CBSE Test Paper-02

Class - 12 Physics Dual Nature of Radiation and Matter

1. If an electron accelerated from rest through a potential of 200 V acquires a speed of $8.4 \times 10^6 \mathrm{ms}^{-1}$, then its e/m is
   a. $1.96 \times 10^{11} \mathrm{Ckg}^{-1}$
   b. $1.86 \times 10^{11} \mathrm{Ckg}^{-1}$
   c. $1.76 \times 10^{11} \mathrm{Ckg}^{-1}$
   d. $1.66 \times 10^{11} \mathrm{Ckg}^{-1}$
2. A photon behaves as if it had a mass equal to
   a. hvc
   b. c^2/hv
   c. hv/c
   d. hv/c^2
3. Cathode rays traveling from east to west enter into region of electric field directed towards north to south in the plane of paper. The deflection of cathode rays is towards
   a. West
   b. East
   c. North
   d. South
4. When ultraviolet rays incident on metal plate then photoelectric effect does not occur, it occurs by incidence of
   a. X-rays
   b. Light waves
   c. Radio waves
   d. Infrared rays

5. A photoelectric cell converts
   a. light energy into electric energy
   b. electric into light energy
   c. light energy into heat energy
   d. light energy into sound energy
6. Show the variation of photoelectric current with collector plate potential for different intensities but same frequency of incident radiation.
7. How does the stopping potential applied to a photocell change, if the distance between the light source and the cathode of the cell is doubled?
8. Light of frequency 1.5 times the threshold frequency is incident on a photosensitive material. If the frequency is halved and intensity is doubled, what happens to photoelectric current?
9. Define the terms: (i) work function, (ii) threshold frequency and (iii) stopping potential, with reference to photoelectric effect.Calculate the maximum kinetic energy of electrons emitted from a photosensitive surface of work function 3.2 eV, for the incident radiation of wavelength 300 nm.
10. What is the effect on the velocity of the emitted photoelectrons if the wavelength of the incident light is decreased?
11. A particle is moving three times as fast as an electron. The ratio of the de Broglie wavelength of the particle to that of the electron is 8.3×10^{-4}. Calculate the particle's mass and identify the particle.
12. The emitter in a photoelectric tube has a threshold wavelength of $6000\overset{o}{\mathrm{A}}$. Determine the wavelength of the light incident on the tube if the stopping potential for this light is 2.5 V.
13. i. Ultraviolet light of wavelength 2271 $\overset{o}{A}$ from a 100 W mercury source is incident on a photocell made of molybdenum metal. If the stopping potential is 1. 3 V, estimate the work function of the metal.

ii. How would the photocell respond to high intensity? (10^5 W/m^2) red light of wavelength 6328 $\overset{o}{A}$ produced by a He-Ne laser?

14. i. State two important features of Einstein's photoelectric equation.

    ii. Radiation of frequency 10^{15} Hz is incident on two photosensitive surfaces P and Q. There is no photoemission from surface P. Photoemission occurs from surface Q but photoelectrons have zero kinetic energy. Explain these observations and find the value of work function for surface Q.

15. Why are de-Broglie waves associated with a moving football not visible? The wavelength λ, of a photon and the de-Broglie wavelength of an electron have the same value. Show that the energy of the photon is $\frac{2\lambda mc}{h}$ times the kinetic energy of the electron, where m, c and h have their usual meanings for electron.

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Class - 12 Physics (Dual Nature of Radiation and Matter)
Answers

1. c. $1.76 \times 10^{11} \mathrm{Ckg}^{-1}$

   Explanation: $eV_0 = \frac{1}{2}mv^2$

   $\frac{e}{m} = \frac{v^2}{2V_0} = \frac{(8.4\times10^6)^2}{2\times200} = 1.76 \times 10^{11} CKg^{-1}$

2. d. hv/c^2

   Explanation: Kinetic mass of photon = $\frac{h}{c\lambda} = \frac{h}{c(\frac{c}{\nu})} = \frac{h\nu}{c^2}$

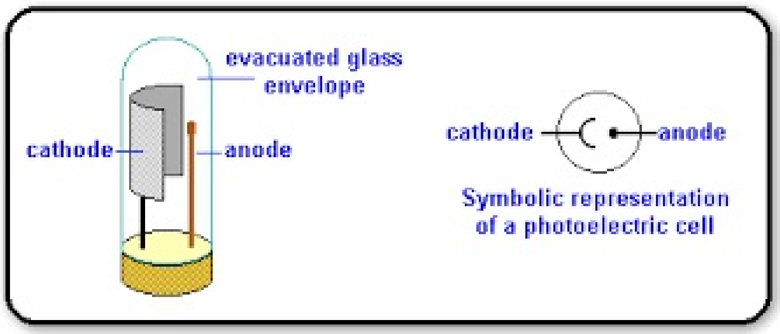
3. c. North

   Explanation: Cathode rays (stream of negatively charged particles) deflect in opposite direction of field i.e. towards north.

4. a. X-rays

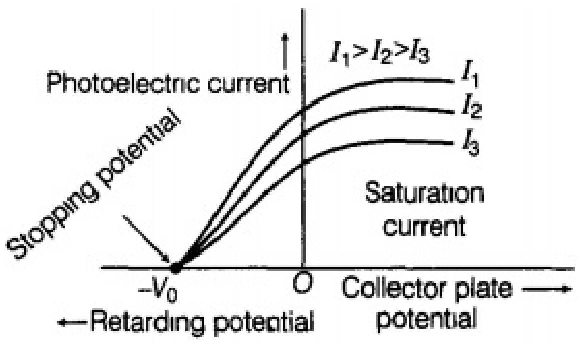
   Explanation: since frequency of X-rays is greater then that of U-V rays.

