Problem Set 1

1. You are in a Star Trek Spaceship Voyager in which you discover an universe with quite different physical laws from those with which we are familiar. Investigating the chemical elements in the alternative universe, you discover these properties:

Symbol	Atomic Weight	State	Electrical Conductivity	Reactivity
Ai	13.90	Gas	Very low	Very low
Bc	11.13	Soft, low-melting solid	High	Very high
Bh	1.42	Gas	Very low	Very low
Dr	30.27	Hard, brittle solid	Semiconductor	Medium
Dt	8.28	Hard, high melting solid	Very high	High
Fn	35.74	Soft, low-melting solid	High	Very high
Fq	32.45	Hard, high-melting solid	Very high	High
Ik	4.82	Diatomic gas	Very low	Very high
On	20.33	Soft, low-melting solid	High	Very high
Sk	16.89	Hard, brittle solid	Semiconductor	Medium
Uc	6.14	Hard, brittle solid	Very low	Medium low
Ye	15.23	Diatomic, volatile* liquid	Very low	Very high
Zw	28.11	Diatomic, volatile solid	Very low	Very high

*Volatile = easily vaporized

A. Arrange these elements into a periodic table. [NOTE: All elements in the first row have been identified. All periods, if complete, would contain the same number of elements.]

B. If a new element, E, with atomic weight 23.1, were discovered, what would its properties be?

C. Are there any other elements that have not yet been discovered? If so, what would their properties be?

2. Calculate the de Broglie wavelengths of the following:

   a. a 0.8 g bullet with velocity $340 ms^{-1}$.
   b. a 10^{-5} g particle with velocity $10^{-5} ms^{-1}$.
   c. a 10^{-8} g particle with velocity $10^{-8} ms^{-1}$.
   d. an electron moving with velocity $4.8*10^{6} ms^{-1}$.

3. A typical mass for a horse is 510 kg, and a typical galloping speed is 22 kilometers per hour. Use these values to answer the following questions.

a. What is the momentum of a galloping horse? What is its wavelength?
b. If a galloping horse's velocity and position are simultaneously measured, and the velocity is measured to within ± 1.0%, what is the uncertainty of its position?
c. Suppose Planck's constant was actually 0.01 J s. How would that change your answers to (a) and (b)? Which values would be unchanged?

4. The N shell has the principal quantum number n equal to four. Determine the quantum numbers (l and ml) of all the possible AOs in this shell. What new feature arises in this shell that is not present in the M shell? How do the energies of these orbitals in the N shell compare with one another? How many electrons could be accommodated in the N shell? Orbitals for which the orbital angular momentum quantum number, l, takes the value 4 are given the letter g. In which shell would you expect g orbitals first to appear?

5. For the B^{4+} ion

(a) Calculate the **binding energy** to three significant figures of an electron for the **(i)** ground state and **(ii)** second excited state. **(iii)** Calculate the energy difference between these two states.

(b) If an electron falls from the n=3 to n=1 state, calculate the wavelength of light emitted

6. What is an eigen function and what are eigen values? For the operator $\frac{d}{d\Theta}$ or $\frac{d^2}{d\Theta^2}$ is the function sin Θ an eigen function? How about the function $e^{-3\Theta}$ for the same operators $\frac{d}{d\Theta}$ or $\frac{d^2}{d\Theta^2}$?

7. (a) How many values of the quantum number l are possible when n = 7? (b) How many values of m are allowed for an electron in a 6d-subshell? (c) How many values of m are allowed for an electron in a 3p-subshell?

8. How would you represent the wave function(s) in the $\psi_{n,l,m}$ format for electron in the H-atom that exists in 5p orbital. Example, $\psi_{n,l,m}$ corresponding to $2p_z$ will be $\psi_{2,1,0}$; etc