# Sample Question Paper - 3
# Physics (042)
# Class- XII, Session: 2021-22
# TERM II

**Time Allowed: 2 hours** **Maximum Marks: 35**

**General Instructions:**

1. There are 12 questions in all. All questions are compulsory.
2. This question paper has three sections: Section A, Section B and Section C.
3. 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.
4. 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.
5. You may use log tables if necessary but use of calculator is not allowed.

**Section A**

1. In a centre trap full wave rectifier, the load resistance $R_L$ = 1 k$\Omega$. Each diode has a forward bias dynamic resistance of 10$\Omega$. The voltage across half the secondary winding is 220 sin 314t. Find **[2]**
   i. the peak value of current
   ii. the dc value of current and
   iii. the rms value of current

2. Explain, in brief, why Rutherford's model cannot account for the stability of an atom. **[2]**

   OR

   a. An X-ray tube produces a continuous spectrum of radiation with its short wavelength end at 0.45 $\overset{o}{A}$. What is the maximum energy of a photon in the radiation?
   b. From your answer to (a), guess what order of accelerating voltage (for electrons) is required in such a tube?

3. Explain the two processes involved in the formation of a p-n junction diode. Hence define the term barrier potential. **[2]**

**Section B**

4. The radius of the innermost electron orbit of a hydrogen atom is $5.3 \times 10^{-11}$ m. What are the radii of the n = 2 and n = 3 orbits? **[3]**

5. The resistivity of pure silicon is 3000 $\Omega$m and the electron and hole mobilities are 0.12 $m^2 V^{-1} s^{-1}$ and 0.045 $m^2 V^{-1} s^{-1}$ respectively, determine **[3]**

i. the resistivity of a specimen of the material when $10^{19}$ atoms of phosphorus are added per $m^3$

ii. the resistivity of the specimen if further $2 \times 10^{19}$ boron atoms per $m^3$ are also added.

6. Plot a graph showing the variation of binding energy per nucleon as a function of mass number. Which property of nuclear force explains the approximate constancy of binding energy in the range 30 < A < 170? **[3]**

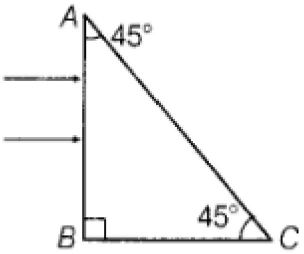
How does one explain the release of energy in both processes of nuclear fission and fusion from the graph?

7. A beam of light consisting of two wavelengths $6500\mathring{A}$ and $5200\mathring{A}$, is used to obtain interference fringes in a Young's double slit experiment. **[3]**

i. Find the distance of the third bright fringe on the screen from the central maximum for wavelength $6500\mathring{A}$.

ii. What is the least distance from the central maximum where the bright fringes due to both the wavelengths coincide?The distance between the slits is 2 mm and the distance between the plane of the slits and the screen is 120 cm.

8. Two monochromatic rays of light are incident normally on the face AB of an isosceles right-angled prism ABC. The refractive indices of the glass prism for the two rays 1 and 2 are respectively 1.35 and 1.45. Trace the path of these rays after entering through the prism. **[3]**

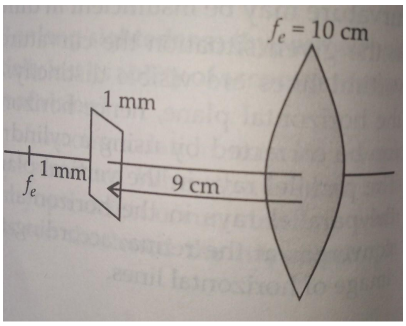



OR

a. At what distance should the lens be held in order to view the squares distinctly with the maximum possible magnifying power?

b. What is the magnification in this case?

c. Is the magnification equal to the magnifying power in this case? Explain.




9. i. Describe briefly three experimentally observed features in the phenomenon of photoelectric effect. **[3]**

ii. Discuss briefly how wave theory of light cannot explain these features.

10. At what angle should a ray of light be incident on the face of a prism of refracting angle 60° so that it just suffers total internal reflection at the other face? The refractive index of the **[3]**

material of the prism is 1.524

11. The oscillating magnetic field in a plane electromagnetic wave is given by **[3]**

$B_y = (8 \times 10^{-6}) \sin[2 \times 10^{11} t + 300\pi x] T$

i. Calculate the wavelength of the electromagnetic wave.

ii. Write down the expression for the oscillating electric field.

