MET 320 SYLLABUS

MET 320 - METALLURGICAL THERMODYNAMICS
(4-0) 4 credits. Prerequisites: PHYS 211, CHEM 112, MATH 125. The principles of chemical thermodynamics and their application to metallurgical engineering processes. Topics covered include the zeroth, first and second laws of thermodynamics, the fundamental equations of state for open and closed systems, criterion of equilibrium, heat capacities, reaction equilibrium constants and their dependence upon temperature and pressure, chemical potential, standard and reference states, stability diagrams, and solution thermodynamics. This course is cross-listed with ENVE 320.

TEXTBOOK
Introduction to the Thermodynamics of Materials, 5th Ed. by David Gaskell (3rd or 4th ed is OK)

INSTRUCTOR
Dr. S. M. Howard MI 114 Ph. 394 -1282
Stanley.howard@sdsmt.edu Open Office Policy

REQUIRED/ELECTIVE
MET 320 is required for all B.S. Metallurgical Engineering. It is a required course for B.S. Environmental Engineering students taking the Metallurgical Engineering emphasis.

COURSE OBJECTIVES
Students who satisfactorily complete this course will be able to determine the effects of temperature, pressure, and concentration on chemical reactions.

COURSE OUTCOMES
Students who satisfy the following outcomes will receive a passing grade

• Given the initial state (i.e., two of the following: T, P, V), the final state (i.e., one of the following: T, P, V), and the path followed (isothermal, isochoric, isobaric, adiabatic, reversible, free expansion) by an ideal gas, the student will be able to calculate $\Delta U$, $\Delta H$, $\Delta S$, q, and w.
• The student will be able to calculate $\Delta S_{\text{Total}}$ when a body of given mass, heat capacity, and initial temperature equilibrates with a heat sink of specified temperature.
• The student will be able to calculate $\Delta S_{\text{Mixing}}$ when two or more pure components at the same temperature, pressure, and state form an ideal solution.
• Given a chemical reaction where the temperatures and amounts of reactants, the final temperature and amounts of the products, and corresponding enthalpies of formation at 298 K and the heat capacities are specified, the student will determine the heat added to or removed from the system.
• The student will be able to integrate the Clausius and the Clausius-Claperyon Equations and, given all but one of the variables in the equation, solve for the remaining variable using the equation. The student must recognize that melting or boiling point information constitutes a (T,P) set.
• The student will be able to calculate $\Delta G$ for a condensed-phase reaction at constant temperature as a function of pressure given the molecular weights and densities of the reactants and products and the $\Delta G$ at a specified pressure.
• The student will be able to determine the equilibrium constant for a reaction from $\Delta G^\circ$ of formation data for the reaction and to correctly describe the standard state for each component involved in the reaction.
• The student will calculate the equilibrium state (partial pressures, moles) for a reaction involving known initial amounts of gases and pure condensed phases occurring at a given temperature and pressure. The student will be provided either the $\Delta G^\circ$ or $K_{\text{Eq}}$ for the reaction.
• The student will determine activities and activity coefficients for component i from the integral molar Gibbs energy of mixing and from the partial molar Gibbs's energy of mixing for component i.
• The student will derive the Fundamental equations for an open system, the Maxwell Relations, the "Other" Thermodynamic relationships, the criterion of equilibrium for systems at constant temperature and pressure.
• The student will calculate the cell potential for electrolytic cells involving dissolved components in non-aqueous systems.
• The student will determine using the Ellingham Diagram relative oxide stabilities, equilibrium oxygen pressures, equilibrium H2/H2O and CO/CO2 ratios for any reaction on the Ellingham Diagram.
TOPICS

