CBSE Test Paper-05

Class - 12 Physics (Nature of Radiation & Matter)

1. The lowest frequency of light that will cause the emission of photoelectrons from the surface of a metal (for which work function is 1.65 eV) will be:
   a. $4 \times 10^{10} Hz$
   b. $4 \times 10^{-10} Hz$
   c. $4 \times 10^{14} Hz$
   d. $4 \times 10^{11} Hz$
2. Each photon has the same speed but different
   a. rest mass
   b. energy
   c. radius
   d. frequency
3. If an electron accelerated through a potential difference of 500 volt attains a speed of 1.33 $\times 10^7 \mathrm{ms}^{-1}$ then specific charge of the electron should be
   a. 1.76 $\times 10^{11} \mathrm{Ckg}^{-1}$
   b. 1.66 $\times 10^{11} \mathrm{Ckg}^{-1}$
   c. 1.86 $\times 10^{11} \mathrm{Ckg}^{-1}$
   d. 1.96 $\times 10^{11} \mathrm{Ckg}^{-1}$
4. The maximum kinetic energy of photoelectrons emitted from a surface when photons of energy 6 eV fall on it is 4 eV. The stopping potential is
   a. 2 V
   b. 10 V
   c. 4 V
   d. 6 V
5. A stream of electrons enters an electric field with $10^7 \mathrm{ms}^{-1}$ at right angle to it. If the strength of field is $3 \times 10^4 \mathrm{V/m}$, the magnetic field acting perpendicular to electric field for producing no deflection of the beam is
   a. 4 $\times 10^{-3} \mathrm{T}$
   b. 0.3 $\times 10^{-3} \mathrm{T}$
   c. 3 $\times 10^{-3} \mathrm{T}$

d. 3.5×10^{-3}T

6. State de-Broglie hypothesis.

7. How will the photoelectric current change on decreasing the wavelength of incident radiation for a given photosensitive material?

8. Define the intensity of radiation on the basis of photon picture of light. Write its SI unit.

9. An electron is accelerated through a potential difference of 100 V. What is the de-Broglie wavelength associated with it? To which part of the electromagnetic spectrum does this value of wavelength correspond?

10. Plot a graph showing the variation of stopping potential with the frequency of incident radiation for two different photosensitive materials having work-functions ϕ_1 and $\phi_2 (\phi_1 > \phi_2)$. On what factors does the (i) slope and (ii) intercept of the lines depend?

11. Plot a graph showing the variation of photoelectric current with anode potential for two light beam of same wavelength but different intensity.

12. For what kinetic energy of a proton, will the associated de-Broglie wavelength be 16.5 nm?

13. Write Einstein's photoelectric equation and mention which important features in photoelectric effect can be explained with the help of this equation.
The maximum kinetic energy of the photoelectrons gets doubled when the wavelength of light incident on the surface changes λ_1 from to λ_2. Derive the expressions for the threshold wavelength λ_0 and work function for the metal surface.

14. A deuteron and an α-particle are accelerated with the same accelerating potential. Which one of the two has (i) greater value of de-Broglie wavelength, associated with it and (ii) less kinetic ?

15. Find the de-Broglie wavelength of neutron at 27°C. Given, Boltzmann constant, 1.38×10^{-23}J molecule^{1}k^{-1}, h = 6.63×10^{-34}Js mass of neutron 1.66×10^{-23}kg

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Answers

1. c. $4 \times 10^{14} Hz$

   Explanation: Work function

   $\phi = h\nu_0$

   $\phi = 1.65eV = 1.65 \times 1.6 \times 10^{-19} J$

   threshold frequency

   $\nu_0 = \frac{\phi}{h} = \frac{1.65 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}} = 4 \times 10^{14} Hz$

2. d. frequency

   Explanation: Each photon travels with the speed of light. Energy of photon is $h\nu$.

   ν is the frequency of photon. Energy depends on frequency.

