ARJUNA NEET BATCH

Structure of Atom

LECTURE - 7

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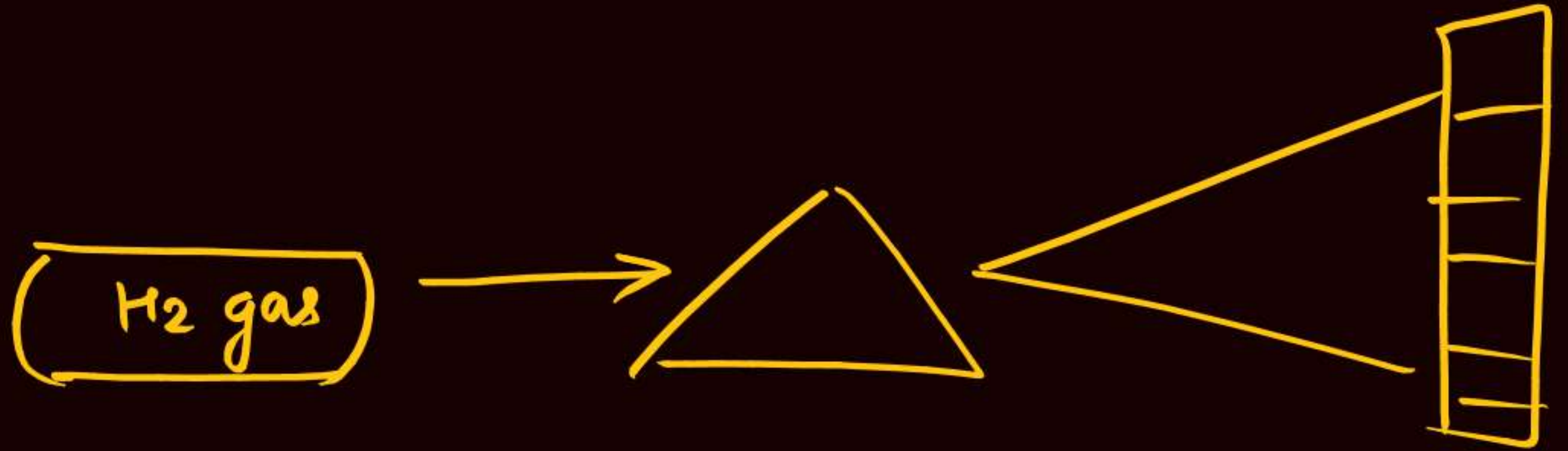


