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. (ν – 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

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

* 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 $\Delta E = \frac{12400}{\lambda(A^0)}$ 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) $r = 1$, $a = 0$

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

  (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

$$F = \frac{IA\cos\theta}{c}, \qquad P = \frac{F\cos\theta}{A} = \frac{I}{c}\cos2\,\theta$$

(b) r = 1, a = 0

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

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

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

* De Broglie wavelength

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

* Radius and speed of electron in hydrogen like atoms.

$$r_n = \frac{n^2}{Z}a_0 \qquad a_0 = 0.529\ \text{Å}$$

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

* Energy in nth orbit

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

* Wavelength corresponding to spectral lines

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

for Lyman series	$n_1 = 1$	$n_2 = 2, 3, 4$..........
Balmer	$n_1 = 2$	$n_2 = 3, 4, 5$..........
Paschen	$n_1 = 3$	$n_2 = 4, 5, 6$..........

* 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,

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

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

Here μ - reduced mass

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

* Minimum wavelength for x-rays

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

* Moseley's Law

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

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

* Average radius of nucleus may be written as

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

$${}_Z^A X \rightarrow {}_{Z-2}^{A-4} Y + {}_2^4 He$$

Q-value is

$$Q = \left[m\left({}_Z^A X\right) - m\left({}_{Z-2}^{A-4} Y\right) - m\left({}_2^4 He\right)\right] C^2$$

* Beta- minus decay

$${}_Z^A X \rightarrow {}_{Z+1}^{A} Y + \beta^- + \nu^-$$

Q- value = $[m({}_Z^A X) - m({}_{Z+1}^{A} Y)]c^2$

* Beta plus-decay

$${}_Z^A X \longrightarrow {}_{Z-1}^{A} Y + \beta+ + \nu$$

Q- value = $[m({}_Z^A X) - m({}_{Z-1}^{A} Y) - 2me]c^2$

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

$${}_Z^A X + e \longrightarrow {}_{Z-1}^{A} Y + \nu$$

Q - value = $[m({}_Z^A X) - m({}_{Z-1}^{A} Y)]c^2$

* 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.
* Half life : $T_{1/2} = \frac{0.693}{\lambda}$
* 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 $\frac{1}{t} = \frac{1}{t_1} + \frac{1}{t_2}$.