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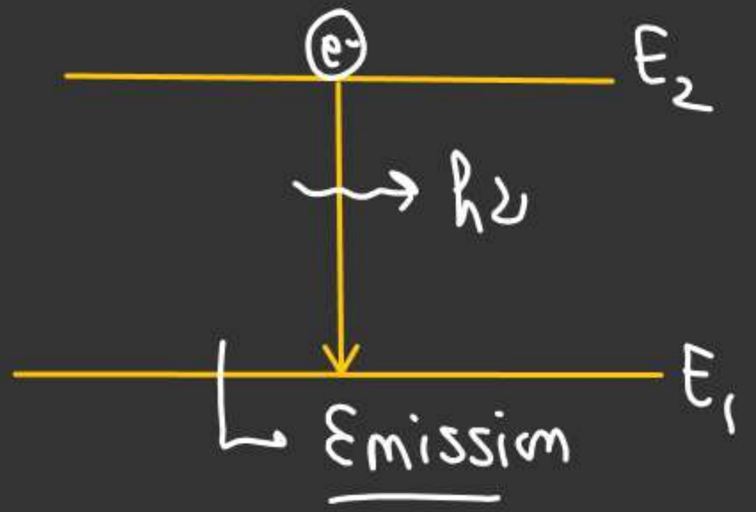
ATOMIC STRUCTURE

Bohr's Postulates :-

1. Electron's revolve around the Nucleus & Electrostatic force of attraction provides necessary Centripetal force.

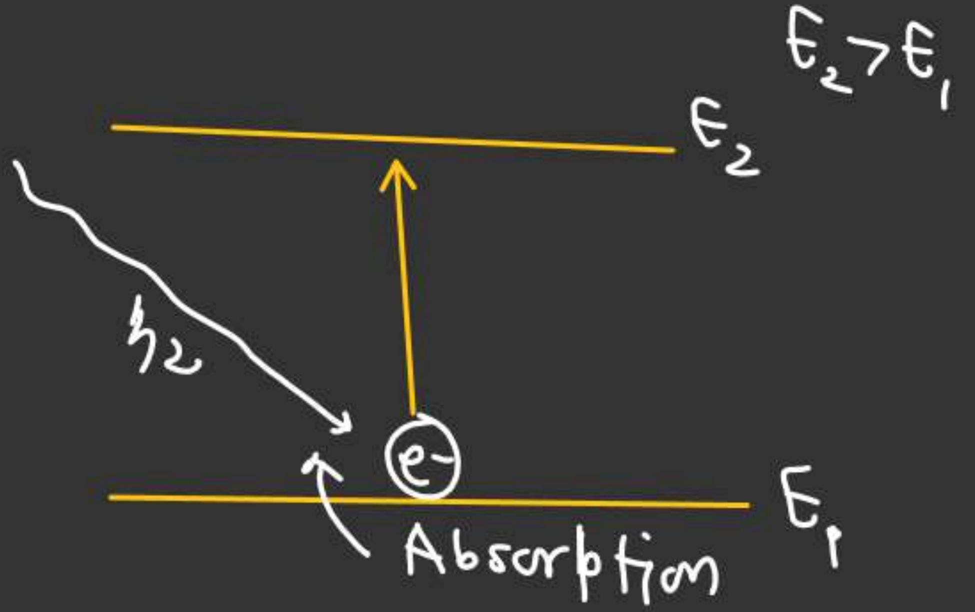
2. Electron's only emit or absorb energy in the form of photon if they have transition from higher energy level to lower energy level & vice versa.