5. a. light energy into electric energy

   Explanation: 

   A photo cell is a device which converts light energy into electric energy.

6. The variation of photoelectric current with collector plate potential for different intensities at constant frequency is shown below.



7. When the distance between the light source and the cathode is changed, the intensity of light changes accordingly. However, the stopping potential does not depend upon the intensity of incident light.

8. If the frequency is halved, the frequency of incident light will become $\frac{1.5}{2} = 0.75$ times the threshold frequency. Hence, photoelectric current will be zero.

9. For definition of terms
   - work function
   - threshold frequency
   - stopping potential

   Numerical:

   The maximum kinetic energy of emitted photoelectron is given by :

   $K.E. = \frac{1}{2}mv_{\max}^2 = hv - \phi_0$

   $\Rightarrow E = \frac{hc}{\lambda} - \phi_0$

   $\Rightarrow E = \frac{6.6\times10^{-34}\times3\times10^8}{300\times10^{-9}} - 3.2 \times 1.6 \times 10^{-19}$

   $= 6.6 \times 10^{-19} - 5.12 \times 10^{-19}$

   $= 1.48 \times 10^{-19} J$

10. There will be an increase in the velocity of the emitted photoelectrons.

    As $\frac{1}{2}mv_{\max}^2 = h\frac{c}{\lambda} - \phi_0$

11. Given $v_1=3v_e$

    according to the de-Broglie wavelength, $\lambda = \frac{h}{mv}$

    so

    $\frac{\lambda_1}{\lambda_2} = \frac{M_e v_e}{M_1 v_1} = 8.3 \times 10^{-4}$

    $\therefore \quad M_1 = \frac{M_e v_e}{8.3\times10^{-4}(3v_e)} \quad (\because v_1 = 3v_e)$

    $= \frac{91\times10^{-31}}{8.3\times10^{-4}\times3} = 0.36 \times 10^{-27}\text{kg}$

    the particle may be proton or neutron.

12. The work function is

    $\phi_0 = h v_{th} = \frac{hc}{\lambda th} = \frac{12.4\times10^3 eV\times\mathring{A}}{6000\mathring{A}}$

= 2.07 eV

The photoelectric equation then gives

$eV_0 = hv - \phi_0$

$\Rightarrow eV_0 = \frac{hc}{\lambda} - \phi_0$

or $2.5eV = \frac{12.4 \times 10^3 eV\overset{o}{A}}{\lambda} - 2.07eV$

or $\lambda = 2713\overset{o}{A}$

13. i. Einstein's photoelectric equation is given by

KE_{max}= hv - ϕ

But, KE_{max} = eV_0

V_0 =1.3 V

eV_0 = hv - ϕ_0

$\Rightarrow$ ϕ = hv - eV_o

Here, h = 6.63 $\times$ 10^{-34}J-s

$\lambda = 2271\overset{o}{A} = 227 \times 10^{-10}$m

v= $\frac{c}{\lambda} = \frac{3 \times 10^8}{2271 \times 10^{-10}} = 1.32 \times 10^{15}$Hz

eV_o = 1.6 $\times$ 10^{-19} $\times$1.3 = 2 $\times$ 10^{-19}J

Work function, = hv - eV_0

= (6.63 $\times$ 10^{-34}) $\times$ (1.32 $\times$ 10^{15}) - 2$\times$$10^{-19}$

$= \frac{6.76 \times 10^{-19}}{1.6 \times 10^{-19}}$eV

Work function, ϕ_0 = 4.22 eV

ii. $\lambda = 6328 \times 10^{-10}$m

KE_{max}= hv - ϕ......(i)

Here, hv= $\frac{hc}{\lambda} = 3.14 \times 10^{-19}\text{J} = 1.96\text{eV}$

But, $\phi = 4.22$ eV i.e. hv $< \phi$

Therefore, KE_{max}< 0 [From Eq(i)]

Which is not possible.

14. i. Einstein's photoelectric equation is

eV_0 = K_{max} = hv- ϕ_0

Important features of this equation are given below

a. Photoemission occurs when frequency of incident radiation is more than the threshold frequency,

$v_0 = \frac{\phi_0}{h}$

b. Energy of emitted photoelectron is proportional to energy of incident photon.

ii. i. The threshold frequency of surface P is greater than 10^{15} Hz, and that is the reason no photoemission takes place.

ii. For surface Q, the threshold frequency is equal to 10^{15} Hz. So, photoemission takes place but photoelectrons have zero kinetic energy.

If, the kinetic energy of the elctrons emitted from surface B has to be increased then, the wavelength of the incident radiation has to be decreased.

Energy of incident photon is less than work function of P but just equal to that of Q.

For Q, Work function,

$$\phi_0 = \frac{hv}{e}(\text{eV}) = \frac{6.6\times10^{-34}\times10^{15}}{1.6\times10^{-19}} = 4.1\text{eV}$$

15. Because of large mass of a football, the wavelength associated with a moving football is small. So its wave nature is not visible.

de-Broglie wavelength of electron,

$$\lambda = \frac{h}{p}$$

Momentum of electron,

$$p = \frac{h}{\lambda}$$

K.E. of electron $= \frac{1}{2}mv^2 = \frac{p^2}{2m} = \frac{h^2}{2m\lambda^2} [\because p = mv]$

Energy of a photon $= \frac{hc}{\lambda}$

$$\therefore \frac{\text{Kinetic energy of photon}}{\text{Kinetic energy of electro}} = \frac{hc}{\lambda} \cdot \frac{2m\lambda^2}{h^2} = \frac{2\lambda mc}{h}$$

$\therefore$ Energy of photon $= \frac{2\lambda mc}{\lambda} \times$K.E. of electron