SUMMARY REPORT

TEACHING OF UNDERGRADUATE CHEMICAL ENGINEERING THERMODYNAMICS

A mini-session presented at the

Annual Meeting

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COURSE LEVEL AND FORMAT

Chemical engineering majors take two three-hour courses in thermodynamics in their degree program.

Table 7 shows that about 2/3 of the colleges offer two courses while about 1/3 offer only one course. Seven colleges offer three courses. About 1/4 of all thermodynamics courses are offered in the sophomore year while about 1/4 are offered in the junior year. The most usual sequences are second semester sephomore and first semester junior year, and first semester junior year and second semester junior year.

Laboratory periods were reported by 20 colleges. Four reported 1 hr per week, 6 reported 2 hours per week and 10 reported 3 hours per week. A number indicated that these laboratory hours were recitation, problem, seminar or tutorial sessions, rather than experimental periods.

GRADUATE ASSISTANTS

Graduate assistants play a very small part in the teaching of undergraduate thermodynamics. Only 20 of 219 courses used graduate assistants. In 10 courses the G.A. gave less than 10% of the lectures; in 5 courses he gave 10%, and in 3 courses he gave more than 10%. Several of these questionnaires noted that the G.A. participated principally in recitation or problem sessions.

DIFFICULT CONCEPTS

The questionnaire asked respondents to identify those concepts which were difficult for the students to grasp. Entropy led the list followed closely by fugacity. Those concepts listed on 10 or more questionnaires are given below:

Entropy	49
Fugacity	37
Activity	15
Partial Molar Properties	12
Standard States	11

INTRODUCTION

This is the third survey on the teaching of undergraduate chemical engineering thermodynamics which has been conducted by the Chemical Engineering Education Projects Committee since 1971. The survey in 1973 received 59 replies, while the 1976 survey showed 80 replies. The present survey showed 123 replies, the most received on any survey within the past twelve years.

The attached questionnaire was sent in May, 1982 to the chairman of each chemical engineering department in the United States and Canada (170 departments) together with a cover letter asking him to give the questionnaire to the appropriate faculty member for completion. A follow-up letter was mailed in early September to schools which had not replied.

Some universities offer a core thermodynamics course followed by a chemical engineering thermodynamics course. Most give two thermodynamics courses within the chemical engineering department for ChE majors only. This survey is concerned with courses taken only by chemical engineering students.

CORE COURSES

Core courses in thermodynamics, taken by all or most enigneering students, were reported by 30 colleges. The 127 sections annually of core courses had an average enrollment of 46.7 students per section. These courses were taught faculty from the chemical and mechanical engineering departments. It should be noted that the course content of the core course is often similar to that of the first chemical engineering course.

TEXTBOOK

The textbook by Smith and Van Ness, now in its third edition, was used in 75% of the Thermodynamics courses taught within chemical engineering departments. In the 1976 survey, this text was used in 60% of the courses, and in 1973 it was used in 50% of the courses. The texts by Sandler and by Balzhiser were each used in about 10% of the courses (Table 9).

In core courses the text by Van Wylen and Sonntag was used in 62% of the colleges listing a text.

TABLE 1

CHEMICAL ENGINEERING

THERMODYNAMICS COURSE LEVEL

Semester Basis

	Number of Courses	
	First Course	Second Course
Sophomore Year		
Semester 1	10	0
Semester 2	14	8
Junior Year		
Semester 1	37	13
Semester 2	10	31
Senior Year		
Semester 1	4	4
Semester 2	0	1
Total Courses	75	57

OTHER TRENDS

Students use the computer to solve more than 10% of the homework problems in 46 of 123 schools replying.

Self-paced instuction is used in only 2 of the 219 courses surveyed.

Each of the thermodynamics courses at colleges on the semester system meets 3 hours per week. However, 34 of the courses on the quarter system meet hours per week while 22 meet 4 hours per week.

About half of the courses have three tests per semester while one-fourth have four tests.

ENGINEER-IN-TRAINING EXAMINATION

Only one of the schools replying to the questionnaire requires taking the E.I.T. examination as a condition for graduation. Fifty-four schools reported both the number of graduates and the number of persons taking the E.I.T. test. On the average, 33.5% of the graduates took the test.

Some positive reasons for taking the test (number of replies in parentheses) are:

> It is an incentive to take the P.E. exam later (20).
>
> It is easier to take the E.I.T. now than later in their careers (40).
>
> It helps their professional progress in their careers (24).
>
> The P.E. license may be required of all engineers in the future (16).

