
GG602 – Theoretical Petrology

Course Description and Organization

Instructor: Julia Hammer phone: 6-5996 jhammer@hawaii.edu

Office Hours: after class or by appointment

Meeting times and location: MWF 8:30- 9:20 am F 12:30- 1:20 pm POST 703

Text: Nordstrom, D.K. and Munoz, J.L.. 1994. *Geochemical Thermodynamics*: Cambridge, Blackwell, 493 p.

Credits: 4

Related Texts:

Carmichael, I.S.E., and Eugster, H.P., 1987, *Thermodynamic Modeling of Geological Materials: Minerals, Fluids, and Melts*, in Ribbe, P.H., ed., *Reviews in Mineralogy*, Volume 17: Washington, Mineralogical Society of America, p. 499.

Carroll, M.R. and Holloway, J.R., 1994, *Volatiles in Magmas*, in Ribbe, P.H., ed., *Reviews in Mineralogy*, Volume 30: Washington, Mineralogical Society of America, p. 398.

Gibbs, J.W., 1993, *The Scientific Papers of J. Willard Gibbs, Volume I, Thermodynamics*: Woodbridge, Ox Bow Press, 434 p.

Hargraves, R.B., 1980, *Physics of Magmatic Processes*: Princeton, Princeton Univ. Press, 585 p.

Kondepudi, D. and Prigogine, I., 1998, *Modern Thermodynamics*: New York, John Wiley and Sons, 486 p.

Lasaga, A.C. and Kirkpatrick, R.J., 1981, *Kinetics of Geochemical Processes*, in Ribbe, P.H., ed., *Reviews in Mineralogy*, Volume 8: Washington, Mineralogical Society of America, p. 398.

Lasaga, A.C., 1998, *Kinetic Theory in the Earth Sciences*: Princeton, Princeton Univ. Press, 810 p.

Porter, D.A. and Easterling, K.E., 1997, *Phase Transformations in Metals and Alloys*: London, Chapman and Hall, 514 p.

Powell, R., 1978, *Equilibrium Thermodynamics in Petrology*: New York, Harper and Row, 284 p.

Richardson, S.M. and McSween, H.Y., 1989, *Geochemistry: Pathways and Processes*: Englewood Cliffs, Prentice Hall, 488 p.

Expected Background: This course is intended for graduate students who have some background in physical chemistry and igneous/metamorphic petrology and who are interested in the geologic application of chemical thermodynamics and kinetic theory. Maths prerequisites are college calculus and linear algebra. Experience with spreadsheets and computer programming is helpful.

Topics: Topics covered include Gibbs free energy and its temperature, pressure, and composition derivatives; phase equilibria and liquid immiscibility; fugacity, activity, and chemical potential; ideal and nonideal solutions; volatile solubilities; diffusion, reaction rate laws, and phase transformations. The principles underlying various quantitative petrologic models will be presented. Applications to igneous petrology, volcanology, and planetary science will be emphasized in problem sets and class projects.

Structure: The course is administered in 3 weekly lectures and 1 Friday session, which will be used for problem solving, lecture, asides, discussion of course projects, etc.

Grading:

Course project: a term paper 5-10 pages long (not counting references, figures, computer programs), written in journal style format, on an aspect of petrologic methods or principles will constitute 25% of your course grade. The topic should be selected, in consultation with instructor, by 10 March. A detailed outline should be submitted by 31 March. Class presentations are on 2 May and the project is due 5 May.

Exams: there will be two mid-term exams that will count 20% each toward the final grade.

Homework: homework assignments will count 35% toward the course grade. Assignments will be handed out in class, and generally will be due a week later. You may discuss homework problems outside class, but the work turned in must be your own.

week	date	topics	Suggested reading
week 1	M Jan 13 W Jan 15 F Jan 17	systems, state functions, energy, 1 st and 2 nd laws, ideal gas law	Nordstrom and Munoz CH 1 and 2
week 2	M Jan 20 – no class W Jan 22 F Jan 24	Maxwell relations, graphical derivations of thermodynamic parameters, Euler integration, Legendre transformations	Nordstrom and Munoz CH 3
week 3	M Jan 27 W Jan 29 F Jan 31	unary system with 3 phases, phase rule, Gibbs-Duhem equation, Clausius Clapyron equation	Nordstrom and Munoz CH 4
week 4	M Feb 3 W Feb 5 F Feb 7	isentropic processes, critical points, liquid immiscibility, binary systems	notes
week 5	M Feb 10 W Feb 12 F Feb 14	chemical potential, the equilibrium condition	Nordstrom and Munoz CH 4
week 6	M Feb 17 – no class W Feb 19 F Feb 21	phase topology of multicomponent systems, Schreinemakers analysis	Nordstrom and Munoz CH 4
week 7	M Feb 24 W Feb 26 F Feb 28	nonideal behavior (activity, fugacity), solution models (ideal mixtures, excess terms, real mixtures)	Nordstrom and Munoz CH 5 and 6
week 8	M Mar 3 W Mar 5 F Mar 7	numerical petrologic solution models	notes
week 9	M Mar 10- <u>topics due</u> W Mar 12 F Mar 14	oxidation-reduction reactions, fO ₂	Nordstrom and Munoz CH 10
week 10	M Mar 17 – no class W Mar 19 – no class F Mar 21 – no class M Mar 24 – no class W Mar 26 – no class F Mar 28 – no class	Lunar and Planetary Science Conf. <u>Take-home midterm Exam</u> SPRING BREAK	
week 12	M Mar 31- <u>outline due</u> W Apr 2 F April 4	volatile solubilities and solution mechanisms in silicate melts (H-C-O-S)	Handouts-- MSA v. 30
week 13	M Apr 7 W Apr 9 F Apr 11	rate laws, transition state theory, Arrhenius parameters	Handouts—Lasaga CH 1-4
week 14	M Apr 14 W Apr 16 F Apr 18 – no class	diffusion, Stokes-Einstein relations, Fick's 1 st and 2 nd Laws	Handouts—Lasaga CH 1-4
week 15	M Apr 21 W Apr 23 F Apr 25	nucleation theory (homogeneous, heterogeneous)	Handouts—Porter and Easterling
week 16	M Apr 28 W Apr 30 F May 2- <u>presentations</u>	crystal growth, constitutional supercooling	Handouts—MSA v.8
week 17	M May 5- <u>projects due</u> W May 7	crystal dissolution, zoning, growth rate laws, CSD theory	Handouts—Lasaga CH 7