Deriving Three Thermodynamic Equations In Vapor- Liquid Equilibrium Studies

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One of the interesting and difficult aspects of teaching thermodynamics is to find the simplest way of presenting the rigorous derivations of equations especially for multicomponent systems. This note shows such a pathway of deriving three equations in the area of phase equilibrium. They are simpler than those in available textbooks. This results in time-saving in presentation and facilitates learning. It was found very useful for the instruction purposes.

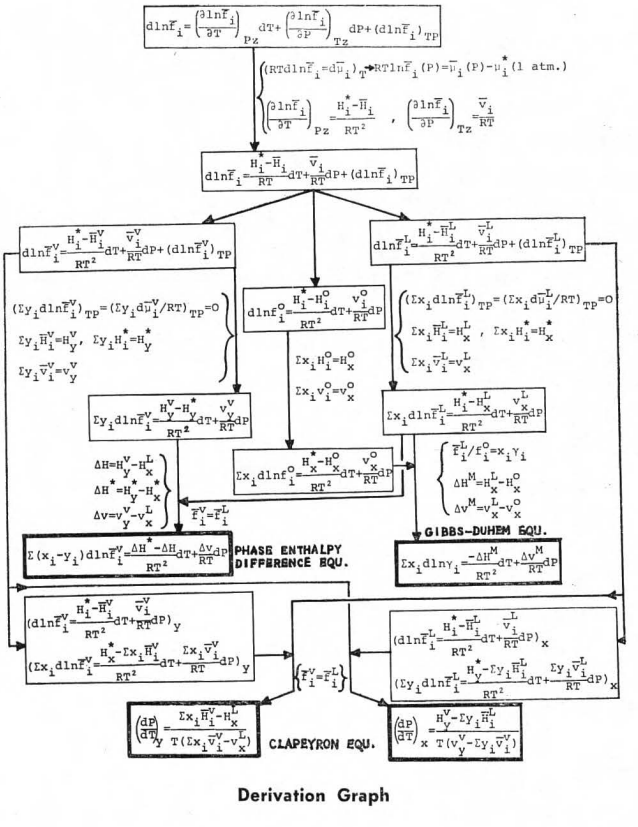
The derivation graph uses all conventional notations such as f for fugacity. Superscripts V and L indicate vapor and liquid phase, a bar — implying a mixture and for most cases also partial molal quantity, * for ideal gas and o for standard state. Subscripts x,y,z, indicate composition of mixtures and i,1,2,n, are component identities.

The first equation on the graph refers to the total variation of $\ln\bar{f}_i$ as the sum of three contributors on the right-side. They refer respectively to those due to changes of temperature, pressure and composition vector z, i.e. $(z_1,z_2,\ldots, z_n)$. It is basically the chain rule of differentiation with the use of a restrictive differential $(d\ln\bar{f}_i)_{PT}$ to represent a group of partial composition derivatives.

Following this pathway, students are made aware of all restrictions carried along. For example, the Gibbs-Duhem equation does not include the phase equilibrium criteria while the other two equations do. Therefore, to use this equation for vapor-liquid equilibrium criterion

$$\bar{f}_i^L = \bar{f}_i^V \quad \text{into} \quad \gamma_i = \bar{f}_i^L / x_i f_i^o$$

These equations are available in literature. Reference 5 shows the unrestricted multicomponent Gibbs-Duhem equation and the Enthalpy-difference equation for binary systems. Articles 3 and 4 have Enthalpy-difference equation and



Derivation Graph

Clapeyron equation for multicomponent systems. Classical and lengthy derivations of Clapeyron equation for a binary system in reference 1. This type of derivation was recently extended to a multicomponent system (ref. 2).

REFERENCES

1. Dodge, B. F. "Chemical Engineering Thermodynamics" McGraw-Hill Book Co. (1944) p. 135 (eq. IV. 156).
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5. Van Ness, H. C. "Classical Thermodynamics of Non-electrolyte Solutions" McMillian Co., N. Y. (1964) p. 79, eq. 4-21; p. 138, eq. 6-42.

BOOK REVIEW (from p. 131)

earlier, and some of the choices come down to questions of personal taste. However, it seems to me that the author missed at least one good opportunity to reinforce his earlier discussions of polymer synthesis by failing to point out some of the well established connections between flow properties and molecular structure.

In summary, the book gives a good general survey of polymer science. The omissions can be handled by supplementary lectures and outside reading. It should make a very suitable textbook for introductory courses.

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sentation of salary statistics or results of surveys which conclude that chemical engineers have happier marriages than other professions.

Emphasis of Presentation. One last point to remember is that our main function is one of guidance rather than that of strong persuasion. Our job is not to get as many people enrolled in chemical engineering as possible, but to attract those to whom chemical engineering will be inherently satisfying. Therefore, we should emphasize the choice of a career over the choice of a discipline. The flexibility and breadth of application and use of chemical engineers in a wide variety of industries—not just the chemical process industries—should be stressed, as well as how other branches of engineering can be served by chemical engineers.

Sources of Information. Some of the most meaningful data that we can present about chemical engineering is our own testimony of what we know about chemical engineering and what chemical engineering means to us. In doing this we should remember that such feelings probably will not be motivating to the audience until the basic needs have been shown to be satisfied. The AIChE publishes an excellent career guidance booklet[4] which contains information on programs for primary schools, secondary schools, junior colleges, and universities. The booklet also contains current statistical data on job opportunities, salary levels, etc., which are needed to answer questions. Incidently, a study of the list of typical questions included in the publication gives insight into the concerns and feelings of students.

SUMMARY

The problem of declining enrollments in chemical engineering is symptomatic of poor effectiveness in the career guidance work now being carried on by chemical engineers.

A number of factors operate during career guidance presentations. If these factors are considered, a presentation's effectiveness can be enhanced. If they are neglected during the design of the presentation, its effectiveness can be severely reduced. These factors include:

- The psychological needs of the audience are very different from those of the speaker.
- Motivational incentives are different for various members of a given group.
- The needs of security and belonging take precedence over the need for success.

Improved presentations may be obtained if:

- Presentations are designed as carefully as the other things which engineers design.
- Current knowledge of motivational systems and student needs is used in the design.
- The hierarchical structure of need fulfillment is recognized and made a part of the design.
- The presentation is made relevant to the current needs of the audience. □

LITERATURE CITED

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4. Galluzo, J. F., "Career Guidance Manual for Chemical Engineers," A.I.Ch.E., Career Guidance Committee, 1970.