OR

Monochromatic light of wavelength 589 nm is incident from air on a water surface. What are the wavelength, frequency and speed of (a) reflected, and (b) refracted light? Refractive index of water is 1.33.

**CASE STUDY**

12. **Read the source given below and answer the following questions:** **[5]**

The lens maker's formula is a relation that connects focal length of a lens to radii of curvature of two surfaces of the lens and refractive index of the material of the lens. It is $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$, where $\mu$ is refractive index of lens material w.r.t. the medium in which lens is held. As $\mu_v > \mu_r$, therefore, $f_r > f_v$. Mean focal length of lens for yellow colour is $f = \sqrt{f_r \times f_v}$.

i. Focal length of a equiconvex lens of glass $\mu = \frac{3}{2}$ in air is 20 cm. The radius of curvature of each surface is

a. 10 cm

b. -10 cm

c. 20 cm

d. -20 cm

ii. A substance is behaving as convex lens in air and concave in water, then its refractive index is

a. greater than air but less than water

b. greater than both air and water

c. smaller than air

d. almost equal to water

iii. For a thin lens with radii of curvatures $R_1$ and $R_2$, refractive index n and focal length f, the factor $\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ is equal to

a. $\frac{1}{f(n-1)}$

b. f(n - 1)

c. $\frac{(n-1)}{f}$

d. $\frac{n}{f(n-1)}$

iv. A given convex lens of glass $\left(\mu = \frac{3}{2}\right)$ can behave as concave when it is held in a medium of \mu equal to

a. 1

b. $\frac{3}{2}$

c. $\frac{2}{3}$

d. $\frac{7}{4}$

v. The radii of curvature of the surfaces of a double convex lens are 20 cm and 40 cm respectively, and its focal length is 20 cm. What is the refractive index of the material of the lens?

a. $\frac{5}{2}$
b. $\frac{4}{3}$
c. $\frac{5}{3}$
d. $\frac{4}{5}$

**Solution**

**PHYSICS - 042**

**Class 12 - Physics**

**Section A**

1. The voltage across half the secondary winding is V = 200 sin 314t
   i. Peak value of voltage, $V_0$ = 220 V
      $\therefore$ Peak value of current is
      $I_0 = \frac{V_0}{r_d+R_L} = \frac{220}{10+1000}$ = 0.2178 A = 217.8 mA
   ii. d.c. value of current,
      $I_{dc} = \frac{2I_0}{\pi} = 2 \times 0.637 \times 217.8$ = 138.66 mA
   iii. rms value of current is
      $I_{rms} = \frac{I_0}{\sqrt{2}} = 0.707 \times 217.8$ = 154 mA
2. When an electron revolves around the nucleus radiates electromagnetic energy and hence radius of orbit of electron decreases gradually. Thus, electron will finally on spiral path of decreasing radius and at the end, it will fall into nucleus, but this does not happen. Also, according to it we should obtain radiation of all possible wavelength but in actual practice atomic spectrum is a line spectrum.Thus, Rutherford atomic model cannot account for stability of atom.

   OR

   We are given an X-ray tube.

   Wavelength of the radiation, $\lambda = 0.45\overset{o}{A} = 0.45 \times 10^{-10}$m, Planck 's constant h = 6.62 $\times$ $10^{-34}$ Js

   speed of light, c = 3 $\times 10^8$ $ms^{-1}$
   a. The maximum energy of photon is given by,
      $E = h\nu = h\frac{c}{\lambda}$
      $\Rightarrow \quad E = \frac{6.62\times10^{-34}\times3\times10^8}{0.45\times10^{-10}}$
      $= 44 \times 10^{-16}$J
      i.e., $E = \frac{44\times10^{-16}}{1.6\times10^{-19}}eV$
      = 27.5 $\times$ $10^3$ eV
      = 27.5 keV
   b. To produce electrons of 27.5 keV, accelerating potential of 27.5 kV to 30 KV is required.
3. **Diffusion:** It is the process of movement of majority charge carriers from their majority zone (i.e., electrons from n p and holes from p $\rightarrow$ n) due to the electric field developed at the junction. Motion gives rise to diffusion current.
   **Drift:** Process of movement of minority charge carriers (Le., holes from n $\rightarrow$ p and electrons from p $\rightarrow$ n) due to the electric field developed at the junction.
   **Barrier potential:** The loss of electrons from the n-region and gain of electrons by p-region causes a difference of potential across the junction, whose polarity is such as to oppose and then stop the further flow of charge carriers. This (stopping) potential is called Barrier potential.

