CBSE Board
Class XII Physics
Sample Paper - 1
Term 2 – 2021-22

Time: 2 hours   **Total 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. The image of a candle is formed by a convex lens on a screen. The lower half of the lens is painted black to make it completely opaque. Draw the ray diagram to show the image formation. How will this image be different from the one obtained when the lens is not painted black?   [2]

2. Find the maximum frequency and minimum wavelength of X-rays produced by 30 keV electrons.[2]

OR

An electron, alpha particle and proton have the same kinetic energy. Which of these particles has the shortest de Broglie wavelength?   [2]

3. What are the limitations of Bohr's theory of hydrogen?   [2]

SECTION - B

4. How does conductivity change with a rise of temperature in case of semiconductors.   [3]

5. Why does photoelectric emission not take place if the frequency of incident radiation is less than the threshold value?   [3]

6. An electron, α-particle and a proton have the same de Broglie wavelength. Which of these particles has minimum kinetic energy and maximum kinetic energy, and why?
   a) A combination of two thin lenses has a power of +10D. If one of the concave lens has a focal length 1/4m. Find the nature and power of other lens.
   b) State the conditions under which the concave lens behave as a converging lens.   [3]

7. A compound microscope has an objective lens of focal length 2 cm and an eye lens of focal length 5 cm. If an object is placed 3 cm from the objective lens and the final image is formed at the least distance of distinct vision, find the magnification produced. [3]

OR

A semiconductor has equal electron and hole concentrations of $2 \times 10^8/m^3$. On doping with a certain impurity, the hole concentration increases to $4 \times 10^{10}/m^3$.

  i.   What type of semiconductor is obtained on doping?
  ii. Calculate the new electron hole concentration of the semiconductor.

How does the energy gap vary with doping? [3]

8. State any three important characteristics of photons. [3]

9. Draw a labelled ray diagram to show the formation of an image by a compound microscope. Write the expression for its magnifying power.

How does the resolving power of a compound microscope change when the
  a) refractive index of the medium between the object and the objective lens is increased
 b) wavelength of the radiation used is increased [3]

10.
  a) Give one point of difference between nuclear fission and nuclear fusion.
  b) Suppose we consider fission of a Fe^{56}_{26} into two equal fragments of Al^{28}_{13} nucleus. Is the fission energetically possible? Justify your answer by working out Q value of the process. Given mass of $Fe^{56}_{26} = 55.93494$ u and $Al^{28}_{13} = 27.98191$u. [3]
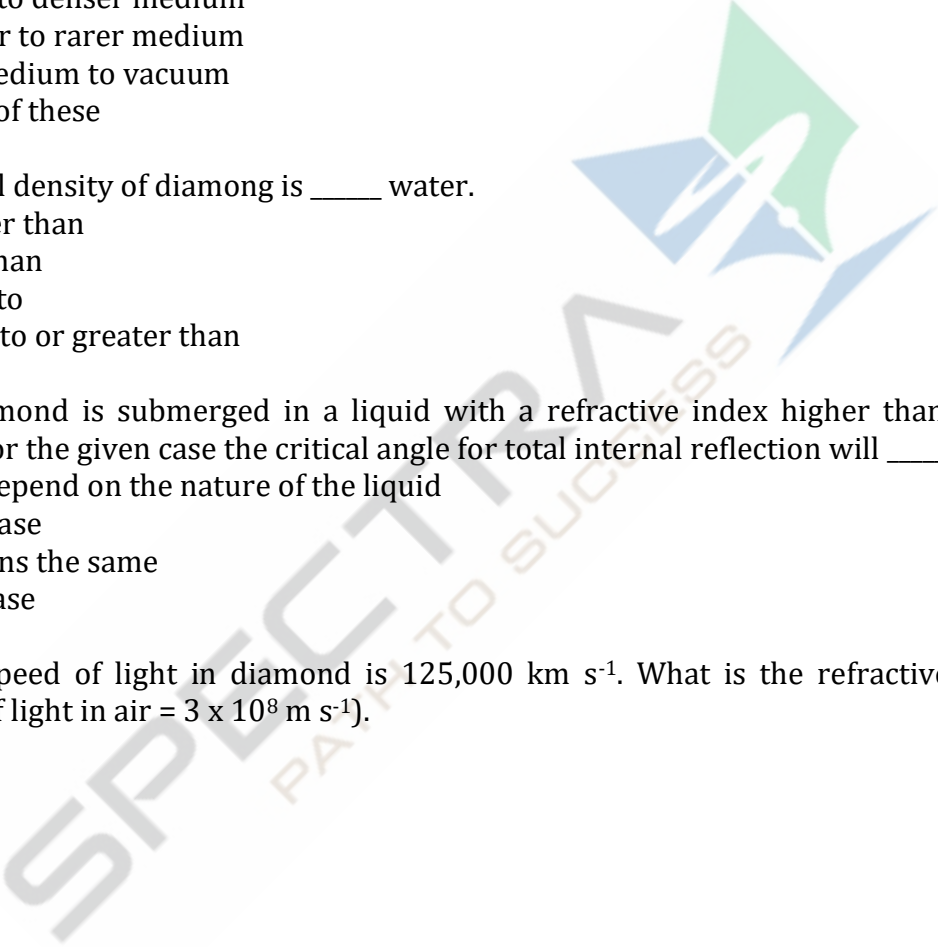
OR

