DCAM classes

Dynamic Classes for Academic Mastery

Physics

NCERT Exemplar Problems

Chapter 11

Dual Nature of Radiation and Matter

Answers

11.1 (d)

11.2 (b)

11.3 (d)

11.4 (c)

11.5 (b)

11.6 (a)

11.7 (a)

11.8 (c)

11.9 (c), (d)

11.10 (a), (c)

11.11 (b), (c)

11.12 (a), (b), (c)

11.13 (b), (d)

11.14 $$\lambda_p / \lambda_d = p_x / p_p = \frac{\sqrt{2m_\alpha E_\alpha}}{\sqrt{2m_p E_p}} = \sqrt{8} : 1$$

11.15 (i) $E_{max} = 2h\nu - \phi$ (ii) The probability of absorbing 2 photons by the same electron is very low. Hence such emissions will be negligible.

11.16 In the first case energy given out is less than the energy supplied. In the second case, the material has to supply the energy as the emitted photon has more energy. This cannot happen for stable substances.

11.17 No, most electrons get scattered into the metal. Only a few come out of the surface of the metal.

11.18 Total E is constant

Let n_1 and n_2 be the number of photons of X-rays and visible region

$$n_1 E_1 = n_2 E_2$$

$$n_1 \frac{hc}{\lambda_1} = n_2 \frac{hc}{\lambda_2}$$

$$\frac{n_1}{n_2} = \frac{\lambda_1}{\lambda_2}.$$

$$\frac{n_1}{n_2} = \frac{1}{500}.$$

11.19 The momentum is transferred to the metal. At the microscopic level, atoms absorb the photon and its momentum is transferred mainly to the nucleus and electrons. The excited electron is emitted. Conservation of momentum needs to be accounted for the momentum transferred to the nucleus and electrons.

11.20 Maximum energy = $h\nu - \phi$

$$\left(\frac{1230}{600} - \phi\right) = \frac{1}{2}\left(\frac{1230}{400} - \phi\right)$$

$$\phi = \frac{1230}{1200} = 1.02\text{eV}.$$

11.21 $\Delta x \Delta p \simeq \hbar$

$$\Delta p \simeq \frac{\hbar}{\Delta x} \simeq \frac{1.05 \times 10^{-34}\,\text{Js}}{10^{-9}\,\text{m}} = 1.05 \times 10^{-25}$$

$$E = \frac{p^2}{2m} = \frac{(1.05\times10^{-25})^2}{2\times9.1\times10^{-31}} = \frac{1.05^2}{18.2}\times10^{-19}\text{J} = \frac{1.05^2}{18.2\times1.6}eV$$

$= 3.8 \times 10^{-2} eV$

11.22 $I = n_A n_A = n_B v_B$

$$\frac{n_A}{n_B} = 2 = \frac{v_B}{v_A}$$

The frequency of beam B is twice that of A.

11.23 $$p_c = |p_A| + |p_B| = \frac{h}{\lambda_A} + \frac{h}{\lambda_B} = \frac{h}{\lambda_c} = \frac{h}{\lambda_c} \text{ if } p_A, p_B > 0 \text{ or } p_A, p_B < 0$$

$$\text{or } \lambda_c = \frac{\lambda_A \lambda_B}{\lambda_A + \lambda_B}$$

If $p_A > 0$, $p_B < 0$ or $p_A < 0$, $p_B > 0$

$$p_c = h\frac{\lambda_B - \lambda_A}{|\lambda_A . \lambda_B|} = \frac{h}{\lambda_c}$$

$$\lambda_c = \frac{\lambda_B . \lambda_A}{|\lambda_A - \lambda_B|}.$$

11.24 $2d \sin\theta = \lambda = d = 10^{-10}$ m.

$$p = \frac{h}{10^{-10}} = \frac{6.6\times10^{-34}}{10^{-10}} = 6.6\times10^{-21}\text{kg m/s}$$

$$E = \frac{(6.6\times10^{-24})^2}{2\times(1.7\times10^{-27})}\times1.6\times10^{-19} = \frac{6.6^2}{2\times1.7}\times1.6\times10^{-2}eV$$

$= 20.5 \times 10^{-2} eV = 0.21 eV$

11.25 6×10^{26} Na atoms weighs 23 kg.

