

Midterm

- 25% of grade
- 2 pages of notes allowed (not 1 page)
- *Must be in your own handwriting*—no copies, printouts, etc.
- Exam:
 - Multiple choice
 - Short answer
 - Longer answer
- Covers everything so far
- BRING A CALCULATOR
- DON'T BE LATE.



Topics

- Intro, Structures
- Ceramic Structures, planes
- Defects in Ceramics
- Mechanical Properties of Ceramics
- Ceramics Phase Diagrams
- Glass and glass processing
- Clay and powder processing, refractories
- Other ceramic processing
- Polymers I
- Polymers II
- Composite Materials I
- Composite Materials II
- Composites Materials III



1. Basic crystal structures
2. Charge neutrality



1. What are the common crystal structures for ceramics?
2. Ceramic Structures based on:
 - a. --maximizing # of nearest oppositely charged neighbors.
3. Structures may be predicted based on:
 - a. ratio of cation to anion radii.
 - b. ratio of cations to anions (a function of relative charge) defines how many sites are filled/empty).
4. The rules and crystal structures are strange for C and glasses.
5. Directions and Planes
 - a. --be able to identify and draw directions and planes.
 - b. --be able to draw lattice and atom positions for {100} and {110} of standard ceramic crystal structures



1. What are the possible strengthening mechanisms for particle reinforced composites (there are 2)?
2. Be able to calculate upper and lower bounds for the Young's modulus of a large particle composite.
3. Know the strengthening mechanism for transformation toughened ceramic composites (Yttria stabilized, small volume, tetrahedral zirconia particles).



1. What types of ionic defects are common for ceramics?
2. How can a ceramic be made to be non-stoichiometric?
3. How do substitutional impurities affect stoichiometry?
4. How is charge neutrality maintained in ionic structures?
5. What is the distinction between dopants and impurities?
6. How do defect concentrations vary with temperature?
7. Be able to propose appropriate defects to counter other impurities/defects.



- Room temperature mechanical response of ceramics is elastic, but fracture is brittle with negligible ductility.
- Elastic modulus and fracture strength are determined differently than for metals. (transverse bending vs. tension). How and why?
 1. Be able to compute the flexural fracture strength of a ceramic from a flex test.
 2. Be able to use fracture toughness to determine the max stress for a given ceramic with flaws of a known size and radius of curvature.
- Ceramic materials are stronger in compression than in tension.
- Elevated temperature properties for ceramics are generally superior to those of metals.
- Viscosity is the mechanism for deformation for amorphous ceramics.
- Porous ceramics exhibit a strong variation in properties—why, and how can this be overcome?
- Many ceramics are extremely hard. Why?



- Diffusion
 - How does diffusion differ in ceramic vs. metallic systems?
 - Why is diffusion important in ceramics?
- Phase diagrams
 - Know how to read binary and ternary phase diagrams.
 - Be able to identify where compounds, phases, and solid solutions exist.
 - Be able to use the lever rule.
 - Be able to apply a phase diagram to understanding dopants and impurities.



- What are standard glass additives, and how do they effect structure and properties?
- How do specific volume and viscosity vary with temperature?
- How are glass sheets and containers prepared?
- Why are annealing and tempering important for glass?



- For cement:
 - Sketch the evolution (or uptake) of heat after water is mixed with cement
 - How does the fabrication of cement components compare to that of clays?
- In terms of processing clays:
 - What is slip, and what is hydroplasticity?
 - Describe casting
 - Describe extruding
 - Describe drying
 - Describe firing
- For powder processing:
 - How does pressing help?
 - Describe sintering and its influence on mechanical properties
- For refractories:
 - Compare and contrast the influence of pores in refractories vs. powder-processed ceramics



- Know basic concepts behind fabrication and use of ANY THREE of the following methods for advanced ceramic processing:
 - **Sol-gel**
 - **Single crystals**
 - **Thermal oxidation**
 - **CVD**
 - **Sputtering**
 - **PLD**
 - **IC microfab**
 - **MEMS**



- How does degree of polarization change with molecular weight?



- How are polymer repeat units assembled?
- How does this affect properties?
- More about polymer mechanics and fracture?
 - Be able to describe basic polymer types
 - Be able to describe, compare, and contrast failure of thermoplastics, semicrystalline polymers, and elastomers.



1. What is the matrix in a composite and what materials are commonly used as a matrix?
2. What are the possible strengthening mechanisms for particle reinforced composites (there are 2)?
3. Know the equation for the critical length (L_c) of a fiber.
4. Know the stress distribution on fibers of various lengths w/r L_c in a composite.
5. Be able to calculate the stresses, strains, and elastic moduli (young's) for continuous aligned fiber composites loaded in longitudinal and transverse directions (ie lots of equations).



- Be able to calculate the longitudinal strength for long, short, and very short fiber composites.
- Be able to calculate the Young's modulus for discontinuous fibers oriented in 3 dimensions, 2 dimensions, or 1 dimension.
- Understand fiber composite fabrication: protrusion, prepreg, and winding.



1. What are the possible strengthening mechanisms for particle reinforced composites (there are 3)?
2. Be able to calculate upper and lower bounds for the Young's modulus of a large particle composite.
3. Know the strengthening mechanism for transformation toughened ceramic composites (Yttria stabilized, small volume, tetrahedral zirconia particles).

