EGR 221- Materials Science
Final Exam Review Sheet, 2015

Final exam will be CLOSED BOOK, CLOSED NOTES***, NO CALCULATOR*.**
BRING A STRAIGHT EDGE!!!

All problems will be multiple choice (or true/false). These may be of similar form to multiple choice questions on the midterms, or they may similar to non-multiple choice midterm exam questions. For example, there may be a phase diagram question asking "what is the composition of alpha at 200 degrees C?" – with multiple choice answers. All questions will be similar in nature to mid-term exam questions – but the answers will all be multiple choice. There may be many options (a through l for example):

a) 100°C b) 182°C c) 300°C d) 27% e) 50% f) 60% g) 74% h) 90%
i) 18wt%Sn, 82wt%Pb j) 61wt%Sn, 39wt%Pb k) 90wt%Sn, 10wt%Pb
l) cannot determine with information given, even with a calculator.

VERY IMPORTANT! Know the following basic units Pa, MPa, GPa, psi, kpsi (ksi).

Determine planes and directions in cubic systems given the Miller indices, and visa versa

Understand how and why the following can affect strength: impurities (solid solutions), precipitates, grain boundary/grain size

Understand what causes dislocations to move, what inhibits them from moving, and what direction they move in a crystal (slip systems).

Understand the following mechanical properties and be able to determine them from a stress-strain curve: yield strength, tensile strength, toughness, ductility, Young's modulus.

Understand the following mechanical properties and the testing used to determine them: hardness, Charpy impact toughness, Poisson's ratio. You do not need to memorize the various hardness tests such as Rockwell, but do know what they have in common (indentations).

Be able to read phase diagrams and determine compositions of phases and determine how much of each phase is present given overall composition and temperature – and visa versa. This includes determining amounts of microstructures (such as eutectic structure and primary alpha) that may be present based on overall composition.

Understand the following microstructures in steel (how are they created, what are their morphologies, relative hardness/strength, toughness/ductility): pearlite, bainite, martensite, spheroidite, tempered martensite and austenite (you don't need to know the relative properties of austenite). Need be able to use a Time-Temperature-Transformation diagram (TTT diagram, a.k.a. isothermal diagram) to determine which of the above microstructures would be formed based off a given cooling history.

Understand the difference between hardening mechanisms of steel (such as formation of martensite) and precipitation heat treating of certain alloys (such as aluminum alloys).

Understand the microstructural differences between thermosetting and thermoplastic polymers (linear/branched vs. crosslinked/networked).

Additional Terminology:

crystal
substitutional solid solution, interstitial solid solution
non-steady state diffusion (transient diffusion), steady state diffusion
phase
free energy, equilibrium, metastable
composition
eutectic reaction (hint: "easily melted." Definition: a reaction that upon cooling a liquid transforms isothermally into two solid phases).
eutectoid reaction (hint: like eutectic, but different – "oid" means "like", an android is human-*like*. Definition: a reaction that upon cooling a single solid phase transforms isothermally into two new/different solid phases).
elastic deformation, plastic deformation
isotropic ("iso" means same – same properties in all directions)
anisotropic ("aniso" means not the same – properties are direction dependent)
thermosetting polymer, thermoplastic polymer

PHASE DIAGRAMS: you must be sure to understand the difference between the following types of questions:

**What is the composition of a phase?* The answer will always be expressed as a percentage of each element. For example, the answer could be: *alpha is composed of 16% Zn and 84% Cu*

**How much of each phase is present (what is the weight or mass fraction of each phase)?* The answer would be something like: *30wt% alpha, 70wt% beta*.

How much of each microstructure is present (what is the weight or mass fraction of each* ***microstructure**)?* The answer would be something like: *30wt% primary α, 70wt% eutectic structure.*

*Be sure to understand the difference between "microstructure" and phase. Microstructure terms include primary alpha (aka proeutectic alpha), eutectic structure, eutectoid structure, pearlite (which is a eutectoid structure for steel), bainite, spheroidite, tempered martensite, martensite (martensite is a metastable phase). Equilibrium phases are what is shown on phase diagrams (α, β, Fe_3C, etc.). You should be able to answer questions similar to those on the exams.

I highly recommend that once you think you understand these things, that you test your knowledge by doing practice problems (such as problems in the book that have answers in the back).