$E = h\nu = \frac{hc}{\lambda}$



$E_2 > E_1$

$$\boxed{h\nu = E_2 - E_1}$$



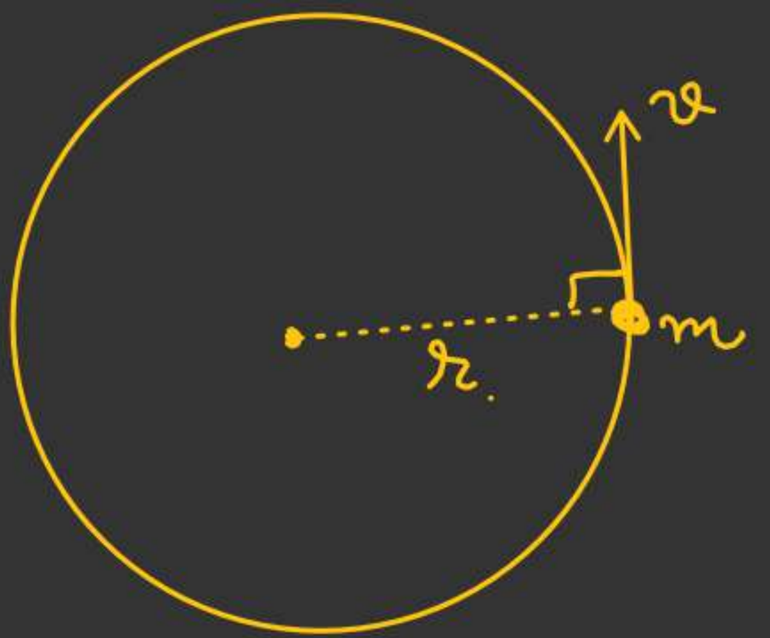
3. Stationary orbit

↳ Electron's revolving in stationary orbit neither emit radiation nor absorb any radiation such orbits are called stationary orbit.

↳ Angular Momentum of electron is quantinized.

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

$n \in I^{+}$



$p = mv.$

$L = p.r$

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Radius, velocity of nth Orbit of Hydrogen like atom