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

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

   $\frac{e}{m} = \frac{v^2}{2V_0} = \frac{(1.33 \times 10^7)^2}{2 \times 500} = 1.76 \times 10^{11} C\ kg^{-1}$

4. c. 4 V

   Explanation: $eV_0 = k_{max}$

   $eV_0 = 4eV$

   $V_0 = 4V$

5. c. $3 \times 10^{-3} \mathrm{T}$

   Explanation: $B = \frac{E}{v} = \frac{3 \times 10^4}{10^7} = 3 \times 10^{-3} T$

6. **De-Broglie hypothesis:** A moving object sometimes acts as a wave and sometimes as a particle or a wave is associated with the moving particle which control this particle in every respect. This wave associated with the moving particle is called matter wave or de-Broglie wave. Its wavelength is given by-

   λ = h/mv

   where, h =Planck's constant, m =mass of object,v =velocity of the object.

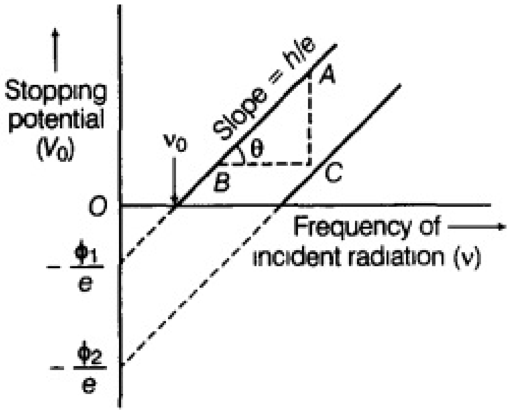
7. Photoelectric current is not affected on decreasing the wavelength of incident

radiation.

8. The intensity of radiation of given wavelength represent the no of energy quanta or photons incident per unit area per time , with each photon having the same energy.
   Intensity of radiation =Energy/Area×time
   Its SI unit is $Wm^{-2}Sr^{-1}$.

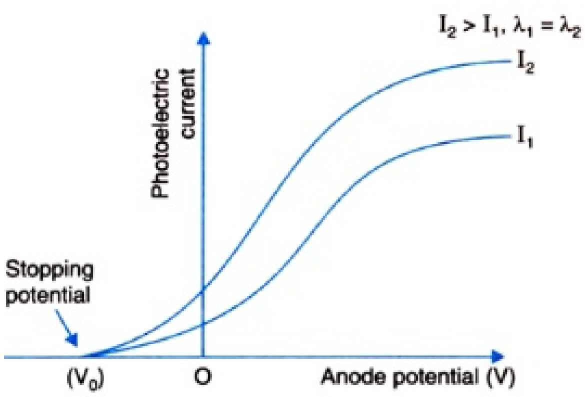
9. Given, V = 100 V. Wavelength of accelerated electron beam from de-Broglie equation
   $\lambda = \frac{12.27}{\sqrt{V}} \overset{o}{A}$
   For V = 100 V ⇒ λ= 1.227$\overset{o}{A}$
   This wavelength belongs to the X-ray part of electromagnetic radiation.

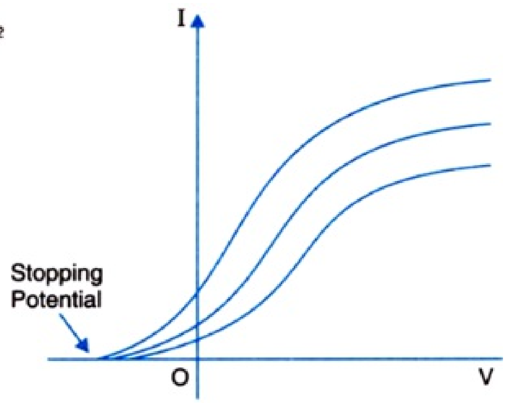
10. The variation of stopping potential with frequency of incident radiation is shown as below·



   i. Slope is determined by h and e (or slope is independent of the metal used).
   ii. Work function of the metal.

