22^{nd} Session: Modern Physics – II
(Atomic Models)

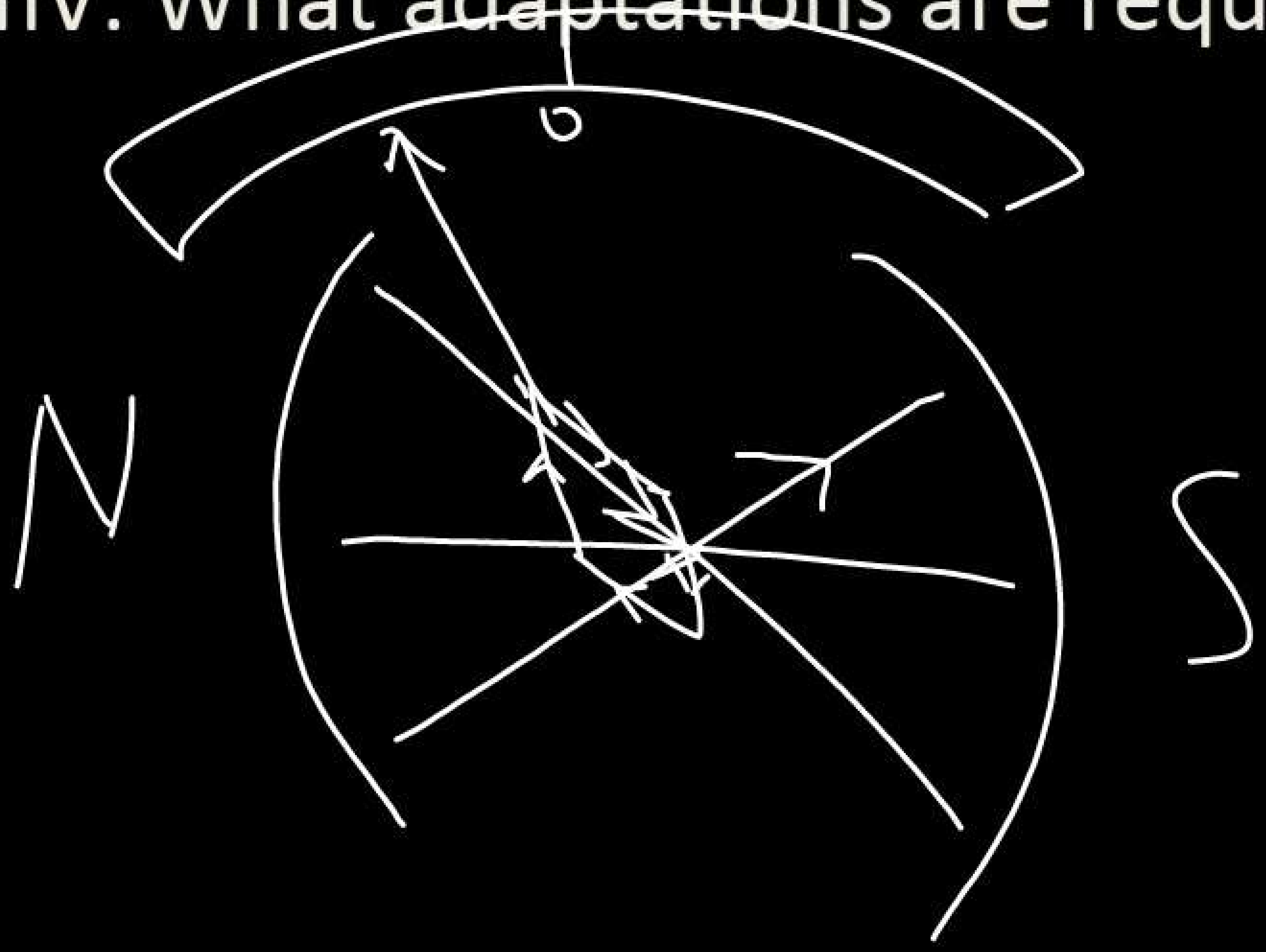
- Question discussion: Galvanometer
- Recap
- Balmer & Paschen Series
- Bohr's atomic model

Question Discussion/Optional

A galvanometer with a scale divided into 100 equal divisions has a current sensitivity of 10 divisions per mA and voltage sensitivity of 2 divisions per mV. What adaptations are required to read 5 A for full scale?