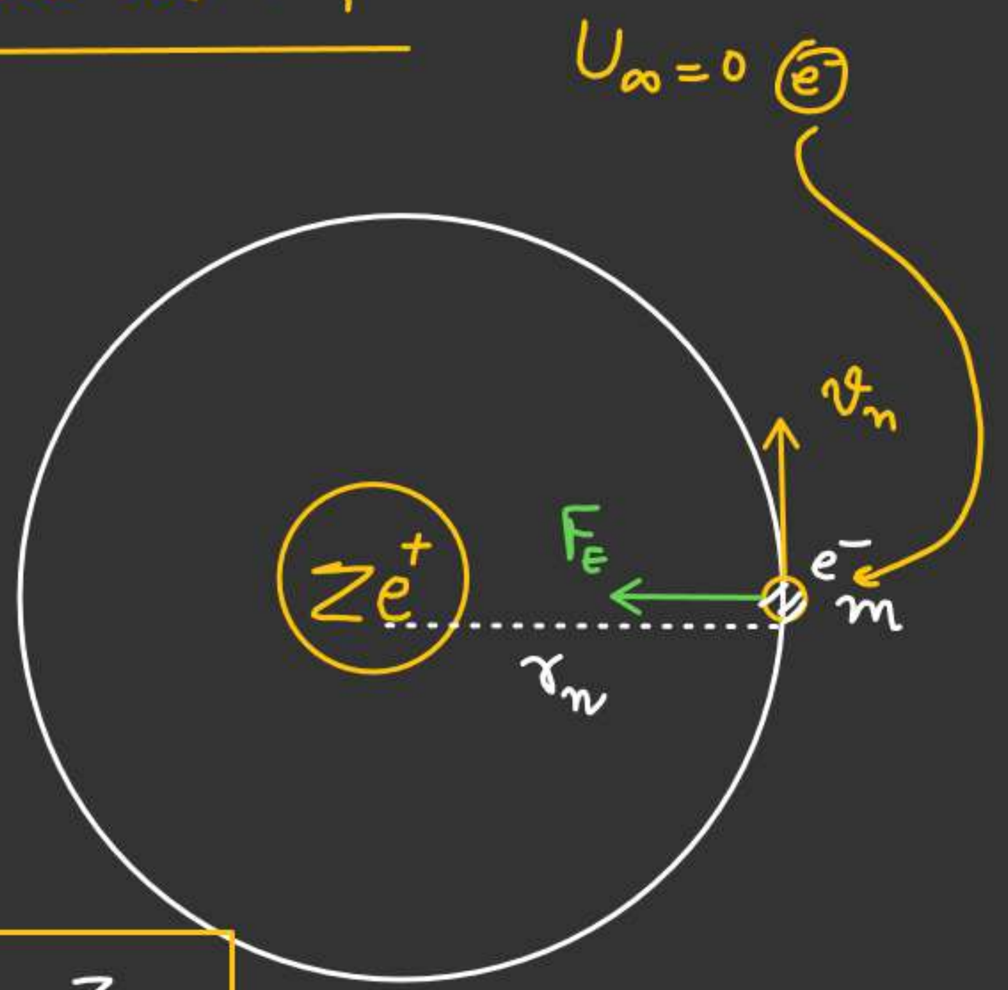
$$F_E = \frac{m v_n^2}{r_n}$$

$$\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r_n^2} = \frac{m v_n^2}{r_n} \quad -(1)$$

$$m v_n r_n = \frac{nh}{2\pi} \quad -(2)$$

h = Planck's constant

$= 6.62 \times 10^{-34}$



$$\boxed{v_n = \frac{Ze^2}{2\varepsilon_0 n h}}$$

$$\boxed{r_n = \frac{\varepsilon_0 n^2 h^2}{\pi m Z e^2}}$$

$$\boxed{v_n \propto Z/n \qquad r \propto \frac{n^2}{Z}}$$

$$\boxed{v_n = (2.18 \times 10^6)\left(\frac{Z}{n}\right)}$$

$\downarrow$ m/s

$$\boxed{r_n = 0.529\,\text{Å} \times \frac{n^2}{Z}}$$

$\text{Å} \rightarrow 10^{-10}\,m$

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Energy of an electron in the nth orbit (Hydrogen like)

$$E_T = (P.E + K.E)$$

$$P.E = \frac{(Ze)(-e)}{4\pi\varepsilon_0 r_n}$$

$$P.E = -\frac{Ze^2}{4\pi\varepsilon_0 r_n}$$

$$P.E = -\frac{Ze^2}{4\cancel{\pi}\varepsilon_0} \times \left(\frac{\cancel{\pi} m Z e^2}{\varepsilon_0 n^2 h^2}\right)$$

$$P.E = -\frac{Z^2 e^4 m}{4\varepsilon_0^2 n^2 h^2}$$

$$\boxed{P.E = -\left(\frac{me^4}{4\varepsilon_0^2 h^2}\right) \times \frac{Z^2}{n^2}} \quad -①$$

$$K.E = \frac{1}{2} m v_n^2$$

$$K.E = \frac{1}{2} m \left(\frac{Ze^2}{2\varepsilon_0 n h}\right)^2$$

$$K.E = \frac{1}{2} m \frac{Z^2 e^4}{4\varepsilon_0^2 h^2 n^2}$$

$$\boxed{K.E = \left(\frac{me^4}{8\varepsilon_0^2 h^2}\right) \frac{Z^2}{n^2}} \quad -②$$

$$\boxed{K.E = |E_T| = \frac{|P.E|}{2}}$$

$$F \propto \frac{1}{r^2}$$

$$E_T = P.E + K.E$$

$$\boxed{E_T = -\frac{me^4}{8\varepsilon_0^2 h^2}\left(\frac{Z^2}{n^2}\right)} \quad ③$$

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Putting value of all constants.

