CHE 151 GENERAL CHEMISTRY FALL, 2004
MARIAN COLLEGE, INDIANAPOLIS

Test 2 Name:

Questions requiring written answers should be answered as succinctly as possible, in sentences. All work should be shown in problem calculations. Use the factor label method in all numerical calculations. You may (and should) use a scientific calculator and a periodic table. Open-book, open-notes. Allow yourself about 1 hour for this test.

1. The work function Φ of a metal is the minimum amount of energy required to remove an electron from the surface of that metal. It is often expressed in electron volts (eV), a unit of energy equal to 1.602×10^{-19} J.
   a) The work functions of gold and potassium are 5.1 eV and 2.3 eV respectively. Convert these values into J.

   b) In two studies of the photoelectric effect a gold surface and a potassium surface are irradiated with electromagnetic radiation of wavelength 300 nm.
      (i) What type of radiation is this?
      (ii) Are electrons emitted from both surfaces? If not, why not? Calculate the kinetic energy in J of any electrons that are emitted.
      (iii) If the kinetic energy is given by $KE = mv^2/2$, calculate the De Broglie wavelength of any electrons that are emitted.

2. The Lyman series in the emission spectrum of the hydrogen atom consists of transitions from higher levels to the n=1 level.
   a) Calculate the maximum and minimum wavelength lines, in nanometers, of this series, noting the n values of the higher levels involved in each.

   b) The series limit of the Balmer series (n_1 = 2) occurs at about 365 nm, corresponding to an energy of 5.49×10^{-19} J. Compare this energy to the *lowest* energy transition in the Lyman series, and *explain* what this implies about the spacing between the energy levels in the H atom.

3. Sketch the shapes of the following hydrogen atom orbitals. (The easiest way to do this is with "boundary surface views".)

(a) 1s

(b) 3s

(c) $2p_z$

(d) $3d_{z^2}$

(e) $3d_{xz}$

4. (a) For each of the following sets of quantum numbers, state which are allowed and which are not. For those that are not allowed, in each case *explain* why not.

(i) $n = 3$, $l = 2$, $m_l = -1$

(ii) $n = 3$, $l = 3$, $m_l = -1$

(iii) $n = 3$, $l = 2$, $m_l = +2$

(iv) $n = 1$, $l = 0$, $m_l = -1$

(v) $n = 9$, $l = 0$, $m_l = 0$

(vi) $n = 4$, $l = -1$, $m_l = -1$

(b) For those sets that are allowed in (a), write out the name of the orbital in *spdf* notation.

(c) How many values does the orbital magnetic quantum number take for a *4f* orbital?

5. a) Explain in your own words how the Pauli principle leads to each atomic orbital being occupied by no more than two electrons.

b) List (i) an anion with charge 2- (ii) a cation with charge 1+ and (iii) a neutral atom all having the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6$.

c) (i)According to Hund's rule, what is the likely number of unpaired electrons in an atom having a configuration $[Ne]3d^4 4s^2$? (ii) Is this likely to be the lowest energy electron configuration for this element?

6. (a) In the photoelectron spectrum of Ar, name the orbitals corresponding to the first three peaks observed, and give the relative peak heights.

(b) The Ne atom is smaller than the F atom, but the F^- ion is larger than either. Explain.

(c) If the bond length in F_2 is 142 pm, and the bond length in Cl_2 is 198 pm, (i) what are the atomic radii of F and Cl, and (ii) what bond length do you predict for the molecule ClF?

TOTAL: 100 points