1. What is the effective nuclear charge felt by a valence electron in a Fluorine atom? (Note: you do not have to solve the Schrodinger wave equation unless you want to) (2)

2. Fill in the electrons in the energy level sketch for atomic oxygen below (2):

```
    2p
   __   __  
  |     |   2s
  | 1s   |
Energy
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3. Sketch a simple 3 dimensional coordinate system and plot out the shape of a p<sub>x</sub> orbital. Take care to mark the positive and negative lobes. Also, draw a simple plot of the wavefunction that describes this orbital (in one dimension), and the corresponding probability distribution plot (in one dimension). (2)

4. A one-dimensional box can approximately describe a conjugated linear molecule. Similarly, a one dimensional ring can approximately describe a conjugated ring or aromatic molecule. Assuming that an electronic excitation of benzene (C<sub>6</sub>H<sub>6</sub>) from the 1<sup>st</sup> to the 2<sup>nd</sup> excited state has energy values of

\[ E = \frac{n^2 \hbar^2}{2m_r^2} \]

where, \( n = 0, 1, 2, \ldots \); \( r \) = radius of the benzene ring and a photon of light of a wavelength 268nm is absorbed, calculate the diameter of the benzene ring. (4)
1. a) Fill the following electron diagram of carbon and oxygen with the correct amount of electrons and correct spin according to Hund’s Rule. Indicate how many unpaired electrons there are for each atom.

Carbon:

\[ 1\text{s} \quad 2\text{s} \quad 2\text{p} \]

Amount of unpaired e\(^{-}\) =

Oxygen:

\[ 1\text{s} \quad 2\text{s} \quad 2\text{p} \]

Amount of unpaired e\(^{-}\) =

b) How would the amount of unpaired e\(^{-}\) change for carbon and oxygen if the 2s orbital and 2p orbital are the same energy (if they are degenerate)?

2. Draw the p\(_z\) orbital in the provided axis. Be sure to correctly shade the orbital to indicate sign. Indicate where the node(s) is located and write down how many total nodes there are in this orbital.

3. The treatment of a particle in a one-dimensional box can be extended to a two-dimensional box of dimensions L\(_x\) and L\(_y\) yielding the following expression for energy:

\[ E_{x,y} = \frac{\hbar^2}{8m} \left( \frac{n_x^2}{L_x^2} + \frac{n_y^2}{L_y^2} \right) \]

The two quantum numbers n\(_x\), and n\(_y\) are independent and can only assume integer values.

a) Determine the quantum number combinations (n\(_x\), n\(_y\)) of the four lowest levels assuming that the box is square (L\(_x\)=L\(_y\)). (Hint: Some combinations can have the same energy)

b) In a box with L\(_x\)=L\(_y\)=10 nm, what is the energy change if an electron makes a transition from the 2\(^{nd}\) excited state to the 3\(^{rd}\) excited state.
1. Calculate $Z_{\text{eff}}$ for the following atoms/ions. Also, show the full electronic structure for each atom/ion. (3)
   a. Cl$^-$
   b. C
   c. Mg$^{2+}$

2. 1. Sketch the forms of the following orbitals using a simple 3-D plot. Clearly specify the portions of the wavefunctions whether to be positive or negative.
   a) $2p_x$
   b) $2p_y$
   c) $2p_z$

2. Sketch the probability distributions functions for all the three orbital. (3)

3. Fill in the electrons in the energy level sketch for atomic nitrogen below(2):

4. What is the momentum of the photon of 500nm wavelength? How does it compare to an electron moving at 10,000m/s? (easily achieved in an old TV-style vacuum tube) (2)