HW8 Solutions

Chapter 8

Prob 1.

(a) 2p electrons

n	l	m_l	m_s
2	1	1	1/2
2	1	1	-1/2
2	1	0	1/2
2	1	0	-1/2
2	1	-1	1/2
2	1	-1	-1/2

(b) There are 6 possible sets for each 2p electrons. So, $6 \times 6 = 36$ possibilities.

(c) There are 6 combinations in which the two sets are identical. So, $36 - 6 = 30$ possibilities.

(d) Since the n number differs between 2p & 3p electrons. So, Pauli principle dose not restrict. So, 36 possibilities.

Prob 3.

(a) For 4f level, m_l can be $3, 2, 1, 0, -1, -2, -3$. And for each m_l, $m_s = \pm\frac{1}{2}$ possible. So, total 14 possibilities.

(b) For three electrons, they all can have $m_s = \frac{1}{2}$ value. So, maximum $\frac{3}{2}$ is possible.

(c) Two electrons can have $m_l = 3$ value. And next largest possible value is $m_l = 2$. So, maximum 8 is possible.

(d) For 10 electrons, only 7 can have $m_s = \frac{1}{2}$ value and others should have $m_s = -\frac{1}{2}$ value. So, maximum 2 is possible.

(e) For maximum m_l, two electrons have $m_l = 3, 2, 1, 0, -1$ each. So, maximum 10 is possible.

Prob 8.

Singly ionized Lithium (Z = 3) has two electrons. By screening effect, we can get $Z_{eff} = 3 - 1 = 2$. Using the electron screening model, we find that

1) for $1s^1 2p^1$ state, $E_n = (-13.6eV)\dfrac{Z_{eff}^2}{n^2} = -13.6eV$

(similar to measured value $-13.4eV$)

2) for $1s^1 3d^1$ state, $E_n = (-13.6eV)\dfrac{Z_{eff}^2}{n^2} \simeq -6.0eV$

(similar to measured value $-6.0eV$)

Chapter 9

Prob 8.

The difference between the ionization energy of K and the electgron affinity of I is $4.34-3.06=1.28eV$.

So, separation distance $R=-\dfrac{e^2}{4\pi\epsilon_0}\dfrac{1}{U} \simeq 1.13nm$.

Prob 9.

(a) Electric dipole moment $p=qR_{eq} \simeq 30.9\times10^{-30}C\cdot m$

(b) Fractional ionic character = $\dfrac{p_{measured}}{qR_{eq}} \simeq 0.88$

Prob 12.

For CN, $k=1.017\times10^4 eV/nm^2$

(a) Reduced mass for CN = $\mu = \dfrac{m(C)m(N)}{m(C)+m(N)} \simeq 6.562u$

So, the vibrational energy $E=\hbar w = \hbar\sqrt{\dfrac{k}{\mu}} \simeq 0.2565eV$.

So, first excited vibrational state energy is $0.2565eV$ higher than ground state.

Second excited vibrational state energy is $2\times0.2565eV=0.5130eV$ higher than ground state.

(b) $k'=0.9658k \Rightarrow \sqrt{k'} \simeq 0.9828\sqrt{k}$

Since $E\propto\sqrt{k}$, first excited vibrational state energy is $0.2521eV$ higher than ground state.

Second excited vibrational state energy is $0.5042eV$ higher than ground state.

Prob 14.

$k=\dfrac{2(E-E_{\min})}{(R-R_{eq})^2} \simeq 310eV/nm^2$

Also, from $\mu=\dfrac{m(Na)m(Cl)}{m(Na)+m(Cl)} \simeq 13.96u$,

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{\mu}} \simeq 7.4 \times 10^{12}\,Hz$$

So, $\lambda = \frac{c}{f} \simeq 40\,\mu m$ (infrared region) and $E = hf \simeq 0.031\,eV$.

So, maximum vibrational quantum number is 8.

Prob 17.

From $\mu = \frac{m(Na)m(Cl)}{m(Na)+m(Cl)} \simeq 13.96u$ and $R_{eq} = 0.236nm$, we can get

$$B = \frac{\hbar^2}{2mR_{eq}^2} \simeq 2.68 \times 10^{-5}\,eV.$$

So,

$L=1$ to $L=0$: $\Delta E = 2B = 5.36 \times 10^{-5}\,eV$ & $\lambda = \frac{hc}{\Delta E} \simeq 23.1\,mm$

$L=2$ to $L=1$: $\Delta E = 4B = 1.07 \times 10^{-4}\,eV$ & $\lambda = \frac{hc}{\Delta E} \simeq 11.6\,mm$

$L=3$ to $L=2$: $\Delta E = 6B = 1.61 \times 10^{-4}\,eV$ & $\lambda = \frac{hc}{\Delta E} \simeq 7.71\,mm$

(Mircowave region)

Prob 18.

R (distance between C and O atoms) $= 0.116\,nm$.

COM is located at C atom, moment of inertia $I = 2m_O R^2$.

From $\frac{\hbar^2}{2I} \simeq 4.84 \times 10^{-5}\,eV = 48.4\,\mu eV$ & eq (9.12) : $E_L = \frac{L(L+1)\hbar^2}{2I}$,

we can get five lowest energies :

$E_0 = 0$, $E_1 = 96.8\,\mu eV$, $E_2 = 290.4\,\mu eV$, $E_3 = 580.8\,\mu eV$, $E_4 = 968.0\,\mu eV$