SUMMARY REPORT

TEACHING OF UNDERGRADUATE THERMODYNAMICS

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INTRODUCTION

The attached questionnaire was sent in May, 1976 to the chairman of each Chemical Engineering Department in the United States and Canada, together with a cover letter asking that the appropriate faculty member complete and return the questionnaire. A follow-up letter was sent in August to those schools (about 110) which had not responded. Replies were received from 90 of the 156 universities contacted. There were 80 completed thermodynamics questionaires and 69 completed unit operations surveys. This year's responses compare with 71 replies to the 1972 survey (Mass and Energy Balances), 59 replies in 1973 (Thermodynamics), 90 replies in 1974 (Kinetics) and 101 in 1975 (Process Dynamics and Control).

In many universities, chemical engineering thermodynamics follows a general thermodynamics course open to chemical and to mechanical engineers, and to other disciplines. This first course usually covers the First and Second Laws, power cycles, thermodynamic charts and tables, and calculation of work. The second course deals with equations of state, non-ideal fluids and equilibria. This survey was concerned principally with the second course, which is limited to chemical engineering students.

TEXTBOOK SELECTIONS

As in each of the previous surveys, one textbook was used in over half of the courses surveyed. The text by Smith and Van Ness, now in its third edition, was used in 60% of the 82 courses reported. Twenty-seven percent used the text by Balzhiser, et al. The other 13 percent used one of six other texts, with no text being used in more than three courses. The second edition of Smith and Van Ness, which was the overwhelming text choice in the 1973 survey, continues to enjoy a popular position in chemical engineering thermodynamics.

A bibliography of texts mentioned in the survey was given below.

Balzhiser, R.E. et al, "Chemical Engineering Thermodynamics", Prentice-Hall, 1972.

Denbigh, K., "Chemical Equilibrium", Cambridge University Press, 1971.

Hougen, O. A., Watson, K. E., and Ragatz, R. A., "Chemical Process Principles" Part 2, 2nd ed., Wiley, 1959.

Sandler, S. I. " A Course in Chemical Engineering Thermodynamics", Wiley, 1972.

TABLE 1

THERMODYNAMICS COURSE LEVEL

Sophomore Year		
	Quarter 1: 0%	Semester 1: 0%
	Quarter 2: 1.7%	Semester 2: 4.3%
	Quarter 3: 3.5%	
Junior Year		
	Quarter 1: 3.7%	Semester 1: 25.2%
	Quarter 2: 9.6%	Semester 2: 28.7%
	Quarter 3: 4.3%	
Senior Year		
	Quarter 1: 5.2%	Semester 1: 7.8%
	Quarter 2: 3.5%	Semester 2: 2.6%
	Quarter 3: 3.0%	

Silver, R. S. and Nydahl, J., "Introduction to Engineering Thermodynamics", West Publishing Co., 1976.

Smith, J. M. and Van Ness, H. C., "Introduction to Chemical Engineering Thermodynamics, 3rd ed., McGraw-Hill, 1975.

Sontag, R. E. and Van Wylen, G. J., "Introduction to Thermodynamics", Wiley, 1971.

Zemansky, M. W. and Van Ness, H. C. "Engineering Thermodynamics", McGraw-Hill, 1966.

COURSE LEVEL AND FORMAT

Chemical Engineering Thermodynamics is a three-hour course offered in the junior year. This is the conclusion from the 1976 survey (Table 1). Seventy-one percent of the courses are offered in the junior year, with a slight tendency toward the second semester. Only 19% are given in the senior year, while 10% occur during the sophomore year.

In 64% of the courses, three hours of lectures are given each week. Although 21% offer four hours lecture weekly, there appeared little relationship between lecture hours and the quarter or semester system. Nine percent of the courses hold class meetings twice weekly, while the remaining 5 percent meet 5 times a week. The average lecture time was 3.22 hours per week.

Laboratory work is required in only 16% of the courses reported. Four percent offer one lab hour per week, 9 percent have 2 hours weekly and 3% have three hours per week.

The length of the academic quarter is 10 weeks. The length of the semester varied from 12 to 16 weeks with an average of 14.6 weeks.

DIFFICULT CONCEPTS

Over a dozen topics of thermodynamics were mentioned as being conceptually difficult. Entropy and fugacity head the list, with entropy cited on 59% of the questionnaires and fugacity on 47%. Activity was a distant third, mentioned on 20% of the replies. Other areas mentioned on 5% or more of the replies are:

Partial molar quantities	13%
Chemical potential	11%
Reversibility	9%
Phase equilibria	6%
Partial derivatives	6%
Standard states	5%
Free energy	5%
Unsteady-state flow	5%

USE OF THE COMPUTER

Computers are extensively used in the engineering applications of several areas of thermodynamics, particularly multi-component equilibria and PVT behavior. In contrast, 53% of the schools replying indicate that the computer is not required in their thermodynamics course. Thirty-six percent require 1 to 2 computer problem solutions per course, while the remaining 11% require 3 to 4 solutions. A few schools indicated that the use of the computer was optional, rather than required, in their courses. It appears that the academic emphasis in these areas is on conveying the principles and theory, rather than so extensive an application as to require computer solution.