How does the size of a nucleus depend on its mass number? Explain why the density of nuclear matter is independent of the size of a nucleus. [3]

SECTION – C

11. Case study:
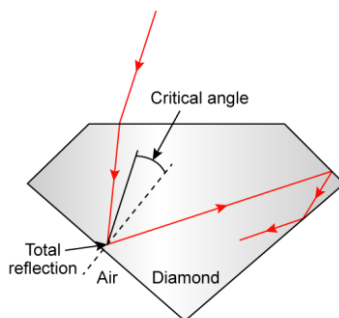
The total internal reflection of light is used in diamond polishing to create a gleaming brilliance. It is adjusted by polishing the diamond with specific cuts so that the majority of light rays approaching the surface are incident with an angle of incidence greater than the critical angle. As a result, they are subjected to multiple reflections and eventually emerge from the top of the diamond. This gives the diamond a brilliant gleam.

1. Diamonds sparkle more than any other materials due to phenomena known as
_____.
a) Diffraction
b) Reflection
c) Total internal reflection
d) Scattering

2. The phenomenon of Total Internal reflection is observed when light travels from
____.
a) Rarer to denser medium
b) Denser to rarer medium
c) any medium to vacuum
d) None of these

3. Optical density of diamong is _____ water.
a) Greater than
b) Less than
c) Equal to
d) Equal to or greater than

4. A diamond is submerged in a liquid with a refractive index higher than that of water. For the given case the critical angle for total internal reflection will _____.
a) will depend on the nature of the liquid
b) decrease
c) remains the same
d) increase

5. The speed of light in diamond is 125,000 km s^{-1}. What is the refractive index? (speed of light in air = 3 x 10^8 m s^{-1}).
a) 1.44
b) 1.66
c) 2.4
d) 4.2

Solution

Ans 1.
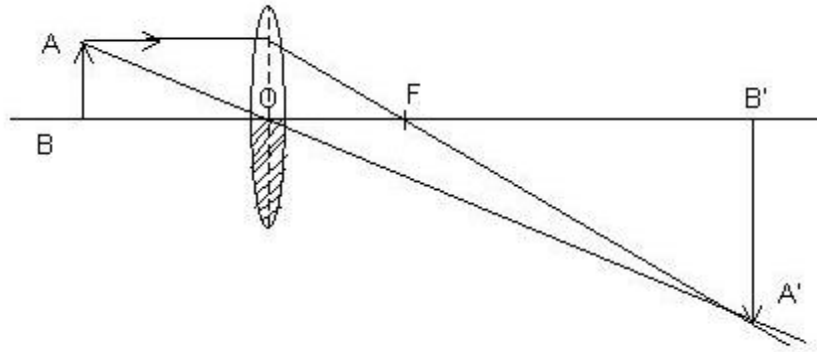
For the given case, there will be no change in height of image as we can see in ray diagram above although it will be less bright.