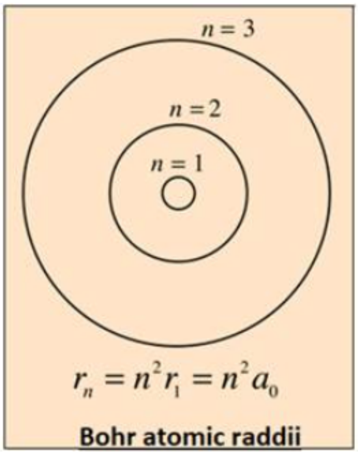
**Section B**

4. Given, the radius of the innermost orbit, $r_1$ = 5.3 $\times$ $10^{-11}$ m

   Then, let $r_2$ be the radius of an orbit at n = 2.

   Then, $r_2 = (n)^2 r_1$

   As shown in the diagram:




$\Rightarrow r_2 = 2^2 \times 5.3 \times 10^{-11}$ m

$\Rightarrow r_2 = 2.12 \times 10^{-10}$ m

For n = 3, we can write the corresponding electron radius as:

$\Rightarrow r_3 = (n)^2\, r_1$

$\Rightarrow r_3 = 3^2 \times 5.3 \times 10^{-11}$ m

$\Rightarrow r_3 = 4.77 \times 10^{-10}$ m

Hence, the radii of an electron for n = 2 and n = 3 orbits are $2.12 \times 10^{-10}$ m and $4.77 \times 10^{-10}$ m

5. The resistivity of pure silicon is given by

$\rho = \frac{1}{\sigma} = \frac{1}{en_i(\mu_e+\mu_h)}$

$\therefore$ Intrinsic carrier concentration,

$n_i = \frac{1}{e\rho(\mu_e+\mu_h)}$

$= \frac{1}{1.6\times10^{-19}\times3000\times(0.12+0.045)}\mathrm{m}^{-3}$

$= 1.437 \times 10^{16}\ \mathrm{m}^{-3}$

i. When $10^{19}$ donor atoms of phosphorus are added per $m^3$:

$n_e n_h = n_i^2 = (1.437 \times 10^{16})^2 = 2.066 \times 10^{32}$

and $n_e - n_h = N_d - N_a = 10^{19}$

As $n_e >> n_h$, therefore, $n_e = 10^{19}$

Hence, $\rho = \frac{1}{en_e\mu_e} = \frac{1}{1.6\times10^{-19}\times10^{19}\times0.12}$

$= 5.21\ \Omega m$

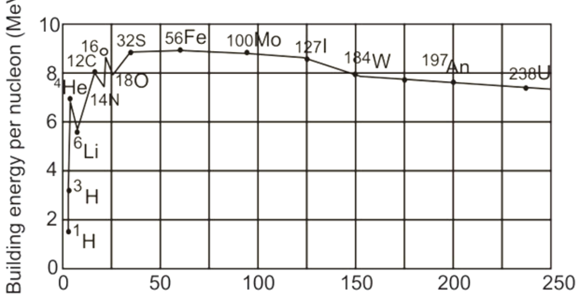
ii. When $2 \times 10^{19}$ acceptor atoms of boron are further added:

$n_h - n_e = N_a - N_d = 2 \times 10^{19} = 10^{19}$

As $n_h >> n_e$, therefore, $n_h \simeq 10^{19}$

Hence, $\rho = \frac{1}{en_h\mu_h} = \frac{1}{1.6\times10^{-19}\times10^{19}\times0.025}$

$= 25\ \Omega m$

6. 


The plot of the binding energy per nucleon versus the mass number A for a large number of nuclei

The nuclear force is short-ranged represents the consistency of binding energy in the range 30 < A < 170.

A heavy nucleus has lower binding energy per nucleon compared to a lighter one. Suppose a nucleus width A = 240 breaks into two nuclei of A = 120, nucleons get more tightly bounded. This implies that energy would be released in fission.

For two ling very light nuclei (A $\leq$ 10) joining to form a heavier nucleus. The binding energy per nucleon of heavier nucleus > binding energy per nucleon of lighter nuclei. This implies that energy is released during fission.

