Assignment 1

I will provide the answers for these questions in around one week and we can look at how the questions are done in tutorial.

Question #1
Oxidation States and RedOx Chemistry

Use the oxidation state (Frost) diagram I provided in class to determine whether the following redox reactions will proceed and, if so, the oxidation states of the products. All reactions are in acidic conditions ([H+] = 1) and there is no need to balance the equations.

(i)  \( \text{Cl}_2 + \text{H}_2\text{O} \rightarrow \)

(ii)  \( \text{MnO}_2 + \text{oxalic acid} \rightarrow \)

(iii)  \( \text{Cu}(+1) + \text{acid} \rightarrow \)

(iv)  \( \text{Fe}(+3) + \text{Cr}(+2) \rightarrow \)

(v)  \( \text{calcium metal} + \text{oxalic acid} \rightarrow \)

Identify the oxidation state of each atom in the following equations and balance the equations:

\[ \text{Cu} + \text{HNO}_3 \rightarrow \text{Cu(NO}_3)_2 + \text{NO} + \text{H}_2\text{O} \]

\[ \text{PO}_3^{-3} + \text{MnO}_4^{-} + \text{H}^+ \rightarrow \text{Mn}(+2) + \text{PO}_4^{3-} + \text{H}_2\text{O} \]
Fe(2+) + MnO$_4^-$ + H$^+$ → Mn(2+) + Fe(3+) + H$_2$O

Question #2
Quantum Numbers and Drawing Orbitals

Provide appropriate quantum numbers for an electron in the following orbitals:

(i) 4s
(ii) 5p$_x$
(iii) 4d$_z^2$
(iv) 3d$_{x^2-y^2}$

Draw reasonable plots (function vs. r) of the radial functions $\Psi$, $\Psi^2$ and $4\pi r^2\Psi^2$ for a 4s orbital.
Draw reasonable representations, indicating their three-dimensional nature as best you can, of the following orbitals [specify the direction of the axes used and include sign of the phase (+ or -) of each lobe]:

(i) 3d_{z^2}

(ii) 2p_x

(iii) 4d_{xz}

Question #3
Energy Level Diagrams and the Bohr Equation

Use the Bohr equation (ignore the correction for effective nuclear charge) to construct an energy level diagram for boron. Determine the energies for the first 4 shells and for n = ∞, label all subshells and don’t forget to include the electrons.
Question #4
Electron Configurations, Ground States, Excited States and Forbidden States

(i) Write the complete electron configuration for the ground state of gallium.

(ii) An “excited state” of an atom has a higher energy configuration than the ground state configuration. Put electrons in the valence orbitals (i.e. boxes) below to give an excited state electron configuration for gallium.

(iii) A “forbidden state” of an atom has a hypothetical electron configuration that defies at least one of the rules we have discussed regarding allowed quantum numbers. Put electrons in the valence orbitals (i.e. boxes) below to give a forbidden electron configuration for gallium.
Question #5
Slater’s Rules and Ionization Energies

Use Slater’s rules to calculate $\sigma$, $Z^*$ and the first ionization energy for three of the elements in group 14. Please show your calculations (that’s the important part) and remember that the first ionization energy is found by the equation $\text{IP} = 13.6 \left( \frac{Z^*}{n^2} \right)$. Compare your calculated ionization energies to the experimental values that I provided in class - is this method accurate for such predictions? Use the back of this page if extra space is required.