Some of the reasons for <u>not</u> taking the test are:

> The value of a P.E. license for chemical engineers is questionable (24).
>
> Preparing for the E.I.T. test takes too much time from other studies (15).
>
> The test content is unfair to ChE's (11).

TABLE 3

ANNUAL NUMBER OF SECTIONS

No. of Sections Annually	Number of Schools	
	Course 1	Course 2
1-2	65	69
3-4	14	11
5-6	5	1
7+	1	0
Total	85	81

TABLE 4

STUDENT ENROLLMENTS PER SECTION

No. of Students	Number of Courses	
	Course 1	Course 2
< 15	1	2
16-30	27	28
31-45	30	21
45-60	8	10
>61	19	20
Total Courses	85	81

TABLE 2

CHEMICAL ENGINEERING

THERMODYNAMICS COURSE LEVEL

Quarter Basis

	Number of Courses	
	Course 1	Course 2
Sophomore Year		
Quarter 1	1	-
Quarter 2	2	1
Quarter 3	3	-
Junior Year		
Quarter 1	6	4
Quarter 2	4	9
Quarter 3	-	5
Senior Year		
Quarter 1	1	1
Quarter 2	-	1
Quarter 3	-	-
Total Courses	17	20

TABLE 6

CORE

THERMODYNAMICS COURSE LEVEL

	No. of Colleges
Sophomore Year	
Semester 1	11
Semester 2	12
Junior Year	
Semester 1	6
Semester 2	1

TABLE 7

NUMBER OF TESTS

	Number of Colleges	
Number of Tests	Semester Basis	Quarter Basis
1	3	3
2	19	16
3	71	24
4	46	12
5+	10	5

*Excludes the final examination

TABLE 5

CORE COURSES

ANNUAL SECTIONS

Number of Sections Annually	No. of Colleges
1-2	6
3-4	6
5-10	6
10+	2

STUDENT ENROLLMENT

PER SECTION

No. of Students	No. of Courses
<20	1
21-50	11
51-100	5
101-150	2
151+	1

Sections of core thermodynamics were reported by 30 colleges.

TABLE 9

TEXTBOOKS

Chemical Engineering Courses	No. of Courses
Smith and Van Ness	122
Sandler	16
Balzhiser et. al.	14
Others	11
No Reply	14
Total	177

Core Courses	
Van Wylen and Sonntag	15
Reynolds and Perkins	5
Others	4
No Reply	6
Total	30

TABLE 8

COURSE DESIGNATION

AND QUANTITY

	No. of Colleges	
One ChE courses	31	
Two ChE courses	54	
Three ChE courses	6	
One core course	5	
Core + ChE courses	25	
One course	36	29.7%
Two courses	79	65.3%
Three courses	6	5.0%

QUESTIONNAIRE ON THE TEACHING OF

UNDERGRADUATE THERMODYNAMICS

INSTRUCTOR ____________________ UNIVERSITY ________________

COURSE NO. TITLE

1. ____
2. ____
3. ____

Answers to the following questions should be based on conditions for the 1981-82 academic year.

	Course Number 1	Course Number 2	Course Number 3
1. Is your school on the semester or quarter system (S or Q?)	______	______	______
2. In which year do most students take this course?(Soph.,Jr.?)	______	______	______
3. In which semester/quarter do most students take this course (1,2,3)?	______	______	______
4. How many sections of this course were offered in 1981-82?	______	______	______
5. What was the average enrollment in each section?	______	______	______
6. In what department was the instructor for this course ChE, ME,..)	______	______	______
7. Did graduate teaching assistants present any lectures in this course(Yes/No)?	______	______	______
8. If question 7 was answered yes, about what per cent of the lectures did TA's give?	______	______	______

over

REPLIES TO QUESTIONNAIRES

The following pages summarize specific replies from the various schools. The entry after "TEXT" is the reply to "In what ways do you feel the textbook for the ChE Thermodynamics course can be improved?" The entry after "DIFF. CONCEPTS" answers the question "What concepts do you feel are particularly difficult for the student to grasp?" The entry after "EXPLANATIONS" is the "explanations of these concepts which you have found most effective."

ACKNOWLEDGEMENTS

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INSTRUCTIONS FOR COMPLETING THE QUESTIONNAIRE

The Chemical Engineering Education Projects Committee of AIChE invites you to share with other faculty members those presentations, explanations, procedures, etc., which you have found effective in teaching undergraduate thermodynamics.

