

## 20. MODERN PHYSICS

\* Work function is minimum for cesium (1.9 eV)

\* work function  $W = h\nu_0 = \frac{hc}{\lambda_0}$

\* Photoelectric current is directly proportional to intensity of incident radiation. ( $\nu$  constant)

\* Photoelectrons ejected from metal have kinetic energies ranging from 0 to  $KE_{\max}$

Here  $KE_{\max} = eV_s$   $V_s$  - stopping potential

\* Stopping potential is independent of intensity of light used ( $\nu$ -constant)

\* Intensity in the terms of electric field is

$$I = \frac{1}{2} \epsilon_0 E^2 \cdot c$$

\* Momentum of one photon is  $\frac{h}{\lambda}$ .

\* Einstein equation for photoelectric effect is

$$h\nu = w_0 + k_{\max} \quad \frac{hc}{\lambda} = \frac{hc}{\lambda_0} + eV_s$$

\* Energy  $\Delta E = \frac{12400}{\lambda(A^0)} \text{ eV}$

\* Force due to radiation (Photon) (no transmission)

When light is incident perpendicularly

(a)  $a = 1$   $r = 0$

$$F = \frac{IA}{c}, \quad \text{Pressure} = \frac{I}{c}$$

(b)  $r = 1$ ,  $a = 0$

$$F = \frac{2IA}{c}, \quad P = \frac{2I}{c}$$

(c) when  $0 < r < 1$  and  $a + r = 1$

$$F = \frac{IA}{c} (1 + r), \quad P = \frac{I}{c} (1 + r)$$

When light is incident at an angle  $\theta$  with vertical.

(a)  $a = 1$ ,  $r = 0$

$$F = \frac{IA \cos \theta}{c}, \quad P = \frac{F \cos \theta}{A} = \frac{I}{c} \cos^2 \theta$$

(b)  $r = 1$ ,  $a = 0$

$$F = \frac{2IA \cos^2 \theta}{c}, \quad P = \frac{2I \cos^2 \theta}{c}$$

(c)  $0 < r < 1$ ,  $a + r = 1$

$$P = \frac{I \cos^2 \theta}{c} (1 + r)$$

\* De Broglie wavelength

$$\lambda = \frac{h}{mv} = \frac{h}{P} = \frac{h}{\sqrt{2km}}$$

\* Radius and speed of electron in hydrogen like atoms.

$$r_n = \frac{n^2}{Z} a_0 \quad a_0 = 0.529 \text{ \AA}$$

$$v_n = \frac{Z}{n} v_0 \quad v_0 = 2.19 \times 10^6 \text{ m/s}$$

\* Energy in nth orbit

$$E_n = E_1 \cdot \frac{Z^2}{n^2} \quad E_1 = 13.6 \text{ eV}$$

\* Wavelength corresponding to spectral lines

$$\frac{1}{\lambda} = R \left( \frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

for Lyman series  $n_1 = 1$   $n_2 = 2, 3, 4, \dots$

Balmer  $n_1 = 2$   $n_2 = 3, 4, 5, \dots$

Paschen  $n_1 = 3$   $n_2 = 4, 5, 6, \dots$

\* The Lyman series is an ultraviolet and Paschen, Brackett and Pfund series are in the infrared region.

\* Total number of possible transitions, is  $\frac{n(n-1)}{2}$ , (from nth state)

\* If effect of nucleus motion is considered,

$$r_n = (0.529 \text{ \AA}) \frac{n^2}{Z} \cdot \frac{m}{\mu}$$

$$E_n = (13.6 \text{ eV}) \frac{Z^2}{n^2} \cdot \frac{\mu}{m}$$

Here  $\mu$  - reduced mass

$$\mu = \frac{Mm}{(M+m)}, \quad M - \text{mass of nucleus}$$

\* Minimum wavelength for x-rays

$$\lambda_{\min} = \frac{hc}{eV_0} = \frac{12400}{V_0(\text{volt})} \text{ \AA}$$

\* Moseley's Law

$$\sqrt{\nu} = a(z - b)$$

a and b are positive constants for one type of x-rays (independent of Z)

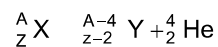
\* Average radius of nucleus may be written as

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

A - mass number

\* Binding energy of nucleus of mass M, is given by  $B = (ZM_p + NM_n - M)c^2$

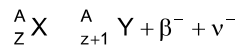
\* Alpha - decay process



Q-value is

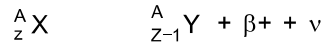
$$Q = [m({}_Z^AX) - m({}_{Z-2}^{A-4}Y) - m({}_2^4\text{He})]c^2$$

\* Beta- minus decay



$$Q\text{-value} = [m({}_Z^AX) - m({}_{Z+1}^AY)]c^2$$

\* Beta plus-decay



$$Q\text{-value} = [m({}_Z^AX) - m({}_{Z-1}^AY) - 2m_e]c^2$$

\* Electron capture : when atomic electron is captured, X-rays are emitted.



$$Q\text{-value} = [m({}_Z^AX) - m({}_{Z-1}^AY)]c^2$$

\* In radioactive decay, number of nuclei at instant t is given by  $N = N_0 e^{-\lambda t}$ ,  $\lambda$ -decay constant.

\* Activity of sample :  $A = A_0 e^{-\lambda t}$

\* Activity per unit mass is called specific activity.

$$* \text{ Half life : } T_{1/2} = \frac{0.693}{\lambda}$$

$$* \text{ Average life : } T_{av} = \frac{T_{1/2}}{0.693}$$

\* A radioactive nucleus can decay by two different processes having half lives  $t_1$  and  $t_2$  respectively. Effective half-life of nucleus is given by  $\frac{1}{t} = \frac{1}{t_1} + \frac{1}{t_2}$ .