ARJUNA NEET BATCH

Atomic Structure

DPP-06

$E \propto \frac{1}{\lambda}$ → highest energy → $n_1 = 1$, $n_2 = \infty$ $\quad Z = 1$

1. If the shortest wavelength in Lyman series of hydrogen atom is A, then the longest wavelength in Paschen series of He^+ is

lowest energy → $n_1 = 3$ → $n_2 = 4$ $\quad Z = 2$

(A) $\frac{5A}{9}$ (B) $\frac{9A}{5}$

(C) $\frac{36A}{5}$ (D) $\frac{36A}{7}$

R → Rydberg constant

for Lyman series

$$\boxed{\bar{\nu} = \frac{1}{\lambda} = 109{,}677\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) Z^2 \text{ cm}^{-1}}$$

$$\frac{1}{\lambda} = 109{,}677\left(\frac{1}{1} - \frac{1}{\infty}\right)(1)^2$$

$$\frac{1}{A} = 109677$$

$$\boxed{\frac{1}{109677} = A}$$

For Paschen series.

$$\frac{1}{\lambda} = 109677\left(\frac{1}{3^2} - \frac{1}{4^2}\right)(2)^2 \text{ cm}^{-1}$$

$$\frac{1}{\lambda} = 109677\left(\frac{7}{144}\right) \times 4$$

$$\lambda = \frac{1}{109677}\left(\frac{\cancel{144}\ 36}{7 \times \cancel{4}}\right)$$

$$\boxed{\lambda = \frac{36A}{7}}$$

$\bar{\nu}$ $\quad n_1 = 2$

2. The wave number of the first emission line in the Balmer series of H-spectrum is: (R = Rydberg constant)

$Z = 1$ $\quad n_1 = 2, \; n_2 = 3$

(A) $\frac{5}{36}R$ (B) $\frac{9}{400}R$

(C) $\frac{7}{6}R$ (D) $\frac{3}{4}R$

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

$$= R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$\boxed{\bar{\nu} = \frac{5R}{36}}$$

$n_2 = 5$ $n_1 = 1$ $(Z = 1)$

3. An $e^{\ominus}$ jumps from 4^{th} Excited state to ground state in H-atom, then find total lines.

(A) 10 (B) 9

(C) 8 (D) 7

Possible lines $= \dfrac{(n_2 - n_1)(n_2 - n_1 + 1)}{2} = \dfrac{(5-1)(5-1+1)}{2}$

$= \dfrac{20}{2}$

$= \boxed{10}$ Ans.

$n_2 = 5$ $n_1 = 2$

4. An $e^{\ominus}$ jumps from 4^{th} Excited state to 1^{st} excited state. Find no. of lines in Lyman series. $\rightarrow n_1 = 1$

(A) 5

(B) 4

(C) 15

(D) Zero

Electron jump from $n_2 = 5$ to $n_1 = 2$

but for lyman series, $n_1 = 1$. So no lines will fall in $n_1 = 1$

$\boxed{\therefore \text{ zero spectral lines}}$

lower energy

$n_1 = 1$ to $n_2 = 2$

5. The ratio of the frequencies of the long wavelength limits of Lyman and Balmer series of hydrogen spectrum is

$n_1 = 2$ $\quad$ $Z = 1$

(A) 27 : 5 $\qquad$ (B) 5 : 27

(C) 4 : 1 $\qquad$ (D) 1 : 4

For lower energy

Lyman series

$n_1 = 1$ to $n_2 = 2$

Balmer series

$n_1 = 2$ to $n_2 = 3$

$$\bar{\nu} = \frac{1}{\lambda} = \frac{\nu}{c}, \quad \bar{\nu} \propto \nu$$

$$\nu \propto \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

Lyman, $\nu \propto \left(\frac{1}{1^2} - \frac{1}{2^2}\right) \Rightarrow \left(\frac{1}{1} - \frac{1}{4}\right), \nu = \frac{3}{4}R$

Balmer, $\nu \propto \left(\frac{1}{2^2} - \frac{1}{3^2}\right) \Rightarrow \left(\frac{1}{4} - \frac{1}{9}\right), \nu = \frac{5}{36}R$

$$\frac{\nu_{Lyman}}{\nu_{Balmer}} = \frac{3R/4}{5R/36} = \frac{3}{\cancel{4}} \times \frac{\cancel{36}\,9}{5} = \frac{27}{5} \Rightarrow \boxed{27:5}$$

Ans.

Ground state to infinity

6. Find the ratio of wavelength of Limiting line of Lyman, Balmer and Paschen.

$n_1 = 1$ $\quad n_1 = 2$ $\quad n_1 = 3$

(A) 1 : 4 : 9 (B) 9 : 4 : 1

(C) 2 : 3 : 6 (D) 4 : 1 : 9

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

$$\frac{1}{\lambda_{Lyman}} = R\left(\frac{1}{1} - \frac{1}{\infty}\right) = R \Rightarrow \lambda_{Lyman} = \frac{1}{R}$$

$$\frac{1}{\lambda_{Balmer}} = R\left(\frac{1}{4} - \frac{1}{\infty}\right) = \frac{R}{4} \Rightarrow \lambda_{Balmer} = \frac{4}{R}$$

$$\frac{1}{\lambda_{Paschen}} = R\left(\frac{1}{9} - \frac{1}{\infty}\right) = \frac{R}{9} \Rightarrow \lambda_{Paschen} = \frac{9}{R}$$

$$\lambda_L : \lambda_B : \lambda_P = \frac{1}{R} : \frac{4}{R} : \frac{9}{R} \Rightarrow \boxed{1:4:9}$$

Ans.