Most chemical engineering programs include two courses in Thermodynamics. The first, or core course, is usually taken by all engineers. The second is usually for chemical engineers only and is taught by the ChE faculty. This questionnaire will cover both courses.

This survey also asks about "teaching conditions": class size, use of graduate teaching assistants, self-paced instructions, and number of sections.

Finally I am including a survey on the E.I.T. exam, now called the Fundamentals of Engineering exam.

Please return your replies as promptly as possible to:

Dr. Edwin O. Eisen
Dept. of Engineering
McNeese State University
Lake Charles, LA 70609.

1. In what ways do you feel the textbook for the ChE Thermodynamics course (not the core course) can be improved?

2. Which concepts do you feel are particularly difficult for the student to grasp?

3. What explanations of these concepts have you found particularly effective?

4. Please give some typical students' reactions upon completing the ChE Thermodynamics course.

	Course Number 1	Course Number 2	Course Number 3
9. Is the course required of most engineers (core) or ChE only?	________	________	________
10. How many of laboratory hours per week are part of this course?	________	________	________
11. Do students use the computer to solve more than 10% of the homework problems in this course? (Yes/No)	________	________	________
12. How many 50-minute lectures are given each week?	________	________	________
13. How many weeks are there in your semester/quarter?	________	________	________
14. How many major tests, excluding final exam, do you give in the course?	________	________	________
15. Does the course use formal self-paced instruction?	________	________	________

QUESTIONNAIRE ON THE TEACHING OF UNDERGRADUATE THERMODYNAMICS

Course No.	TEXT (AUTHOR, TITLE) (Circle chapters covered)
1.	____ 1 2 3 4 5 6 7 8 9 10 11 12 13 14
2.	____ 1 2 3 4 5 6 7 8 9 10 11 12 13 14
3.	____ 1 2 3 4 5 6 7 8 9 10 11 12 13 14

AKRON, U. of

Text (SVN): more generalized approach to first and second law balances

Dif. Concepts: Second law, fugacities, fugacity coefficients, activities, activity coefficients

ALBERTA, U. of

Text (SVN): Reaction coordinate concept for reaction equilibria could be clearer.

Dif. Concepts: Partial molal quantities, excess free energy, entropy

ARIZONA, U. of

Text (SVN): Somewhat disorganized; introduces flow processes too late.

Dif. Concepts: Entropy & Second law

Explanations: Many, many problems.

ARIZONA State U.

Text (SVN): Organization of topics, more realistic and difficult problems, more illustrative examples

Dif. Concepts: Work and Heat.

ARKANSAS U. of

Text (Sandler). Meaning of θ is unclear.

Dif Concepts: Entropy, Fugacity

Explanations: Repetition and examples

AUBURN U.

TEXT (SVN): Clear, concise explanations, well balanced coverage

Dif. Concepts: Chemical potential

Explanations: Working with pertinent problems

BRIGHAM YOUNG U.

Text (Balzhiser et al): Better treatment of phase equilibria

Dif. Concepts: fugacity, activity, free energy (equilibrium constan

BROWN U.

Text (SVN): ChE thermos should be integrated with the traditional calculations of the mass & energy course

BUCKNELL U.

Text (SVN): Excellent text. Somewhat more emphasis on computer methods.

Dif. Concepts: Solution thermodynamics — partial molal quantities & free energies

Explanations: Comparison with pure component properties. Fugacity is like pressure, etc.

CALGARY U. of

TEXT (SVN): New problems, computer applications and advances in phase equilibrium calculations.

Diff Concepts: Entropy, statistical mechanics, activity coefficient prediction and use.

Survey on the Engineering in Training Examination

Most states require two 8-hour written examinations plus a number of years of experience before issuing a Professional Engineer license. The first test, called the EIT exam, is often taken during the senior year. The second, the PE exam, usually can be taken only after the engineering experience has been obtained. The following questions refer to the EIT exam.

1. How many B.S. degrees in ChE were awarded in 1981-82 (August 15, 1981 to August 14, 1982)?____________________

2. Of those receiving degrees, how many took the EIT test?____________________

3. Does your department require taking the EIT exam as a condition of graduation?________

4. Please give two reasons why a senior should take the EIT exam.

5. Please give two reasons why a senior <u>should not</u> take the EIT exam.

CONNECTICUT, U. of

Text (SVN): Change nomenclature to distinguish between total and specific properties, eg. H - total enthalpy; h - molar enthalpy; $\bar{h}_i$ - partial molar enthalpy.

