Thermodynamics

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Introduction to Thermodynamics

What is Thermodynamics?

Thermodynamics is the study of the connection betweenheat andwork, and the conversion of one into the other. This study is important because manymachines and modern devices change heat into work (e.g., an automobile engine) or turn work into heat (e.g., a stove). There are two laws of thermodynamics that explain the connection between work and heat.

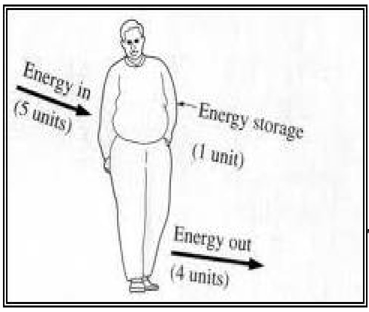
Laws of thermodynamics

The subject matter of thermodynamics is based on three experimental laws, namely:

- **The first law**
- **The second law**
- **The third law**

In thermodynamics, the entire universe is considered in terms of two parts. The part selected for the thermodynamic analysis is called the system. The rest of the universe is treated as the surroundings.

First law of thermodynamics:



The First Law of Thermodynamics is the law of Conservation of Energy. It states that energy cannot be created or destroyed. Instead it is only converted from one form to another, such as from mechanical work to heat, or from heat to light.

Let a system in state A of internal energy EA absorb from the surroundings a certain amount of heat (Q) and undergo a change in its state to B. Let the internal energy in the state B be EB. The increase in internal energy ? E of the system is given by the equation

$$?E = E_B - E_A$$

If W is the work done by the system in the process, then from the first law, the net gain of energy (Q - W) must be equal to ?E, the increase in the internal energy of the system. Therefore:

$$?E = (E_B - E_A)= Q - W \quad \text{or} \quad Q = ?E + W$$

For infinitesimally small changes

$$q= dE + w$$

As per IUPAC conventions, heat absorbed by a system is given a “+” sign, and heat given out of a system is given a “-“ sign. Work done by a system is given a “-“ sign and work done on a system is given a “+” sign.

Second law of thermodynamics:

The second law of thermodynamics is formulated in many ways, as will be addressed shortly, but is basically a law which -- unlike most other laws in physics -- deals not with how to do something, but rather deals entirely with placing a restriction on what can be done.

It is a law that says that nature constrains us from getting certain kinds of outcomes without putting a lot of work into it, and as such, much like the first law of thermodynamics, is also closely tied to the concept of the conservation of energy.

The second law of thermodynamics precisely defines a property called entropy. Entropy can be thought of as a measure of how close a system is to equilibrium; it can also be thought of as a measure of the disorder in the system. The law states that the entropy — that is, the disorder — of an isolated system can never decrease. Thus, when an isolated system achieves a configuration of maximum entropy, it can no longer undergo change: It has reached equilibrium. Nature, then, seems to “prefer” disorder or chaos. It can be shown that the second law stipulates that, in the absence of work, heat cannot be transferred from a region at a lower temperature to one at a higher temperature.

The second law poses an additional condition on thermodynamic processes. It is not enough to conserve energy and thus obey the first law. A machine that would deliver work while violating the second law is called a “perpetual-motion machine of the second kind,” since, for example, energy could then be continually drawn from a cold environment to do work in a hot environment at no cost. The second law of thermodynamics is sometimes given as a statement that precludes perpetual-motion machines of the second kind.

The third law of thermodynamics:

The third law of thermodynamics is essentially a statement about the ability to create an absolute temperature scale, for which absolute zero is the point at which the internal energy of a solid is precisely 0.

Various sources show the following three potential formulations of the third law of thermodynamics:

1. It is impossible to reduce any system to absolute zero in a finite series of operations.
2. The entropy of a perfect crystal of an element in its most stable form tends to zero as the temperature approaches absolute zero.
3. As temperature approaches absolute zero, the entropy of a system approaches a constant

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Reference links:

- http://www.en.wikipedia.org/wiki/entropy
- http://www.en.wikipedia.org/wiki/temperature
- http://www.splung.com/content/sid/6/page/internal_energy

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