7. Find the wavelength of light emitted when $e^{\ominus}$ jumps from second excited state to Ground state in H-atom.

λ $n = 3$

$n = 1$

(A) $\boxed{1026}$ Å

(B) 560 Å

(C) 6011 Å

(D) 512 Å

$$\boxed{n_1 = 1 \text{ to } n_2 = 3}$$

$$\frac{1}{\lambda} = 109677\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \text{cm}^{-1}$$

$$1/\lambda = 109677\left(\frac{1}{1} - \frac{1}{9}\right) \text{cm}^{-1} \Rightarrow 109677\left(\frac{8}{9}\right) \text{cm}^{-1}$$

$$(1\text{cm} = 10^8 \text{Å})$$

$$\lambda = \frac{9}{8 \times 109677} \text{cm}$$

$$\lambda = \frac{9 \times 10^8}{8 \times 109677} \text{Å} = 1025.7 \text{Å} \approx \boxed{1026 \text{Å}}$$ Ans

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8. How many spectral lines are seen for hydrogen atom when electron jump from $n_2 = 5$ to $n_1 = 1$ in visible region? → Balmer series, $n_1 = 2$

(A) 2

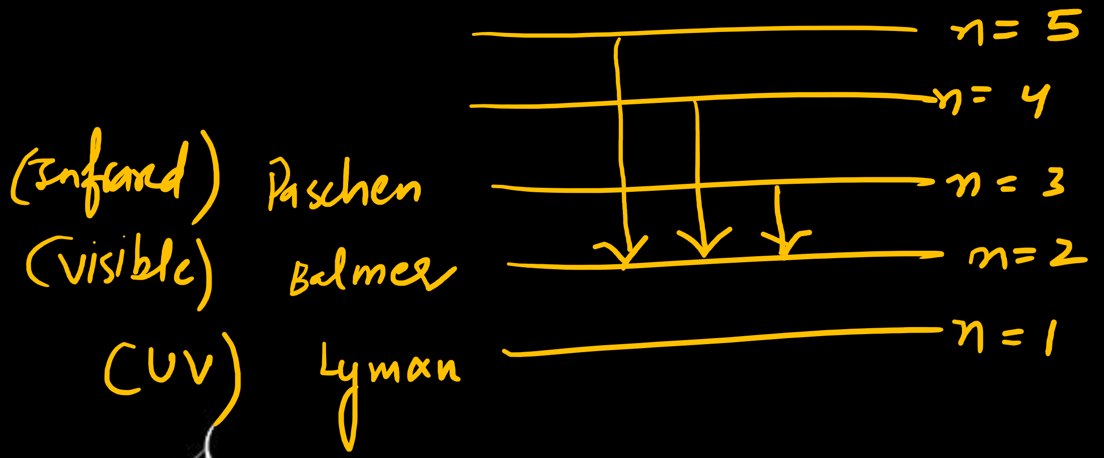
~~(B)~~ 3

(C) 4

(D) 5

$$\boxed{n_2 = 5 \text{ to } n_1 = 2}$$

lines = ?



$$\boxed{\text{No. of spectral lines} = 3}$$

9. Calculate the wavelength of the photon that is emitted when an electron in Bohr orbit n = 2 returns to the orbit n = 1 in the hydrogen atom

$n_2 > n_1$

$n_1 = 1, \; n_2 = 2$

$(Z = 1)$

$$\frac{1}{\lambda} = 109677\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\frac{1}{\lambda} = 109677\left(\frac{1}{1} - \frac{1}{4}\right)$$

$$\lambda = \frac{4}{3 \times 109677}\ \text{cm} = \boxed{1.2156 \times 10^{-5}\ \text{cm}}$$

$1\ \text{cm} = 10^{7}\ \text{nm}$

$1\ \text{cm} = 10^{8}\ \text{Å}$

$\lambda = 1.2156 \times 10^{-5} \times 10^{7}\ \text{nm}$

$$\boxed{\lambda = 121.56\ \text{nm}}$$

$\lambda = 1.2156 \times 10^{-5} \times 10^{8}\ \text{Å}$

$$\boxed{\lambda = 1215.6\ \text{Å}}$$

$\checkmark\ n_1 = 1$ to $n_2 = 2$

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

10. Calculate the wavelengths of the first line and the last line in the Lyman series of hydrogen atom

$n_1 = 1$

$$\frac{1}{\lambda} = 109677\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) cm^{-1}$$

First line, $n_1 = 1$ to $n_2 = 2$

$$\frac{1}{\lambda} = 109677\left(\frac{1}{1} - \frac{1}{4}\right) cm^{-1}$$

$$\boxed{\lambda = 1.2156 \times 10^{-5}\ cm}$$

$$\lambda = 1.2156 \times 10^{-5} \times 10^{7}\ nm$$

$$\boxed{\begin{aligned}\lambda &= 121.56\ nm \\ \lambda &= 1215.6\ \mathring{A}\end{aligned}}$$

$\times 10$

Last line, $n_1 = 1$ to $n_2 = \infty$

$$\frac{1}{\lambda} = 109677\left(\frac{1}{1} - \frac{1}{\infty}\right) cm^{-1}$$

$$\lambda = \frac{1}{109677}\ cm$$

$$\boxed{\lambda = 9.1176 \times 10^{-6}\ cm}$$

$$\lambda = 9.1176 \times 10^{-6} \times 10^{7}\ nm$$

$$\boxed{\begin{aligned}\lambda &= 91.17\ nm \\ \lambda &= 911.7\ \mathring{A}\end{aligned}}$$

$1\ cm = 10^7\ nm$

$1\ cm = 10^8\ \mathring{A}$

$1\ nm = 10\ A$

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Thank You