

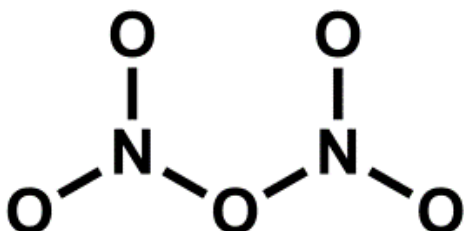
**Exam 3**  
**Monday, Nov 20**

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. Metals conduct more at low temperatures but semiconductors actually conduct more at higher temperatures. A pure semiconductor is not as conductive as either a p- or n-type semiconductor.
- b. A solution of NaF conducts electricity but solid NaF is non-conductive. The solid NaF is also brittle and has a higher boiling point than the similarly structured NaCl.
- c. O<sub>2</sub> is paramagnetic and has a bond order of 2, but Li<sub>2</sub> (perhaps the "dilithium" of Star Trek fame!) is diamagnetic and has a very long and very weak bond (hence its instability and ability to power starships in fiction).

2. (27 pt) For each of the following statements, fill in the blank with an appropriate answer: (3 pts each)

- \_\_\_\_\_ a. An example of an atomic solid
- \_\_\_\_\_ b. The conjugate base of  $\text{HPO}_4^-$
- \_\_\_\_\_ c. Example of a weak acid that can successfully protonate  $\text{HPO}_4^-$
- \_\_\_\_\_ d. The type of doping that adding As to pure Si will lead to
- \_\_\_\_\_ e. The hybridization of the central atom in  $\text{XeF}_4$
- \_\_\_\_\_ f. The type of alloy where the structure is different than either of the original metals
- \_\_\_\_\_ g. A metal ion that is non-acidic
- \_\_\_\_\_ h. The shape of a  $\sigma_{2s}^*$  orbital in a diatomic MO theory description

3. (11 pt) The skeleton structure for  $\text{N}_2\text{O}_5$  is shown below.
- a. Complete a valid Lewis dot structure for it and label any formal charges, label all bonds as  $\sigma$  and  $\pi$ . Indicate the geometry and bond angles of all central atoms. (5 pt)



- b. Then complete the remaining two steps to do a full valence bond description of the molecule, including the picture of the orbitals. Label bonds on both diagrams as  $\sigma$  and  $\pi$ . (use back of page if necessary!) (6 pt)

4. (12 pt) About 5 years ago Pepsi Co. successfully defended a \$50000 lawsuit by an Illinois man who claimed to have found a dead mouse in his can of Mountain Dew. The company brought in a scientist who testified that no mouse could have remained recognizable in the can of soda after being in the can for 74 days (time was based on the can's production date), Let's consider this particularly gruesome statement for a minute. In particular the scientists attested that the pH of the Mountain Dew (3.4) would have affected the  $\text{Ca}_3(\text{PO}_4)_2$  in the bones of the mouse. Consider the two ions that make up the  $\text{Ca}_3(\text{PO}_4)_2$  in bone at that pH.
- a. Draw **two separate** acid-base predominance diagrams (in the pH range of 0-14) for the two components of bone ( $\text{Ca}^{2+}$  and  $\text{PO}_4^{3-}$ ). (6 pt)

$\text{Ca}^{2+}$

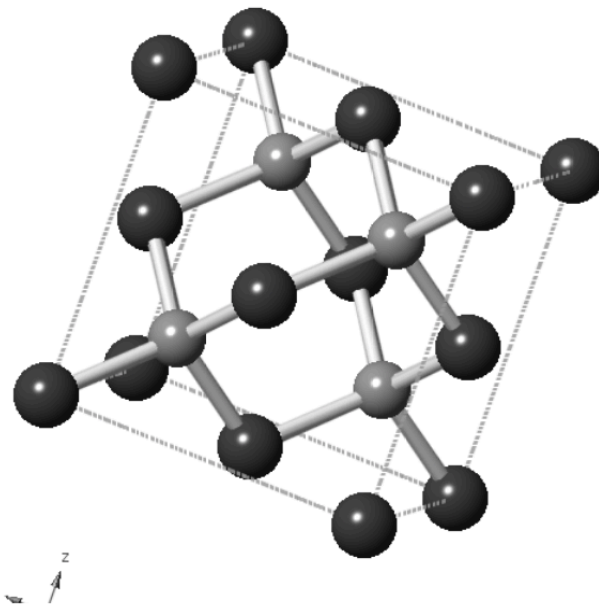
$\text{PO}_4^{3-}$

- b. What forms of **each** of the two ions above are most important at the pH of 3.4 in the Mountain Dew can? (4 pt)
- c. Briefly relate this information back to the case of the mouse in the Mountain Dew can. Note that  $\text{Ca}_3(\text{PO}_4)_2$  is normally an insoluble solid. (2 pt)



Surprise!: A mouse wouldn't stay whole for long in a soda can.  
Credit: Wikimedia Commons/Shutterstock/C&EN

5. (19 pt) Below is a representation of a unit cell of an iodide of a particular transition metal ion. Try to figure out as much as possible using the figure on your test and then use the figure projected from the computer if necessary.
- a. The dark gray atoms are the transition metal ions and the light gray atoms are the iodide (these are gray and purple, respectively on the computer model). Using the symbol T to indicate the transition metal, write the formula for the solid based on the structure. **Show your work clearly** (5 pt).



- b. What is the coordination number of the iodide? (2pt)
- c. What is the coordination number of the transition metal ion? (2 pt)
- d. The transition metal ions form what kind of lattice in this structure? Is this closest packed? (4 pt)
- e. What type of holes do the iodides occupy? (2 pt)
- f. What percentage of those holes are occupied? (2 pt)
- g. At least one of the structures that you've encountered in the lab had an identical arrangement of atoms to this structure (the whole thing: cations + anions). Which one? (2 pt)
6. (6 pt, 3 pt each) Rank each of the following groups as specified.
- a. Rank the following in order of increasing  $pK_b$
- $H_2PO_4^-$   $OH^-$   $AcO^-$   $CN^-$
- c. Rank the following solids in order of increasing boiling point
- Kr      Sc      Ca      K