

1. **Phase rule** We have considered equilibria between various phases, but not the number of phases that may coexist or the constraints that apply to thermodynamics of systems of more than one phase. Willard Gibbs deduced the thermodynamic implications of multiple phases in equilibrium and obtained the phase rule. The rule answers the questions in the absence of external fields is equal to the number of components plus two.
2. **State functions** Although scientists usually have no way of knowing the precise value of the internal energy of a system, they do know that it has a fixed value for a given set of conditions. The conditions that influence this energy include the temperature and pressure. Furthermore, the total internal energy of a system is proportional to the total quantity of matter in the system; energy is an extensive property.
3. **enthalpy** Symbol H . A thermodynamic property of a system defined by $H = U + pV$, where H is the enthalpy, U is the internal energy of the system, p its pressure, and V its volume. In a chemical reaction carried out in the atmosphere the pressure remains constant and the enthalpy of reaction, ΔH , is equal to $\Delta U + p\Delta V$. For an exothermic reaction ΔH is taken to be negative.
4. **entropy** Symbol S . A measure of the unavailability of a system's energy to do work, in a closed system, an increase in entropy is accompanied by a decrease in energy availability. When a system undergoes a reversible change the entropy (S) changes by an amount equal to the energy (Q) transferred to the system by heat divided by the thermodynamic temperature (T) at which this occurs, i.e. $\Delta S = \Delta Q/T$. However, all real processes are to a certain extent irreversible changes and in any closed system an irreversible change is always accompanied by an increase in entropy.
5. In a wider sense entropy can be interpreted as a measure of disorder, the higher the entropy the greater the disorder. As any real change to a closed system tends towards higher entropy, and therefore higher disorder, it follows that the entropy of the universe (if it can be considered a closed system) is increasing and its available energy is decreasing. This increase in the entropy of the universe is one way of stating the second law of thermodynamics.
6. The second law of thermodynamics states that entropy increases for spontaneous processes and that an increase in entropy is associated with transitions from ordered to disordered states. Living organisms, even the simplest bacteria growing in cultures, appear to violate the second law, because they grow and proliferate spontaneously. They convert simple chemical substances into the highly organized structure of their descendants. Write a critical evaluation of this subject. Be sure to state your conclusion clearly and to present detailed, reasoned arguments to support it.
7. Thermodynamics represents one of the cornerstones of the chemical engineering profession. The use of classical concepts such as equilibrium and reversibility, to describe the response of a chemical system to manipulation of state variables such as temperature, pressure and concentration, percolate throughout various areas in which chemical engineers play leading roles. Examples as diverse as dissolution of nutrients in bioreactors, pyrolytic production and environmental remediation of toxic polyaromatic compounds, designing micellar "microextractors" for separations or zeolites for optimal catalytic selectivity, and understanding the performance characteristics of materials, all rely on fundamental principles of thermodynamics and their application to often complex and imperfect processes in the real world. Today, with trends toward miniaturization and the ability of the scientist to manipulate structure and properties at the atomic level, the chemical engineer relies increasingly on statistical mechanics and the tools of molecular simulation to gain a quantitative description of the molecular world and to develop the know-how and technology to understand the interplay between chemical and external variables.
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