STUDENT REACTION

The following representative replies, each quoted in its entirety, were given by the instructors to the question, "Please indicate the typical students reaction upon completing the course."

"Most find difficulty in being able to visualize how all of the separate parts of thermodynamics really belong to one larger picture."

"Feedback has always been positive; worth of material is realized. Most students seem to enjoy material."

"Students find thermodynamics hard to comprehend."

"Relief" (Mentioned in 15% of the replies)

"A little confused." (Mentioned in 10% of the replies)

"They found it difficult but did understand the material."

"He feels that he has learned a great deal. He wishes more time were availabile to concentrate on thermo problems. He is anxious to use his thermo in later courses such as mass transfer."

"All the way from excellent to ugh!"

"They seem to find it interesting and challenging. Many of them prefer the first term where more emphasis is placed on concepts and ideas to the second term where more emphasis is placed on practical applications."

"Students seem pleased with their accomplishments."

"Like leaving the dentist after a thorough cleaning."

"Relief when it is over and shock when it comes back the next year in design."

The most frequently mentioned reactions generally included:

a. The conceptual difficulty of thermodynamics.
b. The hard work demanded by the course.
c. A sense of accomplishment, tempered by a varying degree of uncertainty and confusion.

UNIVERSITY OF ALBERTA

TX: Smith and VanNess, 3rd ed.
(Jr, Sem 1) 3/1

DIFFICULT CONCEPTS
Entropy, fugacity of components in solution; chemical potential.
CHALLENGES
Finding sufficient problems to illustrate concepts, such as chemical potential, for engineering students; explaining how the many facets of thermodynamics are all really part of the basic laws.

UNIVERSITY OF ARIZONA

TX: Balzhiser, et al
(Jr, Sem 2) 4/0

DIFFICULT CONCEPTS
Fugacity; Entropy, although covered fairly well by Balzhiser.
CHALLENGES
Showing general usefulness of the concepts. Conveying a real understanding of Entropy and the Second Law.
TEXT COMMENTS
Balzhiser is satisfactory, but the nomenclature used for multi-component systems is confusing to the students.

UNIVERSITY OF ARKANSAS

TX: Balzhiser, et al (2 courses)
(Jr & Sr, Sem 1 & 2) 3/0, 3/0

DIFFICULT CONCEPTS
Entropy, free energy, chemical potential.
CHALLENGES
Relate to other courses in curriculum and to real life experience.

AUBURN UNIVERSITY

I: Smith & VanNess
(Jr, Qtr 2) 4/0
II: Balzhiser, et al
(Sr, Qtr 1) 4/0

DIFFICULT CONCEPTS
Entropy, Activity
CHALLENGES
Combining Theory and Practicality
TEXT COMMENTS
I: Good all around text.
II: Very good on chemical equilibrium, but awkward at times.

UNIVERSITY OF CALIFORNIA-BERKELEY

TX: Smith & VanNess
(Jr, Qtr 2, Qtr 3) 3/1, 3/1

UNIVERSITY OF CALIFORNIA (DAVIS)

TX: Smith & VanNess
(Jr, Qtr 2 & 3) 3/0, 3/0

DIFFICULT CONCEPTS
Entropy, fugacity, activity
TEXT COMMENTS
Text is pretty good although some problems are quite long.

UNIVERSITY OF CALIFORNIA-LOS ANGELES

TX: Zemansky, Abbott & VanNess
(Sr, Qtr 1) 4/0

DIFFICULT CONCEPTS
Entropy
CHALLENGES
Maintaining interest and demonstrating the need for a rigorous approach simultaneously; concepts of entropy, randomness, and energy availability.

UNIVERSITY OF CALIFORNIA-SANTA BARBARA

TX: Smith & VanNess, 3rd ed.
(Soph, Qtr 3) 3/0

DIFFICULT CONCEPTS
Entropy, fugacity, partial molar quantities.
CHALLENGES
To orient the students, especially sophomores to the importance and utility of what they are learning.
TEXT COMMENTS
Good text for undergraduates, but sections on mixture properties and phase equilibria could be simplified by limiting the coverage and emphasizing "first order correction terms" to ideal behavior instead of covering non-ideal behavior in detail.