7. i. The distance of the mth bright fringe from the central maximum is given by

$y_m = \frac{m\lambda D}{d}$

$\therefore y_3 = \frac{3\lambda D}{d} = \frac{3\times(6500\times10^{-10})\times1.20}{2\times10^{-3}}$

$= 1.17\times10^{-3} m$ = 1.17 mm

ii. Let the nth bright fringe of wavelength $\lambda_n$ and the mth bright fringe of wavelength $\lambda_m$ coincide at a distance y from the central maximum, then

$y = \frac{m\lambda_m D}{d} = \frac{n\lambda_n D}{d}$

or $\frac{m}{n} = \frac{\lambda_m}{\lambda_n} = \frac{6500}{5200} = \frac{5}{4}$

The least integral value of m and n which satisfy the above condition are

m = 5 and n = 4

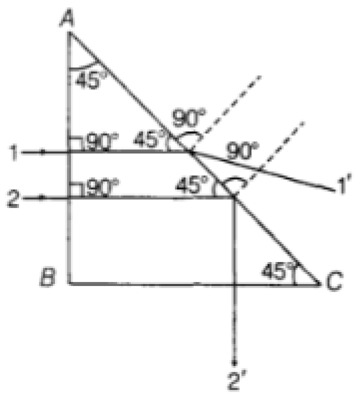
i.e. the 5 $^{th}$ bright fringe of wavelength 5200$\mathring{A}$ coincides with the 4$^{th}$ bright fringe of wavelength 6500$\mathring{A}$.

The smallest value of y at which this happens is:

$y_{min} = \frac{m\lambda_m D}{d} = \frac{5\times(5200\times10^{-10})\times1.20}{2\times10^{-3}}$

$= 1.56\times10^{-3} m$ = 1.56 mm

8.




From the figure, angle of incidence for ray 1 is $45^0$ .

For ray 1, sin i = sin $45^0$ = $\frac{1}{\sqrt{2}} = \frac{1}{1.414}$

For ray 1,

$\mu = 1.35$

$\mu = \frac{1}{\sin c} \Rightarrow \sin c = \frac{1}{\mu} = \frac{1}{1.35}$

Here, $\frac{1}{1.414} < \frac{1}{1.35}$

i.e. sin i < sin c or i < c, so ray 1 will be refracted by the prism.

For ray 2, angle of incidence, i = $45^0$

sin i = sin $45^0$ = $\frac{1}{\sqrt{2}} = \frac{1}{1.414}$

For ray 2, $\mu = 1.45$

$\mu = \frac{1}{\sin c} \Rightarrow \sin c = \frac{1}{\mu} = \frac{1}{1.45}$

Here, $\frac{1}{1.414} > \frac{1}{1.45}$

i.e. sin i > sin c or i > c, so, ray 2 will get total internally reflected.

OR

a. Maximum magnifying power is obtained when the image is at the near point (25 cm). Thus,

v = -25cm, f = +10 cm, u = ?

As, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

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

$= \frac{1}{-25} - \frac{1}{10} = \frac{-2-5}{50} = \frac{-7}{50}$

or $u = -\frac{50}{7} = -7.14cm$

So the lens should be held 7.14 cm away from the figure.

b. Magnitude of magnification is

$m = \frac{v}{u} = \frac{25}{\frac{50}{7}} = 3.5$

c. Magnifying power, $M = \frac{D}{u} = \frac{25}{\frac{50}{7}} = 3.5$

Yes, the magnifying power is equal to the magnitude of magnification because the image is formed at the least distance of distinct vision.

9. i. The three experimentally observed features in the phenomenon of photoelectric effect are -

a) Threshold frequency: The photoelectric effect will occur when the incident frequency is greater or equal to the threshold frequency for a given metal i.e $\nu \geq \nu_0$.

b) The maximum kinetic energy of photoelectron: When the incident frequency is greater than the threshold frequency, the maximum kinetic energy is proportional to $\nu - \nu_0$.

c) No time lag: When energy of incident photon is greater than the work function, the photoelectron is immediately ejected. Thus, there is no time lag between the incidence of light and emission of photoelectron.

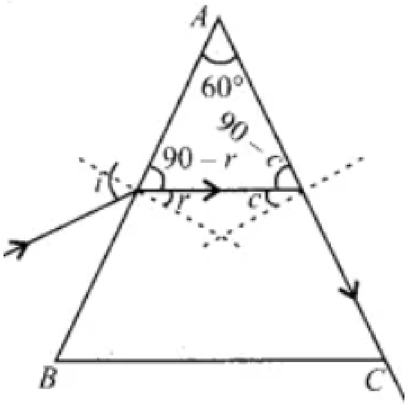
ii. We can not explain these by using wave theory of light because there are following reasons-

a) The instantaneous ejection of photoelectrons.

b) The existence of threshold frequency for a metal surface.

c) The kinetic energy of photoelectrons is independent of the intensity of light and depends on its frequency.

10. The beam should be incident at critical angle or more than critical angle, for total internal reflection at second surface of the prism.