Volume of target = $(10^{-4} \times 10^{-3}) = 10^{-7} m^3$

Density of sodium = (d) = 0.97 kg/m^3

Volume of 6×10^{26} Na atoms = $\frac{23}{0.97} m^3$ = 23.7 m^3

Volume occupied of 1 Na atom = $\frac{23}{0.97\times6\times10^{26}} m^3$ = $3.95 \times 10^{-26} m^3$

No. of sodium atoms in the target = $\frac{10^{-7}}{3.95\times10^{-26}}$ = 2.53×10^{18}

Number of photons/s in the beam for 10^{-4} m^2 = n

Energy per s $nh\nu = 10^{-4}$ J × 100 = 10^{-2} W

$$h\nu \text{ (for } \lambda = 660\text{nm)} = \frac{1234.5}{600}$$

$$= 2.05\text{eV} = 2.05 \times 1.6 \times 10^{-19} = 3.28 \times 10^{-19}\text{J}.$$

$$n = \frac{10^{-2}}{3.28\times10^{-19}} = 3.05\times10^{16}/\text{s}$$

$$n = \frac{1}{3.2}\times10^{17} = 3.1\times10^{16}$$

If P is the probability of emission per atom, per photon, the number of photoelectrons emitted/second

$$= P\times3.1\times10^{16}\times2.53\times10^{18}$$

Current = P × 3.1 × 10^{+16} × 2.53 × 10^{18} × 1.6 × 10^{-19} A

= P × 1.25 × 10^{+16} A

This must equal 100μA or

$$P = \frac{100\times10^{-6}}{1.25\times10^{+16}}$$

$\therefore\ P = 8 \times 10^{-21}$

Thus the probability of photemission by a single photon on a single atom is very much less than 1. (That is why absorption of two photons by an atom is negligible).

11.26 Work done by an external agency $= +\frac{1}{4\pi\varepsilon_0}\cdot\frac{1}{4}\int_d^\infty \frac{q^2}{x^2}dx = \frac{1}{4}\cdot\frac{q^2}{4\pi\varepsilon_0 d}$

With d = 0.1nm, energy $= \frac{(1.6\times10^{-19})\times9\times10^{9}}{4(10^{-10})\times1.6\times10^{-19}}\text{eV}$

$$= \frac{1.6\times9}{4}\text{eV} = 3.6 \text{ eV}$$

11.27 (i) Stopping potential = 0 at a higher frequency for B. Hence it has a higher work function.

(ii) Slope $= \frac{h}{e} = \frac{2}{(10-5)\times10^{14}}$ for A.

$= \frac{2.5}{(15-10)\times10^{14}}$ for B.

$$h = \frac{1.6\times10^{-19}}{5}\times2\times10^{-14} = 6.04\times10^{-34}\text{Js for A}$$

$$= \frac{1.6\times10^{-19}\times2.5\times10^{-14}}{5} = 8 \times 10^{-34} \text{ Js for B.}$$

Since h works out differently, experiment is not consistent with the theory.

11.28 $m_A v = m_A v_1 + m_B v_2$

$$\frac{1}{2}m_A v^2 = \frac{1}{2}m_A v_1^2 + \frac{1}{2}m_B v_2^2$$

$$\therefore \frac{1}{2}m_A(v - v_1)(v_A + v_1) = \frac{1}{2}m_B v_B^2$$

$\therefore$ $v + v_1 = v_2$

or $v = v_2 - v_1$

$$\therefore v_1 = \left(\frac{m_A - m_B}{m_A + m_B}\right)v, \quad \text{and} \quad v_2 = \left(\frac{2m_A}{m_A + m_B}\right)v$$

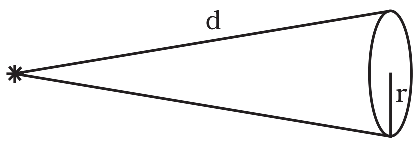
$$\therefore \lambda_{\text{initial}} = \frac{h}{m_A v}$$

$$\lambda_{\text{final}} = \frac{h}{m_A v} = \left|\frac{h(m_A + m_B)}{m_A(m_A - m_B)v}\right|$$

$$\therefore \Delta\lambda = \frac{h}{m_A v}\left[\left|\frac{m_A + m_B)}{m_A - m_B}\right| - 1\right]$$

11.29 (i) $\frac{dN}{dt} = \frac{P}{(hc/\lambda)} = 5\times10^{19}/sec$

(ii) $\frac{hc}{\lambda} = 2.49\text{eV} > W_0$: Yes.



(iii) $P.\frac{\pi r^2}{4\pi d^2}\Delta t = W_0$, $\Delta t = 28.4\text{s}$

(iv) $N = \left(\frac{dN}{dt}\right)\times\frac{\pi r^2}{4\pi d^2}\times\Delta t = 2$