CARNEGIE-MELLON UNIVERSITY

TX: Smith & Van Ness, 2nd ed.
(Soph, Sem 2) 3/0

DIFFICULT CONCEPTS
Non-steady flow open systems.
CHALLENGES
Conveying the beauty and rigor as well as the practical utility of classical thermodynamics.
TEXT COMMENTS
Second edition was far superior to the third edition.

UNIVERSITY OF CINCINNATI

TX: Balzhiser, et al
(Jr, Qtr 2) 4/0

DIFFICULT CONCEPTS
Entropy, partial molar quantities, fugacity, activity, partial fugacity.
CHALLENGES
To relate the concepts to the real world.

CLARKSON COLLEGE OF TECHNOLOGY

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 1) 3/0

DIFFICULT CONCEPTS
Fugacity, Activity
TEXT COMMENTS
Improvement in phase and chemical equilibria.

CLEVELAND STATE UNIVERSITY

TX: Balzhiser, et al
(Jr, Qtr 2) 4/0

DIFFICULT CONCEPTS
Entropy, fugacity
EFFECTIVE EXPLANATIONS
Fugacity can be thought of as an escaping tendency.
TEXT COMMENTS
Students have difficulty in using the derived equations in chapter 11.

UNIVERSITY OF COLORADO

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 2) 3/0

DIFFICULT CONCEPTS
Entropy, fugacity.
CHALLENGES
Trying to explain concepts whic are not exactly clear to you.

COLORADO SCHOOL OF MINES

TX: Balzhiser, et al
(Jr, Sem 1 or 2) 3/0

DIFFICULT CONCEPTS
Energy, Entropy, Equilibrium
CHALLENGES
How to condense the course into one semester of material.
TEXT COMMENTS
Treatment of the first law and irreversible processes could be improved.

CORNELL UNIVERSITY

TX: Balzhiser, et al
(Sr, Sem 1) 3/0

DIFFICULT CONCEPTS
Open System, Availability, Entropy, Standard State
CHALLENGES
Difficult subject because of abstract thinking.

UNIVERSITY OF DELAWARE

TX: Sandler, S.I., "A Course in Chemical & Engineering Thermodynamics"
(Jr, Sem 1) 3/0

DIFFICULT CONCEPTS
Entropy, Fugacity

UNIVERSITY OF DETROIT

TX: Balzhiser, et al
(Pre Sr, Sem 2) 2/0

DIFFICULT CONCEPTS
Fugacity, Entropy
EFFECTIVE EXPLANATIONS
Started at the back of the book where there are more practical examples, and worked toward the front of the book.
CHALLENGES
Level of abstraction required by the students to be able to deal with the concepts involved. Starting with practical examples and moving toward the abstract ideas seems helpful.

DREXEL UNIVERSITY

TX: Smith & VanNess
(Soph, Qtr 2) 4/2

DIFFICULT CONCEPTS
Reversibility, entropy, state function.

UNIVERSITY OF FLORIDA

TX: Smith & VanNess, 3rd ed.
(Jr, Qtr 2 & 3) 4/0, 5/0

DIFFICULT CONCEPTS
Use of mathematics in evaluating changes in state property values.

CHALLENGES
Dealing patiently and effectively with the discontinuity of thought processes involved for the student and their resulting uneven progress and frustration.

UNIVERSITY OF IDAHO

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 1) 3/0

UNIVERSITY OF ILLINOIS - CHICAGO CIRCLE

TX: Smith & VanNess
(Sr, Qtr 1) 4/0

DIFFICULT CONCEPTS
Entropy, Second Law

CHALLENGES
Application of thermodynamics to real cases.

TEXT COMMENTS
Many areas can be improved.

UNIVERSITY OF ILLINOIS-URBANA/CHAMPAIGN

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 1) 3/0

DIFFICULT CONCEPTS
Unsteady-state flow systems; Entropy; Gibbs-Duhem Equation

CHALLENGES
Maintaining student's interest in the more abstract parts of the course.

TEXT COMMENTS
Quite satisfied with the present text.

ILLINOIS INSTITUTE OF TECHNOLOGY

TX: Hougen, Watson & Ragatz
(Jr, Sem 1) 3/0

DIFFICULT CONCEPTS
All concepts seem easy to grasp.

CHALLENGES
Getting students to apply basic principles to solve new problems.

IOWA STATE UNIVERSITY

TX: Balzhiser, et al
(Jr, Qtr 2, Qtr 3) 3/0, 3/0

DIFFICULT CONCEPTS
Entropy

CHALLENGES
Maintaining adequate rigor while retaining sight of engineering objectives; Motivating students.

TEXT COMMENTS
a. Statistical mechanics (Chapter 3) is confusing to students. b. SI units might be preferable. c. More guidance to physical property prediction methods might be preferable.

