

A Second Look at . . . THERMODYNAMICS AND COMMON SENSE

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On page 206 of the fall 1993 issue of *CEE*, I posed a little thermo problem and asked readers to respond. The problem asked what happens to the pressure when a batch of ideal gas is raised isothermally and reversibly from Z_1 to Z_2 . I arrived at my answer with four equations:

$$\Delta U = Q - W \quad (1)$$

$$\Delta U + \Delta E_p + \Delta E_k = Q - W_{sh} - W_{pV} \quad (2)$$

$$\cancel{\Delta U} + \Delta E_p + \cancel{\Delta E_k} = \cancel{Q} - \cancel{W_{sh}} - \int_1^2 p dV \quad (3)$$

ending up with

$$\ell n \frac{p_2}{p_1} = (\text{const.}) \Delta z \quad (4)$$

which tells us that p increases with z !! I asked what, if anything, was wrong with this solution.

I have received thirty-eight responses—from textbook writers, from professors, from students, and even some from mechanical engineers. The remarkable feature of these solutions is that they are so distinctly different, one from the other. Here are examples of what the correspondents say:

► Equations 1 and 2 don't apply when E_p is involved—so I started the analysis incorrectly.

► Equations 1 and 2 are okay—my error comes in one of three places in Eq. 3. Some say that I should have put $Q \neq 0$; others say that I should have put $W_{sh} \neq 0$; still others say that I should have used $\Delta(pV)$, not $\int p dV$.

► The problem is unsolvable as stated because I didn't say anything about the surroundings. Of course, if you assume that $\ell n(p_2/p_1) \propto \Delta z$ for the surroundings, that's what you'll find for the system.

► The assumptions I made are contradictory.

► The sign on g is wrong; just use $-g$ and all works out well.

► The pressure gradient cannot be obtained from thermo alone. You must use a force or momentum balance.

► Just use transport analysis, forget thermo, and the answer pops out.

► Since the system is in equilibrium, you must use the second law with the Gibbs free energy concept to solve the problem.

► One responder said I was correct for the problem as stated.

Now, who is right?

When I read the first solution above I was swayed; when I read the second I got confused; and after I read the third, I was lost.

Because of space limitations I won't present the solutions here. But I will prepare copies of twenty-one solutions and will send them to each of the thirty-eight responders. If other *CEE* readers would like to see these solutions, send me your names and addresses and I will also mail them to you.

The following is a list of the brave souls who dared to challenge my curious conclusion.

J.M. Smith <i>UC Davis</i>	L.L. Lee <i>University of Oklahoma</i>
C.T. Lira <i>Michigan State University</i>	D. Hart, retiree <i>Birmingham, Alabama</i>
A. Patel <i>M.I.T.</i>	M.V. Sussman <i>Tufts University</i>
A.R. Konak <i>S. Alberta Inst. of Technology</i>	M. Koretsky <i>Oregon State University</i>
M.A. Mathews <i>University of Wyoming</i>	R.B. Bird <i>University of Wisconsin</i>
J. Hong <i>UC Irvine</i>	J.P. O'Connell <i>University of Florida</i>
J.D. Lindsay <i>Institute of Paper Science and Technology</i>	E. Müller <i>U. Simon Bolivar, Venezuela</i>
S.S. Iyengar <i>University of Florida</i>	C.M. Sliepcevich <i>University of Oklahoma</i>
Hall and Eubank <i>Texas A & M University</i>	K.M. Khandare <i>West Virginia University</i>
O. Talu <i>Cleveland State University</i>	F.E. Haskin <i>University of New Mexico</i>
J.O. Wilkes <i>University of Michigan</i>	A.G. and C.J. Williamson <i>Canterbury, New Zealand</i>
A.L. Meyers <i>University of Pennsylvania</i>	A. Rakow <i>Colorado State University</i>
D.L. Schruben <i>Texas A & I University</i>	Noel de Nevers <i>University of Utah</i>
N.V. Suryanarayana <i>Michigan Tech. Institute</i>	M. Fehr <i>Uberlandia, Brazil</i>
D.M. Himmelblau <i>University of Texas</i>	Loureiro and Macedo <i>Porto, Brazil</i>
C. Crowe <i>McMaster University</i>	J.C.R. Turner <i>Exeter, England</i>
U. Mann <i>Texas Tech University</i>	S.I. Sandler <i>University of Delaware</i>
A.G. Fredrickson <i>University of Minnesota</i>	Vincenzo Brandani <i>Universite of L'Aquila, Italy</i>
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