Let us first find critical angle for air glass interface.

We know

$\sin C = \frac{1}{^a\mu_g}$

$C = \sin^{-1}\left(\frac{1}{a\mu_g}\right) = \sin^{-1}\left(\frac{1}{1.524}\right)$

Critical angle C = $41^o$

Now we can calculate 'r', as the refracted ray in the prism is incident on the second face at critical angle $i_{c.}$ thus,

$60^o + (90^o - r) + (90^o - C) = 180^o$

or , r = $19^o$

Using Snell's law, required angle of incidence i at first surface can be calculated.

$^a\mu_g = \frac{\sin i}{\sin r}$ or $1.524 = \frac{\sin i}{\sin 19^\circ}$

sin i = 1.524 (sin $19^o$)

sin i = 1.524 $\times$ 0.3256 $\Rightarrow i \cong 29.75^\circ$

11. Given equation is:
$B_y = (8 \times 10^{-6}) \sin[2 \times 10^{11} t + 300\pi x] T$
   i. Comparing the given equation with the equation of magnetic field varying sinusoidally with x and t,
   $B_y = B_0 \sin\left(\frac{2\pi x}{\lambda} + \frac{2\pi t}{T}\right)$, we get
   $\frac{2\pi}{\lambda} = 300\pi$
   Thus, the wavelength of the electromagnetic wave is,
   $\lambda = \frac{2}{300} = 0.0067m$
   ii. $B_0 = 8 \times 10^{-6} T$
   $E_0 = cB_0 = 3 \times 10^8 \times 8 \times 10^{-6}$
   $= 24 \times 10^2 = 2400 Vm^{-1}$
   $\therefore$ The required expression for the oscillating electric field is,
   $E_z = E_0 \sin\left(\frac{2\pi x}{\lambda} + \frac{2\pi t}{T}\right)$
   $= 2400 \sin(300\pi x + 2 \times 10^{11} t) V/m$

OR

Given, $\lambda = 589nm$
$c = 3 \times 10^8 m/s, \mu = 1.33$
   a. For reflected light,
   Wavelength $\lambda = 589nm = 589 \times 10^{-9} m$
   $\nu = \frac{c}{\lambda} = \frac{3 \times 10^8}{589 \times 10^{-9}}$
   $= 5.09 \times 10^{14} Hz$
   Hence, the speed, frequency, and wavelength of the reflected light are $3 \times 10^8$ m/s, $5.09 \times 10^{14}$ Hz, and 589 nm respectively.
   b. Frequency of light does not depend on the property of the medium in which it is travelling. Hence, the frequency of the refracted ray in water will be equal to the frequency of the incident or reflected light in air.
   $v = \frac{c}{\mu}$
   $v = \frac{3 \times 10^8}{1.33} = 2.26 \times 10^8 \text{m/s}$
   Wavelength of light in water is given by the relation,
   $\lambda = \frac{c}{\nu}$
   $= \frac{2.26 \times 10^8}{5.09 \times 10^{14}}$
   $= 444.007 \times 10^{-9} \text{m} = 444.01\ nm$
   Hence the speed, frequency and wavelength of refracted light are $2.26 \times 10^8$ m/s, $5.09 \times 10^{14}$ Hz and 444.01 nm respectively.

**CASE STUDY**

12. i. (c): $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$
   For equiconvex lens, $R_1 = R, R_2 = -R$
   $\frac{1}{20} = \left(\frac{3}{2} - 1\right)\left(\frac{2}{R}\right) = \frac{1}{R}$
   R = 20 cm
   ii. (a): When a lens is immersed in a medium whose refractive index is greater than that of the lens, its nature changes. Here the lens changes its nature when immersed in water it means its refractive index is less than that of water.
   iii. (a): According to lens maker's formula
   $\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \therefore \left(\frac{1}{R_1} - \frac{1}{R_2}\right) = \frac{1}{f(n-1)}$
   iv. (d): $\frac{1}{f_m} = \left(\frac{\mu_g}{\mu_m} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$
   The given lens would behave as concave when $f_m$ becomes negative, for which $\mu_m > \mu_g$.
   Choice (d) is correct.

v. (c): Here, $R_1$ = 20 cm, $R_2$ = -40 cm, f = 20 cm

Using lens maker's formula we get,

$\frac{1}{20} = (\mu - 1)\left(\frac{1}{20} + \frac{1}{40}\right); \frac{1}{20} = (\mu - 1)\frac{3}{40} \Rightarrow \mu = \frac{5}{3}$