UNIVERSITY OF KANSAS

TX: Smith & VanNess
(Jr, Sem 2) 3/0

DIFFICULT CONCEPTS
Entropy, fugacity, conceptualization of phase equilibria.

EFFECTIVE EXPLANATIONS
Similarity in concepts of energy and entropy.

CHALLENGES
Convincing students that the elements of thermodynamics are simple.

KANSAS STATE UNIVERSITY

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 1, Sem 2) 2/0, 3/0

DIFFICULT CONCEPTS
Entropy, reversibility, phase equilibria, hypothetical standard states.

TEXT COMMENTS
Improved treatment of phase equilibria is needed.

UNIVERSITY OF KENTUCKY

TX: Smith & VanNess, 3rd ed.
(Soph, Sem 2) 3/0

DIFFICULT CONCEPTS
Multi-component equilibria.

CHALLENGES
To find enough time to cover mathematical development of thermodynamic concepts and for solution of a sufficient number of problems.

TEXT COMMENTS
Too much mathematical detail, but is a good text.

LAFAYETTE COLLEGE

TX: Zemansky, Abbott, VanNess
(Soph, Sem 2) 2/2

LAMAR UNIVERSITY

TX: Balzhiser, et al
(Jr, Sem 1) 3/0

DIFFICULT CONCEPTS
Partial Derivatives.

CHALLENGES
Helping the student bridge the gap from theory to practice.

LEHIGH UNIVERSITY

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 2) 4/0

DIFFICULT CONCEPTS
Fugacity and Entropy

CHALLENGES
Convincing students that unless they commit the necessary time to solve the problems, they have no hope of understanding the material.

TEXT COMMENTS
Current reaction is considerable disappointment. Authors went overboard in the area of fugacity and mixture properties, resulting in a treatment which is overwhelming to junior chemical engineering students.

UNIVERSITY OF LOUISVILLE

TX: Smith & VanNess
(Jr, Qtr 1) 4-1/2/0

DIFFICULT CONCEPTS
Standard states, activity, fugacity

CHALLENGES
Keeping rigor and practicality in the proper focus.

UNIVERSITY OF LOWELL

TX: Balzhiser, et al
(Jr, Sem 1) 3/0

DIFFICULT CONCEPTS
Entropy, internal energy, partial molar properties, fugacity.

CHALLENGES
Predicting feasibility of a chemical reaction from free energy of reaction; minimum work required in a separation process.

TEXT COMMENTS
After using Balzhiser, we are switching back to Smith & VanNess.

UNIVERSITY OF MASSACHUSETTS

TX: Smith & VanNess, 3rd ed.
(Soph, Sem 2; Jr, Sem 1) 3/3, 3/2

DIFFICULT CONCEPTS
Second Law, availability of energy, definition of work, activity, fugacity.

TEXT COMMENTS
Students find book very hard to use; like the second edition much better than the third edition.

MC NEESE STATE UNIVERSITY

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 2) 3/0

DIFFICULT CONCEPTS
Entropy.

CHALLENGES
Science of thermodynamics needs a major renovation for purposes of clarification. For example, the thermal potential should be defined as its reciprocal, i.e. 1/T. Defining work as positive when energy leaves the system leads to confusion on the definition of enthalpy and the other energy functions.

MC MASTER UNIVERSITY

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 1 or 2) 2/0

DIFFICULT CONCEPTS
Understanding thermodynamic diagram

CHALLENGES
Obtain problems related to potentia chemical processes. The Kellogg ammonia synthesis, particularly the gasification and synthesis sections, has been used as a sourc of problems.

TEXT COMMENTS
Current text is excellent.

UNIVERSITY OF MICHIGAN

TX: Balzhiser, et al
(Jr, Sem 1 & 2) 3/0

DIFFICULT CONCEPTS
Energy itself. Free energy and fugacity. Entropy is better understood than enthalpy.

CHALLENGES
a. To get students to understand what I think I understand.
b. To understand student's line of thought. c. To understand other authors' developments.

TEXT COMMENTS
Text plus AIChE slide notebook is sufficient.

MICHIGAN STATE UNIVERSITY

TX: Balzhiser, et al (2 courses)
(Jr, Qtr 3; Sr, Qtr 1) 3/0, 3/0

DIFFICULT CONCEPTS
Entropy changes and irreversibility; partial molar quantities; excess properties; "Lost" work; limited liquid phase miscibility.

CHALLENGES
Thermodynamics should develop the type of thinking in students required for successful, practicing chemical engineers.