Ans 2.

Energy of electrons

$E = 30 \text{keV} = 30 \times 10^3 \times 1.6 \times 10^{-19}$ joule

From Einstein equation,

$E = h\nu$

$\nu = \dfrac{E}{h} = \dfrac{30 \times 10^3 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}} = 7.27 \times 10^{18} \text{Hz}$ (1)

$\lambda = \dfrac{v}{\nu} = \dfrac{c}{\nu} = \dfrac{3.0 \times 10^8}{7.27 \times 10^{18}} = 0.0413$ nm (1)

OR

de Broglie wavelength:

$\lambda = \dfrac{h}{p} = \dfrac{h}{\sqrt{2mK}}$

For the same kinetic energy, de Broglie wavelength depends on the mass of the particle.
As the alpha particle is the most massive of the three, its de Broglie wavelength will be the shortest.

Ans 3.

The limitation of Bohr's theory of hydrogen are as following.

i. This theory is applicable to the simplest atom like hydrogen with Z = 1. The theory fails in case of atoms of other elements for which Z > 1.

ii. It does not explain why orbits of electrons are taken as circular, while elliptical orbits are also possible.

iii. Bohr's theory does not explain the fine structure of spectral lines even in hydrogen atom.

iv. Bohr's theory of relative intensities of spectral lines is also not explained by this theory.

v. It does not take into account the wave properties of the electrons.

SECTION – B

Ans 4.

Due to the electric field, both electrons and holes in a semiconductor move in the opposite direction with drift velocities v_e and v_h, respectively.

Mobility of electrons is defined as drift velocity per unit electric field.

If there is no electric field, the drift velocity becomes zero.

Thus, mobility of electrons

$$\mu_e = \frac{v_e}{E} \ \text{ or } \ v_e = \mu_e E$$

and mobility of holes is,

$$\mu_h = \frac{v_h}{E} \ \text{ or } \ v_h = \mu_h E$$

We know, $\dfrac{E}{\rho} = e\left(n_e v_e + n_h v_h\right)$

$$\therefore \ \frac{E}{\rho} = e\left(n_e \mu_e + n_h \mu_h\right)E$$

$$\therefore \frac{1}{\rho} = e\left(n_e \mu_e + n_h \mu_h\right)$$

$\Rightarrow$ Conductivity, $\sigma = e\left(n_e \mu_e + n_h \mu_h\right)$

As the number of electrons n_e and the number of holes n_h increase with an increase in temperature, conductivity of the semiconductor also increases with a rise in temperature.

Ans 5.

According to Einstein's photoelectric equation,

$(1/2) mv^2{}_{max} = h\,f - h\,f_0$

where m = mass of the electron

f = frequency of incident radiation

f_0 = threshold frequency

If the frequency of incident radiation is less than the threshold value ($f < f_0$), the KE of the emitted electron is negative, i.e. photoelectric emission will not take place no matter how large the intensity of incident radiation.

Ans 6.

The de Broglie wavelength is

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$$

For the electron, proton and α-particle, λ is same

$$m_e K_e = m_p K_p = m_\alpha K_\alpha = \text{constant}$$

As mass of the electron is minimum, its kinetic energy will be maximum.

As mass of the alpha particle is maximum, its kinetic energy is minimum.

Ans 7.

a) Consider p_1 and p_2 to be the power of lens forming the combination.

