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Property Help: Thermodynamics

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- The Protein Society. http://www.proteinsociety.org/(accessed 10/7/05).

For background reading, see:

1. Bloomfield, Victor A., Donald M. Crothers, and Ignacio Tinoco, Jr. *Nucleic Acids: Structures, Properties, and Functions*. University Science Books: Sausalito, Calif., 2000.
2. Cantor, Charles R. and Paul R. Schimmel. *Biophysical Chemistry*. W. H. Freeman: San Francisco, 1980.
3. Creighton, Thomas E. P*roteins: Structures and Molecular Properties*, 2nd ed. W.H. Freeman: New York, 1993.
4. Eisenberg, David and Donald Crothers. *Physical Chemistry with Applications to the Life Sciences*. Benjamin/Cummings: Menlo Park, Calif., 1979.
5. Hammes, Gordon G. *Thermodynamics and Kinetics for the Biological Sciences*. Wiley-Interscience: New York, 2000.
6. Tinoco, Jr., Ignacio et al. *Physical Chemistry: Principles and Applications in Biological Sciences*, 4th ed. Prentice Hall: Upper Saddle River, N.J., 2002.❖

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pH property Help: Thermodynamics

Linda Shackle

The Four Horsemen of Thermodynamics:
Entropy
Free Energy
Heat Capacity
Heat of Formation

Thermodynamics is the study of energy and equilibrium at a macro, rather than molecular, level. Normally three laws of thermodynamics are given although sometimes a fourth is presented as the "Zeroth Law," a precursor to the First Law. The laws of thermodynamics can be applied in almost all areas of science and engineering. For a practical example, the recent hurricanes[1] that struck the southern United States owe their existence in part to the thermodynamics forces at work in the atmosphere.

Energy, unless restricted, has a tendency to disperse; this tendency is called entropy. S is the symbol for entropy and has units of energy (joule, calorie, British thermal unit) per temperature (Kelvin, Celsius, Fahrenheit, Rankine) hence J $^{\circ}C^{-1}$, Btu $^{\circ}R^{-1}$, etc.

Free energy, as its name implies, is the amount of energy available to the system under study. There are two types of free energy, Gibbs, named after Professor Josiah Willard Gibbs (1839-1903) of Yale University, and Helmholtz, named after Hermann von Helmholtz (1821-1894) a German physicist and physician. Gibbs free energy uses the symbol G and Helmholtz uses A (Arbeitfunktion = work function), however both may sometimes be designated as F. You are more likely to see Gibbs free energy in chemical reference sources and Helmholtz in physics resources.

Heat capacity is defined as the amount of energy needed to change a system's temperature by one unit. The symbol for heat capacity is C; the units are the same as for entropy. Sometimes specific heat capacity is given in thermodynamics tables; specific heat capacity is the amount of energy needed to raise one unit of a substance one degree in termperature. The symbol for specific heat capacity is Cp and the units are the same as for heat capacity except for the addition of the substance unit (ex. J $kg^{-1} K^{-1}$).

Heat of formation is the heat released or absorbed during the formation of a substance. Sometimes the term "enthalpy" is used instead

of "heat" as in "enthalpy of formation". There are many kinds of "Heat of" properties, such as heat of combustion, heat of vaporization; all of them refer to the heat released or absorbed during that specific process. The symbol for heat/enthalpy is H with a subscript indicating the process, so heat of formation is H_f.

Many studies are interested in the change in these properties, so the symbol for change, the greek letter delta (Δ), is placed before the symbol. Ex. ΔS, pronounced as "delta S" or "change in entropy."

Entropy, free energy, heat capacity and heat of formation are usually the first four concepts studied in the field of thermodynamics and the property data for these are almost always found together, especially in chemistry resources. Compared to other property data, these are also relatively easy to find.

Sample Resources:

- NIST WebBook http://webbook.nist.gov/
- Web Elements http://www.webelements.com/
- Yaws' Handbook of Thermodynamic and Physical Properties of Chemical Compounds Available via Knovel, http://www.knovel.com

For More Resources see:

- Index to Chemical, Physical and Other Property Data http://www.asu.edu/lib/noble/chem/property.htm
- Thermodex http://thermodex.lib.utexas.edu/

1. Want to know about how hurricanes form? See these web pages from NOAA: How do tropical cyclones form? http://www.aoml.noaa.gov/hrd/tcfaq/A15.html and Hurricane Dynamics. http://www.aoml.noaa.gov/hrd/hrd_sub/dynamics.html

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