MICHIGAN TECHNOLOGICAL UNIVERSITY

TX: Smith & VanNess, 3rd ed. (2 courses)
(Jr, Qtr 2; Jr, Qtr 3) 3/0, 3/0

DIFFICULT CONCEPTS
Solution thermodynamics.

TEXT COMMENTS
Third edition is a good foundation text. I supplement text with hand-out notes on topics not covered.

UNIVERSITY OF MISSISSIPPI

TX: Balzhiser, et al
(Sr, Sem 1) 3/0

DIFFICULT CONCEPTS
Entropy, fugacity, activity.

UNIVERSITY OF MISSOURI-COLUMBIA

TX: Denbigh, "Chemical Equilibria"
(Jr, Sem 2) 3/0

DIFFICULT CONCEPTS
Entropy and the Second Law.

CHALLENGES
Relate thermodynamics to physical processes familiar to the student.

UNIVERSITY OF MISSOURI-ROLLA

TX: Balzhiser, et al
(Jr, Sem 1) 3/0

DIFFICULT CONCEPTS
Fugacity

UNIVERSITY OF NEBRASKA

TX: Smith & VanNess
(Jr, Sem 2) 3/0

DIFFICULT CONCEPTS
Entropy, fugacity

EFFECTIVE EXPLANATIONS
1. Entropy as a measure of the state of disorder, with many qualitative examples, e.g. black and white marbles.
2. Fugacity as a fanagle factor because G. N. Lewis liked the form of the equation derived using the ideal gas law.

UNIVERSITY OF NEW BRUNSWICK

TX: Smith & VanNess, 3rd ed.
(Soph, Sem 2) 3/0
Denbigh
(Jr, Sem 2) 3/0

DIFFICULT CONCEPTS
First Law; open systems; unsteady state.

CHALLENGES
I would rather teach thermodynamics than any other course, because I believe it is the most difficult course in chemical engineering to teach.

UNIVERSITY OF NEW HAMPSHIRE

TX: Smith & VanNess
(Jr, Sem 2) 3/3

DIFFICULT CONCEPTS
Chemical Thermodynamics, Fugacity

CHALLENGES
Reaching all students, Thorough coverages of subject in limited time.

TEXT COMMENTS
Became more rigorous and thorough but also more confusing to undergraduate.

UNIVERSITY OF NEW MEXICO

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 2)

DIFFICULT CONCEPTS
Partial molar properties; entropy of the universe, activity coefficient, fugacity.

NEW JERSEY INSTITUTE OF TECHNOLOGY

TX: Smith & VanNess, 3rd ed. (2 courses)
(Jr, Sem 1 & 2) 3/0, 3/0

DIFFICULT CONCEPTS
Second Law and real processes; fugacity; activity coefficients

TEXT COMMENTS
Simpler, shorter examples to augment present examples.

UNIVERSITY OF NOTRE DAME

TX: Own Notes
(Jr, Sem 2) 3/0

UNIVERSITY OF NORTH DAKOTA

TX: Balzhiser, et al
(Sr, Sem 1) 3/0

DIFFICULT CONCEPTS
Entropy; chemical potential.

CHALLENGES
Convince students that thermodynamics is an engineering course rather than a science course. Bridge gap between theory and applications.

EFFECTIVE EXPLANATIONS
Fugacity is presented as an engineering fudge factor.

TEXT COMMENTS
Chemical reaction equilibrium chapters need more and simple problems.

NORTHWESTERN UNIVERSITY

TX: Balzhiser, et al
(Soph, Qtr 3) 5/0

DIFFICULT CONCEPTS
Unsteady-state flow processes entropy; irreversibility.

OREGON STATE UNIVERSITY

TX: Smith & VanNess, 2nd ed.
(Jr, Qtr 2) 4/0

DIFFICULT CONCEPTS
Fugacity; chemical potential; Defining the system.

CHALLENGES
Developing a student's ability to apply concepts to engineering problems.

OHIO STATE UNIVERSITY

TX: Smith & VanNess (2 courses)
(Jr, Qtr 1 & 2) 2/2, 2/2

DIFFICULT CONCEPTS
Fugacity

TEXT COMMENTS
Rewritten sections are poor, particularly equations of state and fugacity.

OHIO UNIVERSITY

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 1) 3/2

DIFFICULT CONCEPTS
Defining the system and process; fugacity.

CHALLENGES
Covering material in time allotted.

TEXT COMMENTS
Smith & VanNess, 3rd ed., seems to be the best undergraduate [illegible] available.

PENNSYLVANIA STATE UNIVERSITY

TX: Balzhiser, et al
(Sr, Qtr 1 & 2) 3.75/0

DIFFICULT CONCEPTS
Entropy, fugacity.

CHALLENGES
To spark interest of students. This is done by constantly stressing the applications of what we are studying.

