H Is for Enthalpy, Thanks to Heike Kamerlingh Onnes and Alfred W. Porter

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When students want to know about the origins of the word *enthalpy* and its symbol, *H*, commonly representing the state function of heat[1] as used in thermodynamics and thermochemistry, they can get a variety of answers, depending on the source they use. For example, the *Oxford English Dictionary* (*1*) gives as its earliest reference *The Mollier Steam Tables and Diagrams* of 1927 (*2*). If the students go to the *Academic American Encyclopedia*, they will find Clausius credited in this way: "The term originated in 1850 when Rudolph Clausius used it to mean the sum of the internal energy and flow energy in a thermodynamic system" (*3*). If they consult the *Journal of Chemical Education*, they can find, for *enthalpy*, a question mark by the names of both Clausius and Clapeyron (as possible sources of the term) in an article on the history of thermodynamics notation (*4*).

Clausius and H

So, is Clausius the author of the word *enthalpy*? If students consult papers by this 19th-century thermodynamicist (*5*), they find that he did use the letter H for heat (which he called *Wärme*). In his famous paper of 1865, he states: "H denotes the heat actually present in the body, which, as I have proved, depends solely on the temperature of the body and not on the arrangement of its parts" (*6*). Later in that paper, Clausius devises the term *entropy* for the letter S in his equation for the second law of thermodynamics, but he does not propose a similar term for H (*7*).

Gibbs and "Heat Function for Constant Pressure"

If, then, students look at a volume entitled *Physical Chemistry: an Advanced Treatise*, they might consider that Josiah Willard Gibbs was the originator of the word, judging from the following description: "the familiar definition of *enthalpy* as introduced by Gibbs in 1875 ('heat function for constant pressure')" (*8*). On the other hand, if they check the reference given there, while they will find the words *heat function for constant pressure* and the equation for $\chi = \varepsilon + pv$, they will not find the word enthalpy (*9*). More recently, in *The World of Physical Chemistry*, Keith Laidler, in discussing the work of Gibbs, attributed the term to Kamerlingh Onnes in 1909: "Some years later, in 1909, the Dutch physicist Heike Kamerlingh Onnes (1853–1926) gave H the name enthalpy, from the Greek, εν (en), in, and θαλπος (thalpos), heat, or from the single Greek word, ενθαλπος (enthalpos), to warm within" (*10*). Laidler's references and notes in that book do document some of Kamerlingh Onnes' Nobel work on low-temperature properties of matter but not the 1909 attribution of enthalpy (*11*). Most often, the students will discover no attribution at all. Many writers just use the term enthalpy as though it has always existed.

Kamerlingh Onnes and Enthalpy

However, J. R. Partington, in *An Advanced Treatise on Physical Chemistry* (1949), got the references for enthalpy right.[2] Partington states that "The function H sometimes symbolized by W, I, or (by Gibbs) χ, is now usually called the *heat content*. Kamerlingh Onnes called it *enthalpy* (from θαλπος, heat)" (*12*). In a footnote to his acknowledgment of Kamerlingh Onnes, Partington cites a paper by J. P. Dalton published in *Proceedings Koninklijke Akademie van Wetenschappen te Amsterdam*.[3] Dalton, Carnegie Research Fellow at the Leiden Physical Laboratory of Kamerlingh Onnes, communicated his paper in a meeting of March 27, 1909, simply introducing the word enthalpy and then explaining in a footnote that "This name has been used by KAMERLINGH ONNES to indicate the function ($\varepsilon + pv$)—the 'Heat function' of GIBBS" (*13*).

Porter and "H" for "Enthalpy"

In addition, Partington gave a reference for Alfred W. Porter's promotion of the word enthalpy, as well as Porter's crediting it to Kamerlingh Onnes (*12*). At a conference on The Generation and Utilisation of Cold, which was a joint meeting of The Faraday Society and The British Cold Storage and Ice Association, held October 16, 1922, Porter, then president of The Faraday Society, states his regrets that "Professor [Kamerlingh] Onnes, owing to delicate health, is also prevented from coming" but notes that a member (one Professor Crommelin) of the Leyden Cryogenic Laboratory is present (*14*). Further in his opening remarks to the conference, Porter says: "The quantity E + pv is what is usually known in England as Total Heat or Heat Contents. I submit that these names are not satisfactory, because the quantity is not heat in general; and the presence here of a member of the Leyden Laboratory encourages me to press the claims of the name proposed by Kamerlingh Onnes, viz., Enthalpy—a name which I have used for some years" (*15*). Then, in proposing to use H for enthalpy, Porter makes the clever observation that H is both an English capital letter and a Greek capital letter (eta): "We can denote it [enthalpy] by H, which can stand either for capital h (Heat Contents) or for Greek E (Enthalpy) at the option of the reader" (*15*). (If readers were to follow Porter's Greek option, they would begin reading the title of the present paper as "Eta is for Enthalpy.")[4]

Of course, Heike Kamerlingh Onnes is known for accomplishments other than suggesting the word enthalpy. He is the 1913 Nobel Laureate in Physics for work on properties of matter at low temperatures and for work on liquefying helium, an achievement which he published just before the enthalpy paper of his coworker Dalton. Kamerlingh Onnes is also recognized for discovering superconductivity.

Although not as scientifically prominent as Kamerlingh Onnes, Porter had solid credentials as Professor of Physics in the University of London, Fellow of the Royal Society, and President of the Faraday Society. In 1931, he authored a brief, history-laden monograph on thermodynamics (*16*). In a recent book about the Faraday Society, Porter was recognized for the time and thought he had given to that group, and he was also cited as follows: "He was primarily a teacher. From his original contributions—'numerous, notable and varied'—he appears as a critic of current theories rather than as a pioneer of wholly new ideas" (*17*).

Both of these scientists deserve additional recognition: Heike Kamerlingh Onnes for introducing into science the word enthalpy and Alfred W. Porter for affixing that word to the symbol H.

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Notes

1. Enthalpy is equal to internal energy plus the product of pressure and volume, symbolized as $H = E + PV$, or $H = U + PV$.

2. Partington's references also included one to a paper by George Tunell in which Tunell cited "Gibbs's chi function or the total heat (also called heat content, enthalpy, enkaumy)" (*18*). Partington (*12*) claimed that the origin of the word enkaumy was the Greek word καυμα, burning, heat. (Obviously, enthalpy won the popularity contest.)

3. This journal was published in Dutch as well as in English. Cornell University's Olin Library has both sets available on open stacks. This paper cites the English version.

4. Although Porter's observation is witty, strictly speaking the Greek word for enthalpy requires another type of Greek "E", that is, epsilon, instead of eta.

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