Chem Ed

# EDITORIALLY SPEAKING

An issue devoted chiefly to papers discussing the teaching of thermodynamics may be an appropriate place for some remarks about conventions, definitions, and symbols. The inherent abstractness of thermodynamics seems to have led those writing about it to adopt a truly amazing variety not only of symbols, but even of conventions for definition. The rule appears to be every author (or school) for himself, even to the point of changing from one edition to another of the same work. Certainly the contrast is apparent between writings in the European and American traditions. In the IUPAC report published in *J. Am. Chem. Soc.*, **82,** 5520 (1960), two parallel columns are required for listing thermodynamic symbols. For example, European practice designates the Helmholtz free energy by "$F$," American practice uses "$A$." Europeans use "$G$" for what they call the "Gibbs function"; Americans wave their copies of Lewis and Randall around and shout, "free energy, $F$." Incidentally, the set of recommendations soon to appear call these quantities simply "Helmholtz energy, $A$" and "Gibbs energy, $G$."

Through an editor's eyes, this situation is deplorable. Many a blue pencil would remain sharp if there were one unassailable standard for authors to follow. However, as a professor trying to help fresh minds (N.B., not empty minds!) to develop a thorough understanding, we find stimulation rather than despair in the situation.

As long as fundamental concepts remain, and enthalpy is $H$, and entropy is $S$, with the old standbys $P$, $T$, and $V$, no student should have trouble deciding what $U$, $E$, $F$, $A$, or $G$ represent. In fact, it can be one sure way of insuring a student's learning more than a sequence of hieroglyphics when handling equations. Of course, authors owe it to their readers to define unique symbolism. Nevertheless, a student's encounter with unfamiliar symbols can serve to reinforce rather than confuse if his understanding of concepts is sound.

We have found the same to be true when students are presented with ideas expressed in terms of different conventions. We are sure that if a text expresses the first law in the form $\Delta E = q - w$, that students will broaden their understanding of the concepts "energy" and "system" if the alternative convention of $+w$ for work done on the system (energy in the same "direction" as $q$) is used in some supplementary assigned readings.

Similarly, there is real teaching value to the dilemma resulting from trying to use incomplete or conflicting sets of conventions. Students readily grasp the reasonableness of choosing zero for the potential of the hydrogen electrode. They are glad also to accept zero for the $\Delta H^\circ{}_f$ and $\Delta G^\circ{}_f$ for the aqueous hydrogen ion. They really begin to understand what is going on, however, only after they have tried to decide what to do about the 15.6 cal mole$^{-1}$ deg$^{-1}$ for $S^\circ$ that turns up when they use tabulated values in the familiar equation $\Delta H^\circ = \Delta G^\circ + T\Delta S^\circ$. (That $G$ instead of $F$ does not look so bad after all!) We promise readers an excellent feature review on this theme early in 1963.

The professor who ignores the challenge of the variety in electrochemical conventions also is missing a perfect opportunity to demand careful thinking and thorough understanding from his students. The true meanings of "electromotive force," "electrode potential," "cells," "half-cells," etc. have to emerge in terms of fundamental processes such as oxidation-reduction, flow of electrons, decrease in Gibbs energy, etc. This cannot be done by thinking only within the framework of a cozy set of rules relating right, left, plus, minus, commas, bars, etc. (For real help, see THIS JOURNAL, **34,** 433 (1957)).

The classroom is the place for demanding careful thinking, not necessarily complete agreement on what is incidental to the fundamentals. It should be refreshing to the student to recognize the difference between the incidental and the fundamental. Certainly symbols belong in the former if the IUPAC report can say with delightful candor:

> . . . complete agreement has not been attained on the use of symbols for certain quantities and . . . it may be necessary . . . to agree to disagree and to say so.

The whole point of these comments is lost if the last three words of this quotation are ignored!