MSE228 Engineering Quantum Mechanics
Quiz 6 Duration: 30 minutes Open Book Quiz

1. A certain atom has six electrons in the 3d level. (a) What is the maximum possible total m_l for the six electrons, and what is the total m_s in that configuration? (b) What is the maximum possible total m_s for the six electrons, and what would be the largest possible total m_l in that configuration?

$6\,\bar{e}$ in $3d$. $n=3$ & $l=2 \Rightarrow m_l = -2, -1, 0, +1, +2$

i) max $m_l = ?$ two $\bar{e}$ in $+2$ $\underset{\searrow -1/2}{\overset{+1/2}{}}$

two $\bar{e}$ in $+1$ $\underset{\searrow -1/2}{\overset{\nearrow +1/2}{}}$ $\Big\}$ $2\times(+2) + 2\times(+1) + 2\times(0) = 6 = m_l$ (total) maximum

two $\bar{e}$ in 0 $\underset{\searrow -1/2}{\overset{+1/2}{}}$ $\Big\}$ $0 = m_s$ (total)

ii) max $m_s = ?$ $m_l = -2 \quad -1 \quad 0 \quad +1 \quad +2$

$+1/2 \;\; +1/2 \;\; +1/2 \;\; +1/2 \;\; +1/2$ $\Big\}$ $m_s = +2$ (total) maximum & $m_l = 1\times(-2) + 1\times(-1) + 1\times(0)$

$-1/2$ $+ 1\times(1) + 2\times(2)$

$= +2$ (total) maximum

2. The ground state of helium has the configuration $1s^2$. Use the electron screening model to predict the energies of the following excited states of helium: (a) $1s^1 2s^1$ (measured value -4.0 eV); (b) $1s^1 2p^1$ (-3.4 eV); (c) $1s^1 3d^1$ (-1.5 eV).

Ground state Helium : $1s^2$ use $E_n = Z_{eff}^2 \frac{E_1}{n^2}$ in excited states

i) $1s^1 2s^1$, nuclear charge $+2e$ is screened by $1s^1 \bar{e}$. $(+2e - 1e = 1e)$

(experimental) $\rightarrow Z_{eff} = 1$ for the outer $\bar{e}$. $\Rightarrow E_2 = 1^2 \left(\frac{-13.6eV}{2^2} \right) = -3.4 eV$

$-4eV > -3.4 eV \rightsquigarrow 2s\,\bar{e}$ is closer to nucleus than the model predicts.

ii) $1s^1 2p^1$, $E_2 = -3.4 eV$ equal to experimental value. good agreement.

iii) $1s^1 3d^1$, $E_3 = 1^2 \frac{(-13.6eV)}{3^2} = -1.5 eV$ equal to experimental value.

(as expected since no penetration to $1s\,\bar{e}$)