→ Emission spectrum

$H_2 \longrightarrow H \longrightarrow$ Transition

gas

$1e^{\ominus}$

ground state

10^{-6} to 10^{-8} s

Wavelength

Objective of today's class

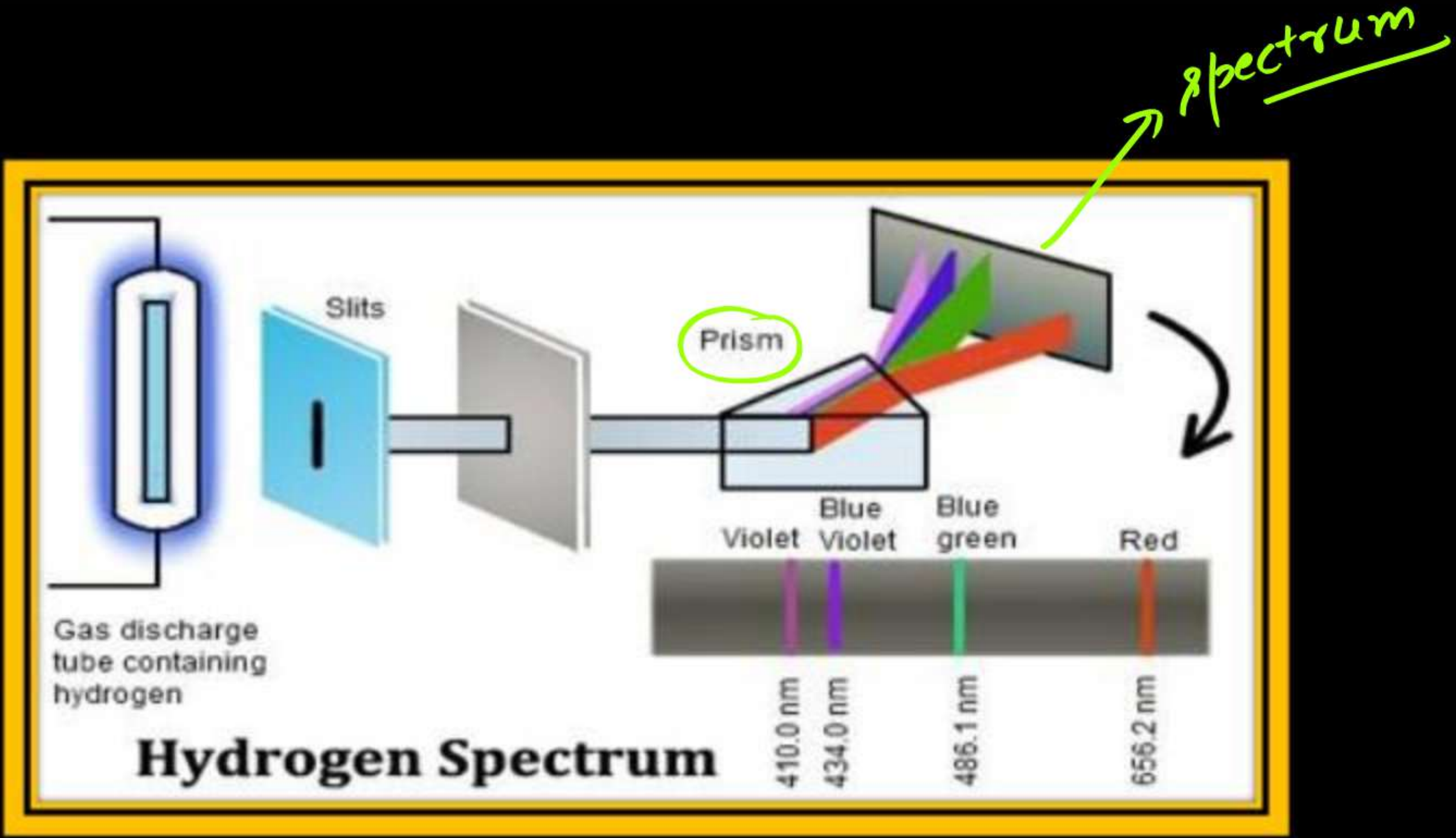
LINE SPECTRUM OF HYDROGEN

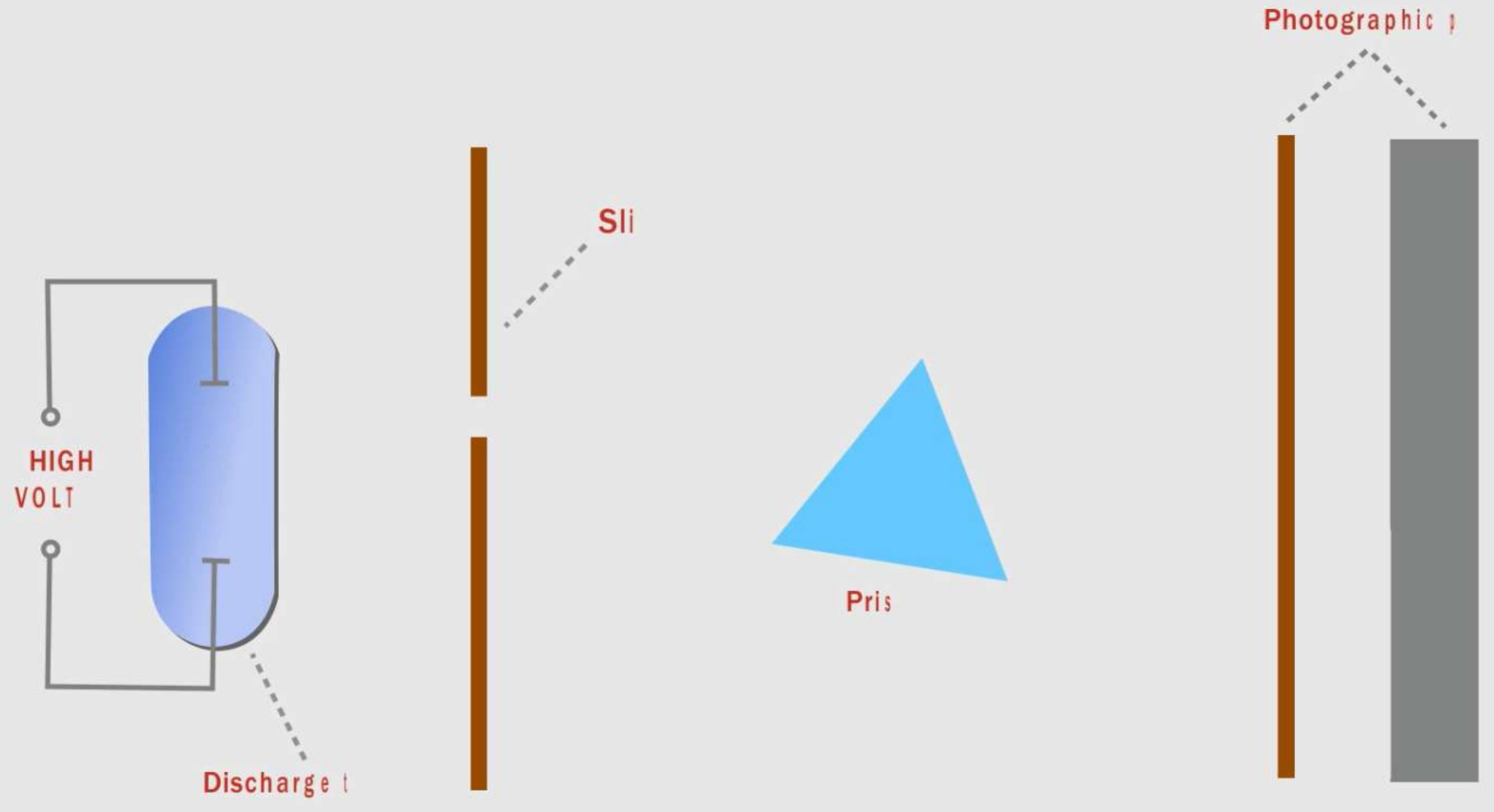
LINE SPECTRUM OF HYDROGEN

Emission Spectrum :-

When energy is provided to H_2 molecule then the dihydrogen is first splitted into hydrogen atom.

When energy is provided to the single $e^{\ominus}$ present in hydrogen atom then the $e^{\ominus}$ is excited to higher energy level for a while (10^{-6} to 10^{-8} s) highly unstable and get back after transitions.


spectrum
Slits
Prism
Gas discharge tube containing hydrogen
Violet
Blue Violet
Blue green
Red
410.0 nm
434.0 nm
486.1 nm
656.2 nm
Hydrogen Spectrum