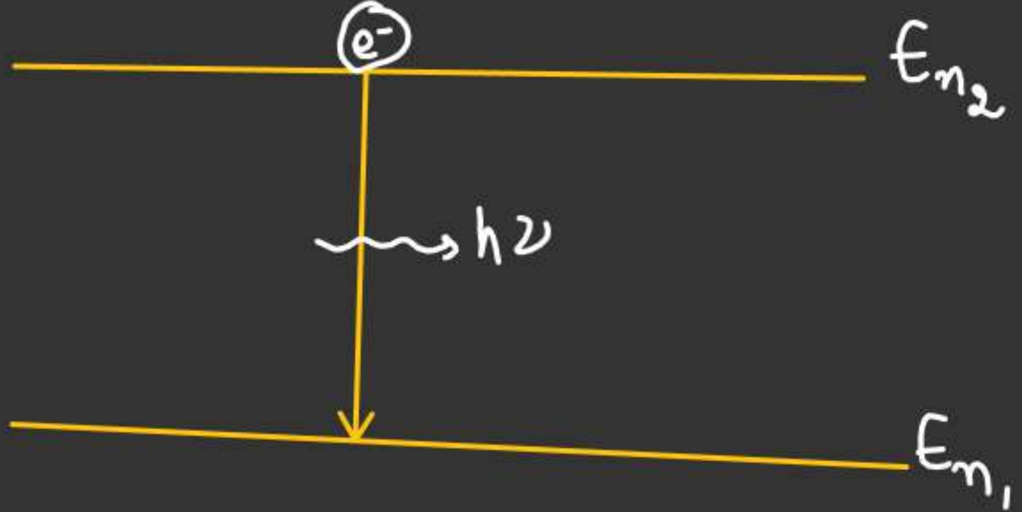
$$\boxed{K.E = \frac{13.6\,(e.v) \times z^2}{n^2}}$$

$$\boxed{P.E = -27.2\,(e.v) \times \frac{z^2}{n^2}}$$

$$\boxed{E_T = -13.6\,(e.v) \times \frac{z^2}{n^2}}$$

⇓

[Total Energy of Hydrogen like atom at nth orbit



$$E_{n_2} - E_{n_1} = \frac{hc}{\lambda}$$

$$\frac{-13.6\,z^2}{n_2^2} - \left(-\frac{13.6\,z^2}{n_1^2}\right) = \frac{hc}{\lambda}$$

$$13.6\,z^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = \frac{hc}{\lambda}$$

$$\boxed{\frac{1}{\lambda} = \frac{13.6\,z^2}{hc}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]} \rightarrow \boxed{\frac{1}{\lambda} = Rz^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]}$$

$$Rhc = 13.6$$

$$R = \frac{13.6}{hc}$$

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Hydrogen Spectrum

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

for hydrogen $Z = 1$.

