii) Difference between diffraction and interference:

Diffraction	Interference
It occurs due to superposition of the secondary wavelets.	It occurs due to superposition of the light waves from two coherent sources.

3. (i) State an advantage of a reflecting telescope over a refracting telescope. [2]

(ii) Where should an object be kept in front of a convex lens in order to get an image of the same size as the object?

Ans. (i) The advantages of a reflecting telescope over a refracting telescope: In reflecting telescope, there is no chromatic aberration as the objective is a mirror.

(ii) Object should be placed at $2f$ distance in front of a convex lens to get an image of same size.

4. (i) A biconvex lens made of glass (refractive index 1.5) has two spherical surfaces having radii 10 cm and 20 cm. Calculate its focal length. [2]

OR

(ii) Calculate the refractive index of the material of an equilateral prism if its angle of minimum deviation is 30°.

Ans. (i)
$$\frac{1}{f} = (1.5-1)\left(\frac{1}{10}-\frac{1}{-20}\right)$$

Or,
$$\frac{1}{f} = 0.5 \times \frac{3}{20}$$

$$\therefore \quad f = \frac{40}{3} = 13.33 \text{ cm}$$

OR

(ii) Refractive index $= \mu = \dfrac{\sin\frac{A+\delta_m}{2}}{\sin\frac{A}{2}}$

Prism is equilateral. So, A = 60°

Angle of minimum deviation = δ_m = 30° (given)

$$\therefore \quad \mu = \frac{\sin\frac{60°+30°}{2}}{\sin\frac{60°}{2}}$$

$$= \frac{\sin 45°}{\sin 30°}$$

$$= \frac{1/\sqrt{2}}{1/2} = \sqrt{2}$$

5. With reference to semiconductor physics, define the following terms. [2]

(i) Doping

(ii) Depletion region

Ans. (i) Doping: Doping is the process of adding impurities to intrinsic semiconductors to alter their conductivity.

(ii) Depletion region: It is a region in a semiconductor junction of p-type and n-type materials, in which there is neither free electrons nor holes.

6. (i) Threshold wavelength for a certain metal for photoelectric effect is 600 nm. Calculate its: [2]

(a) threshold frequency.

(b) work function.

OR

(ii) Calculate the minimum amount of energy released when an electron annihilates a positron.

Ans. (i) (a)
$$\lambda_0 v_0 = c$$

Or, $v_0 = c/\lambda_0$

$$\therefore \quad v_0 = (3 \times 10^8)/(600 \times 10^{-9})$$
$$= 5 \times 10^{14} \text{ Hz}$$

(b) Work function $= W = hv_0$

$$\therefore \quad W = 6.6 \times 10^{-34} \times 5 \times 10^{14}$$
$$= 3.3 \times 10^{-19} \text{ J}$$
$$= 3.3 \times 10^{-19}/1.6 \times 10^{-19} \text{ eV}$$
$$= 2.06 \text{ eV}$$

OR

(ii)
$$e^- + e^+ = \gamma_1 + \gamma_2$$

Energy released $= E = mc^2$

$= 2 \times (9.1 \times 10^{-31}) \times (3\times10^8)^2$J

$= 2 \times (9.1 \times 10^{-31}) \times (3\times10^8)^2/1.6 \times 10^{-19}$ eV

$= 1.02$ MeV

SECTION-C [18 Marks]

7. (i) When two thin lenses are kept in contact, show that their effective focal length or equivalent focal length 'F' is given by: [3]

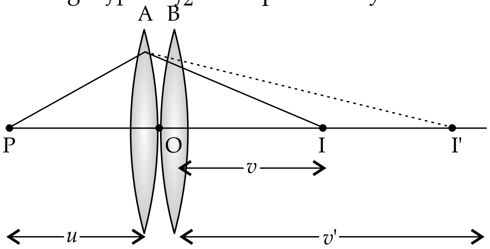
$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

where the terms have their usual meaning.

OR

(ii) Using Huygen's wave theory, prove the laws of reflection of light.

Ans. (i) Let us consider two thin lenses A and B of focal length f_1 and f_2 are kept coaxially in contact.



Lenses are so thin that it may be assumed that their optical centers coincide.

Let an object is placed at P at a distance u from lens A and it forms a real image I at a distance v' from the lenses which act as the virtual object for second lens B. Lens B forms a final image I at a distance v from the lenses.