Dif. Concepts: Fugacity, chemical potential

Explanation: Point out that fugacity and chemical potential are a measure of escaping tendency.

CORNELL U.

Text (SVN): Supplement with information from Mech Engrg thermo book.

Diff Concepts: Entropy, fugacity

Explanations: ~~Sletter's~~ Sandlers approach is good for entropy

DREXEL U

Dif. Concepts: Fugacity, excess Gibbs free energy, partial properties

FLORIDA, U. of

Text (Sandler): less mathematical in appearance and exercises Pictorial display of phase and reaction equilibria behavior.

Diff concepts. Use of fugacity equations to solve problems Choice of reference states. Use of models for equations of state. Solution properties

GEORGIA Inst of Technology

Text (SVN): Develop first & second laws from energy and entropy balances so as to stress the congruence ~~of~~ with the balances in transport classes.

Dif. Concepts: Second law

HOUSTON, U. of

TEXT (Several): Improve on discussion of azeotropes, partially miscible systems near critical point, use of equations of state to predict multicomponent equilibria, and colloidal phenomena

DIF CONCEPTS: Units and dimensions

HOWARD U.

Dif Conc: Partial molar quantities, fugacity

IDAHO, U. of

TEXT (SVN): Handle real problems with non-ideal systems. Calculation of G^E from real data

Dif. Concept: fugacity & activity; non-ideal deviations

ILLINOIS (CHICAGO), U. of

TEXT (SVN): More conceptual material, less detail

Dif. Concepts: Standard or reference states

ILLINOIS INST. OF TECH.

TEXT (SVN): Provide more worked problems. Make more concise.

Dif. Concepts: Reversibility; fugacity in mixtures.

Explanations: Go through many examples

CALIFORNIA State U., LONG BEACH

Text (SVN): Chapter 8 needs to be simplified.

Dif Concepts: Phase relationships

CALIFORNIA Inst TECHNOLOGY

Text (SVN): More information on phase equilibria. Better exposition of basic theory

Dif. Concepts: Entropy, Second law, fugacity, non-ideal mixtures

Explanations: Utilize approach suggest by several text books

CARNEGIE-MELLON U.

Text (SVN): Excellent in all respects.

Concepts: Properties of homogeneous mixtures, excess properties. Standard states.

Explanations: Weber & Meissner have a simpler, more direct approach to activity coefficients.

CASE-WESTERN RESERVE U.

TEXT (SVN): Too much emphasis on VLE. Not enough on ionic systems & metallurgical systems.

Dif. Concepts: Fugacity, Standard states, Second law, Entropy.

CATHOLIC U. of America

Text (Van Wylen & Sonntag): Clearer explanations of concepts. More examples from real situations

Dif. Concepts: Entropy, irreversibility, fugacity, Gibbs Function, Helmholtz Function.

CINCINNATI U. of

Text. (Van Wylen & Sonntag): Most texts contain too much material for an undergraduate text.

Dif Concepts: Entropy, partial properties

CLARKSON College

Text (SVN): Excellent text. Notation in chapter 7 and 8 is difficult to follow

CLEVELAND STATE U.

Text: (SVN): Give answers to 1/2 of problems. Coordinate acentric factor theory better. All in all a good text.

COLORADO State U.

Text (SVN): Fuller discussion of calculation of VLE compositions. Discussion of non-ideal solution models

Dif Concepts: Entropy, Partial Molal properties, Fugacity

Explanations: Illustration of concept by describing expt. in which $\bar{V}_i$ is determined. Experimentally measuring V_{TOTAL} as i is added in small increments to fixed amount of the other components at fixed T&P.

COLORADO, U. of

Text (SVN): Need text which includes foundations of thermodynamics, plus a concise treatment of phase equilibria and chemical reaction equilibria

Dif. Concepts: Entropy and the Second law

McMASTER U.

TEXT (SVN): Laboratory section would be helpful.

Diff Concepts: Activities and related concepts.

McNEESE State U.

TEXT (VanWylen, Sonntag) More examples.
(SVN) Conceptual development of fugacity.

Dif. Concepts: Activity, fugacity, partial molal quantities

Explanations. Energy level box for entropy

MICHIGAN TECH U.

TEXT (Denbigh): Needs better treatment of modern techniques & approaches.

Diff Concept: Chemical potential. Difficulty in understanding the physical meaning of calculus

Explanations: Lots of homework problems, handouts.