TEXT COMMENTS
"Understanding Thermodynamics" by VanNess has a particularly good explanation of the Second Law

UNIVERSITY OF PITTSBURGH

TX: Smith & VanNess, 3rd ed.
(Soph, Sem 2) 2/2

DIFFICULT CONCEPTS
Entropy. The various partial derivatives

TEXT COMMENTS
Too much emphasis on ideal gases.

POLYTECHNIC INSTITUTE OF NEW YORK

TX: Smith & VanNess, 2nd ed.
(Jr, Sem 2) 4/0

DIFFICULT CONCEPTS
1. Choosing a system and applying the First Law in a systematic way.
2. Evaluating work using the environment.
3. Concept of absolute temperature vs. empirical temperature.
4. Application of chemical potential to phase and chemical equilibrium problems.
5. Effects of friction and irreversibility in the conversion of heat to work.

CHALLENGES
Explanation of above concepts.

TEXT COMMENTS
Third edition of Smith & VanNess is grossly inadequate.

PRINCETON UNIVERSITY

TX: Smith & VanNess
(Jr, Sem 1 & 2) 4/0

DIFFICULT CONCEPTS
Entropy; availability of energy; irreversibility.

TEXT COMMENTS
I would like to see larger charts for problem use.

QUEEN'S UNIVERSITY

TX: Smith & VanNess
(Jr, Sem 1) 3/2

DIFFICULT CONCEPTS
Enthalpy, entropy, activity, fugacity, partial molar quantities, differential quantities.

CHALLENGES
Showing the student the utility of thermodynamics.

RENSSELAER POLYTECHNIC INSTITUTE

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 2) 3/0

DIFFICULT CONCEPTS
Fugacity.

CHALLENGES
Overcoming the "cookbook" approach to problem solving.

UNIVERSITY OF RHODE ISLAND

TX: Smith & VanNess
(Jr, Sem 1) 2/3

DIFFICULT CONCEPTS
Any abstract concepts are difficult for the student.

UNIVERSITY OF SASKATCHEWAN

TX: Hougen, Watson, Ragatz
(Jr, Sem 2) 3/0

DIFFICULT CONCEPTS
Entropy, fugacity, activity, chemical potential, standard state

EFFECTIVE EXPLANATIONS
Denbigh's development of the Second Law in "Principles of Chemical Equilibrium"; Use of the films by Sir George Porter "Laws of Disorder."

CHALLENGES
Motivating students to be interested in the subject.

TEXT COMMENTS
Needs to be updated.

UNIVERSITY OF SOUTH CAROLINA

TX: Balzhiser, et al
(Jr, Sem 1) 9/0

DIFFICULT CONCEPTS
Fugacity coefficient, partial molar properties, mathematics associated with mixture properties.

CHALLENGES
a. Conveying relationship between thermodynamics and other chemical engineering subjects such as mass transfer and kinetics. b. Explaining difficult thermodynamic concepts so as to make them seem obvious to the student.

TEXT COMMENTS
Text is poor on multicomponent systems. Chapters on electrochemistry and irreversible thermodynamics could be left out.

SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 2) 3/0

DIFFICULT CONCEPTS
Entropy; chemical equilibrium.

CHALLENGES
Overcoming the pre-conceived notion that thermodynamics is a difficult subject. Get students to master the concepts of the thermodynamic laws so that applications become almost automatic.

TEXT COMMENTS
Latest edition represents a good job of modernizing and updating their previous edition. A few answers in the solutions manual appear incorrect.

STATE UNIVERSITY OF NEW YORK-BUFFALO

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 1) 4/0

DIFFICULT CONCEPTS
Calculation of work; Defining the system.

CHALLENGES
Making it seem simpler than we know it is.

EFFECTIVE EXPLANATIONS
Use of wine and whiskey to demonstrate partial molar properties.

UNIVERSITY OF TENNESSEE

TX: Smith & VanNess, 3rd ed.
(Soph, Qtr 3) 3/1

DIFFICULT CONCEPTS
Fugacity

TEXT COMMENTS
Settle first law:
$\Delta U = Q - W$ or $\Delta U = Q + W$

TENNESSEE TECH UNIVERSITY

TX: Smith & VanNess (2 courses)
(Jr, Qtr 2, Sr, Qtr 1) 3/0, 3/0

DIFFICULT CONCEPTS
Second Law; fugacity; partial molar properties.

UNIVERSITY OF TEXAS-AUSTIN

TX: Balzhiser, et al
(Jr & Sr, Sem 1 & 2) 3/0

DIFFICULT CONCEPTS
Activity, fugacity

TEXT COMMENTS
More problems related directly to chemical engineering would be useful.

