EK424 THERMODYNAMICS AND STATISTICAL MECHANICS (Fall 2018)

Thermodynamics is the study of *processes* (e.g., expansion of a gas, boiling of water, or diffusion of ions across a membrane). When is a process favorable? When is it unfavorable or impossible? How much energy does a process require in order to take place? We will study the thermodynamics of two types of processes: mechanical and chemical. Biological systems make wide use of both forms (e.g., in the mechanical beating of a heart, or the chemical conversion of glucose into useful work), and a good understanding of thermodynamics is essential for designing molecules that interact with living organisms.

Course info: We will examine all of the usual topics in chemical thermodynamics. This course will emphasize a statistical/molecular view.

The class meets at 9 AM-10:45 AM Tuesdays and Thursdays in PHO 211. Prerequisites for this class are chemistry (CH102), calculus (MA226), physics (PY212), and probability theory (EK381). EK424 itself is a prerequisite for upper-division courses in molecular bioengineering and biomechanics.

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Textbooks: Tinoco et al., *Physical Chemistry: Principles and Applications in Biological Sciences*, 5th ed. (*recommended*)

We will cover material that corresponds roughly to Tinoco's Chapters 1-6 and 12.

Various documents on the EK424 Blackboard website (http://learn.bu.edu)

For more information:

Dill and Bromberg, *Molecular Driving Forces* (thorough; used in 2005-2008)
Connors, *Thermodynamics of Pharmaceutical Systems* (practical examples; used in 2004)

Denbigh, *Principles of Chemical Equilibrium* (dry and abstract; used in 2003)
Lehninger, *Bioenergetics* (nice intro to basic thermo)
Atkins, *The Laws of Thermodynamics: A Very Short Introduction* (short, but good)
Chang, *Physical Chemistry for the Biosciences*
McQuarrie and Simon, *Molecular Thermodynamics*

The OpenCourseWare webpage at MIT (http://ocw.mit.edu) has lots of useful information as well. The course most similar to EK424 is Statistical Thermodynamics of Biomolecular Systems.

Grading: Final exam 40%
Midterm 35%

Both exams are cumulative. The final exam will emphasize material covered after the midterm.

Homework 25%

Problem sets will be due at the end of class on Thursday. **Electronic photographs and late homework will not be accepted.** You are expected to work on the assignments individually, except for selected problems where teamwork is allowed and encouraged.

My philosophy on grading:

A = You could be a grader next year
B = You have a solid understanding of the material
C = You can solve simple problems
D = You try hard
F = …

Plagiarism will result in automatic failure in accordance with BU policy.

EK424 TIMELINE

Dates		Topics	Reading
Sep	4	Introduction	Ch. 1
	6	1st Law; kinetic theory	Ch. 2 (p. 13-30)
	11	Energy changes; heat capacity	
	13	Biomechanical work	
	18	2nd Law; entropy	Ch. 3 (p. 55-65)
	20	Partition function; Boltzmann factor	Ch. 5 (p. 151-180)
	25	Boltzmann distribution	
	27	"Ask a Stupid Question" Day	
Oct	2	Expected values (MRI, size of biopolymers, …)	Ch. 12 (p. 463-480)
	4	How to find the partition function for any system	
	9	*NO CLASS*	
	11	How to find everything from a partition function	
	16	Equilibrium; fluctuations	
	18	Review	
	23	**MIDTERM**	
	25	Chemical potential	
	30	Free energy; enthalpy	Rest of Ch. 2 and 3
Nov	1	Energies of reaction	
	6	Reactions in gases	Ch. 4
	8	Reactions in liquids; polymerization	
	13	Simple binding reactions (receptors, enzymes, …)	Rest of Ch. 5
	15	Complex binding reactions (hemoglobin, DNA, …)	
	20	Phase transitions	Ch. 6
	22	*NO CLASS*	
	27	Clausius-Clapeyron equation	
	29	Colligative properties	
Dec	4	Osmosis	
	6	Extractions	
	11	Review	
		FINAL EXAM (date, time, and location TBA)	