Lecture 6

3. Choosing a Basis

A basis is a reference chosen by you for the calculations you plan to make in any particular problem, and a proper choice of basis frequently makes the problem much easier to solve.

The basis may be a period of time such as hours, or a given mass of material, such as 5 kg of CO_2, or some other convenient quantity.

For liquids and solids in which a mass (weight) analysis applies, a convenient basis is often 1 or 100 lb or kg; similarly, 1 or 100 moles is often a good choice for a gas.

Example 16

A liquefied mixture has the following composition: n-C_4H_{10} 50% (MW=58), n-C_5H_{12} 30% (MW=72), and n-C_6H_{14} 20% (MW=86). For this mixture, calculate: (a) mole fraction of each component. (b) Average molecular weight of the mixture.

Solution

Basis : 100 kg

	kg	mass fr.	MW	k mol	mol fr.
n-C_4H_{10}	50	0.5	58	0.86	0.57
n-C_5H_{12}	30	0.3	72	0.42	0.28
n-C_6H_{14}	20	0.2	86	0.23	0.15
	100			1.51	1.00

Average molecular weight = $\frac{total\ mass}{total\ mol} = \frac{100\ kg}{1.51\ kg\ mol} = 66.2\ \frac{kg}{k\ mol}$

Example 17

Given that a 50.0 kg test run of gas averages 10.0% H_2, 40.0% CH_4, 30.0% CO, and 20.0% CO_2, what is the average molecular weight of the gas?

Solution

Basis: 100 kg mol or lb mol of gas

Component	Percent = kg mol or lb mol	Mol wt.	Kg or lb
CO_2	20.0	44.0	880
CO	30.0	28.0	840
CH_4	40.0	16.04	642
H_2	10.0	2.02	20
Total	100.0		2382

$$\text{Average molecular weight} = \frac{2382\ \text{kg}}{100\ \text{kg mol}} = 23.8\ \text{kg/kg mol}$$

4. Temperature

Temperature is a measure of the energy (mostly kinetic) of the molecules in a system. This definition tells us about the amount of energy.

Four types of temperature:

Two based on a relative scale, degrees Fahrenheit (°F) and Celsius (°C), and two based on an absolute scale, degree Rankine (°R)and Kelvin (K).

The relations between °C, °F, K,and °R are:

$$T_{^{\circ}F} = 1.8\, T_{^{\circ}C} + 32$$

$$T_K = T_{^{\circ}C} + 273$$

$$T_{^{\circ}R} = T_{^{\circ}F} + 460$$

Temperature Conversion

$\Delta^{o}C = \Delta K$ and

$\Delta^{o}F = \Delta^{o}R$

Also, the $\Delta°C$ is larger than the $\Delta°F$

$$\frac{\Delta^{o}C}{\Delta^{o}F} = 1.8$$

$$\frac{\Delta K}{\Delta^{o}R} = 1.8$$

Example 18

Convert 100°C to (a) K, (b) °F, and (c) °R.

Solution

$$\text{(a)} \quad (100 + 273)°C \, \frac{1\ \Delta K}{1\ \Delta°C} = 373\ K$$

or with suppression of the Δ symbol,

$$(100 + 273)°C \, \frac{1\ K}{1°C} = 373\ K$$

$$\text{(b)} \quad (100°C) \frac{1.8\ \Delta°F}{1\ \Delta°C} + 32°F = 212°F$$

$$\text{(c)} \quad (212 + 460)°F \, \frac{1\ \Delta°R}{1\ \Delta°F} = 672°R$$

Example 19

The heat capacity of sulfuric acid has the units J/(g mol)(°C), and is given by the relation

Heat capacity = $139.1 + 1.56 * 10^{-1}T$

where T is expressed in °C. Modify the formula so that the resulting expression has the associated units of Btu/(lb mol) (°R) and T is in °R.

Solution

step 1:

$$T_{ºC} = \frac{[T_{ºR} - 460 - 32]}{1.8}$$

Step 2:

$$\text{heat capacity} = \left\{139.1 + 1.56 * 10^{-1}\left(\frac{[T_{ºR} - 460 - 32]}{1.8}\right)\right\} * \frac{1\,J}{g\,mol\,(ºC)} \left| \frac{1\,Btu}{1055\,J} \right| \frac{454\,g\,mol}{1\,lb\,mol} \left| \frac{1ºC}{1.8ºR} \right.$$

$$= 23.06 + 2.07 * 10^{-2} T_{ºR}$$

Note the suppression of the Δ symbol in the conversion between °C and °R.