For the lens A

$$1/f_1 = 1/v' - 1/u \qquad \ldots(i)$$

For the lens B,

$$1/f_2 = 1/v - 1/v' \qquad \ldots(ii)$$

adding equations (i) and (ii)

$$1/f_1 + 1/f_2 = 1/v - 1/u \qquad \ldots(iii)$$

Let us consider an equivalent lens of focal length F which will produce n image at I for an object at P, then

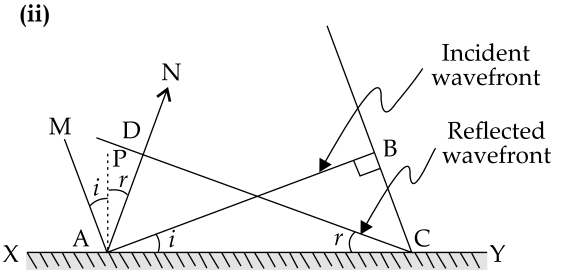
$$1/F = 1/v - 1/u \qquad \ldots(iv)$$

Comparing equations (iii) and (iv)

$$1/F = 1/f_1 + 1/f_2$$

OR

(ii)



XY = plane reflector

AB = incident plane wavefront. MA is the corresponding incident ray.

CD = reflected plane wavefront. AN is the corresponding reflected ray.

AP = normal to the surface XY.

$\angle MAP$ = angle of incidence = i

$\angle NAP$ = angle of reflection = r

AB wavefront touches the reflecting surface first and point A becomes the source of secondary wavelets in the same medium.

t = time taken by the incident wave front to reach from B to C

v = velocity of light in the medium.

So, $BC = vt$

By this time secondary wavelets originating from A have the same radius $AD = vt$.

A hemisphere is drawn whose centre is A and radius is AD.

Tangent DC drawn at point D of the hemisphere is the reflected wavefront.

Now in ΔADC and ΔABC,

$$AD = BC = vt$$
$$\angle ADC = \angle ABC = 90°$$

AC is the common side.

So, the triangles are congruent.

$$\therefore \quad \angle ACD = \angle BAC \qquad \ldots(i)$$

In ΔADC,

$$\angle DAC = 90° - r$$
$$\angle ADC = 90°$$

So, $\angle ACD = r$

Similarly, $\angle BAC = i$

From equation (i),

$$\angle ACD = \angle BAC$$

So, $\angle i = \angle r$

This is 1st law of reflection.

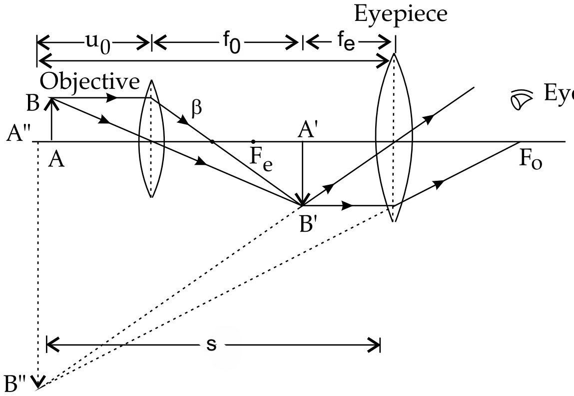
It is also seen from the figure that the incident ray MA, reflected ray AN and normal AP lie at a same point A and on the same plane.

This is the 2nd law of reflection.

8. Draw a neat labelled ray diagram of a compound microscope when the image is formed at the least distance of distinct vision D. Write the expression for its angular magnification (magnifying power) in this setup. [3]

Ans. [Derivation of formula is not required.]

Diagram of compound microscope when image is formed at least distance of distinct vision D:



Angular magnification = $1 + D/f_e$

9. Monochromatic light of wavelength 620 nm is incident on a pair of slits which are separated by 1.5 mm. If the screen is kept 60 cm away from the plane of the two slits, calculate: [3]

(i) Fringe separation i.e., fringe width.

(ii) Distance of the 10^{th} bright fringe from the centre of the interference pattern.