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

$(n_2 > n_1)$

$\lambda_{min} \Rightarrow (\Delta E)_{max}$

$\Downarrow$

$n_1 = 1;\ n_2 \to \infty$

$\frac{hc}{\lambda} = \Delta E$

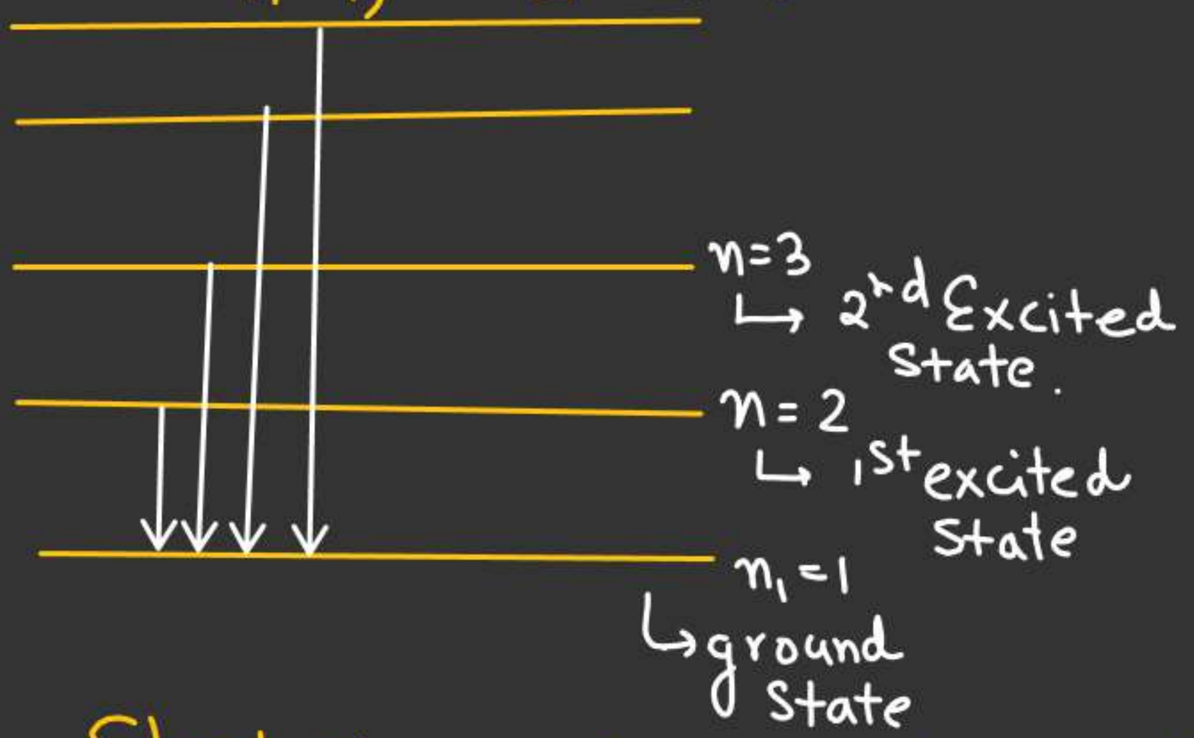
$\lambda = \frac{hc}{\Delta E}$

$\lambda_{max} \Rightarrow (\Delta E)_{min}$

$\hookrightarrow n_1 = n,\ n_2 = (n+1)$

Lyman Series (Ultraviolet)

$n_1 = 1,\quad n_2 = 2, 3, 4 \ldots$



Shortest wavelength & longest wavelength Corresponding to Lyman Series.

$$\frac{1}{\lambda_{min}} = R\left[\frac{1}{(1)^2} - \frac{1}{\infty}\right] = R$$

$$\lambda_{min} = \frac{1}{R}$$

$$\frac{1}{\lambda_{max}} = R\left[\frac{1}{(1)^2} - \frac{1}{(2)^2}\right]$$

$$\frac{1}{\lambda_{max}} = \frac{3R}{4}$$

$$\lambda_{max} = \frac{4}{3R}$$

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** Balmar Series (Visible zone)

$n_1 = 2, \quad n_2 = 3, 4, 5, 6 \ldots$

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

** Paschen Series (Infra red)

$n_1 = 3, \quad n_2 = 4, 5, 6 \ldots$

$$\frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{n_2^2}\right]$$

** Bracket Series (Infra Red)

$n_1 = 4, \quad n_2 = 5, 6, 7, \ldots$

$$\frac{1}{\lambda} = R\left[\frac{1}{4^2} - \frac{1}{n_2^2}\right]$$

** P- fund.

$n_1 = 5, \quad n_2 = 6, 7, 8 \ldots$

$$\frac{1}{\lambda} = R\left[\frac{1}{5^2} - \frac{1}{n_2^2}\right]$$

Ex:-

Balmar.

$$\frac{1}{\lambda_{min}} = R\left[\frac{1}{4} - \frac{1}{\infty}\right]$$

$$\lambda_{min} = \frac{4}{R} \checkmark$$

$$\frac{1}{\lambda_{max}} = R\left[\frac{1}{4} - \frac{1}{9}\right]$$

$$\frac{1}{\lambda_{max}} = \frac{R5}{36} \checkmark$$

:

$$\boxed{\begin{aligned} hc &\approx 12375\ (e \cdot V) \\ &\approx 12422\ (e \cdot V) \end{aligned}}$$

: <u>For hydrogen</u> $E_T = -\frac{13.6}{n^2}$

$n = 4$ $(-0.85\ e \cdot v)$

$n = 3$ $(-1.5\ e \cdot v)$

$n = 2$ $(-3.4\ ev)$

$n = 1$ $(-13.6\ e \cdot v)$

ATOMIC STRUCTURE

Q.21 A particle of mass m moves in circular orbits with potential energy $V(r) = Fr$, where F is a positive constant and r is its distance from the origin. Its energies are calculated using the Bohr model. If the radius of the particle's orbit is denoted by R and its speed and energy are denoted by v and E, respectively, then for the n^{th} orbit (Here h is the Planck's constant.) **(2020)**

