CH301H Fall 2011

HW 8 Key

1. a) $n=2,\ l=2,\ m=1,\ m_s=1/2$: not allowed, $l=0,1,\ldots n-1$

   b) $n=3,\ l=1,\ m=1,\ m_s=-1/2$: allowed

   c) $n=1,\ l=2,\ m=0,\ m_s=1/2$: not allowed, $l=0,1,\ldots n-1$

   d) $n=4,\ l=-1,\ m=0,\ m_s=-1/2$: not allowed $l \nless 0$

   e) $n=3,\ l=2,\ m=0,\ m_s=-1/2$: allowed

   f) $n=3,\ l=-3,\ m=0,\ m_s=-1/2$: not allowed, $l \nless 0$

2. a) $n=2,\ l=0$: 2s

   b) $n=4,\ l=2$: 4d

   c) $n=6,\ l=3$ 6f

   d) $n=3,\ l=1$ 3s

3. # angular nodes $= l$

   # radial nodes $= n-l-1$

   total # of nodes $= n-1$

   1b) angular nodes = 1
   radial nodes = 1
   total nodes = 2

   1e) angular nodes = 2
   radial nodes = 0
   total nodes = 2

   2a) angular nodes = 0
   radial nodes = 1
   total nodes = 1

   b) angular nodes = 2
   radial nodes = 1
   total nodes = 3

   c) AN = 3
   RN = 2
   Tot = 5

   d) AN = 1
   RN = 1
   Tot = 2

4. $2p_z$: $\psi(r,\theta,\phi) = R(r)\,Y(\theta,\phi)$

$$R(r)_{2p_z} = \frac{1}{2\sqrt{6}}\left(\frac{Z}{a_0}\right)^{3/2} \sigma e^{-\sigma/2}$$

$$Y(\theta,\phi)_{2p_z} = \left(\frac{3}{4\pi}\right)^{1/2} \cos\theta$$

$$\psi(r,\theta,\phi) = \frac{1}{2\sqrt{6}}\left(\frac{Z}{a_0}\right)^{3/2} \sigma e^{-\sigma/2} \left(\frac{3}{4\pi}\right)^{1/2} \cos\theta$$

$$\sigma = \frac{Zr}{a_0}$$

$$\psi(r,\theta,\phi) = \underbrace{\frac{1}{2\sqrt{6}}\left(\frac{Z}{a_0}\right)^{3/2}}_{\text{constant}} \underbrace{\left(\frac{Zr}{a_0}\right)}_{\text{const.}\times r} e^{-Zr/2a_0} \underbrace{\left(\frac{3}{4\pi}\right)^{1/2}}_{\text{const.}} \cos\theta$$

reduces to: $\psi(r,\theta,\phi) = C\,r\,e^{-Zr/2a_0} \cos\theta$

where I have ~~reduced~~ combined all the constants to the constant C

$$P = \psi^2(r,\theta,\phi) = C^2 r^2 e^{-Zr/a_0} \cos^2\theta$$

- where will this equal 0? at $r=0$ and at $\theta = \frac{\pi}{2}, \frac{3\pi}{2}$

- Based on our definition of spherical polar coordinates, θ is the angle off the z-axis. Therefore $\theta = \pi/2$ or $3\pi/2$ by definition places us in the x-y plane.

5. a) Si: $1s^2 2s^2 2p^6 3s^2 3p^2$

b) Rb: $[Kr] 5s^1$

c) Cl: $[Ne] 3s^2 3p^5$

d) O: $1s^2 2s^2 2p^4$

6. period 2 valance e:

	1s	2s	2px	2py	2pz	
Li:	↑↓	↑				paramagnetic
Be:	↑↓	↑↓				not
B:	↑↓	↑↓	↑			paramagnetic
C:	↑↓	↑↓	↑	↑		paramagnetic
N:	↑↓	↑↓	↑	↑	↑	paramagnetic
O:	↑↓	↑↓	↑↓	↑	↑	paramagnetic
F:	↑↓	↑↓	↑↓	↑↓	↓	paramagnetic
Ne:	↑↓	↑↓	↑↓	↑↓	↑↓	not.

7. a) Be^+ : $1s^2 2s^1$

C^- : $1s^2 2s^2 2p^3$

Ne^{2+} : $1s^2 2s^2 2p^4$

Mg^+ : $1s^2 2s^2 2p^6 3s^1$

P^{2+} : $[Ne] 3s^2 3p^1$

Cl^- : $[Ne] 3s^2 3p^6$

As^+ : $[Ar] 4s^2 4p^2$

I^- : $[Kr] 5s^2 5p^6$

8. N:

↑↓	↑↓	↑	↑	↑
1s	2s	$2p_x$	$2p_y$	$2p_z$

The 2p orbital is half full in the most favorable configuration of unpaired electrons (according to Hund's rules) - all unpaired and of the same spin. Data on IE and EA show us that it is harder to ionize N than C or O, and that it is very difficult to add an extra e^- to N (EA not recorded). Taking all that information, it seems like this electron configuration gives N a special stability.