Sharif University of Technology
School of Mechanical Engineering
Center of Excellence in Energy Conversion

Advanced Thermodynamics

Lecture 1

Dr. M. H. Saidi

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Basic Definitions

- Thermodynamics: study of the macroscopic consequences of myriads of atomic coordinates, which, by statistical averaging, do not appear explicitly in a macroscopic description of system.

- Simple System: macroscopically homogeneous, isotropic, unchanged, chemically inert, sufficiently large that surface effects can be neglected, not acted by electric, magnetic, gravitational fields.

- State Principle: the number of independent properties required to specify the equation of state of a system is equal to the number of possible reversible work modes in the system plus one, one accounts for heat transfer within the system.

Different Work Modes

- For a general quasi-equilibrium system $dW = -\sum_k F_k dX_k$
- dW, F_k, and dX_k are generalized work, force, and displacement respectively and k denotes for each type of work mode.

- Simple wire system $dW = F\,dl$,

  1^{st} law $\rightarrow dQ = dU - F\,dl$, U function of any two of (F, l, T)
- Simple magnetic system $dW = H\,dM$,

  1^{st} law $\rightarrow dQ = dU - H\,dM$, U function of any two of (H, M, T)
- Simple electric system $dW = e\,dy$,

  1^{st} law $\rightarrow dQ = dU - e\,dZ$, U function of any two of (e, Z, T)
- Simple surface tension system $dW = s\,dX$,

  1^{st} law $\rightarrow dQ = dU - s\,dA$, U function of any two of (s, A, T)
- Simple hydrostatic or simple compressible system $dW = P\,dV$,

  1^{st} law $\rightarrow dQ = dU - P\,dV$, U function of any two of (P, V, T)

- F, H, e, s, and P are the generalized force.

Different Work Modes …

- Energy is a point function and dU is an exact differential, $\int dU = 0.$
- Work and Heat are path functions and ∂W and ∂Q are inexact differentials.
- Heat capacities of quasi-equilibrium systems:

$$C_{X_k} = \frac{1}{m}\left(\frac{\partial Q}{\partial T}\right)_{X_k} \text{ and } C_{F_k} = \frac{1}{m}\left(\frac{\partial Q}{\partial T}\right)_{F_k}$$

  - For a simple compressible system $C_{V\ or\ P} = \frac{1}{m}\left(\frac{\partial Q}{\partial T}\right)_{V\ or\ P}$

- Simple wire system C_t and C_l
- Simple magnetic system C_H and C_M
- Simple electric system C_e and C_Z
- Simple surface tension system C_s and C_A
- Simple hydrostatic C_V and C_P

Equilibrium

- The macroscopic equilibrium state is associated with incessant and rapid transitions among all the atomic states consistent with the BCs.

- A system is in thermodynamics equilibrium if no change occurs in it while it is isolated from the environment. The thermodynamics equilibrium includes all mechanical, chemical, and thermal equilibrium.

- The state of a system in thermodynamics equilibrium may be shown in thermodynamics coordinates. If the system is not in equilibrium, some of its macroscopic properties vary from one point to the other and it is impossible to show its state in thermodynamics coordinates.