MSE160 Problem Set 3

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1 Question 1: [4 pts.]

The four different types of quantum numbers describe different quantum states of electrons that occupy an atom, which include n, l, m_l, and m_s.

- The quantum number **n** is known as the principal quantum number, and it represents the number of energy sub-levels there are present in the atom and the orbital size of each energy level. It also describes the most probable distance of the electrons from the nucleus, and as **n** increases, the distance to the nucleus and the size of the orbital increases. The values the principal quantum number can hold are integer values, where n > 0.
- The quantum number **l** is known as the orbital angular momentum quantum number. It shows the shape of the orbital and describes the general region that an electron occupies. The values the angular momentum quantum number can hold are $\{0 \leq l \leq (n-1) \mid l \in \mathbb{Z}\}$.
- The quantum number $\mathbf{m_l}$ is known as the magnetic quantum number, which represents the orbital orientation of the space. It also represents the number of available electrons in each subshell. The values $\mathbf{m_l}$ can hold are $\{-l \leq m_l \leq +l\}$.
- The quantum number $\mathbf{m_s}$ is known as the spin quantum number, and it designates the direction of the electron's spin. When the spin quantum number is positive, the electron spins upwards and when the spin quantum number is negative, the electron spins downwards. The only values that $\mathbf{m_s}$ can hold are $\pm\frac{1}{2}$.

2 Question 2: [3 pts.]

If n = 3, values l, m_l, and m_s can hold are l = 0, 1, 2, m_l = 0, ±1, ±2, and $m_s = \pm\frac{1}{2}$.

- l = 0, m_l = 0, $m_s = \frac{1}{2}$
- l = 0, m_l = 0, m_s = -$\frac{1}{2}$
- l = 1, m_l = -1, $m_s = \frac{1}{2}$
- l = 1, m_l = 0, $m_s = \frac{1}{2}$
- l = 1, m_l = 1, $m_s = \frac{1}{2}$
- l = 1, m_l = -1, m_s = -$\frac{1}{2}$
- l = 1, m_l = 0, m_s = -$\frac{1}{2}$
- l = 1, m_l = 1, m_s = -$\frac{1}{2}$

- l = 2, m_l = -2, $m_s = \frac{1}{2}$
- l = 2, m_l = -1, $m_s = \frac{1}{2}$
- l = 2, m_l = 0, $m_s = \frac{1}{2}$
- l = 2, m_l = 1, $m_s = \frac{1}{2}$
- l = 2, m_l = 2, $m_s = \frac{1}{2}$
- l = 2, m_l = -2, m_s = -$\frac{1}{2}$
- l = 2, m_l = -1, m_s = -$\frac{1}{2}$
- l = 2, m_l = 0, m_s = -$\frac{1}{2}$
- l = 2, m_l = 1, m_s = -$\frac{1}{2}$
- l = 2, m_l = 2, m_s = -$\frac{1}{2}$

3 Question 3: [2 pts.]

- $1s^3 2s^2$: The problem with this configuration is that the s orbital can only go up to 2 since it can only hold 2 electrons in the subshell. Another problem is that fluorine has 9 electrons, and the configuration only adds up to 5 electrons.
- $1s^2 2s^1 2p^1$: Again, there are not sufficient electrons to satisfy the 9 electrons that fluorine has. In addition, the 2s orbital is not filled with both electrons before filling the 2p orbital.
- $1s^2 2s^1 2p^6$: Again, the 2s orbital is not filled with both electrons before the 2p orbital is filled.

The correct electron configuration for fluorine is $1s^2 2s^2 2p^5$.

4 Question 4: [5 pts.]

4.a :

The term electronegativity defines an element's tendency to lose or accept electrons when bonding with another element. For instance, in an ionic bond, the electronegativity between the two elements is very high; thus, one element (the electropositive element) will have a large tendency to transfer electrons to the other element (the electronegative element), which has a large tendency to accept the electron. This occurs since all elements strive to achieve a ground state with a full set of valence electrons, whether it is required to lose or gain electrons.

4.b :

The electronegativities of magnesium (Mg) and oxygen (O), respectively, are 1.2 and 3.5. Since the electronegativity of magnesium is much lower than the electronegativity of oxygen, it has a greater tendency to lose an electron to form a cation. Therefore, magnesium is electropositive and oxygen is electronegative.

4.c :

The percent ionic character is calculated using the equation:

$$\% \text{ ionic character} = (1 - e^{-\frac{(X_A - X_B)^2}{4}}) \times 100\% \tag{1}$$

where X_A and X_B represent the electronegativities of the elements.

For magnesium oxide (MgO), the electronegativities of magnesium (Mg) and oxygen (O) are 1.2 and 3.5, respectively, which mean $X_{Mg} = 1.2$ and $X_O = 3.5$. Calculating for the % ionic character, we obtain:

$$\% \text{ ionic character} = (1 - e^{-\frac{(1.2-3.5)^2}{4}}) \times 100\% = 0.7335 \times 100\% \approx 73.4\% \tag{2}$$

Having a high percent ionic character means there is a higher tendency for the elements to form an ionic bond between each other, and vice versa.