In general, extensive properties are denoted using upper-case letters, while intensive properties are denoted using lower-case letters. However, there are exceptions, including *ONE NOTABLE EXCEPTION*: Temperature is denoted using upper-case *T*, even though it is an intensive property.

State and Path Functions

A *state function* is a property whose value does not depend on the path taken to reach that specific value. In contrast, functions that depend on the path from two values are call *path functions*. Both path and state functions are often encountered in thermodynamics.

State Property or State Function

The property of a system that depends on the state variables is known as a state property. The change in the state property does not depend upon how the process is carried out. That is, the value of a state property depends only on the state of the system and not on the process by which this state is reached. A function that depends only on the state variables is known as a state function.

Thermodynamic properties like of a system internal energy (U), enthalpy (H), entropy (S), Helmholtz energy(A) and free energy (G) change with the change in variables like temperature, pressure, volume and amount of substance in the system. The changes in these properties depend upon the initial and final states of the system. They do not depend upon the path followed during the change. Therefore, these thermodynamic properties are also **state properties or state functions**. The following are considered to be state functions in thermodynamics: Mass, Energy (E) { Enthalpy (H), Internal energy (U), Gibbs free energy (G), Helmholtz free energy (F), Exergy (B) }, Entropy (S), Pressure (P), Temperature (T), Volume (V), Chemical composition, Specific volume (v) or its reciprocal Density (ρ), Fugacity, Altitude, Particle number (n_i).

Characteristics of state functions: Let z be a state function that depends upon two variables x and y. This is written as

$$z = f(x,y)$$

For a process (State1) →(State2), the change in state functions only depends on the initial and final states, regardless of the path taken. Using enthalpy as an example and assuming that the parameter that changes is temperature, then this can be expressed through integrals, as

$$\int_{T_1}^{T_2} dH = H(T_2) - H(T_1)$$

This is equivalent to

$$\Delta H = H_{final} - H_{initial}$$

If we now use Boyle’s law (constant temperature):

$\alpha_1 = \alpha$ (T, P) and $\alpha_0 = \alpha$ (T, P_0) and using equation 2.2 we have

$$P\alpha(T, P) = P_o\,\alpha(T, P_o) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (2.5)$$

In this case, we keep temperature constant since Boyle’s law deals with constant temperature condition.

From Equation 2.4,

$$\alpha(T, P_o) = \frac{\alpha(T_0,\ P_0)}{T_0}.T \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.6)$$

Substituting (2.6) into (2.5) we obtain:

$$P\ \alpha(T, P) = \frac{\alpha(T_0,\ P_0)}{T_0}.T \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.7)$$

From Charles’ law, P_o is constant (1012.13 *mb*) and α (T_o, P_o) is the specific volume (volume of 1 gm of gas at T_o, P_o); T_o = 273.16 and P_o = 1012.13 mb. Therefore, T_o and P_o are standard temperature and standard pressure respectively.

$$\therefore P\ \frac{\alpha(T_0,\ P_0)}{T_0}.T = \text{constant}$$

If we now let $R = P_o\ \frac{\alpha(T_0\ P_0)}{T_0}$

Then the gas equation becomes

$$P\ \alpha\ =\ RT \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (2.8)$$

Where *R* is the universal gas constant.

Since $\frac{1}{\rho} = \alpha$

Then

$$P = \rho RT \qquad\qquad 2.9$$

$$pV = R^*T$$

2.11

and the ideal gas equation f for *n* moles of a gas can be written as

$$pV = nR^*T$$

2.12

We know n is given by mass/molecular weight, then n=M/m thus,

$$pV = \frac{M}{m} R^*T$$

2.13a

Or

$$P = \frac{R^*}{m}\frac{M}{V}T$$

2.13b

If each gas obeys separately the ideal gas law, then 2.13 can be written as

$$P_k = \frac{R^*}{m_k}\frac{M_k}{V}T$$

2.14

From Dalton’s law

$$P = \sum P_k = \frac{R^*T}{V}\sum\frac{M_k}{m_k}$$

2.15