

INORGANIC CHEMISTRY -FINAL EXAM

December 17, 1996

Name _____

Instructions: There are 10 questions worth a total of 200 points. You have until noon to finish the exam. A periodic table with electronegativities, a symmetry flow chart, and two scratch pages are included at the end of the exam. These may be detached from the exam if you wish. Place all answers on the exam pages, the scratch pages will not be graded. Show all work where appropriate!

GOOD LUCK AND HAVE A HAPPY HOLIDAYS!

1. For the following atoms and or ions, give the complete electronic configuration ($1s^2 2s^2 \dots$ etc.). [20 pts]

Mn²⁺ _____

Cs⁻ _____

Cu _____

P _____

Sn²⁺ _____

2. For the following molecules and ions,

A) Predict the correct idealized VSEPR geometries [16 pts]

B) Determine the hybridization of the central atom [8 pts]

C) Determine the symmetry point group [16 pts]

CS₂

BBr₃

XeF₄

SF₆

3. Potassium reacts with oxygen to give potassium superoxide, KO_2 .

A) Draw a molecular orbital diagram of the superoxide ion, O_2^- , indicating which orbitals are occupied by electrons. [15 pts]

B) How many unpaired electrons are in O_2^- ? [5pts]

C) What is the oxygen-oxygen bond order? [5 pts]

4. A.) Classify the following as either hard acids (HA), hard bases (HB), soft acids (SA), or soft bases (SB)? [16 pts]

Co _____

ethylene _____

Na⁺ _____

AsH₃ _____

N³⁻ _____

H⁺ _____

GaCl₃ _____

Hg²⁺ _____

B.) The molecule, Me₂NPF₂, forms acid-base adducts with BH₃ and BF₃, respectively. However, the structure of the acid-base adduct with BH₃ is different than that of the BF₃ adduct.

- i) Draw Lewis structures for Me₂NPF₂, and the two different acid-base adducts. [6 pts]

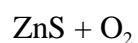
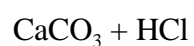
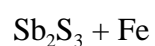
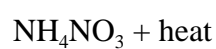
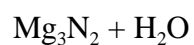
ii) Explain why one adduct is formed when BH₃ is the Lewis acid whereas another adduct is formed when BF₃ is the acid. [3 pts]

5. In the closest packing of spheres, the repeating pattern ABABAB... corresponds to which closest packed arrangement? [15 pts]

6. The mineral corundum, Al_2O_3 , has a hexagonal closest packed arrangement of oxide ions with the aluminum ions filling octahedral holes. What fraction of the octahedral holes in the lattice are filled by aluminum ions? What is the coordination geometry of the aluminum ions? [15 pts]

7. White phosphorous, P_4 , can react with oxygen to form two oxides, P_4O_6 and P_4O_{10} . What are the structures of these two oxides and how are they related to the structure of P_4 ? [10 pts]

8. Complete the following reactions, showing all products. [10 pts]



9. The lattice energy of an ionic compound, NaCl, is defined as follows.



A) Construct a thermodynamic cycle (*diagrammatically*) relating the lattice energy of NaCl to the ΔH_f of NaCl and other important atomic and bond parameters such as ionization energies, bond dissociation energies, etc. (Hint: The ΔH_f corresponds to the reaction: $\text{Na}(\text{s}) + \frac{1}{2}\text{Cl}_2 \rightarrow \text{NaCl}(\text{s})$) [10 pts]

B) Write an exact equation which relates the E_{lattice} to these other parameters. [5 pts]

C) Explain the origin of any potential discrepancies between the lattice energy obtained by this method with that obtained using crystal data and the appropriate Madelung constant? [5 pts]

10. Describe the commercial synthesis of the following inorganic compounds. Use equations as appropriate. [20 pts]

A. NH_3

B. NaOH (produces Cl_2 as well)

C. H_2SO_4

D. aluminum