Study Guide for Exam Three

For Exam three, you will need

- a non-programmable, non-graphing calculator (You will NOT be allowed to share or **borrow** a calculator or use a cell phone for a calculator during the exam.)
- a #2 pencil
- a scantron (like the one for exam 1)

Exam 3- Protocol: (same as Exam 1 and 2)

- Read each question and the directions carefully. The directions may change from problem to problem.
- If you don't know how to do a problem, skip it and move on. Careful of the time. Some of the multiple choice questions will be worth only a few points but could take a while. Try to do the big point problems that you know how to do first.
- Be sure any work you do is clear and easy to follow. I am not a mind reader.
- Follow all of the rules of significant figures and label all answers with the appropriate units.

Exam 3 will primarily cover chapter 9 (all sections except section 10) and chapter 11 (sections 11-13). For this exam, we jumped around a bit in the textbook, so focus on the content covered in lecture, then fill in the gaps with the textbook. This exam may include any problems assigned from those chapters (including worksheets) and anything covered in lecture. For this exam, your lecture notes should be a primary source of information for a lot of the solid state and semiconductor/LED content. The exam will consist of multiple-choice questions, some true-false questions, some short answer questions, and some problems. etc. Don't ask me too many specific questions because I haven't written the exam yet!

What should you know from Chapters 1-5? (The same as the other exams – see other study guides for more information.)

What should you know from Chapter 9?

- The three types of bonding (ionic, covalent, and metallic), a brief definition of each, and what type of atoms (metal, nonmetal, metalloid) participate in that type of bonding.
- How to count valence electrons and draw a Lewis symbol for an element
- Lattice energy – definition, what it is, how it can be affected (charge of ion, size of ion)?
- Born-Haber cycle – can you identify all of the pieces if they were given in a diagram like Figure 9.4 in the text or in a Hess's Law problem like problem 9.47 or on the worksheet? Could you translate the words to balanced equations and vice versa (like the problems on worksheet 6)?
- What does an ionic solid look like in 3-D and how does that affect its properties like conducting? Ability to be stretched into a wire?

- How to draw a Lewis structure (including those with multiple bonds) for molecules and ions. What to do with "extra" electrons after all of the atoms have 8 electrons. What to do if you are short electrons and the atoms all don't have 8 electrons.
- What is electronegativity and how the trend goes on the periodic table. How does electronegativity influence your Lewis structure
- How to decide if a bond is polar or not and in which direction
- What are resonance structures? When does a molecule have resonance structures? Can you draw a resonance hybrid structure?
- What is formal charge and how to calculate it for any atom in any molecule?
- Exceptions to the octet rule
- How do metals bond? What is the "electron-sea" model and how does it explain a metal's properties (like conductivity, malleability, and ductility)?

What should you know from Chapter 11?

- Crystalline versus amorphous solids. What are the key differences?
- What is a unit cell? Lattice point? Can you identify a unit cell given an extended 2-D or 3-D structure?
- The three different types of unit cells in the cubic system: simple cubic (sc), body-centered cubic (bcc), and face-centered cubic (fcc). Which pack squarely? Which pack hexagonally?
- What is a coordination number?
- For each unit cell type, you should know the packing efficiency, the edge length of the unit cell (or recognize it on the equation sheet), the volume of the unit cell, and the coordination number of an atom in that unit cell type.
- What is a z-diagram? How to draw them. How to read them.
- How do you count atoms in a unit cell? Corners, edges, faces, and centers all contribute how much to a unit cell?
- Density calculation problems and the many variations that are possible. You also need to know the conversion between pm to cm.
- What are ionic solids? How do they form? How do you determine the stoichiometry of an ionic solid? What is its empirical formula?
- For band theory, can you draw the picture when 2 atomic orbitals come together and form two new molecular orbitals? What does that picture look like when you do that for an Avogadro's number of atoms?
- What is a valence band? Conduction band? What are they really made up of?
- What does the band structure (picture or diagram) look like for a metal/conductor? Semiconductor? Insulator? What are the relevant band gap sizes in each?
- How to improve conductivity of semiconductor using doping. What is doping? The two types of doped semiconductors (n-type and p-type). What elements are used for either type and why? What will the band structure look like after doping and why?

- Why as you move down a group in Group IV does the band gap decrease? Can you argue why using atomic size and electronegativity? When is the size argument best? When is the electronegativity argument best?
- Why different compound semiconductors with the same edge length have dramatically different band gaps although they all have a combined 8 valence electrons?
- How do you move electrons across a band gap and the corresponding calculations using light energy, thermal energy, and electrical energy?
- How do electrons return to the valence band after absorbing energy (radiatively and non-radiatively) and which is favored when?
- How does a LED or p-n junction work?
- Temperature effects on conductors, semiconductors, and insulators. What happens on the atomic level when you heat them up or cool them down that explains the change in conductivity/resistance or change in the size of the band gap?
- Why does the light intensity change when you heat or cool a semiconductor? What is happening on the atomic level to do this?
- What is a superconductor? How does it repel a magnet?
- How do you change the band gap of a compound semiconductor (no doping allowed!)?

What should you know from the labs?

- The different types of unit cells, how to determine the edge length, coordination number, number of atoms in a unit cell, and the stoichiometry of an ionic solid. How to draw a z-diagram.
- What happened to the conductor under room temperature conditions? Low temperature conditions and why (explain what is happening on the atomic level)?
- What happened to the LED (semiconductor) under room temperature conditions? Low temperature conditions and higher temperature conditions and why (explain what is happening on the atomic level)?
- What happened to the superconductor? The magnet?

You should also be familiar with the material from Exam 1 and 2. It can show up on this exam as well. However, if any material from Exam 1 or 2 shows up on this exam, you can count on it being a significant topic and something you probably know since you have done many problems of that type. I won't bring back minor details from Exam 1 and 2 to test you on Exam 3. You have a good idea based on the quizzes what I may ask from the Exam 1 and 2 material. HOWEVER, to explain the behavior and the changes of band gaps we have used periodic trends (in particular atomic size and electronegativity) to explain these concepts. These trends should be fresh in your mind. The calculations for light, energy, wavelength, and frequency should also be fresh in your mind.

The main thing is to keep practicing problems and work on the problems and worksheets. You have good practice there. If you need help, send me an email or come to office hours. Good luck with the studying!