

**INORGANIC CHEMISTRY - MAKEUP FINAL EXAM**

*January 21, 1997*

**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]

Zn<sup>2+</sup> \_\_\_\_\_

Nb \_\_\_\_\_

Cu \_\_\_\_\_

P<sup>3-</sup> \_\_\_\_\_

Pb<sup>2+</sup> \_\_\_\_\_

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]

N<sub>3</sub><sup>-</sup>

GeBr<sub>4</sub>

IF<sub>4</sub><sup>-</sup>

PbCl<sub>2</sub>

3. The cyanide ion,  $\text{CN}^-$ , is isoelectronic with  $\text{N}_2$ .

A) Draw a molecular orbital diagram of  $\text{CN}^-$ , indicating which orbitals are occupied by electrons. [15 pts]

B) How many unpaired electrons are in  $\text{CN}^-$ ? [5pts]

C) What is the carbon-nitrogen 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]

Zn \_\_\_\_\_

acetylene \_\_\_\_\_

Ba<sup>2+</sup> \_\_\_\_\_

NH<sub>3</sub> \_\_\_\_\_

O<sup>2-</sup> \_\_\_\_\_

H<sub>2</sub>Se \_\_\_\_\_

GaCl<sub>3</sub> \_\_\_\_\_

Pb<sup>2+</sup> \_\_\_\_\_

B.) The molecule, Me<sub>2</sub>NPF<sub>2</sub>, forms acid-base adducts with BH<sub>3</sub> and BF<sub>3</sub>, respectively. However, the structure of the acid-base adduct with BH<sub>3</sub> is different than that of the BF<sub>3</sub> adduct.

- i) Draw Lewis structures for Me<sub>2</sub>NPF<sub>2</sub>, and the two different acid-base adducts. [6 pts]

- ii) Explain why one adduct is formed when BH<sub>3</sub> is the Lewis acid whereas another adduct is formed when BF<sub>3</sub> is the acid. [3 pts]

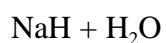
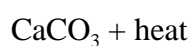
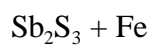
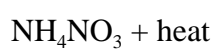
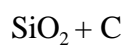
5. Describe the repeating pattern in a hexagonal closest packed structure where independent layers are denoted by the symbols A, B, C, etc. [15 pts]

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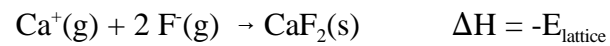
6. Zinc phosphide,  $Zn_3P_2$ , has a cubic closest packed arrangement of oxide ions with the aluminum ions filling tetrahedral holes. What fraction of the tetrahedral holes in the lattice are filled by aluminum ions? What is the coordination geometry of the aluminum ions? [15 pts]

7. Elemental sulfur exists in a number of allotropic forms of which the yellow “flowers” of sulfur is the most stable form. Describe the structure of the yellow form of sulfur. How is it related to the “plastic” form of sulfur? [10 pts]

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



9. The lattice energy of the ionic compound,  $\text{CaF}_2$ , is defined as follows.



A) Construct a thermodynamic cycle (*diagrammatically*) relating the lattice energy of  $\text{CaF}_2$  to the  $\Delta\text{H}_f$  of  $\text{CaF}_2$  and other important atomic and bond parameters such as ionization energies, bond dissociation energies, etc. (Hint: The  $\Delta\text{H}_f$  corresponds to the reaction:  $\text{Ca}(\text{s}) + \text{F}_2(\text{g}) \rightarrow \text{CaF}_2(\text{s})$ ) [10 pts]

B) Write an exact equation which relates the  $E_{\text{lattice}}$  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 and/or purification of the following inorganic compounds. Use equations as appropriate. [20 pts]

A.  $\text{NH}_3$

B.  $\text{HCl}$

C. silicon

D.  $\text{O}_2$