   Then,

   $$p = p_1 + p_2$$

   $$p_2 = -\frac{1}{\frac{1}{4}} = -4D$$

   We have P = +(-4)

   p_1 = +14D

   Since the power is positive, which means that it is convex lens.

b) When concave lens is placed in a medium having refractive index (μ_1) greater the refractive index (μ_2) of the lens material, the concave lens behaves as a converging lens.

Ans 8.

u = −3 cm , f_0 = 2 cm, f_e = 5 cm

Applying the lens formula to the objective lens,

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

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{2} - \frac{1}{3}$$

$$\frac{1}{v} = +\frac{1}{6}$$

v = 6 cm

$$M = -\frac{v}{u}\left(1 + \frac{D}{f}\right)$$

$$M = -\frac{6}{3}\left(1 + \frac{25}{5}\right)$$

M = −12

OR

Given: $n_i = 2 \times 10^8/m^3$

On doping $n_h = 4 \times 10^{10}/m^3$

On doping, hole concentration will increase; hence, it is a p-type semiconductor.

Since $n^2_i = n_e n_h$

$$n_e = \frac{n^2_i}{n_h} = \frac{(2 \times 10^8)^2}{4 \times 10^{10}}$$

$$\Rightarrow n_e = 10^6 \text{ m}^{-3}$$

The energy gap decreases with doping because the acceptor level gets created between the valance band and the conduction band.

Ans 9.
1. Photons travel in a straight line with the speed of light.
2. Rest mass of a photon is zero or a photon cannot exist at rest.
3. The equivalent mass of a photon is
   - $E = h\nu = mc^2$
   - $m = h\nu/c^2$
4. Due to the change in wavelength, photons travel with different speeds in different media.
5. Momentum of photon is
   - $p = h/\lambda$

Ans 10.
a)
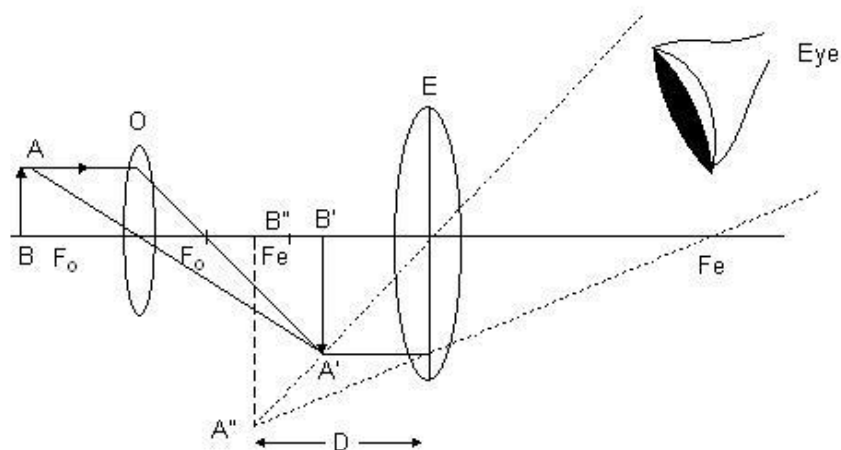
Here,
O = objective lens
E = Eye piece
AB = object, A" B" = final image
Magnifying power (m) of a compound microscope is given by

$$m = \frac{L}{f_o}\left(1 + \frac{d}{fe}\right)$$

Where L = distance between C_1 and C_2

f_e, f_o are focal lengths of the eye-piece and the objective

d = distance of the final image formed from the eye-piece

Hence we can conclude that on increasing μ, the resolving power will increase.

b)

Resolving power of a compound microscope is given by

$$R.P = \frac{2\mu \sin \theta}{\lambda}$$

Where μ is the refractive index of the medium between the object and objective lens, θ is half the angle of the cone of light from the point object and λ is the wavelength of radiations used.

Hence we can conclude that on increasing λ, the resolving power will decrease.

