

ME 262A - Physical Gas Dynamics

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Check out the WWW page for the course: <http://www.stanford.edu/~cap/262A.htm>

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Objectives and Scope

ME 262A is an introduction to the microscopic view of the thermophysical and transport properties of gases. It emphasizes a conceptual understanding, based on the microscopic behavior of molecules, and it is intended as a preliminary to courses in combustion, plasma sciences or reactive gas dynamics. The initial section on kinetic theory of gases develops the molecular basis for familiar macroscopic properties such as pressure and temperature as well as transport properties by considering the collisions among the particles that make up the gas. The section on chemical thermodynamics introduces the criteria for equilibrium in reacting systems, first from a macroscopic viewpoint and then from a molecular perspective by application of statistical mechanics to describe the properties of systems comprising a large number of particles.

Resource Material

The required text is: *Introduction to Physical Gas Dynamics*
W. G. Vincenti and C. H. Kruger

Course Structure

The lectures will emphasize concepts and theory and will follow the resource material fairly closely. In some cases, the textbook will be supplemented by additional notes and handouts. Weekly problem sessions will be scheduled to provide solutions to example problems and to answer questions about course material. Biweekly problem sets will be assigned to give you practice in application of basic concepts and theory. You may discuss the solution approach for assigned problems with your colleagues; but, work submitted should represent your original effort. Extensions of up to one class period for submission of problem sets will be granted **with prior approval**. A series of short (10 minute) closed-book quizzes will be given on most Fridays (see Course Schedule for dates). These quizzes will focus on material presented during the previous week. One of these quizzes will be a "throwout."

Grading

The course grade will be based on problem sets (30%), short quizzes (15%), one in-class midterm exam (15%), and one three-hour final examination (40%).

Course Outline and Schedule

(Lec #)Date	Topic
(1) Sept. 24	Introduction to kinetic theory; §I.1, I.2
(2) Sept. 26	Kinetic theory interpretation of macroscopic gas properties; equipartition of energy; §I.3 [†]
(3) Sept. 29	Introduction to the concepts of mean free path, cross section and collision frequency; §I.4
(4) Oct. 1	Elementary, microscopic basis for transport coefficients; §I.5
(5) Oct. 3	Velocity distribution function, differential particle flux; §II.2, II.3, [†] first short quiz
(6) Oct. 6	Differential property flux, differential collision rate; §II.3, II.4 [†]
(7) Oct. 8	Equilibrium velocity distribution function - Maxwell's argument, differential collision cross section; §II.5, II.6
(8) Oct. 10	Differential cross section, conditions for equilibrium (revisited); §II.6 second short quiz
(9) Oct. 13	Equilibrium speed distribution, cross sections revisited; §II.5, II.6 [†]
(10) Oct. 15	Collision frequency, mean free path, transport coefficients; §II.7 [†]
(11) Oct. 17	Reactive collisions, chemical equilibrium; §II.7 [†] third short quiz
(12) Oct. 20	Reaction cross section, van't Hoff equation, Le Chatelier's principle [†]
(13) Oct. 22	Chemical equilibrium, Boltzmann equation [†]
(14) Oct. 24	Chemical energy, 1st law analysis of reacting systems, heat of reaction; §III.2 -4 [†] fourth short quiz
(15) Oct. 27	Heat of formation, entropy, 2nd law constraints on reacting systems [†]
(16) Oct. 29	2nd law applied to reactive systems, conditions for equilibrium; §III.5 - 7 [†]
(17) Oct. 31	Chemical potential, law of mass action; §III.8 [†]
(18) Nov. 3	Equilibrium constants, van't Hoff equation revisited; §III.9,10 [†] Nov. 5 Midterm Examination
(19) Nov. 7	Introduction to statistical mechanics and quantum mechanics; §IV.1 - 3 [†]
(20) Nov. 10	Concept of discrete states, Schrödinger's equation; §IV.3 [†]
(21) Nov. 12	Translational, electronic, rotational and vibrational energy states; §IV.3 [†]
(22) Nov. 14	Enumeration of microstates, statistical models; §IV.4 [†] fifth short quiz

Course Outline and Schedule (continued)

(Lec#) Date	Topic
(23) Nov. 17	Boltzmann statistics, most probable macrostates Boltzmann distribution; §IV.5,6
(24) Nov. 19	Partition functions and their relation to thermodynamic properties; §IV.7,8
(25) Nov. 21	Translational, electronic contributions to the partition function; §IV.9-11 sixth and final short quiz
(26) Nov. 24	Rotational, contributions to the partition function; §IV.12
(27) Nov. 26	Vibrational Contribution to the partition function; §IV.12
Nov. 28	No lecture - Thanksgiving break
(28) Dec. 1	Dissociation equilibrium, the law of mass action; §IV.12
(29) Dec. 3	Law of mass action, examples
(30) Dec. 5	Review, problems from previous final exams

Final Examination (8:30-11:30 a.m.) *Date to be Announced*

† - indicates departure from presentation in text

Readings and Exercises

Week	Reading*	Homework	Due Date
Sept. 22	Chapter I: § 1-3	I 4.1, 4.2, 5.1, 5.2, S1	Oct. 8
Sept. 29	Chapter I: § 4,5 Chapter II: § 1-3		
Oct. 6	Chapter II: §4-6	II 5.1, 5.3, 7.1, S2	Oct. 22
Oct. 13	Chapter II: §7		
Oct. 20	Chapter III: §2-4	III 3.1, 9.1, 10.1, S3, S4	Nov. 5
Oct. 27	Chapter III: §5-8		
Nov. 3	Chapter III: §9,10 Chapter IV: §1-3	IV 4.1, 6.1, 7.2, 9.2	Nov. 19
Nov. 10	Chapter IV: §4		
Nov. 17	Chapter IV: §5-11	IV 10.1, 12.6, S5, S6	Dec. 3
Nov. 24	Chapter IV: §12		
Dec. 1	Chapter IV: §12 (review)		

*Vincenti and Kruger