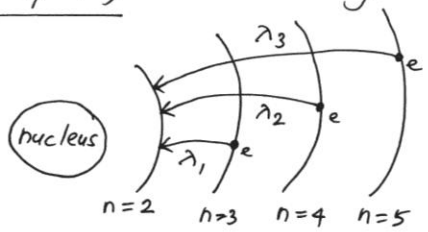
Sem 1 (2009/2010) : Quantum Theory

Q_1 (a)



$$\frac{1}{\lambda} = Z^2 R_H \left[\frac{1}{2^2} - \frac{1}{n^2}\right]$$

Li^{2+} ($Z = 3$) - has a single electron.
(Same as H atom - Bohr Theory can be used)

($n = 3 \rightarrow n = 2$)

$$\frac{1}{\lambda_1} = 3^2 (109678\ cm^{-1})\left(\frac{1}{4} - \frac{1}{3^2}\right)$$

$$= 9(109678)(0.25 - 0.11)\ cm^{-1} = 1.382 \times 10^5\ cm^{-1}$$

$$\therefore \lambda_1 = \left(\frac{1}{1.382 \times 10^5}\right) \times 10^7\ nm$$

$$= 72.36\ nm\ (Ans)$$

($n = 4 \rightarrow n = 2$)

$$\frac{1}{\lambda_2} = 9(109678)\left(0.25 - \frac{1}{4^2}\right) cm^{-1}$$

$$= 1.851 \times 10^5\ cm^{-1}$$

$$\therefore \lambda_2 = \left(\frac{1}{1.851 \times 10^5}\right)(10^7)\ nm$$

$$= 54.0\ nm\ (Ans)$$

($n = 5 \rightarrow n = 2$)

$$\frac{1}{\lambda_3} = 9\left(109678\right)\left(0.25 - \frac{1}{5^2}\right) cm^{-1}$$

$$= 2.073 \times 10^5\ cm^{-1}$$

$$\lambda_3 = \left(\frac{1}{(2.073 \times 10^5)}\right) \times 10^7\ nm$$

$$= 48.2\ nm\ (Ans).$$

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Q1 (6) C (2.4) $\xrightarrow{-5e^-}$ C^{5+} (1, $Z=6$) ← Bohr Theory can be used for this C^{5+} ion (pseudo-hidrogen atom)

Given that: $r = \frac{\epsilon_0 n^2 h^2}{\pi m e^2 Z}$

For H atom ($Z=1$): $r_H = \frac{\epsilon_0 (1^2) h^2}{\pi m e^2 (1)} = \frac{\epsilon_0 h^2}{\pi m e^2}$

For C^{5+} ion ($Z=6$): $r_{C^{5+}} = \frac{\epsilon_0 (1^2) h^2}{\pi m e^2 (6)} = \frac{\epsilon_0 h^2}{6 \pi m e^2}$

$$\frac{r_{C^{5+}}}{r_H} = \frac{\left(\frac{\epsilon_0 h^2}{6\pi m e^2}\right)}{\left(\frac{\epsilon_0 h^2}{\pi m e^2}\right)} = \frac{1}{6}$$

$$\therefore r_{C^{5+}} = \frac{1}{6} r_H$$

∴ The first Bohr orbit of this C^{5+} species is one sixth (1/6) of hydrogen atom. ie. radius for C^{5+} is six time smaller compared to radius of H atom.
This is because in H atom, there is only one proton in the nucleus. However in C^{5+}, there are 6 protons. Therefore the electrostatic attraction of the six protons in C^{5+} species is six times stronger than in H atom.

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