Solid State Chemistry – CHM4627 – Spring 2017
Study Guide – Suggested Topics - Exam 3
Primarily Chapter 3 to end of chapter 5
A periodic table will be given. Bring a calculator.

- Describe the solid state or ceramic method for synthesizing solids
  - Describe the primary factors (e.g. diffusion) that control solid state reactions

- Given a desired compound,
  - Be able to calculate amounts of reagents needed
  - Be able to estimate synthesis temperature based on given melting points of reactants.
    - Define, explain, and use Tamman’s Rule

- Describe the sealed tube method and give an example reaction

- Describe the use of a special atmosphere synthesis method and give an example

- Describe techniques that can be used to reduce particle sizes (e.g. spray-drying and freeze-drying)

- Describe techniques that can be used to reduce improve mixing (e.g. co-precipitation and precursor method)

- Describe the precursor method and give an example

- Describe the stages of the sol-gel method and give an example

- Describe microwave synthesis and give an example synthesis (e.g. superconductor)

- Describe combustion synthesis and given an example

- Describe high pressure methods, advantages/disadvantages, and give an example
  - Describe several types of high pressure methods (e.g. hydrothermal)

- Describe a method to prepare microporous and mesoporous solids

- Describe the synthesis of synthetic diamonds and some properties

- Describe CVD, describe the process, and give an example

- Describe, illustrate, and give a specific example of several methods to prepare single crystals
  - VPE
  - MBE
  - CVT
  - Czochralski
  - Float-zone
  - Zone refining
  - Verneuil method
  - Skull melting
  - Solution methods

- Describe the reasons for use of a particular synthesis method, identify the advantages and disadvantages of each method.

- Identify the synthesis technique most likely to be useful in the synthesis of a given compound.

- Describe what is meant by intercalation compounds and give examples

- Describe free electron theory and its limitations.
  - Be able to identify how many electrons are in the “electron sea” of a specific amount of a given element.

- Describe and be able to sketch a density of states (DOS) for a given element.
  - Identify and describe an experimental method to determine the density of states

- Describe electrical conductivity in metals and reasons for electrical resistance and its temperature dependence.

- Describe and explain the temperature dependence of the conductivity of a metal and semiconductor

- Describe the extension and application of MO theory to solids
Illustrate and describe bonding for a 1D chain of H-like or other atoms
  - Be able to determine the number of nodes
  - Be able to fill in the molecular orbitals with electrons and identify the LUMO and HOMO

Describe the formation of bands using the LCAO approach
- Describe the influence of orbital overlap
- What is meant by term bandwidth? Bandgap?

Sketch and describe the bands in metals and semiconductors
  - Explain the trends as one proceeds down a group
  - Explain the influence of the band structure/gap on the electrical conductivity

Describe an extrinsic and intrinsic semiconductor
- Explain the process of photoconductivity and the role of semiconductors
- Describe doped semiconductors (n- and p-type)
- Describe a p-n junction
- Describe a Field Effect Transistor (FET) and MOSFET and illustrate the configuration
- Sketch and describe the band structure of GaAs and d-block MO
  - Explain why certain MO are semiconductors and some are metallic

Describe the types of defects that occur in crystals
  - Describe and compare/contrast Schottky and Frenkel defects

Describe why defects are formed even though it is energetically unfavorable
- Describe how to predict the number of defects and estimate the number of defects given a temperature and ΔH
- Describe and provide examples of intrinsic and extrinsic defects
- Describe the relationship between defects and ionic conductivity
- Describe and illustrate the process of ionic migration in a crystal with (a) Schottky defects and (b) Frenkel Defects.

Compare and contrast ionic and electronic conductors for various materials and provide a relative range for the conductivity.
- Describe how to obtain the activation energy from a the temperature dependence of the ionic conductivity
- Explain why the conductivities of some solid electrolytes do not follow a smooth change with temperature (e.g. AgI).
- Explain which types of defects are most important at low and high temperature
- Define and compare primary and secondary batteries
- Explain why a fast ion conductor exhibits high conductivity (e.g. RbAg₄I₅)
- Describe an oxygen ion conductor, uses, and how a Nernst lamp functions.
- Describe several oxygen and sodium ion conductors
- Describe the components of a battery
  - Describe a lithium battery and advantages and disadvantages
  - Describe a lithium-ion battery and advantages and disadvantages
  - Describe a sodium battery and advantages and disadvantages
  - Describe a Zebra battery and advantages and disadvantages

Illustrate a fuel cell and describe how it works and the advantages/disadvantages in the generation of electrical power
- Describe the components and operating temperature range for several fuel cells: PAFC, AFC, MCFC, DMFC, PEFC, SOFC, PEM
  - Identify the abbreviations
Identify and write the half-reactions occurring at the anode and cathode and the overall reactions for each type of fuel cell

- Describe how oxygen meters and oxygen sensors function
  - Electrode reactions
  - Cell potential
- Describe how electrochromic metals function and possible applications
- Describe how transition metal switchable mirrors function and possible applications
- Describe the chemistry and process of black and white photographic film
- Describe the process responsible for color changes in NaCl when exposed to X-rays, Cl₂ gas, and sodium metal.
- Explain what is meant by the term Vegard’s Law
- Describe the formation of electronic defects and clusters (e.g. Koch-Cohen cluster)
- Be able to illustrate a cluster defect in a rock-salt structure
- Explain the defect clusters present in uranium dioxide
- Describe, sketch and explain the defects that occur in titanium monoxide
- Describe and sketch planar defects: dislocation, grain boundaries, shear planes
- Describe, sketch, and explain formation of shear structures in WO₃₋ₓ
- Describe, sketch, and explain formation of planar intergrowth structures in tungsten bronzes
  - Explain the use of electron microscopy to view intergrowth structures
- Describe and explain formation of block structures in O-deficient Nb₂O₅ and mixed oxides with Ti or W
- Describe 3d defects: pentagonal columns, infinitely adaptive structures
- Describe the electronic properties and conductivity of four basic types of non-stoichiometric oxides (ABCD)
  - Describe how conduction occurs in these oxides
  - Describe how charge balance is maintained
  - Explain the influence of the non-stoichiometry on the crystal structure
  - Explain how the non-stoichiometry influences electronic properties and relate n-type or p-type semiconductor like conduction to the four types of non-stoichiometric oxides.
  - Describe how non stoichiometry may be measured with experimental techniques (e.g. density)
- Describe valence induction

*Note: The list of topics is not exhaustive and there may be questions on a topic covered in lecture that is not listed above. 3/27/17*