Ans. (i) Fringe width $\beta = \lambda D/d$

$$\lambda = 600 \text{ nm} = 620 \times 10^{-9} \text{ m}$$
$$D = 60 \text{ cm} = 0.6 \text{ m}$$
$$d = 1.5 \text{ mm} = 1.5 \times 10^{-3} \text{ m}$$

$$\therefore \text{ Fringe width } \beta = \frac{620 \times 10^{-9} \times 0.6}{1.5 \times 10^{-3}} = 0.248 \text{ mm}$$

(ii) Distance of 10^{th} bright fringe from the centre of interference pattern $= n\beta = 10 \times 0.248$ mm

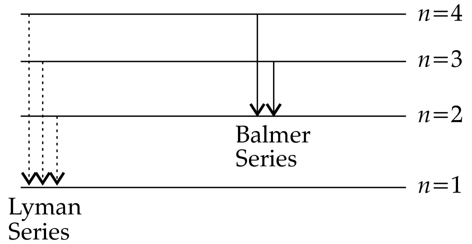
$$= 2.48 \approx 2.5 \text{ mm}$$

10. Draw an energy level diagram for hydrogen atom showing four lowest energy levels. On it, show transitions responsible for the emission of lines of [3]

(i) Balmer series by a continuous line.

(ii) Lyman series by a dotted line.

Ans.



11. Read the passage given below and answer the questions that below. [3]

India built its first nuclear reactor Apsara, at Trombay Maharashtra, in the year 1956. It was used mainly to generate electric power nuclear reactors are also used to produce radio-isotopes which are used in the fields of research, medicine, agriculture etc. Unlike thermal power stations, nuclear power stations don't cause atmospheric pollution. Still, there is opposition to installing them as there is an apprehension that there may be a radiation leakage which can be harmful to the people living nearby.

(i) In a nuclear reactor, what is the function of cadmium rods?

(ii) In a nuclear reactor, which material is used as moderator?

(iii) Given any one balanced equation representing the nuclear fission reaction taking place in a nuclear reactor.

Ans. (i) Function of cadmium rods: Cadmium rods are used as control rods. Control rods are used in nuclear reactors to control the rate of fission of the nuclear fuel by absorbing neutrons.

(ii) Function of moderator: Moderator in a nuclear reactor slows down the neutrons produced from fission and thus increases the probability of a neutron interacting with nuclear fuel.

(iii) Balanced nuclear reaction:

$$^{235}_{92}\text{U} + {}^{1}_{0}n \longrightarrow {}^{89}_{36}\text{Kr} + {}^{144}_{56}\text{Ba} + 3\,{}^{1}_{0}n + \text{Energy}$$

12. Answer the following questions. [3]

(i) (a) Draw a labelled circuit diagram of half wave rectifier.

(b) Show graphically how output voltage varies with time in case of a half wave rectifier when an AC voltage is fed to it from the mains.

OR

(ii) With reference to Semiconductor, answer the following questions:

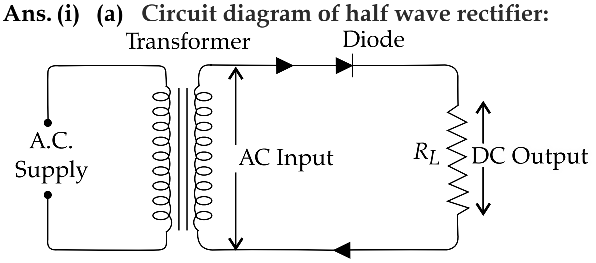
(a) Show how a junction diode can be forward biased.

(b) Draw a labelled V-I characteristic curve of a junction diode during forward bias.

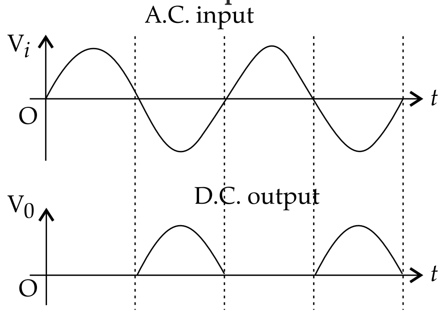
Constants & Useful Relations:

1	Speed of light in vacuum	c	3×10^{8} m/s
2	Planck's constant	h	6.6×10^{-34} Js
3	Mass of an electron/position	m	9.1×10^{-31} kg
4	1nm	=	1×10^{-9} m

Ans. (i) (a) Circuit diagram of half wave rectifier:

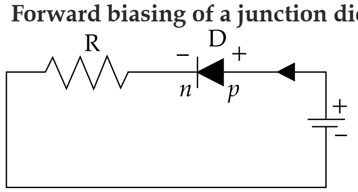


(b) Variation of output voltage with respect to time for A.C. input:



OR

(ii) (a) Forward biasing of a junction diode:



A junction diode is forward biased when n-side of the diode is connected to –ve terminal of the battery and p-side is connected to the +ve terminal of the battery.

(b) V-I characteristics of a forward biased diode: