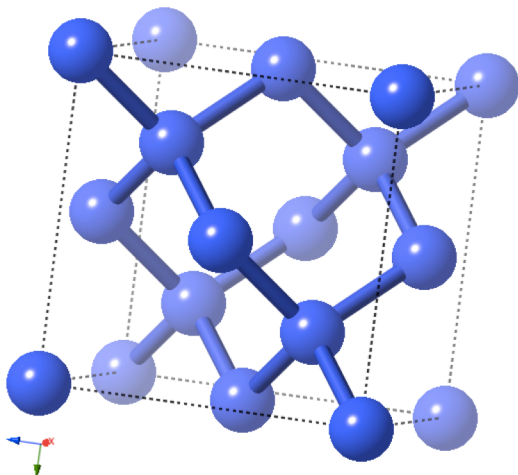


**Exam 3**  
**Monday, Nov 21**

1. (24 pt) For each of the following statements, justify using the information you've learned from this class. **Illustrate your answers with chemical equations and/or diagrams- a picture is frequently worth a thousand words!** (8 pt each)
- a. A solution of HF is less acidic than one with the same concentration of HCl. A solution of  $F^-$  has a higher pH than that of a solution of  $Cl^-$ .
- b. The compound CaO is brittle and non-conductive while the element Ca is both conductive and malleable and the element  $O_2$  is non-conductive and has a really low boiling point.
- c.  $XeF_4$  is non-polar, while  $SF_4$  and  $CF_3Br$  are polar.

2. (23 pt) Below and on the screen is a representation of a unit cell of one possible structural form (allotrope) of elemental tin (Sn). Try to figure out as much as possible using the figure on your test and then use the computer at the front of the room if necessary.



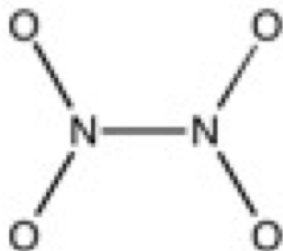
- a. (4 pt) Count the number of atoms of tin in the unit cell, *showing your work clearly!*
- b. (4 pt) **Some** of the atoms in this structure form the same structure as one of the 4 basic structures (bcc, etc) you examined. **Mark the atoms involved on the diagram with X's** and identify the type of basic lattice structure.

- c. For the atoms you marked above, is this a type of closest packing? If so, what kind? If not, why not? (4 pt)
- d. (2 pt) The remaining Sn atoms are located in holes. What kind of holes?
- e. (2 pt) What percentage of that type of hole are occupied?
- f. (2 pt) What is the coordination number of the **corner** atoms?
- g. If the Sn has a radius of 1.54 Å, calculate the length of the side of the unit cell. Show your work clearly! (3 pt)
- h. Which of the 5 types of solid would Sn form? (2 pt)

3. (21 pt) For each of the following statements, fill in the blank with an appropriate answer: (3 pts each)

- \_\_\_\_\_ a. The  $pK_b$  for  $HC_2O_4^-$
- \_\_\_\_\_ b. An example of a molecular solid
- \_\_\_\_\_ c. An example of a non-basic oxo anion
- \_\_\_\_\_ d. The hybridization for an atom with 4 bonded atoms and 1 lone pair.
- \_\_\_\_\_ e. The shape of the  $\sigma_{2p}$  orbital (draw it in the blank)
- \_\_\_\_\_ f. The type of alloy where the new alloy forms a structure that is different from either of the pure metals.
- \_\_\_\_\_ g. The bond order for  $B_2$  using MO theory (assume s-p mixing)

4. (11 pt) The molecule  $N_2O_4$  is a colorless compound that is used synthetically as a source of  $NO_2$  in chemical reactions. It is also a powerful oxidant that is used in rocket fuel! Its skeleton structure is shown below:



- a. (5 pt) Complete the Lewis dot structure and label all formal charges. Indicate the geometry, bond angle, and hybridization of each central atom in the molecule. For each bond indicate  $\sigma$  or  $\pi$ .
- b. Complete a full valence bond description for this molecule, including drawing a picture that shows which orbitals interact to form bonds and a final picture that indicates the geometry of the molecule. (6 pt)

5. (9 pt total) Acid mine drainage is frequently a problem in coal producing areas such as those in southwestern Indiana and southern Illinois. Drainage water that comes off piles of mine waste frequently has a pH as low as 1. The runoff from acid-mine drainage is frequently an orange color due to the presence of  $\text{Fe}^{3+}$  ions in the water. However as that water flows away from the mine and is diluted and mixed with clean water a nasty yellow-brown precipitate forms. Draw a predominance diagram for  $\text{Fe}^{3+}$  in aqueous solution, labeling all the relevant information. (4 pt)

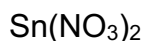
Explain the observations discussed above based on your diagram. Comment on the bioavailability of the  $\text{Fe}^{3+}$  when it comes out of the mine vs. later when it is diluted. (5 pt)

6. (8 pt total) For each of the following, circle as indicated and offer a **brief** justification, clearly indicating the data needed to make the determination.

a. Lowest boiling point:



b. Sats that will give acidic solutions when dissolved in solution



7. (4 pt) Would you expect an acid-base reaction between  $\text{H}_2\text{PO}_4^-$  and  $\text{NO}_2^-$  to occur or not? Clearly show your reasoning.