• First Law of Thermodynamics (9 classes)
• Second Law of Thermodynamics (9 classes)
• 2nd Law Statement, Carnot Cycle, 4 Propositions
• Statistical Entropy (2 classes)
• Physical Meaning of Entropy, Boltzman Equation, Mixing Entropy, Stirling's Approximation
• Auxiliary Functions (3 classes)
• Fundamental Equations of State, Maxwell Relationships, Other Thermodynamic Relations, Chemical Potential, Gibbs-Helmholtz Equation, Criteria of Equilibria
• Heat Capacity and Entropy Changes (5 classes)
• Sensible Heats, Transformation Heats, Reaction Heats, ΔCp, ΔH=f(T), ΔS=f(T), Adiabatic Flame Temperatures, Heat Balances, JANAF Thermochemical Tables
• Phase Equilibria in One Component Systems (6 classes)
• Clausius-Claperyon Equation, Heats of Vaporization From Vapor Pressure Data, Shift in Transformation Temperature with Pressure
• The Behavior of Gases (3 classes)
• Compressibility Factor, Law of Corresponding States, Equations of State, Fugacity
• Reactions Equilibria (13 classes)
• Solution Thermodynamics (9 classes)
• Absolute and Partial and Integral Molar Quantities, Relative and Partial Integral Molar Quantities, Ideal Solutions, Excess Quantities, Gibb's Duhem Equation, Tangent Intercept Method, a=f(T), Change in Reference State, 1 wt % Reference State Interaction Parameters
• Phase Equilibria and Electrochemistry (as time permits)
• Tests (5 classes)

CLASS SCHEDULE
9:00 – 9:50 MWRF MI 220

GRADING
Homework 10 points each 40 *
Short quiz every day 10 points each 450 *
3 or 4 Hour exams 100 points each 300 - 400
Final exam 150**
* These are approximate numbers based on previous sections.
** Sometimes the fourth hour exam is combined with the final.

The final grade is based directly on the total points achieved. There is no additional weighting. On rare occasions a student's grade may be raised (but never lowered) for subjective considerations such as an excellent homework file. The final grade section average is normally between 2.9 and 3.2.

ADA STATEMENT
Students with special needs or requiring special accommodations should contact the instructor, Dr. Howard at 394 1282 or the campus ADA coordinator at 394-2416 at the earliest opportunity.

RELATIONS OF COURSE OUTCOMES TO PROGRAM OUTCOMES
a) Apply Knowledge of Math, Science, and Engineering
c) Optimally Select Material and Design Materials Treatment and Production Processes
POLICIES

- Students who are ill should not attend class or enter the MI Building. Use email and the telephone.
- All exams sheets provided by the instructor MUST be turned in on top of each exam.
- Most homework is not graded but all homework must be kept in a bound notebook available for inspection.
- Students who wish to be excused should leave a message at 394-1282 before the absence. Excuses are allowed for sickness, emergencies, etc. Students who were unable to call before the absence occurred should discuss the absence with Dr. Howard.
- Excused absences from short quizzes will result in the assignment of an estimated grade for the missed quiz. Unexcused absences will result in a zero. No quizzes or exams are thrown out.
- Students who return from an excused absence may elect to write a one-page paper on the previous day’s lecture in lieu of taking the short quiz the day of their return to class.
- Short quizzes will cover only material from the lecture.
- Students who miss an hour exam for an excused reason will be given a make-up exam but it will probably be more difficult and longer than the missed exam. Students are expected to take makeup hour exams within three days after their return from an excused absence.
- Dr. Howard has an open door policy. His schedule is posted on the door to MI114. Students are welcome to call Dr. Howard at 394-1282 or email him at stanley.howard@sdsmt.edu. Appointments are discouraged unless there is a significant reason to make one. The 30 minute period before an hour exam is generally not a good time to ask questions since it is reserved for exam writing and printing.

LABORATORY

None

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT

- This course prepares students in the basics of resource recovery, concentration and recycling and therefore provides students with the necessary basis to design, operate and optimize metallurgical processes taking place in practice.
- Ethical and professional conducts are emphasized throughout the course and also emphasized is global awareness in the field of extractive metallurgy.

ASSESSMENT AND EVALUATION

One Final Exam – required by all students
Three or Four Hour Exams
Daily Short Quizzes

EXPECTATIONS:

College Calculus, Chemistry, Physics

COMPUTER USAGE

Know Elementary Excel

PREPARED BY

S. M. Howard