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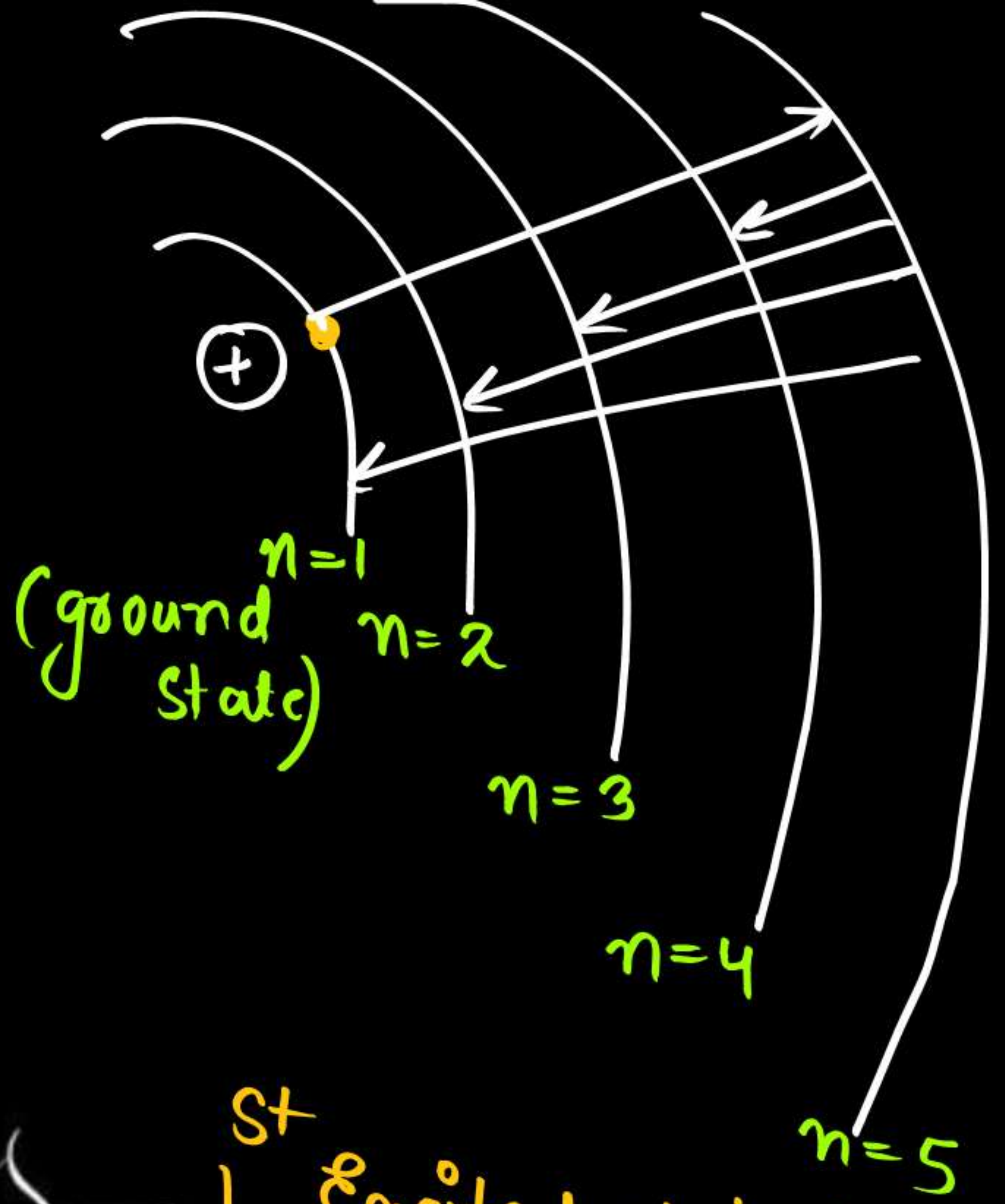


1^{st} Excited state ⇒ n = 2

$$\boxed{\bar{\nu} = \frac{1}{\lambda} = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)}$$

Z ⇒ Atomic no.