Ans 11.

a) Fission is the splitting of a large atom into two or more smaller ones. Fusion is the fusing of two or more lighter atoms into a larger one. Fission reaction does not normally occur in nature.

b)

$$Fe^{56}_{26} \rightarrow 2Al^{28}_{13}$$
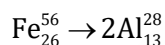
$M_1 = 55.93494$ u atomic mass of Fe

$M_2 = 27.98191$ u is the atomic mass of Al

Q value is $\left(M_1 - 2M_2\right) \times 931.5 \text{Mev}$

$\left(55.93 - 2 \times 27.98\right) \times 931.5$

$= -26.902 \text{MeV}$

Qis negative. Hence fission is not possible.

OR

The radius (size) R of the nucleus is related to its mass number (A) as

$R = R_0 A^{1/3}$, where $R_0 = 1.1 \times 10^{-15}$ m

If *m* is the average mass of a nucleon, then

Mass of the nucleus = mA, where A = mass number

Volume of the nucleus $= \frac{4}{3}\pi R^3 = \frac{4}{3}\pi R_0^{3} A$

$\therefore$ Density of the nucleus $\rho_N = \dfrac{\text{mass}}{\text{volume}} = \dfrac{mA}{\frac{4}{3}\pi R_0^3 A}$

$$\rho_{N} = \frac{3m}{4\pi R_{0}^{3}}$$

Thus, nuclear density ρ_{N} is independent of mass number A.

SECTION – C

Ans 12.

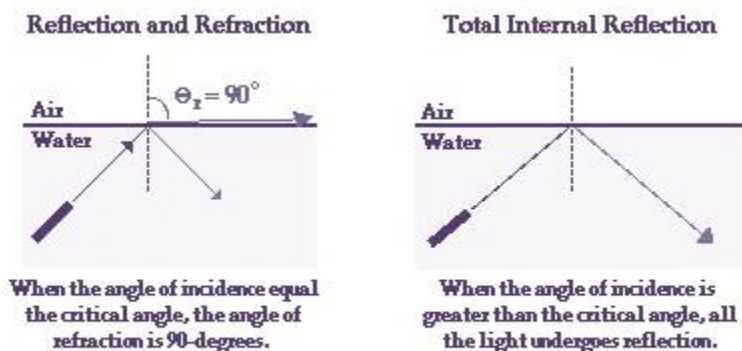1. Correct answer -b: Its critical angle with reference to air is too small.

   Diamonds sparkle more than other materials due to total internal reflection coupled with a large index of refraction.

   The critical angle for a diamond-to-air surface is only 24 °. When a ray of light enters a diamond it undergoes a series of total internal reflections due to the very small critical angle. This traps the ray of light due to which sparkles

   As a result, the ray of light gets trapped for some time within the diamond. So, it is due to this trapped energy that makes the diamond sparkle.

2. Correct answer – b: denser medium to rarer medium.

   The phenomenon of Total Internal reflection is observed when light travels from denser medium to rarer medium.

Reflection and Refraction	Total Internal Reflection
When the angle of incidence equal the critical angle, the angle of refraction is 90-degrees.	When the angle of incidence is greater than the critical angle, all the light undergoes reflection.

3. Correct answer – c: It has high refractive index

   Refractive index is measurement of optical density.

   Hence we can conclude that, optical density of diamond is greater than water.

4. Correct answer – d: Increase

   When diamond is submerged in a liquid with a refractive index higher than that of water, the critical angle for total internal reflection will increase.

5. Correct answer – c: 2.4

   Given that,

   Speed of light in diamond, $v = 125 \times 10^{6}$ m/s

   Speed of light in air, $c = 3 \times 10^{8}$ m/s

   Refractive index of diamond, $\mu_d = $?

   Now,

   $$\mu = \frac{c}{v} = \frac{3 \times 10^{8}}{125 \times 10^{6}} = 2.4$$