

Why Are q and Q Used to Symbolize Heat?

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Question

Why are q and Q used to symbolize heat and when should one use the lower versus the upper case?

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Answer

An upper-case Q was first used to symbolize “the absolute quantity of heat” by the French engineer, Benoit-Paul-Émile Clapeyron (figure 1), in his famous memoir of 1834 in which he first quantified what is now known as the Carnot cycle (1). Carnot himself did not use a symbol for the quantity of heat in his original memoir of 1824, which was largely verbal rather than mathematical in character, and Clapeyron most likely selected the letter Q to emphasize that he was dealing with the *quantity* of heat rather than with its *intensity* or temperature, for which he used an upper-case T . Building on the work of Clapeyron in the 1850s and 1860s, Clausius not only continued to use Q to symbolize heat in his various memoirs on the theory of heat, he also employed an upper-case W to represent mechanical work (2).

However, as the theory of thermodynamics continued to evolve, several authors felt the necessity of distinguishing between various sources of heat, while displaying little agreement with regard to the resulting symbolism. Thus, in his famous memoir of 1873 on the application of the entropy concept to the phenomenon of chemical equilibrium, the German chemist, August Horstmann, used an upper-case Q to “denote the quantity of heat required to decompose one mole of a compound” but a lower-case q to represent “the actual heat of decomposition” or the net heat of reaction (3), whereas Fritz Haber, in his 1901 monograph on the thermodynamics of technical gas-reactions, followed the lead of Helmholtz in using an upper-case Q to denote standard heats of reaction and transition, but a lower-case q to represent the bound or “latent” heat due to isothermal entropy generation (i.e. $T\Delta S$) (4).



Figure 1. Benoit Paul Émile Clapeyron (1799-1864).

In contrast, Lewis and Randall, in their famous 1923 monograph on thermodynamics, made no use of the upper-case Q and instead consistently employed both a lower-case q for heat and a lower-case w for work (5), while Samuel Glasstone, in his 1947 textbook, *Thermodynamics for Chemists*, adopted the convention of employing the lower-case letters, q and w , for arbitrary, path-dependent, infinitesimal quantities of heat and work, but the upper-case letters, Q and W , for their algebraic sums (6). Apparently this eclecticism is still very much with us as the most recent IUPAC

guide to quantities, units, and symbols in physical chemistry lists both q and Q as equally valid symbols for heat, though it also lists Q as the symbol for electrical charge and for the reaction quotient (7).

Literature Cited

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2. The most important of these papers are collected together in English translation in R. Clausius, *The Mechanical Theory of Heat*, Van Voorst: London, 1867.

3. A. Horstmann, "Theorie der Dissociation," *Ann. Chem. Pharm.*, **1873**, 170, 192-210. An English translation appears as A. Horstmann, "The Theory of Dissociation," *Bull. Hist. Chem.*, **2009**, 34(2), 76-82.

4. F. Haber, *Thermodynamik technischer Gasreaktionen*, Oldenbourg: München, 1905, pp. 10, 14. An English translation appears as F. Haber, *Thermodynamics of Technical Gas-Reactions*, Longmans, Green and Co: London, 1908.

5. G. N. Lewis, M. Randall, *Thermodynamics and the Free Energy of Chemical Substances*, McGraw-Hill: New York, NY, 1923, pp. 621-623.

6. S. Glasstone, *Thermodynamics for Chemists*, Van Nostrand: New York, NY, 1947, pp. 40-41.

7. E. R. Cohen et al., Eds., *Quantities, Units, and Symbols in Physical Chemistry*, 3rd ed., IUPAC and RSC Publishing: Cambridge, 2007, pp. 16, 56, 58.

Do you have a question about the historical origins of a symbol, name, concept or experimental procedure used in your teaching? Address them to Dr. William B. Jensen, Oesper Collections in the History of Chemistry, Department of Chemistry, University of Cincinnati, Cincinnati, OH 45221-0172 or e-mail them to jensenwb@ucmail.uc.edu