$\bar{\nu}$ = Wave number

λ = wavelength

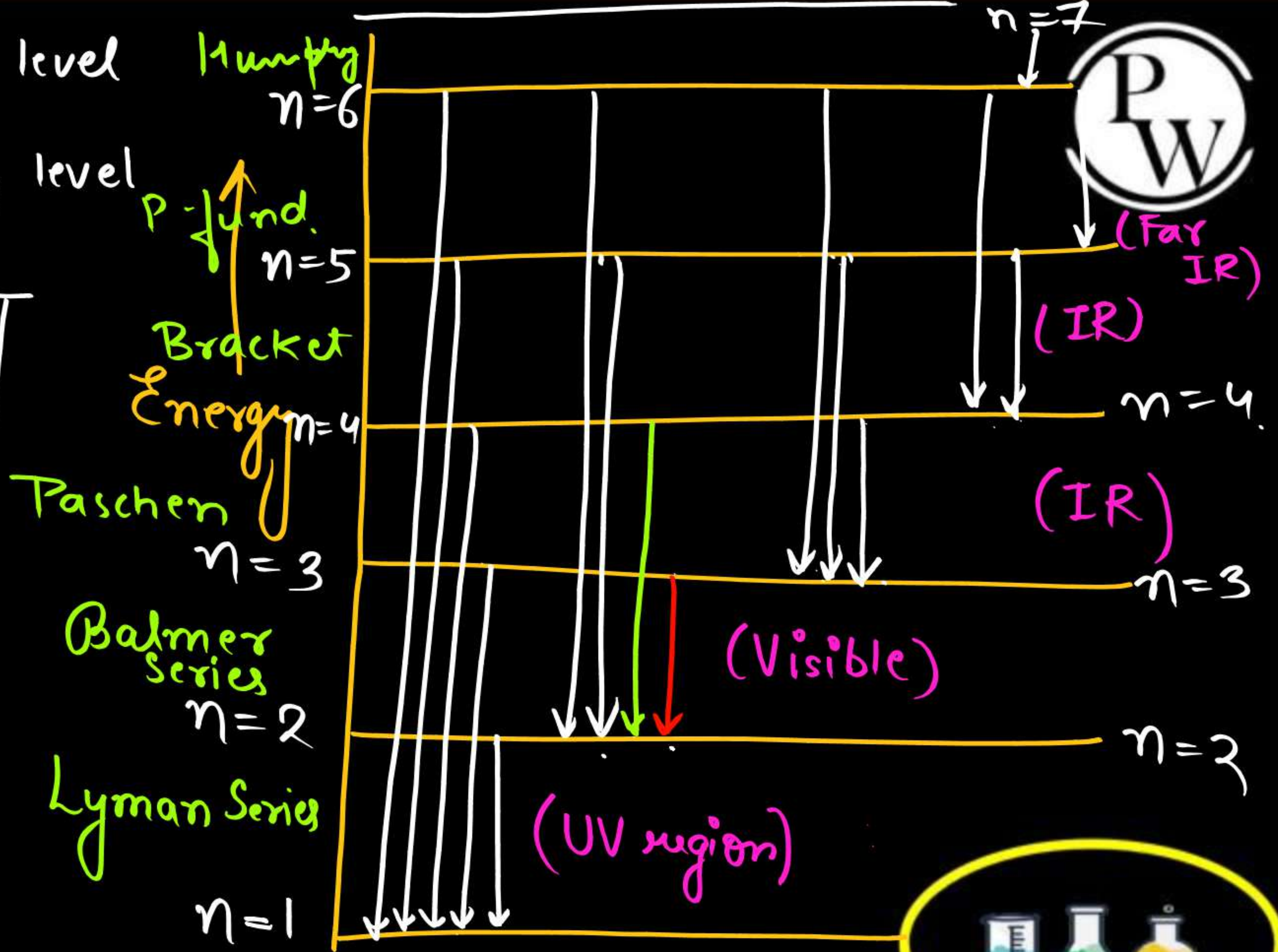
R_H = Rydberg constant = 109677 cm^{-1}

$$\boxed{\frac{1}{R} = 912\,Å}$$

$$\boxed{\frac{1}{R} = 91.2\,nm}$$

$n_1 \Rightarrow$ lower energy level

$n_2 \Rightarrow$ Higher energy level



n=7

Limiting line → Last line of any series is known as Limiting line.

$$\boxed{n_2 = \infty}$$

$$\bar{V} = \frac{1}{\lambda} = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\bar{V} = \frac{1}{\lambda} = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{(\infty)^2}\right)$$

$$\lambda \propto n_1^2$$

Total no. of spectral lines

$$\Rightarrow \frac{(n_2 - n_1)(n_2 - n_1 + 1)}{2}$$

Series	n_1	n_2	Region
Lyman Series	1	2, 3, 4, 5, 6...	UV region
Balmer series	2	3, 4, 5, 6, 7	Visible
Paschen	3	4, 5, 6, 7	Infra Red
Bracket	4	5, 6, 7	Infra Red
P-fund	5	6, 7	Infra Red
Humphrey	6	7	Far IR

$\Rightarrow$ Total no. of Spectral lines = $\sum(n_2 - n_1)$

$\Rightarrow$ For No. of lines in particular Series $\Rightarrow$ $(n_2 - n_1)$

Q. An e^- jumps from 4^{th} Excited state to ground state. Calculate total no. of spectral lines and no. of lines in a particular series.