$$NiAB = C\theta$$

$$\frac{\theta}{i} = \frac{NAB}{C}$$



$$\tau = \vec{M} \times \vec{B}$$

$$= NiA \times B \sin \underset{90^\circ}{\alpha}$$

$$= C\theta$$

Applying Rydberg's Formula

$n_1 = 2$

$R = \mathbf{1.09737 \times 10^7}$ m^{-1}

Take n_f = **2 (Balmer Series, VISIBLE)** in Rydberg's formula, get range of λ values

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

$$= 1.1\times10^7\left(\frac{1}{2^2} - \frac{1}{n_2^2}\right)$$

$n_2 \to 3, 4, 5 \cdots \infty$

$$\frac{1}{\lambda_1} = 1.1\times10^7\left(\frac{1}{4} - \frac{1}{9}\right)$$

$$\lambda_1 = \frac{36}{5\times1.1\times10^7}$$

$$\boxed{\lambda_1 = 656\,nm}$$

$$\frac{1}{\lambda_\infty} = 1.1\times10^7\left(\frac{1}{4} - \frac{1}{\infty}\right)$$

$$\boxed{\lambda_\infty = \frac{4}{1.1\times10^7} = 365\,nm}$$

365

×2

656

$\boxed{Z = 1}$

Applying Rydberg's Formula

$n_2 = 4, 5, 6 \cdots \infty$

R = **1.09737×10^{7}** m^{-1}

Take n_f **= 3** **(Paschen Series, IR)** in Rydberg's formula, get range of λ values

$$\frac{1}{\lambda_\infty} = 1.1\times10^7\left(\frac{1}{3^2} - \frac{1}{\infty}\right)$$

$$\frac{1}{\lambda_1} = 1.1\times10^7\left(\frac{1}{3^2} - \frac{1}{4^2}\right)$$

$$\lambda_1 = \frac{9\times16}{7.7\times10^7} = 1875\text{nm}$$

$$\lambda_\infty = \frac{9}{1.1\times10^7} = 822\text{nm}$$

$(n_1 = 2, n_2 \rightarrow 3, 4, 5 \cdots \infty)$

Q. Balmer series was observed & analyzed before Lyman & Paschen. Why?

$(n_1 = 3, n_2 \rightarrow 4, 5, 6 \cdots \infty)$

$(n_1 = 1, n_2 \rightarrow 2, 3, 4 \cdots \infty)$

Brackett $\rightarrow (n_1 = 4, n_2 \rightarrow 5, 6 \cdots \infty)$

Pfund $\rightarrow (n_1 = 5, n_2 \rightarrow 6, 7 \cdots \infty)$

Bohr's Atomic Model **(1913)**

Bohr's Postulates

1). The electrons revolve around nucleus in circular orbits.

2). The e^- can only occupy certain stationary orbits, in which their energies will be const.
e^- can jump from one orbit to other.

$n \rightarrow n^{th}$ stationary orbit.

Bohr's Atomic Model **(1913): 13 quantities**

2 (v_n, r_n)

velocity

radius of the orbit.

3 (PE_n, KE_n, TE_n)

4 (ω_n, f_n, i_n, T_n)

angular freq.

Oscillation freq.

current

Time period.

4 (B_n, a_n, M_n, L_n)

Magnetic field

Centripetal acc.

Magnetic moment

Ang. Momentum

$-2E_n + E_n = -E_n$

Mnemonic

3). When an $\bar{e}$ jumps from one orbit to other. It emits or absorbs a photon.

$$\boxed{(E_2 - E_1) = \frac{hc}{\lambda}} \rightarrow \text{explains H-spectrum.}$$

4). The angular momentum of $\bar{e}$ in any stationary orbit is quantized.

$$m_e v_e r = n\left(\frac{h}{2\pi}\right).$$

Derive v_n & r_n for Bohr's Model of H atom.

$$\frac{m_e v_n^2}{r_n} = \frac{k(Ze)e}{r_n^2} \quad \text{--- (1)} \quad \Rightarrow m_e v_n^2 r_n = kZe^2$$

$$\Rightarrow \left(\frac{nh}{2\pi}\right) v_n = kZe^2$$

$$m_e v_n r_n = \frac{nh}{2\pi} \quad \text{--- (2)} \quad \Rightarrow \boxed{v_n = \left(\frac{2\pi}{nh}\right) kZe^2}$$