(A) $R \propto n^{1/3}$ and $v \propto n^{2/3}$

(B) $R \propto n^{2/3}$ and $v \propto n^{1/3}$

(C) $E = \frac{3}{2}\left(\frac{n^2h^2F^2}{4\pi^2 m}\right)^{1/3}$

(D) $E = 2\left(\frac{n^2h^2F^2}{4\pi^2 m}\right)^{1/3}$

$U(r) = Fr.$

$F_c = -\frac{dU(r)}{dr} = -F\frac{d}{dr}(r) = -F$

$F = \frac{mv^2}{R}$ — (1)

$mvr = \frac{nh}{2\pi}$ — (2)

$E_T = P.E + K.E$

$= F(r) + \frac{1}{2}mv^2$

(B, C) check

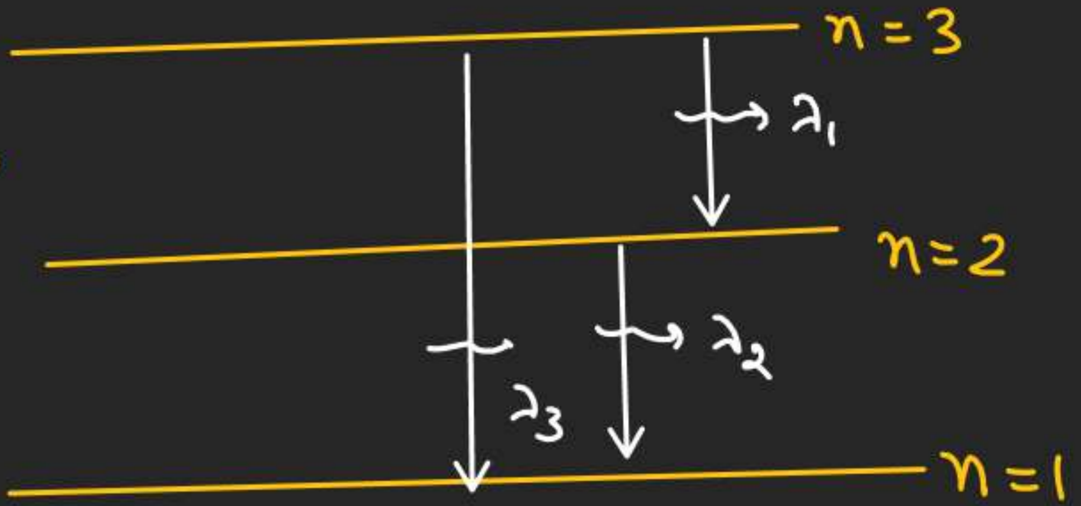
ATOMIC STRUCTURE

Q.22 The radius of the orbit of an electron in a Hydrogenlike atom is $4.5a_0$, where a_0 is the Bohr radius. Its orbital angular momentum is $\frac{3h}{2\pi}$. It is given that h is Planck constant and R is Rydberg constant. The possible wavelength(s), when the atom de-excites, is (are) **(2013)**

(A) $\frac{9}{32R}$ ✓ (B) $\frac{9}{16R}$ (C) $\frac{9}{5R}$ ✓ (D) $\frac{4}{3R}$

a_0 = Bhor's orbit $= 0.529\,\mathring{A}$

$^3C_2 = \frac{3!}{2!\,1!} = 3$



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

Angular Momentum

$\frac{3h}{2\pi} = \frac{nh}{2\pi} \Rightarrow n = 3$ ✓

$4.5a_0 = r = \frac{a_0 n^2}{Z}$

$Z = \frac{9}{4.5} = \frac{90}{45}$

$Z = 2$

$\frac{1}{\lambda_1} = RZ^2\left[\frac{1}{3^2} - \frac{1}{2^2}\right]$, $\frac{1}{\lambda_2} = ?$ $\frac{1}{\lambda_3} = ?$