

Important Definitions in Thermodynamics

Systems

System	a finite portion of matter or a restricted portion of space upon which attention is focused, e.g., gas in a bottle or the inside of a pipe and whatever happens to be in it at the moment.
Surroundings/ Environment	everything outside the system (which has a direct bearing on its behavior)
Enclosure	a real or imaginary surface which separates the system from its surroundings (can identify a control mass - <i>finite portion of matter</i> - or control volume - <i>restricted portion of space</i>).
Reference Frame	coordinate system against which the motion of the system (or control volume/control mass) is measured; in inertial reference frame, free particles move at constant velocity.
Isolated System	system which exchanges no energy (i.e., heat or work) or matter with its surroundings.
Closed System	system which may exchange energy but not mass with its surroundings (similar to a Control Mass)
Open System	system which may exchange both energy and mass with its surroundings (related to a Control Volume)

Equilibrium

Equilibrium exists if there is no tendency for a system to undergo spontaneous (macroscopically observable) change; different types of equilibrium can be defined.

In terms of isolated systems, the different types of equilibrium can be described as follows.:

Mechanical exists when there is no unbalanced force (electrostatic forces not included typically) in the interior of the system (leads to the mechanical-thermodynamic concept of pressure).

Thermal exists when all parts of the system are at the same temperature or equivalently when there is no tendency for energy transfer as heat (the basis of the thermodynamic concept of temperature).

- Chemical* exists when the system has no tendency to undergo a spontaneous change in chemical composition (or phase) - no matter how slow.
- Electrostatic* exists when there is no unbalanced electrostatic force or equivalently no tendency for charge flow in the system.
- Thermodynamic* exists when the system is in equilibrium with respect to all of the above possible changes (for the purposes of this class, *mechanical*, *thermal* and *chemical* equilibrium is all that is usually required; we do not consider uncharged -nonionized- gases).

Properties and State

- Property** any characteristic or attribute of a system which can be quantitatively evaluated, what matter *has* (e.g., volume, mass, energy, pressure, polarization) - not work or heat (these are done on or to a system).
- Extensive Properties** depend on the size or extent of the system and are additive - value of the property of the total system is the sum of the values of all the constituent parts (e.g., volume V and mass M); have values regardless whether the system is in an equilibrium state or not.
- Intensive Properties** independent of the size of the system and are not additive (e.g., temperature T and pressure P; and can define intensive versions of extensive properties, usually by dividing by mass, e.g., specific volume $v \equiv V/M = p^{-1}$); in the absence of equilibrium, intensive properties have no meaning or may vary from point to point in larger system if subsystems considered to be in “local” equilibrium.
- State** the condition of a system, as described by a list of the values of its properties; some minimum number of relevant properties are required to uniquely define a state.

Mixtures

- Mixture** any collection of matter.
- Constituent/Species** each part of the mixture (or group of particles in a microscopic sense) which is distinguishable from the rest by virtue of its chemical structure.
- Component** those constituents whose amounts can be varied independently (from the other constituents). For example in a mixture of two inert gases, both constituents would be components.

Phase	a quantity of matter which is homogeneous in chemical composition and physical structure (note: a single phase can consist of several components).
Homogenous System	has only one phase.
Inhomogeneous System	has more than one phase.
Pure Substance	has same chemical structure in all states but may have several distinguishable phases (e.g., water is chemically H ₂ O but can exist in gaseous, liquid and solid phases).
Independent Substance	its thermodynamic properties are not functions of the other constituents in the mixture.