UNIVERSITY OF TEXAS-AUSTIN

TX: Balzhiser, et al
(Jr, Sem 1 or 2) 3/0

DIFFICULT CONCEPTS
Entropy; use of fugacity in calculating activity coefficients; practical use of Maxwell's relations and the convenience functions.

CHALLENGES
Developing confidence in the student.

TEXT COMMENTS
Material on the open system energy balance is tough for students. Chapters on multi-component systems and phase equilibria are poor.

TEXAS A&M UNIVERSITY

TX: Smith & VanNess
(Jr, Sem 2) 3/0

DIFFICULT CONCEPTS
Entropy, Gibbs Free Energy, Helmholtz Free Energy

TEXT COMMENTS
Text material should be more readable for student.

TEXAS TECH UNIVERSITY

TX: Smith & VanNess, 3rd ed. (2 course
(Sr, Sem 1 & Sr, Sem 2) 3/0, 3/0

DIFFICULT CONCEPTS
Entropy; effect of pressure and temperature on equilibrium conversion.

TEXT COMMENTS
Third edition of Smith & VanNess is excellent.

TULANE UNIVERSITY

TX: Smith & VanNess
(Jr, Sem 1) 4/0

DIFFICULT CONCEPTS
Fugacity; activity; phase equilibria.

CHALLENGES
Nomenclature, adequate problems, separation of materials.

TEXT COMMENTS
Improved treatment of phase equilibria.

UNIVERSITY OF TULSA

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 1) 3/0

DIFFICULT CONCEPTS
Entropy.

CHALLENGES
Relating thermodynamics to the physical world.

VANDERBILT UNIVERSITY

TX: Balzhiser, et al
(Jr, Sem 2) 3/0

DIFFICULT CONCEPTS
Entropy, activity, activity coefficient, partial molar properties, chemical potential.

VILLANOVA UNIVERSITY

TX: Smith & VanNess, 3rd ed.
(Sr, Sem 1) 4/0

DIFFICULT CONCEPTS
Excess Free Energy
EXPLANATIONS
Use of practical examples to illustrate some abstract concept.
TEXT CONCEPTS
There should be more examples to illustrate each concept.

UNIVERSITY OF VIRGINIA

TX: Smith & VanNess
(Jr, Sem 2) 3/0

DIFFICULT CONCEPTS
Availability, Entropy
CHALLENGES
Convincing the student that thermodynamics is relevant and useful.
TEXT COMMENTS
Too detailed and advanced for a junior year course.

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

TX: Hougan, Watson, Ragatz, 2nd ed.
(Sr, Qtr 1, Qtr 2) 3/0, 3/0

DIFFICULT CONCEPTS
Abstract mathematical arguments; Statistical thermodynamics.

UNIVERSITY OF WASHINGTON (SEATTLE)

TX: Smith & VanNess
(Jr, Qtr 2) 4/0

DIFFICULT CONCEPTS
Fugacity, Activity Coefficients.
TEXT COMMENTS
Seems OK.

WEST VIRGINIA INSTITUTE OF TECHNOLOGY

TX: Smith & VanNess, 3rd ed.
(Jr, Sem 1) 3/0

DIFFICULT CONCEPTS
Fugacity, Gibbs free energy.
CHALLENGES
Applications to reality; Leaving student with enough confidence in his thermodynamics ability that he will use thermodynamics to analyze future problems.
TEXT COMMENTS
Need for self-paced texts.

WIDENER COLLEGE

TX: Sonntag & VanWylan, "Introduction to Thermodynamics"
(Jr, Sem 1) 4/0

DIFFICULT CONCEPTS
Entropy
CHALLENGES
1. The subject is basically difficult to comprehend.
2. Thermodynamics is very comprehensive; therefore good practical examples are needed.
TEXT COMMENTS
We need a "Schaum Series" type of thermodynamics book as a help to the students.

UNIVERSITY OF WINDSOR

TX: None, students receive notes in text form. Students have access to 15 to 20 texts from departmental collection.
(Jr, Sem 1 & 2) 2/2

DIFFICULT CONCEPTS
Reversibility; Entropy and the Second Law; Activity Coefficient.
CHALLENGES
Application of rigorous mathematical principles to partial molar quantities. Integrating path functions; Relating thermodynamic concepts to real life situations.

UNIVERSITY OF WISCONSIN-MADISON

TX: Smith & VanNess
(Jr, Sem 2) 4/0

DIFFICULT CONCEPTS
Entropy; fugacity; activity.
CHALLENGES
Instilling in students the feeling that thermodynamics is relevant to their future work as chemical engineers.
TEXT COMMENTS
Needs a better discussion of entropy; Generalized equation of state and its application is made unnecessarily complex.