MISSOURI-COLUMBIA, U. of

TEXT (SVN): The general treatment of the mathematics of the thermodynamic functions is lacking in thermodynamic text books

Diff. Concepts: Second law and its experimental demonstration

MISSOURI-ROLLA, U. of

TEXT (SVN) More problems and a larger variety. More up-to-date correlations

Dif. Concepts: Solution theory, Standard States, Partial molal Properties, Entropy.

N.J INSTITUTE OF TECH.

TEXT (SVN): Probably chapters 6 & 7 can be presented better.

Dif. Concepts. Entropy, fugacity

Explanations: For entropy, some help from Denbigh. Fugacity, mostly in terms of escaping tendency.

NEW HAMPSHIRE, U. of

TEXT (Balzhiser): Discussion of chemical thermodynamics and equilibrium is vague and difficult to teach. SVN is worse in this respect.

Diff. Concepts: Fugacity, entropy

NEW MEXICO STATE U.

TEXT (Sandler): Weak in process efficiency analysis

Diff Concepts: Entropy; Concept of "component" in the phase rule; Meanings and calculations of properties of hypothetical states.

NEW YORK - BUFFALO, Stat U.

TEXT (SVN) Try to figure out way to write chapter 7 & 8 more clearly.

Dif. Concepts. The numbers of these involved makes the course difficult.

NORTH CAROLINA STATE U.

TEXT: Combination of Balzhiser (simple & in great detail) plus Denbigh (elegant and requiring careful reading) is very good. Better treatment of phase equilibria in terms of practical problems

Diff Concepts: fugacity, chemical potential, activity

ILLINOIS-Urbana Champaign, U. of

TEXT (Balzhiser): Better material on phase equilibria

Diff Concepts: Entropy, phase equilibria

Explanations: PLATO instruction (individualized computer aided instruction.

IOWA, U. of

TEXT (SVN) Explain application of reversible process to irreversible process; explain second law more fully; Explain exact differential & state variable

Diff Concepts: Entropy, free energy, activity, fugacity, chemical potential & reversible processes.

Explanations: Through actual examples

KANSAS State Univ

TEXT (None in particular) The emphasis always seems to be on manipulation without understanding

Dif Concepts: Students start not knowing what thermo is and get more and more confused as more abstract functions are defined.

KANSAS, U. of

TEXT (SVN): Nomenclature, organization

Dif. Concept: Phase equilibria, rigorous calculation procedure

LAMAR U.

TEXT (SVN) Fewer pages & pages of derivations; more problems related to industrial applications.

Diff Concepts: Partial derivatives, such as Maxwell Relations and reciprocals.

LEHIGH U.

TEXT (SVN) Each edition is worse than before. Currently the sections on phase and reaction equilibria are complex and confusing. Material on flow, refrigeration & power is babyish and sometimes wrong.

Diff. Concepts: Phase equilibria

LOWELL U. of

TEXT (SVN): Equations for shaft work of ideal gases are not included soon enough. Much of chapter 10 should be incorporated into chapter 2. Concept of availability should be integrated in to chapter 5

Diff. Concepts: Entropy, availability, lost work.

MAINE, U. of

TEXT (SVN): Order of chapters should be 1-6, 10-12, 7-9, 13

Diff. Concepts: Entropy. Development of fundamental property relationships

MANHATTAN College

TEXT (SVN): Notation

Diff Concepts: Second Law, fugacity.

MASSACHUSETTS, U. of

TEXT (SVN): Less extensive derivations. Too many different nomenclature symbols. Too many archaic equations of state. Few practical examples

Diff Concepts. Entropy. Multicomponent phase equilibria

ROSE-HULMAN Inst. of Techn.

TEXT (Bowden): Needs more complete subject index.

Diff. Concepts: Entropy, fugacity, residual properties

RUTGERS U.

TEXT (SVN): Several chapters should be rewritten. More sophisticated problems. Some subject matter out of sequence

Diff. Concepts: Real gas effects – equations of state; chemical reaction equilibria.

Explanations: Stepwise state change pathways. Incremental free energy changes, virial equation

SOUTH CAROLINA, U. of

TEXT: (Sandler): Notation is confusing; Problems are lousy; Mathematics is not rigorously applied!

Diff. Concepts: Partial differentiation of thermodynamic variables; partial molar properties

STANFORD U.

TEXT (SVN): Notation for residual quantities, excess quantities and property changes on mixing tend to leave students confused.

Diff concepts. Partial molar quantities and their applications

Explanations. A combination of graphical explanations and exact mathematical definitions and treatment

TEXAS A&I U.

