Ch-12: Atoms

1. Distance of closest approach-Estimation of nuclear size

$$r_0 = \frac{Ze^2}{m\pi\epsilon_0 v^2}$$

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2. Impact parameter:

Relation between Impact parameter b and the scattering angle θ

$$b \propto cot\left(\frac{\theta}{2}\right)$$

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3. Postulates of Bohr's theory of hydrogen atom

Angular momentum of hydrogen atom

$$L_n = mvr = \frac{nh}{2\pi}$$

Frequency of the emitted radiation

$$f = \frac{E_2 - E_1}{h}$$

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4. Radius of electron: n^{th} radius of electron;

$$r_n = \frac{\epsilon_0 n^2 h^2}{\pi m Z e^2}$$

$$r_n \propto \frac{n^2}{Z}$$

$$r_n = r_1 n^2 \; or \; r_n \propto n^2$$

$$r_1 = \frac{\epsilon_0 h^2}{\pi m e^e}$$

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5. Speed of nth orbit in Bohr's model of hydrogen atom

$$v_n = \frac{e^2}{2\epsilon_0 nh}$$

$$v_n = \frac{v_1}{n}$$

$$v_1 \propto \frac{1}{n}$$

Where,

$$v_1 = \frac{e^2}{2\epsilon_0 h} = \frac{c}{137} = 2.19 \times \frac{10^6 m}{s} = Maximum\ Speed$$

And, $c = speed\ of\ light\ in\ vacuum$

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6. Speed of nth orbit in Bohr's model of hydrogen like atom

$$\boldsymbol{v_n = \frac{Ze^2}{2\epsilon_0 nh}}$$

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7. Fine structure constant

$$\alpha = \frac{e^2}{2\epsilon_0 ch}, so\ v = \alpha \frac{c}{n}$$

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8. Energy of the electron of H atom:

The total energy in the n^{th} orbit is the sum of kinetic energy and potential

$$E_n = -\frac{me^4}{8{\epsilon_0}^2 n^2 h^2}$$

Where

$$E_n = \frac{E_1}{n^2} = \frac{-13.6}{n^2} = \frac{-Rhc}{n^2}\ \ (in\ eV)$$

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9. Absorption of energy: When the electron in the atom can jump from lower orbit to higher orbit, it absorbs energy.

10. Emission of energy: When an electron jumps from higher to lower orbit, it emits energy.

Energy of photon is equal to the difference of two orbits. $[E_i - E_f = hf]$

11. Ground state and ground state energy: The energy associated with ground state (n = 1)

12. Ionization energy: It is the energy required to make the electron jump from present orbit to the infinite orbit.

$$E_{ionisation} = E_{\infty} - E_n = 0 - (E_n) = 13.6\ eV$$

13. Energy needed to remove the electron from any energy level means Ionisation Energy.

(Minimum energy required to free the electron from ground state of the hydrogen atom is 13.6 eV, it is called ionization energy.)

14. Ionization Potential:

$$Ionisation\ Potential = \frac{Ionisation\ energy}{e}$$

15. Excitation energy: If lower state energy is E_{n_1} and higher state energy is E_{n_2}, then excitation energy:

$$\Delta E_{n_1 n_2} = E_{n_2} - E_{n_2}$$

16. Excitation Potential

$$Excitation\ Potential = \frac{Excitation\ energy}{e}$$

17. Wavelength of photon emitted in De-excitation:

$$E = hf = \frac{hc}{\lambda} = E_i - E_f$$

$$E_n = -\frac{Rhc}{n^2} = -\frac{13.6}{n^2}$$

Where,

$$Rhc = 13.6\ eV$$

18. Rydberg formula: In General

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

Energy of the emitted radiation (H atom),

For H-spectrum, wave number = 1/λ related as

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

[For **Lyman series**: $n_f = 1, n_i = 2, 3, 4, ------$; belongs to UV spectrum, for **Balmer series:** $n_f = 2, n_i = 3, 4, 5, ----$; belong to visible spectrum, for **Paschen series**: $n_f = 3, n_i = 4, 5, 6, -----$; belongs to Infra-red, for Bracket series: $n_f = 4, n_i = 5, 6, 7, ----$belongs to infrared; for p-Fund series: $n_f = 5, n_i = 6, 7, 8, -----$;belongs to infrared]