$n_2 = 5 \qquad n_1 = 1$

Ans Total no. of spectral lines $\Rightarrow \dfrac{(n_2-n_1)(n_2-n_1+1)}{2}$

n_2-n_1 $n_2=5$

$$\Rightarrow \frac{(5-1)(5-\cancel{1}+\cancel{1})}{2}$$

$$\Rightarrow \frac{\overset{2}{\cancel{4}} \times 5}{\cancel{2}} \Rightarrow \underline{\underline{10 \text{ Lines}}}$$

No. of lines in Lyman $(n_1=1) \Rightarrow$ 4 lines

— " — Balmer $(n_1=2) \Rightarrow n_2-n_1 \Rightarrow 5-2 \Rightarrow$ 3 lines

— " — Paschen $(n_1=3) \Rightarrow n_2-n_1 \Rightarrow 5-3 \Rightarrow$ 2 lines

— " — Bracket $(n_1=4) \Rightarrow 5-4 \Rightarrow$ 1 line

OR

Total no. of Spectral lines $\Rightarrow \sum (n_2 - n_1)$

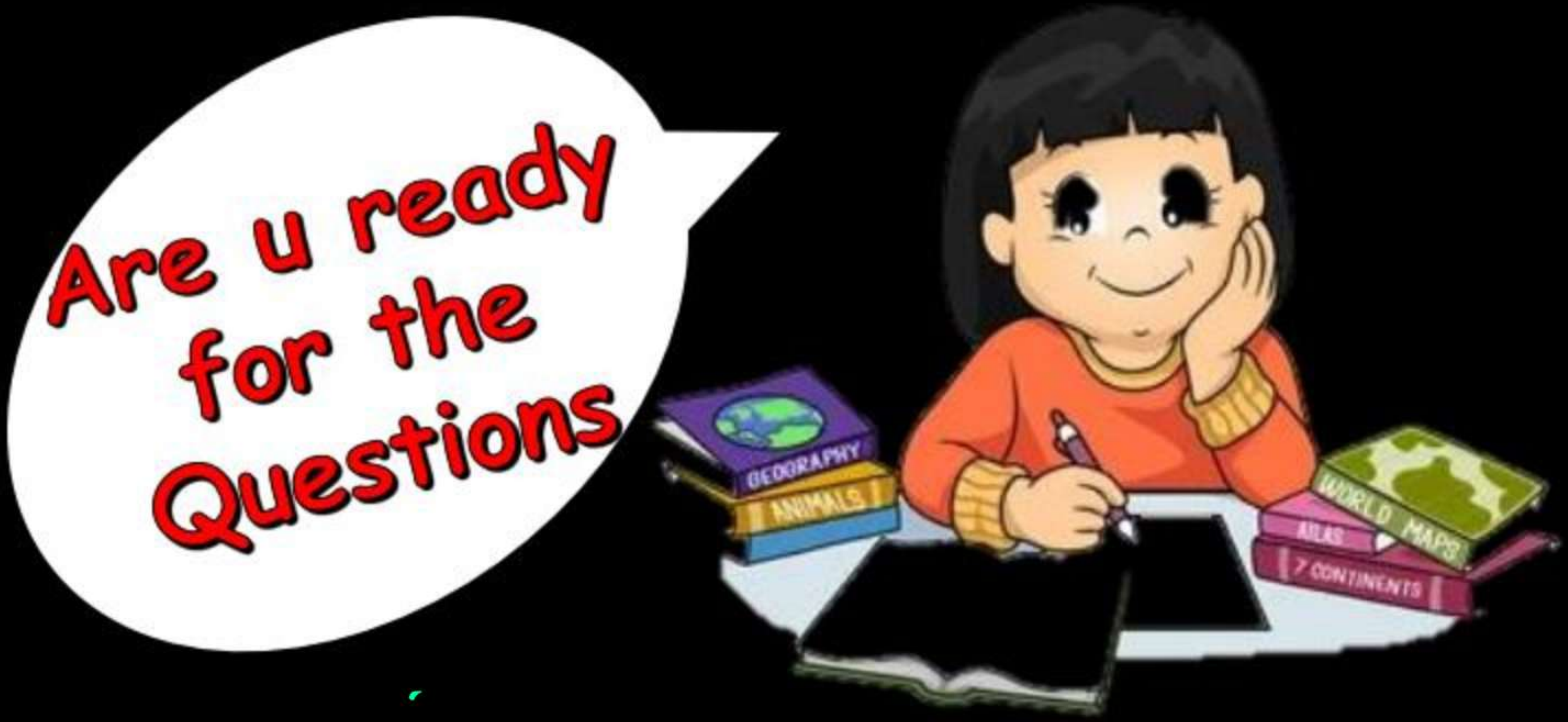
$$\Rightarrow \sum (5-1) \Rightarrow \sum 4 \Rightarrow \underset{\text{Lyman}}{4} + \underset{\text{Balmer}}{3} + \underset{\text{Paschen}}{2} + \underset{\text{Bracket}}{1}$$

