

The First Law of Thermodynamics

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Introduction

In this section, we introduce the first law of thermodynamics and examine sign conventions.

Heat and Work

Heat is the spontaneous flow of energy from one object to another caused by a difference in temperature. Work is defined as any other transfer of energy into or out of the system. Examples of work are: pushing on a piston, stirring a cup of coffee, passing current through a resistor, etc. In each case the temperature will rise as the system's energy is increased. We don't say that the system is being heated because the flow of energy is not spontaneous.

Heat and work refer to energy in transit, we can talk about how much energy is in a system, talking about how much work is in a system is meaningless.

The First Law of Thermodynamics

Let E be the internal energy of a system then

$$(\text{Energy input by Heating}) = \Delta E + (\text{Work done by system on surroundings}).$$

This is called the first law of thermodynamics, clearly it is just a statement of the law of conservation of energy. We will use Q , and W to denote large or finite changes, we'll use q , and w to denote infinitesimal changes. Thus we will write

$$Q = \Delta E + W,$$

or

$$q = \Delta E + w.$$

Q, q are negative if heat leaves the system, W, w are negative if work is done on the system. While many authors write q and w as inexact differentials, our author has avoided it as there is no Q or W to take the differential of. That is Q and W are not state functions. When a system changes from state 1 to state 2, while ΔE is determinate, Q and W are path dependent.

Other Sign Conventions

There are other sign conventions in use. Many authors, especially chemists define $\Delta E = Q + W$ so that any work done on the system is positive.