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Physics Tutorial - 8

Q.1. Balmer series

Shortest wavelength = ? , longest wavelength = ?

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \qquad R = 1.097 \times 10^7 \ m^{-1}$$

$n_1 = 2$, $n_2 = \infty$ for shortest wavelength

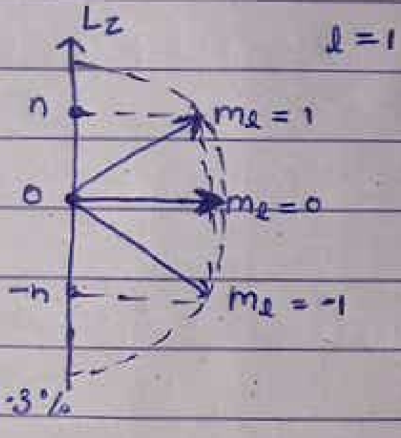
$\lambda_s = 364.6 \ nm$ Ans

$n_1 = 2$, $n_2 = 3$ for longest wavelength

$\lambda_L = 656.3 \ nm$ Ans

Q.2. 32 elements (6s, 4f, 5d, 6p → 16 orbitals → 32 e^-)

Q.3. P state



$l = 1$

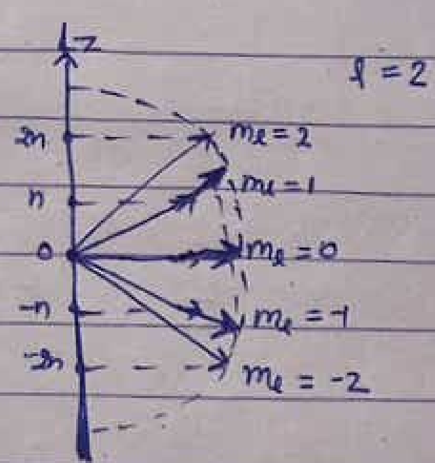
$m_l = 0 \pm 1$

$L = \sqrt{l(l+1)}\hbar = \sqrt{2}\hbar$

$L_z(max) = \hbar$

Percentage difference = $\frac{\sqrt{2}-1}{\sqrt{2}} \times 100 = 29.3\%$

d State



$l = 2$

$m_l = 0, \pm 1, \pm 2$

$L = \sqrt{l(l+1)}\hbar = \sqrt{6}\hbar$

$L_z(max) = 2\hbar$

Perc. diff. = $\frac{\sqrt{6}-2}{\sqrt{6}} \times 100 = 18.4\%$

f state

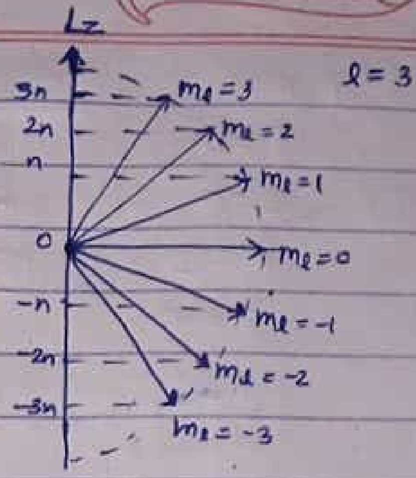
$l = 3$

$m_l = 0, \pm 1, \pm 2, \pm 3$

$L = \sqrt{l(l+1)}\hbar = \sqrt{12}\hbar$

$L_z(max) = 3\hbar$

$\% \text{ diff.} = \frac{\sqrt{12} - 3}{\sqrt{12}} \times 100 = 13.4\%$



Q.4. orbital angular momentum :

$|\vec{L}| = \hbar\sqrt{l(l+1)}$

$L_z = m_l\hbar$

$= -\hbar, 0, +\hbar$ ✓

$2\,^2P_{3/2} \rightarrow n = 2$

$L = 1$

$M_l = 3, \; M = 2$

$J = 1/2$

$S = 1/2$

Spin Angular momentum :

$S_z = m_s\hbar = -\frac{\hbar}{2}, +\frac{\hbar}{2}$ ✓

Total Angular momentum :

$J = |l \pm s| = |l+s| \rightarrow |l-s| = 3/2 \rightarrow 1/2$

$J_z = \frac{3}{2}\hbar, \hbar, 1/2\hbar$ ✓

Q.5. $2\,^2P_{5/2}, \; 2\,^2P_{7/2}$

$n = 2$

$l = 0, 1 \longrightarrow l = 0, s = 1/2, j = 1/2, M = 2$, so $2\,^2S_{1/2}$

$l = 1, s = 1/2, j = 1/2, 3/2, M = 2$, so $2\,^2P_{1/2}, 2\,^2P_{3/2}$

$J \rightarrow 1/2$ to $3/2$ in p orbital

$J = 5/2, 7/2$ not exist

They are impossible to exist because the e^- cannot stable, occur in their orbital.

Q.6. ~~The lowest excited state of~~

For He atom $He \rightarrow 1s^2$

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① $n=1$ ② $n=2 \rightarrow 1s^1 2s^1, 1s^1 2p^1, 2s^2, 2s^1 2p^1, 2p^2$

$l=0$ ~~$l=0,1$~~

$S=0$ ~~(i) $l=0$,~~

$M=1$ ③ $n=3 \rightarrow 2p^1 3s^1, 2s^1 . 3s^1, 3s^2, 3s^1 3p^1$.

$J=0$

1^1S_0

Q.7. $l = 2$ state $\begin{cases} m_l = 2 \\ m_l = 1 \\ m_l = 0 \end{cases}$

for $\Rightarrow s = 1/2, 3/2, 1, 0$.

$J = 5/2, 7/2, 3, 2$ ✓ Ans

Q.8. $\Delta E = \frac{e h B}{2m\pi} \rightarrow B = \frac{2\pi m \Delta E}{eh}$ —① $v = \frac{c}{\lambda} \rightarrow \Delta v = \frac{c\Delta\lambda}{\lambda^2}$

$\Delta E = h\Delta v = \frac{hc\Delta\lambda}{\lambda^2}$ —② from ① & ②: $B = \frac{2\pi m}{e\cancel{h}} \frac{\cancel{h}c\Delta\lambda}{\lambda^2}$

$B = \frac{2\pi m c\Delta\lambda}{e\lambda^2} = 18.61T$ Ans

Q.9. $\Delta\lambda = \frac{\mu_B \lambda^2}{hc} = \frac{9.27\times10^{-2}\times0.3\times(450\times10^{-9})^2}{6.63\times10^{-34}\times3\times10^8} = 2.83\times10^{-12} m$ Ans

$\left(\mu_B = \frac{eh}{4\pi m}\right)$

Q.10. $\Delta\lambda = \frac{eB\lambda^2}{4\pi mc}$, $\Delta\lambda = 3.23\times10^{-11} m$, $B = 5T$

$\lambda = 5\times10^{-7} m$, $c = 3\times10^8 m/s$

$3.23\times10^{-11} = \frac{e\times5\times(5\times10^{-7})^2}{m\times4\times3.14\times3\times10^8}$

$\frac{e}{m} = 4.868\times10^{11}$ Ans