$\Rightarrow$ 10 Lines

$$\boxed{\bar{\nu} = \frac{1}{\lambda}} \qquad \boxed{\nu = \frac{c}{\lambda}}$$

NOTE: $\rightarrow$ first line of any series have longest (maximum) Wavelength & minimum Energy & vice Versa.

$E \propto \frac{1}{\lambda}$


Are u ready for the Questions
GEOGRAPHY
ANIMALS
WORLD MAPS
ATLAS
7 CONTINENTS

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Q. An $e^{\ominus}$ jumps from 5^{th} excited state to ground state. Then find total line & individual lines in each series.

$n_2 = 6 \qquad n = 1$

Total no. of lines $= \sum (n_2 - n_1)$

$= \sum (6-1) \Rightarrow \sum 5$

$\Rightarrow \underset{\text{Lyman}}{5} + \underset{\text{Balmer}}{4} + \underset{\text{Paschen}}{3} + \underset{\text{Bracket}}{2} + \underset{\text{Pfund}}{1}$

$\Rightarrow$ 15 lines

OR Total no. of Lines $\Rightarrow \dfrac{(n_2 - n_1)(n_2 - n_1 + 1)}{2}$

$\Rightarrow \dfrac{(6-1)\overset{3}{(\cancel{6}-\cancel{1}+\cancel{1})}}{\cancel{2}} \Rightarrow \boxed{15 \text{ lines}}$

No. of lines in lyman $= 6-1 \Rightarrow 5$ lines

— " — Balmer $= 6-2 \Rightarrow 4$ lines

— " — Paschen $= 6-3 \Rightarrow 3$ lines

— " — Bracket $= 2$ lines

— " — Pfund $= 1$ lines

15

Q. An $e^{\ominus}$ jumps from 5^{th} excited state to 1^{st} excited state. Find no. of line in (i) Lyman (ii) Visible region

$n_2 = 6$ $n_1 = 2$

(i) Lyman series.

$\cancel{\Rightarrow n_2 - n_1}$

$\cancel{\Rightarrow 6 - 2}$

$\cancel{\Rightarrow 4 \text{ lines}}$

$\Rightarrow$ ZERO

(ii) Visible region.

$n_2 = 6.$ $n_1 = 2.$

$\Rightarrow (n_2 - n_1) \Rightarrow 6 - 2 \Rightarrow 4$ line

Q. Find the ratio of wavelength of limiting line of Lyman, Balmer & Paschen.

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

$Z = \text{const}$

$R = \text{cons.}$

$n_2 = \infty$

$$\lambda \propto n_1^2$$

$\lambda_{Lyman} : \lambda_{Balmer} : \lambda_{Paschen}$

$n_1^2 : n_2^2 : n_3^2$

$$\boxed{1 : 4 : 9}$$

Q. Find the wavelength of radiation of H-atom when $e^{\ominus}$ jumps from second excited state to ground state in A°.

H- atom $\quad Z = 1$

$n_2 = 3 \quad n_1 = 1$

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

$$\Rightarrow \frac{1}{\lambda} = R_H (1)^2 \left(\frac{1}{1} - \frac{1}{9}\right)$$

$$\Rightarrow \frac{1}{\lambda} = R_H \left(\frac{9-1}{9}\right) \Rightarrow R_H \times \frac{8}{9}$$

$$\Rightarrow \lambda = \frac{9}{8} \times \frac{1}{R}$$

$$\Rightarrow \frac{9}{8} \times 912 \Rightarrow 1026 A^{\circ}$$

Q. Find ratio of λ for 1st & 2nd line for balmer series of He.

$$\frac{1}{\lambda} = \cancel{R_H}\, \cancel{Z^2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

