

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. ($\nu - \text{constant}$)

* 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 (ν -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

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

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

* 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 θ 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) $0 < r < 1, \quad a + r = 1$

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

* De Broglie wavelength

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

* 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 $n_1 = 1 \quad n_2 = 2, 3, 4, \dots$

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

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

* 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 μ - 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)

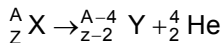
* Average radius of nucleus may be written as

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

A - mass number

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

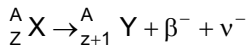
* Alpha - decay process



Q-value is

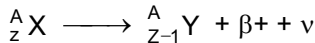
$$Q = [m({}^A_Z X) - m({}^{A-4}_{Z-2} Y) - m({}^4_2 \text{He})]c^2$$

* Beta- minus decay



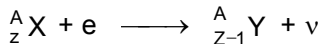
$$Q\text{-value} = [m({}^A_Z X) - m({}^A_{Z+1} Y)]c^2$$

* Beta plus-decay



$$Q\text{-value} = [m({}^A_Z X) - m({}^A_{Z-1} Y) - 2me]c^2$$

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



$$Q\text{-value} = [m({}^A_Z X) - m({}^A_{Z-1} Y)]c^2$$

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

$$\frac{1}{t} = \frac{1}{t_1} + \frac{1}{t_2}.$$

