***CHEM105 Test 1*** *Please show all formulas, all equations, and all work to receive any credit*

1. Today is the 24th day of the month. In celebration of today, please answer the following concerning Cr.
   a. Complete the following table showing, in the order that they are filled, the quantum numbers for each of the 24 electrons in a chromium atom that is in the ground electronic state.

| ***Electron number*** | ***n*** | ***l*** | $m_l$ | $m_s$ |
|---|---|---|---|---|
| ***1*** | | | | |
| ***2*** | | | | |
| ***3*** | | | | |
| ***4*** | | | | |
| ***5*** | | | | |
| ***6*** | | | | |
| ***7*** | | | | |
| ***8*** | | | | |
| ***9*** | | | | |
| ***10*** | | | | |
| ***11*** | | | | |
| ***12*** | | | | |
| ***13*** | | | | |
| ***14*** | | | | |
| ***15*** | | | | |
| ***16*** | | | | |
| ***17*** | | | | |
| ***18*** | | | | |
| ***19*** | | | | |
| ***20*** | | | | |
| ***21*** | | | | |
| ***22*** | | | | |
| ***23*** | | | | |
| ***24*** | | | | |

   b. Calculate the binding energy per nucleon, in units of J/nucleus, for the chromium-51 isotope. Its mass is 50.9447 amu; the masses of a proton and neutron are 1.0078 amu and 1.0087 amu.

   c. $^{51}$Cr has a half-life of 27.7 days. Predict how many grams of an initial 2.45 g quantity of chromium-51 would remain after 200.0 days.

d. Photoionization energy refers to the amount of photon energy required to eject an electron from an atom. The first photoionization energy of chromium was reported to be 6.8 eV. Photons with energies of 12.0 electron volts (eV) were used to eject electrons from chromium atoms.

i. Draw the complete electron configuration for the resulting $Cr^{+}$ ion created.

ii. Sketch a diagram of the photoionization process and write an equation for the energies involved in the process.

iii. Calculate the wavelength, in nm, of a 12.0 eV photon. ***Note***: 1 eV = $1.602 \times 10^{-19}$J.

iv. Calculate the ejected electron's kinetic energy, in Joules, from the photoionization process.

v. Calculate the velocity of the electron ejected by the photoionization process. The mass of an electron is $9.10 \times 10^{-31}$ kg.

2. Quantify the relative strengths of Coulombic interactions for these pairs of charges
   +2 charge separated by 200 pm from a -1 charge
   +3 charge separated by 100 pm from a -2 charge
   +1 charge separated by 50 pm from a -3 charge

3. The Sun emits its highest intensity electromagnetic radiation at a wavelength of 480 nm. Calculate the surface temperature of the sun.

4. Compare the chemical reactivity of potassium atoms with the reactivity of sodium atoms. Clearly explain and justify your rationale using fundamental chemical principles.

5. Define electronegativity and compare the electronegativity of carbon atoms with the electronegativity of oxygen atoms. Use fundamental physical principles and Coulomb's Law to clearly explain your predicted difference.

6. Draw the complete Lewis structures for:

   a. $N_2O_4$

   b. Triphosphate ion $(P_3O_{10})^{-5}$

7. Complete the following table

| **Molecule** | $HSO_4^-$ | $COCl_2$ | $ClF_5$ | $O_2NCl$ | $SF_5^+$ |
|---|---|---|---|---|---|
| Number of Valence Electrons | | | | | |
| Lewis Structure (include all nonzero formal charges & resonance structures) | | | | | |
| Electron Arrangement | | | | | |
| Molecular Geometry | | | | | |
| Bond Angle(s) | | | | | |
| Hybridization | | | | | |
| Polar or Nonpolar Molecule | | | | | |
| Number of sigma ($\sigma$) bonds | | | | | |
| Number of pi ($\pi$) bonds | | | | | |
| Bond Order (specify atoms) | | | | | |