⇒ 1st line of Balmer of He

$Z = 2$

$n_1 = 2 \quad n_2 = 3$

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

$$\frac{1}{\lambda} = \cancel{R_H}\, \cancel{Z^2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

2nd line of Balmer of He.

$n_1 = 2 \quad n_2 = 4$

$n_1 = 2 \quad n_2 = 3$

$$\Rightarrow \frac{\dfrac{1}{\lambda_{1^{st}\text{ line of Balmer}}}}{\dfrac{1}{\lambda_{2^{nd}\text{ line of Balmer}}}} = \frac{\left(\dfrac{n_2^2 - n_1^2}{n_1^2 n_2^2}\right)}{\left(\dfrac{n_2^2 - n_1^2}{n_1^2 n_2^2}\right)} \Rightarrow \frac{\left(\dfrac{5}{36}\right)}{\left(\dfrac{12}{64}\right)}$$

$(n_1 = 2)\ (n_2 = 4)$

$$\Rightarrow \frac{\lambda_{2^{nd}}}{\lambda_{1^{s}}} = \frac{5}{\cancel{36}_{\,9}} \times \frac{\cancel{64}^{\,\cancel{16}\,4}}{\cancel{12}_{\,3}} \Rightarrow \frac{20}{27} \Rightarrow \frac{27}{20}$$

$\Rightarrow$

Q. Find the longest wavelength in Balmer series of He^{+} in nm.

$Z = 2 \qquad n_1 = 2 \qquad n_2 = 3$

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

$$\Rightarrow \frac{1}{\lambda} = R \times 4 \left(\frac{1}{4} - \frac{1}{9} \right) \Rightarrow \frac{1}{\lambda} = R_H \times \cancel{4} \left(\frac{5}{\cancel{36}\,9} \right)$$

$$\Rightarrow \lambda = \frac{1}{R} \times \frac{9}{5}$$

$$\Rightarrow \lambda = 91.2 \times \frac{9}{5}$$

$$\Rightarrow \underline{164.4\,nm}$$

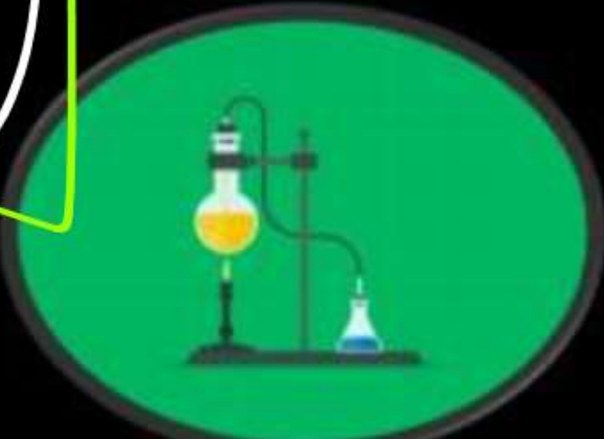
Q. **Which transition in H-atom will have the same wavelength as in second line in Balmmer of corresponding He.**

H- atom $\quad = \lambda = \quad$ Second line in Balmer series of He.

$Z = 1 \quad n_1 = ? \quad n_2 = ? \qquad\qquad n_1 = 2 \quad n_2 = 4 \quad Z = 2$

$$\frac{1}{\lambda} \Rightarrow \cancel{R_H}\, Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = \cancel{R_H}\, Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\Rightarrow 1\boxed{\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)} = 4\left(\frac{1}{4} - \frac{1}{16}\right) = \boxed{\left(\frac{1}{1} - \frac{1}{4}\right)}$$



$n_1^2 = 1$ $n_1 = 1$

$n_2^2 = 4$ $n_2 = 2$

1st Line of Lyman series

thanks
for watching

Saturday

Structure of Atom

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