WORCESTER POLYTECHNIC INSTITUTE

TX: VanWylen & Sonntag (2 courses)
(Soph, Term 3; Soph, Term 4)
5/0, 5/0

DIFFICULT CONCEPTS
Partial Molar quantities.
TEXT COMMENTS
Weak in chemical engineering areas of mixtures, solutions, phase and chemical equilibria.

UNIVERSITY OF WYOMING

TX: Silver & Nydahl: "Introduction to Engineering Thermodynamics"
(Jr, Sem 2) 3/0

DIFFICULT CONCEPTS
Entropy; irreversible processes.
CHALLENGES
Show the applicability of thermodynamics to the real world.

QUESTIONNAIRE ON TEACHING OF UNDERGRADUATE THERMODYNAMICS

Instructor____

University____

1. To what extent is the digital computer required in your course?

2. Are laboratory experiments or demonstrations used to reinforce the classroom lectures? Please list any experiments used.

3. Please indicate the typical student's reaction upon completion of the course.

4. What concepts seem to be most difficult for the student to grasp?

5. Please list some explanations you have found particularly effective. (Use another sheet if necessary.)

6. Some particular challenges in teaching thermodynamics are:

7. Course Title(s) | Class Hr/Week | Lab Hr/Week

Course Title(s)	Class Hr/Week	Lab Hr/Week
1. ______________________	__________	__________
2. ______________________	__________	__________

8. Level of Course

Course 1 (Circle 2): Jr/Sr 1st/2nd Semester 1st/2nd/3rd Quarter

Course 2 (Circle 2): Jr/Sr 1st/2nd Semester 1st/2nd/3rd Quarter

9. Text(s) and Resources (Author/Title)

Course 1 ____
Circle chapters usually covered 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Course 2 ____
Circle chapters usually covered 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

10. Students

Class Size: Course 1 ____________ Course 2 ____________

Major (ChE, ME): Course 1 ____________ Course 2 ____________

11. How long is your quarter or semester?

_______ weeks per semester/quarter (circle 1)

12. Is there a need for a better textbook in Thermodynamics? In what areas can the text you now use be improved?

13. Please attach a copy of your course outline.

14. _____ I (do, do not) plan to attend the Chicago meeting.

PRELIMINARY SURVEY ON UNIT OPERATIONS

The CEEP Subcommittee on Shared Teaching Experiences will conduct a survey over the next few years on the teaching of undergraduate unit operations. To help us divide this large area into manageable portions, a questionnaire was sent with the 1975 survey to determine the amount of class time devoted to each of 23 topics, as well as the number of courses taught in this area. Laboratory and design courses were excluded.

Sixty-nine replies were received. On the average, each school devoted 3.35 courses to this area. Twelve schools offer two (2) courses, 31 schools offer three (3) courses and 20 schools offer four (4) courses. No attempt was made to differentiate between schools on the quarter and semester systems. Based on past surveys, 20 to 25% of the schools have three quarters to the academic year.

The hours for each topic were added and normalized to 117 hours, equivalent to three courses of 39 hours (13 weeks) each. Additional hours were alloted to tests and examinations. The table shows that the total hours are alloted roughly as 1/4 each to Heat Transfer and Fluid Flow, 3/8 to Mass Transfer and 1/8 to Other Topics. The number of schools reporting at least some time for each topic is also listed. A number of topics were written in by the respondents. The time shown for these is generally low.

From these results, it was decided that the 1977 survey will include Heat Transfer and Fluid Flow, while the 1978 survey will cover Mass Transfer and everything else.

NORMALIZED CLASS HOURS

Basis: 117 Hours

	Hours	Reporting
Mass Transfer		
Gas Absorption	9.5	69
Distillation	15.5	69
Liquid Extraction	7.1	67
Diffusion	8.9	68
Absorption	1.9	42
Humidification*	1.2	16
Total	44.0	
Heat Transfer		
Conduction	7.9	69
Radiation	4.6	69
Natural Convection	3.5	69
Forced Convection	7.8	68
Heat Exchangers	6.3	69
Evaporation*	1.3	15
Total	31.4	
Fluid Flow		
Fluid Statics	3.7	69
Incompressible Flow	14.4	69
Compressible Flow	3.6	61
Drag Forces	4.6	69
Flow Measurement	4.1	69
Total	30.4	
Other Topics		
Filtration	2.01	38
Fluidization	1.44	37
Mixing	1.08	27
Leaching	1.81	38
Crystallization	0.79	19
Drying	2.50	42
Size Reduction	0.38	11
Ion Exchange	0.42	14
New Newtonian-Flow*	0.35	1
Dimensional Analysis	0.39	3
Total	11.18	

* Not listed on original questionnaire