**Review for general terms, 1st and 2nd Law of Thermodynamics**

Before deriving the 1st Law of Thermodynamics, it is important to recall the following terms:

A ***system*** is any region with a volume and surrounded by boundaries.

The rest of the universe is ***surroundings***. So, system and surroundings make up the ***universe***.

Isolated system is the one that doesn’t allow material and energy exchange.

Open system is the one that only allows both the material and energy exchange.

Closed system is the one that allows only energy exchange.

Figure

***State*** is the point at which system has constant thermodynamic properties such as temperature, volume, and pressure. Position of the system can also be included in these properties.

***Intensive property*** is a property which is independent of the system’s mass such as temperature, pressure, viscosity and density.

***Extensive property*** is the one that is dependent on the mass of the system such as volume, kinetic energy and potential energy.

***Specific properties*** are extensive properties.

An extensive property can be converted into an intensive property by diving the extensive property by the mass (moles) of the system (see below).

 and

Both and are intensive properties and also called as specific properties.

**State and Path Functions**

While heat (Q) and work (W) are path functions, internal energy (U), entropy (S) and enthalpy (H)are state functions. So, for U, H and S, their differences (U2-U1 or H2-H1 or S2-S1) are only dependent on the initial and final states of the system, not on the path followed.

Figure

**Irreversible work and reversible work**

Recall the reversible processes take place when the changes occur sufficiently slowly that gradients do not appear in the system. So accordingly, irreversible reversible work are defined as follows.

Wirr = − Pext Vsys

Wrev = −

Some additional definitions are important to consider or neglect some terms in the energy balances:

*Isometric (Isochoric)* processes take place at constant volume.

*Isobaric* processes take place at constant pressure.

*Isothermal* processes take place at constant temperature.

*Adiabatic* processes are the ones in which heat exchange is absent.

**First Law of Thermodynamics for Closed Systems**

Q + W = ΔU + ΔEK + ΔEP

W represents the expansion-compression work. Δ represents the changes between the initial and final states of the system.

**First Law of Thermodynamics for Open Systems**

+ = Δ+ Δ+ Δ

Ws represents the shaft work. Δ represents the changes between the inlet and outlet streams that crosses the system.

**Second Law of Thermodynamics**

Entropy (S) is included as a parameter to define the second law of thermodynamics. It represents the order or disorder of a system.

While is a path function, dividing it by temperature turns it into a state function, S.

For a reversible process, dS=0.

For an irreversible process, dS > 0.

Second Law also states the following:

dSuniverse = dSsys + dSsurr ≥ 0

meaning that any spontaneous process leads to an increase in the entropy of an isolated system.

References:

Ismail Tosun, “The Thermodynamics of Phase and Reaction Equilibria”, 2012, Elsevier.

D. Winterbone and A. Turan , "Advanced Thermodynamics for Engineers", 1996, Butterworth-Heinemann.