Travelling Over Unfamiliar Areas

You will have to learn to enter many areas which are now foreign to you. Some of these areas will be technical areas such as electronics, biotechnology, materials, *etc.* However, many other areas, such as business accounting, management, psychology, communications, *etc.*, will be totally unrelated to your technical background. You'll have to use a combination of formal and self-education to make the transition into these new areas. Successful engineers indicate that after a few months of self-education, they can move into any new area, interact with experts in the area, and make contributions to the area.

Decision Making

You will have to learn to make decisions with a limited amount of information. It will often be necessary to make a decision on the basis of knowledge sufficient for action but insufficient to satisfy the intellect. This is quite different from solving problems on an examination where you have all the required information.

THE GOOD NEWS

Up to this point, my presentation has been rather pessimistic and you may feel overwhelmed by the challenges that you are going to face. There is a positive side to the picture, however. For one thing, the United States is the best-equipped nation to survive this war because we know the terrain and we essentially started the war. When the movement of the industrial revolution came together with the movement for individual freedom in the United States, the result was a system which other countries would emulate. Our main opponents in this war are not the countries who have different systems of government, such as the Russians, but the countries who have copied our system.

There is another very optimistic aspect concerning this war. All previous wars were zero sum wars. If one country gained territory, someone had to lose territory. But this war is different and everyone could win to some degree. If the United States continues to lead in science and engineering, this engine could drag the rest of the world to a higher standard of living.

Finally, a chemical engineering education is the best preparation for survival and success. As Carl Gerstacker said when he was CEO of Dow Chemical: "A chemical engineering education is the best education for whatever you want to do in life, and particularly if you do not know what you want to do." In many ways, the chemical engineering degree is the liberal arts degree of the technological age. The reasons for this are very basic to the chemical engineering curriculum. You have learned fundamentals that have broad applicability. You have been taught to think and solve technical problems and the same techniques can be used in all areas of human endeavor, and should be, since the aim of a true chemical engineering education is to teach people to continue to learn. Your professors have given you the basic training required to win this war, but some skills can only be learned in the heat of battle. □

ChE letters

THE PLEASURES OF USING MODELL AND REID

Dear Editor:

I have enclosed an item for inclusion in your "Letters" section. I am suggesting that an explanatory note be added in Chapter 8 of Modell and Reid. Note that I have already corresponded with Bob Reid about this and he has agreed with my suggestion.

I would appreciate your publishing this in a forthcoming issue.

Comment on
Thermodynamics and Its Applications

Among the pleasures of using *Thermodynamics and Its Applications* by Modell and Reid (1983) is the precise, logical way with which the subject is developed and the corresponding traceability of any given result to first principles. For the discerning reader, operations are explained in sufficient detail to avoid having to puzzle over results and having to reconstitute missing steps. I have found one instance, however, where an additional note of explanation might be helpful.

The book bases its development on fundamental equations and shows early on the important role played by the Legendre transform in providing a link among the various fundamental forms. Coupling these forms to specific state equations (the Peng-Robinson is the equation of choice in the book) is done in terms of departure functions, both for pure fluids (Chapter 7) and for mixtures (Chapter 8).

Understandably, the analysis begins in both cases with the Helmholtz energy. Differentiating the pure-fluid expression (Eq. 7-81) with respect to temperature yields the entropy departure function, but not without an interesting aside that the authors perceptively highlight in a footnote. The operation in question (expressed intensively) is

$$\frac{\partial}{\partial T}\left[A(T,V) - A^{0}(T,V^{0})\right]_V = \frac{\partial}{\partial T}\left[-\int_{\infty}^{V}\left(P - \frac{RT}{V}\right)dV + RT\, ln\,\frac{V^{0}}{V}\right]_V \quad (1)$$

and its well known result follows:

$$S(T,V) - S^{0}(T,V^{0}) = \frac{\partial}{\partial T}\left[\int_{\infty}^{V}\left(P - \frac{RT}{V}\right)dV\right]_V - R\, ln\,\frac{V^{0}}{V} \quad (2)$$

The footnote on page 155 calls attention to the fact that differentiation at constant molar volume implies a change in the intensive state. Since this variation forces the hypothetical reference condition $A^0(T, V^0 = RT/P)$ to change as well, this latter variation must be accounted for in the result. Expressing the differential of the reference condition

$$dA^0 = -S^0\,dT - P\,dV^0$$

the variation is seen to be

$$\left(\frac{\partial A^0}{\partial T}\right)_V = -S^0 - P\left(\frac{\partial V^0}{\partial T}\right)_V$$

The second term on the right, however, is exactly canceled by a term resulting from the differentiation in Eq. 1,

$$\frac{\partial}{\partial T}\left[RT\, ln\, V^0\right]_V = R\, ln\, V^0 + P\left(\frac{\partial V^0}{\partial T}\right)_V$$

and to the less-than-careful reader, the scenario is invisible from Eq. 2.