TEXT (SVN): Needs to be updated to include important new advances.

Diff. Concepts: Almost all of them.

TEXAS A&M U.

TEXT (SVN): Increased emphasis on basic ideas and elimination of ambiguous statements

Diff Concepts: Mixture properties and equilibrium

Explanations: The μ_i as molecules of i are removed by replacement with molecules of j at constant P & T for a PGM. How μ_i changes at frozen composition as P & T

TEXAS, U. of

TEXT (SVN): Broaden treatment of multi-stage compressors. Rewrite chapters 7 & 8; in their present form they are confusing to nearly all students.

Diff. Concepts: Entropy, chemical potential. Unsteady-state energy balance. Vapor compression refrigeration systems.

TEXAS TECH U.

TEXT (SVN): More worked examples in text. Problems involving the application of solution thermodynamics should be provided

Diff Concepts: Partial molar properties. Fugacities. Activities. Standard states.

TOLEDO, U. of

TEXT (SVN) Chapters 7 & 8 are particularly poor from a teaching standpoint

Diff Concepts choice of systems: entropy

UTAH, U. of

TEXT (Balzhiser) Focus emphasis on key equations. Some partial molar quantity derivations are confusing – probably a notation difficulty

Diff Concepts partial molar quantities

NORTH DAKOTA, U. of

TEXT (SVN): Practical problems on VLE, calculation of phase data.

Diff Concepts: Fugacity, activity coefficient

NOTRE DAME, U. of.

TEXT (Sandler): More example problems, more equation of state work

Diff Concepts: State functions, applications of partial derivatives to thermodynamic functions

Explanations: Any analogies to real life problems are helpful to the student.

OHIO State U.

TEXT (SVN): Rewrite chapters 3, 6, 7, 8.

Diff Concepts: Entropy, fugacity, activity coefficient

OHIO U.

Diff. Concepts: Entropy, Lost Work, inapplicability of PV=RT

Explanations. Energy level box for entropy.

OKLAHOMA, U of

TEXT (BALZHISER) Better answer book needed. Chapter 7 example problems should be reworked.

Diff. Concepts: Physical interpretation of thermodynamic variables

QUEEN'S UNIVERSITY

TEXT (SVN): heavier emphasis on thermodynamic analysis of processes section. Upgrade generalized correlations for thermodynamic properties

Diff. Concepts: Properties of mixtures and solutions

RHODE ISLAND, U. of

Diff Concepts: Reversible & Irreversible Processes; fugacity and chemical equilibrium

Explanations. Because of molecular interactions at high pressures, a corrected pressure (fugacity) is used so that equations derived for ideal gases can be used.

RICE U.

TEXT (Balzhiser): The section on the "Entropy Balance" is particularly poor and confusing to the student

Diff. Concepts: The entire thought process of attacking thermodynamic problems.

Explanations: Property relationships and mathematical manipulations are introduced immediately. A systematic approach for finding property changes under any conditions is introduced. Most of the time this enables students to learn thermo.

ROCHESTER, U. of

TEXT (Sandler): The lack of a clear discussion of fundamental aspects (in contrast to applications) is limiting

Diff. Concepts: distinctions between process and state functions; use of process boundary conditions; use of entropy function

Explanation Discussion of the experimental basis of the discovery of entropy is useful.

VILLANOVA U.

TEXT (SVN): Improvements in example and homework problems.

Diff Concepts: Entropy, Reversibility, Fugacity.

VIRGINIA, U. of

TEXT: No text is really (a) readable (b) has good example problems (c) has good homework problems.

Diff Concepts: Equilibrium in reacting systems.

Explanations: Use fuel cell examples and other practical examples.

WASHINGTON U.

TEXT (SVN): Better organization of material in chapter 7.

Diff. Concepts: Solution thermodynamics.

WATERLOO, U. of

TEXT (SVN): Consistency of notation & conventions. Abolishing some prejudices of the authors.

Diff Concepts: All the abstract functions are anathmas for most students.

WEST VIRGINIA, U. of

TEXT (Sandler): More computer examples, especially in phase and chemical equilibria (chapters 8 and 9). More homework problems.

Diff Concepts: Fugacity, second law, combined phase and chemical equilibria.

WISCONSIN-MADISON, U. of.

TEXT (SVN): Use consistent nomenclature. Chapter 10 could be moved up to near chapter 3. No mention of K_γ and the like in chemical reaction equilibria

Diff. Concepts: Excess and mixing property. Reference states. Infinite dilution properties