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: Tu-Th 3:00-4:15 or as mutually agreed upon

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

Credits: 3

Related Texts:

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.

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.

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. Math prerequisites are two semesters of college calculus. Linear algebra is helpful. 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 two 75-minute lectures per week.

Grading:

Exams: there will be one mid-term exam that will count 25% toward the course grade, and one final exam that will count 25% toward the course grade.

Homework: homework assignments will count 50% 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.

Schedule (flexible, depending on student pace and interests)

week	date	topics	Reading
week 1	Week of Jan 13	systems, state functions, energy, 1st and 2nd laws, ideal gas law	Nordstrom and Munoz CH 1&2
week 2	Week of Jan 20	Maxwell relations, graphical derivations of thermodynamic parameters, Euler integration	Nordstrom and Munoz CH 3
week 3	Week of Jan 27	unary system with 3 phases, phase rule, Gibbs-Duhem equation, Clausius Clapyron equation	Nordstrom and Munoz CH 4
week 4	Week of Feb 3	isentropic processes, critical points, liquid immiscibility, binary systems	notes
week 5	Week of Feb 10	chemical potential, the equilibrium condition	Nordstrom and Munoz CH 4
week 6	Week of Feb 17	nonideal behavior (activity, fugacity), solution models (ideal mixtures, excess terms, real mixtures)	Nordstrom and Munoz CH 5
week 7	Week of Feb 24	theory of solutions, cont.	Nordstrom and Munoz CH 6
week 8	Week of March 3	energetics and mineral stability	Putnis CH 8 and 9 (selections)
week 9	Week of March 10	thermobarometry	RiMG v.69 CH 3
Week 10	Week of March 17	oxidation-reduction reactions, fO_2	Nordstrom and Munoz CH 10
Week 11	Week of March 24	SPRING BREAK	
week 12	Week of March 31	volatile solubilities and solution mechanisms in silicate melts (H_2O)	RiMG v. 30 and v. 69 (selections)
week 13	Week of April 7	volatile solubilities and solution mechanisms in silicate melts (H-C-O-S)	RiMG v. 30 and v. 69 (selections)
week 14	Week of April 14	kinetic theory	Putnis CH 10
week 15	Week of April 21	Siliciate melts: relaxation and viscosity	RiMG v. 32 CH 2&3 (selections)
week 16	Week of April 28	transformation processes (homogeneous nucleation, diffusion)	Putnis CH 11
week 17	Week of May 5	Transformation processes, cont. (magnetic transitions and magnetic properties)	Putnis CH 12 (selection)