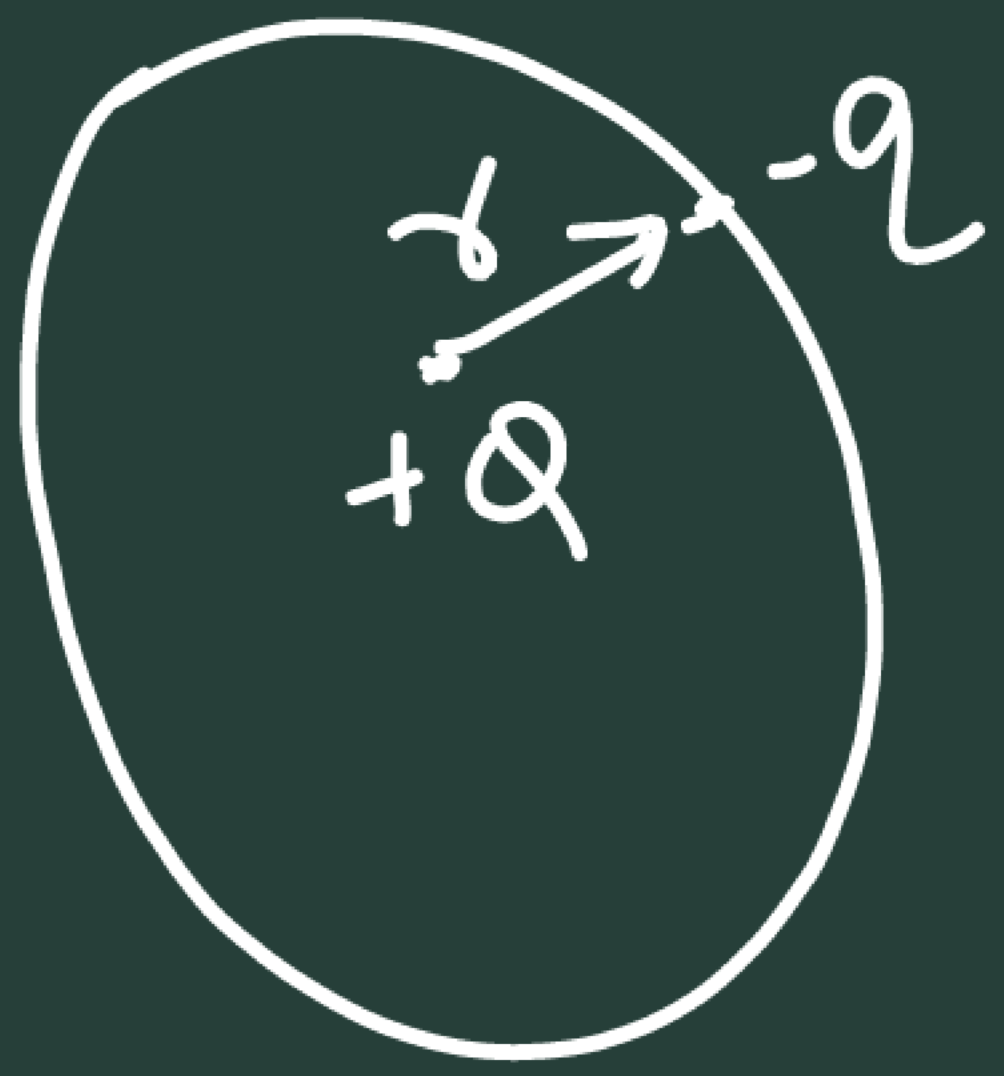
$$\boxed{v_n = \left(2.18 \times 10^6 \, m/s\right) \frac{Z}{n}} \quad \boxed{v_n = \left(\frac{2\pi k e^2}{h}\right) \times \left(\frac{Z}{n}\right)}$$

$$m v_n r_n = \frac{nh}{2\pi}$$

$$v_n = \left(\frac{2\pi}{nh}\right) kZe^2$$

$$r_n = \left(\frac{nh}{2\pi}\right) \frac{1}{m v_n} = \left(\frac{nh}{2\pi}\right)^2 \frac{1}{kZe^2 m_e}$$

$$\boxed{r_n = \left(\frac{nh}{2\pi}\right)^2 \frac{1}{kZe^2 m_e}} \qquad \boxed{r_n = (0.529\,\text{Å}) \frac{n^2}{Z}}$$


-q
r
+Q