11.





12. Here, $\lambda = 16.5nm = 16.5 \times 10^{-9}m$
   and mass of proton $m = 1.6 \times 10^{-27}kg$

Using de-Broglie equation
$\lambda = \frac{h}{mv}$
$\Rightarrow v = \frac{h}{m\lambda}$
$\therefore K.E. = \frac{1}{2}mv^2 = \frac{1}{2}m \cdot \frac{h^2}{m^2\lambda^2}$
$K.E. = \frac{h^2}{2m\lambda^2}$
$= \frac{6.63\times10^{-34}\times6.63\times10^{-34}}{2\times1.6\times10^{-27}\times16.5\times10^{-9}\times16.5\times10^{-9}}$
$K.E. = \frac{6.63\times6.63\times10^{-34-34+27+9+9}}{2\times1.6\times16.5\times16.5}$
$K.E. = 0.05045 \times 10^{-68+45}$
$= 5.045 \times 10^{-2} \times 10^{-23}$
$K.E. = 5.045 \times 10^{-25} J$

13. Einstein's photoelectric equation
$K_{\max} = \frac{1}{2}mv^2 = hv - \phi_0 = hv - hv_0$ ....(i)
Important properties :

i. In interaction of radiation with matter, radiation behaves as, if It is made up of particles called photons.
ii. Each photon has energy E (= hv = hc/λ) and momentum p(= hv/c =hc /λ), where c is the speed of light, h is Planck's constant, v and λ are frequency and wavelength of radiation respectively.

From Eq. (i),
$K_{\max} = \frac{hc}{\lambda_1} - \phi_0$
According to question,
$K_{\max} = \frac{hc}{\lambda_1} - \phi_0$........(i)
$2K_{\max} = \frac{hc}{\lambda_2} - \phi_0$ ....(ii)
From Eqs. (ii) and (iii), Also
$2\left(\frac{hc}{\lambda_1} - \phi_0\right) = \frac{hc}{\lambda_2} - \phi_0$
$\phi_0 = \frac{2hc}{\lambda_1} - \frac{hc}{\lambda_2} = hc\left(\frac{2}{\lambda_1} - \frac{1}{\lambda_2}\right)$
Also, $\phi_0 = \frac{hc}{\lambda_0}$
$\therefore \quad \frac{hc}{\lambda_0} = hc\left(\frac{2}{\lambda_1} - \frac{1}{\lambda_2}\right)$
or $\frac{1}{\lambda_0} = \frac{2\lambda_2-\lambda_1}{\lambda_1\lambda_2}$

$\lambda_0 = \frac{\lambda_1 \lambda_2}{2\lambda_2 - \lambda_1}$

14. i. de-Broglie wavelength is given by

$\lambda = \frac{h}{\sqrt{2mV_0q}} \Rightarrow \lambda \propto \frac{1}{\sqrt{mq}}$ x = {-b \pm \sqrt{b^2-4ac} \over 2a}

$\frac{\lambda_d}{\lambda_a} = \frac{1/\sqrt{2me}}{1/\sqrt{4m2e}} = \frac{2}{1}$

wavelength of deuteron is two times the wavelength of $\alpha\ particle$

ii. $\frac{\mathrm{KE}_d}{\mathrm{KE}_a} = \frac{V_0 e}{V_0 2e} = \frac{1}{2}$

KE of deuteron is half of K.E. of $\alpha\ particle$

15. Here, T = 27°C = 27 + 273 = 300 K

Energy of neutron at temperature Tk is

$E = \frac{3}{2}kT = \frac{3}{2} \times 1.38 \times 10^{-23} \times 300$

= 6.21 $\times$ 10^{-21}J

Now, $\lambda = \frac{h}{\sqrt{2mE}} = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 1.66 \times 10^{-27} \times 6.21 \times 10^{-21}}}$

or $\lambda = 1.46\overset{o}{A}$