Symbols and Nomenclature in Physical Science

PROF. A. V. HILL'S recent letter[1] directing attention to the confusion arising out of the inconsistent use of symbols is a timely reminder of the need for greater uniformity. A certain amount of work in this direction has already been done. In 1914, committees of the Physical Society of London, and of the International Electro-Technical Commission reported upon this subject[2] and made certain suggestions as regards some of the more important physical symbols. The Smithsonian Physical Tables contains a table of symbols for electrical and magnetic quantities as adopted by the American Institute of Electrical Engineers, and the International Critical Tables gives a list of symbols based upon the recommendation of the International Association of Chemical Societies[3]. More recently, the S.U.N. Commission of the International Union of Pure and Applied Physics has recommended symbols for a limited number of physical quantities[4]. General agreement, however, upon anything like a sufficient number of symbols is not yet in sight.

Pending such agreement, as a step in the right direction and to prove its urgency, it would be instructive to have tables showing the variety of symbols employed by different authorities for the same physical quantity. A table giving symbols of some common thermodynamic quantities as found in a number of textbooks was compiled by the S.U.N. Commission in its report (mentioned above) and a similar table is appended here as an example; it will be seen how readily confusion can arise. Not only do the symbols differ, but also terms such as 'free energy' and 'thermodynamic potential' are used with different meanings by different authors.

With the exception of entropy, the various quantities given in the table are forms of (or have the

Quantity \ Author	Gibbs (1876)	Bryan (1903)	Goodenough (1912)	Planck (1922)	Planck (Eng. Trans. 1929)	Lewis and Randall (1923)	W. C. M. Lewis (1925)	S.U.N. Commission
Entropy	η	S	S	S	φ	S	S	S, P
Heat given to system	Q	Q	Q	Q	Q	Q	Q	—
Work given to system	−W	−W	W	A	W	−W	A	−W
'Free energy' (Helmholtz)	ψ	$\mathfrak{F}_v$	F	F	F	A	f	F
'Free energy' (Lewis and Randall)	ζ	$\mathfrak{F}_p$	φ	—	—	F	φ	G
Heat content	χ	$\mathfrak{F}_s$	I	W	H	H	—	H, I
Internal energy	ε	U	U	U	U	E	U	U, E

dimensions of) energy, and the relation between them, using Gibbs's notation, is:

$$\overbrace{\underbrace{Q + \zeta}_{\chi} \underbrace{- W}_{\psi}}^{\varepsilon}$$

where Q, W and ζ stand for the energies obtained by multiplying the extensive quantities, entropy, volume and mass by their respective intensive factors (or potentials), temperature $(d\varepsilon/dS)_{v,m}$, pressure $(d\varepsilon/dv)_{s,m}$ and thermodynamic potential $(d\varepsilon/dm)_{s,v}$. It is unfortunate that many authors have used the term 'thermodynamic potential' in referring to energy quantities. Bryan[5] has used it to denote ψ, χ and ζ; Ogg, in the English translation of Planck's "Thermodynamics", refers to the energy equivalent of ζ as "thermodynamic potential at constant pressure", and the term is used in the same sense even in the International Critical Tables.

In its recent report the S.U.N. Commission states (p. 20): "As to the four quantities, U, $U - TS$, $U - TS + PV$, $U + PV$, it was pointed out that they are all cognate and should be regarded as on a parity in the sense that they are all potentials, so that by suitable differentiations of each, any of them can yield the complete state of a substance, entropy or temperature, pressure or volume, thermoelectric current or e.m.f. . . . The British Committee are also prepared to accept the name Thermal Potential for Gibbs' function." It may be pointed out, however, that Gibbs (*Scientific Papers*, **1**, 92) used the term potential in a different sense; he defined his thermodynamic potential as "the differential coefficient of the energy taken with respect to the variable expressing the quantity of the substance", as we have done above.

Two other points may be here touched upon:

Owing to the relatively large number of physical concepts, authors have often recourse to Greek, German and other alphabets in order to find distinctive letters. An alternative way would be to use a combination of two or more letters as is done for chemical symbols. This would also have the advantage of allowing one to distinguish between, say, gas pressure *Pg* and osmotic pressure *Ps*, while at the same time indicating other generic similarity.

The addition of one or more letters could be resorted to in order to direct attention to the operational meaning attached to a given symbol: for example, *Psh* might stand for "osmotic pressure measured hydrostatically across a semi-permeable membrane", while *Psf* might indicate "osmotic pressure calculated from freezing point determinations". The need for some such device to express the operational meaning of concepts in order to prevent many unnecessary controversies and paradoxes has been discussed at length in a previous paper[6].

To summarise—there are three points worth consideration:

(1) The need for comparative tables giving the different symbols used for the same concept by various scientific workers.

(2) The advantages of symbols consisting of several letters.

(3) The advisability of using symbols which express the operational meaning of a concept.

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[1] NATURE, **136**, 222; 1935.
[2] NATURE, **94**, 541, 545; 1915.
[3] *J. Chem. Soc.*, **119**, 502; 1921.
[4] NATURE, **135**, 419; 1935.
[5] "Encyc. Math. Wissensch.", Bd. 5, t. 1, p. 74; 1903.
[6] *Science Progress*, **26**, 126; 1931.

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