1. Answer the following questions: (35%)

(1). Compare the electronegativity of the N orbital involved in the N-H bond in each of the following species: NH_3 NH_4^+ NH_2^-  $CH_3C{\equiv}NH^+$

(2) List the substances in order of increasing boiling points.

LiF, LiBr, CCl_4, NH_3, CH_4, SiC, CsI

(3) Give the approximate pKa values for the following acids:

(a) H_3PO_3, (b) HNO_3, (c) $HClO_4$

(4) When no chemical reaction occurs, the solubility of a gas in a liquid is proportional to the magnitude of the van der Waals interaction energy of the gas molecules. Give the order of the relative solubility of O_2, N_2, Ar, and He in water.

(5) Most substances expand when they are heated, leading to decrease density with increase temperature. However, $H_2O(l)$ has a maximum density at 4°C. How can you explain this?

2. Sketch sigma bonding orbitals that result from the combination of the following orbitals on seeparate atoms: p_z and d_{z^2}, s and p_z, $d_{x^2-y^2}$ and $d_{x^2-y^2}$. (10%)

3. Which of each of the following pairs might be expected to be more ionic ? (10%)

(a) $CaCl_2$ or $MgCl_2$ (b) NaCl or CuCl (similar radii)

4. Should the value of the heat of a reaction calculated from the variation of K_p with temperature be affected by the units in which K_p is expressed ? Under what circumstances would ΔH be unaffected and under what circumstances affected by selection of units for the K_{eq} ? (10%)

5. When dilute nitric acid reacts with Cu turnings in a test tube, a colorless gas is formed that turns brown near the mouth of the tube. Explain the observations and write equations for the reactions involved. (10%)

6. For each of the following pairs indicate which substance is expected to be

(a) More covalent (Fajans' rules): $CaCl_2$ or $CdCl_2$, CaO or NaF (6%)

(b) Harder: Al_2O_3 or Ga_2O_3 MgF_2 or TiO_2 (6%)

7. Describe four general categories of bonds briefly and give an example for each one. (13%)