A similar situation arises in Chapter 8 where the Helmholtz energy (Eq. 8-130, now in extensive form to permit mole-number operations) is differentiated to yield the difference in chemical potential and, ultimately, an equation-of-state-based expression for the fugacity coefficient. The procedure is

$$\frac{\partial}{\partial N_i}\left[\underline{A}(T, \underline{V}, N_1, N_2, \ldots, N_n) - \underline{A}^0(T, \underline{V}^0, N_1, N_2, \ldots, N_n)\right]_{T, \underline{V}, N_j[i]}$$

$$= \frac{\partial}{\partial N_i}\left[-\int_{\infty}^{\underline{V}}\left(P - \frac{NRT}{\underline{V}}\right)d\underline{V} + NRT\, ln\frac{\underline{V}^0}{\underline{V}}\right]_{T, \underline{V}, N_j[i]} \quad (3)$$

where

$$N = \sum_{k=1}^{n} N_k$$

and $N_j[i]$ signifies that all mole numbers except N_i are held constant. The intermediate result (in terms of chemical potentials) is

$$\mu_i - \mu_i^0 = -\int_{\infty}^{\underline{V}}\left[\left(\frac{\partial P}{\partial N_i}\right)_{T, \underline{V}, N_j[i]} - \frac{RT}{\underline{V}}\right]d\underline{V} + RT\, ln\frac{\underline{V}^0}{\underline{V}} \quad (4)$$

Once again, the differentiation constraints imply that when N_i is varied there will be a change in the intensive state of the mixture and a corresponding movement of the reference condition

$$\underline{A}^0(T, \underline{V}^0 = NRT/P,\ N_1, N_2, \ldots, N_n)$$

Continued on page 169.

so (more concisely, you cannot do what you cannot do). If students have passed courses in chemistry, physics, calculus, and stoichiometry without cheating, they clearly had the talent to pass them. So where did they get the idea that their high achievements so far (and getting through the freshman engineering curriculum is indeed a high achievement) are somehow fraudulent? Asking this gets us into psychological waters that I have neither the space nor the credentials to navigate; suffice it to say that if you are human you are subject to self-doubts, and chemical engineering students are human.

What can we do for these self-labeled impostors?

Mention the impostor phenomenon in classes and individual conferences and encourage the students to talk to one another about it.

There is security in numbers: students will be relieved to learn that those around them—including that hotshot in the first row with the straight-A average—have the same self-doubts.

Remind students that their abilities—real or otherwise—have sustained them for years and are not likely to desert them in the next twenty-four hours.

They won't believe it just because you said so, of course—those self-doubts took years to build up and will not go away that easily. But the message may get through if it is given repeatedly. The reassurance must be gentle and positive, however; it can be helpful to remind students that they have gone through the same ritual of fear before and will probably do as well now as they did then, but suggesting that it is idiotic for a straight-A student to worry about a test will probably do more harm than good.

Point out to students that while grades may be important, the grade they get on a particular test or even in a particular course is not that crucial to their future welfare and happiness.

They will be even less inclined to believe this one but you can make a case for it. One bad quiz grade rarely changes the course grade, and even if the worst happens, a shift of one letter grade changes the final overall GPA by about 0.02. No doors are closed to a student with a 2.84 GPA that would be open if the GPA were 2.86. (You may not think too much of this argument but I have seen it carry weight with a number of panicky students.)

Make students aware that they can switch majors without losing face.

It is no secret that many students enter our field for questionable reasons—high starting salaries, their fathers wanted them to be engineers, their friends all went into engineering, and so on. If they can be persuaded that they do not *have* to be chemical engineers (again, periodic repetition of the message is usually necessary), the consequent lowering of pressure can go a long way toward raising their internal comfort level, whether they stay in chemical engineering or go somewhere else.

Caution, however. Students in the grip of panic about their own competence or self-worth should be deterred from making serious decisions (whether about switching curricula or anything else) until they have had a chance to collect themselves with the assistance of a trained counselor.

One final word. When I refer at seminars to feeling like an impostor among one's peers, besides the resonant responses I get from students I usually pick up some pretty strong vibrations from the row where the faculty is sitting. That's another column.

REFERENCE

1. Pauline R. Clance, *Impostor Phenomenon: Overcoming the Fear that Haunts Your Success*, Peachtree Pubs., 1985. □

LETTER TO THE EDITOR

Continued from page 167.

The differential of this quantity is

$$d\underline{A}^{0} = -\underline{S}^{0}\,dT - P\,d\underline{V}^{0} + \sum_{k=1}^{n} \mu_k^{0}\,dN_k$$

and the variation in question is

$$\left(\frac{\partial \underline{A}^{0}}{\partial N_i}\right)_{T,\underline{V},N_j[i]} = \mu_i^{0} - P\left(\frac{\partial \underline{V}^{0}}{\partial N_i}\right)_{T,\underline{V},N_j[i]}$$

By analogy with the previous case, the second term on the right is canceled by differentiation of the NRT $ln\,\underline{V}^0$ term in Eq. 3 and is accordingly absent from Eq. 4. The fact that this cancellation has taken place is not apparent from the expression appearing at the top of page 204, and a note to this effect may help students follow the development.

Literature Cited: Modell, M., and R. C. Reid, *Thermodynamics and Its Applications* (2nd ed.), Prentice-Hall, Englewood Cliffs, NJ (1983).

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