9.8 Summary

In dealing with multicomponent systems, the new element is composition, which is expressed through the number of moles (or mass) of each component. If composition remains constant during a process, a multicomponent mixture behaves as a pure fluid in all respects except when multiple phases are present. This observation makes the extension of the theoretical relationships from pure components to mixtures straightforward, though algebraically more involved. Of practical importance is the application of cubic equations to mixtures, which makes possible the calculation of volume, enthalpy and entropy of systems with several components. The new element is the introduction of mixing rules, which are recipes for the calculation of the parameters of the mixture EOS from those of the pure components. Like the equations themselves, mixing rules are *empirical*. The mathematical form of mixing rules is guided by theoretical considerations but ultimately these equations are based on trial and error.

Equations of state such as the Soave-Redlich-Kwong and the Peng-Robinson, are appropriate for like, nonpolar components. Components that interact strongly cannot be represented accurately by these equations. It is important then to establish whether a given equation of state is appropriate for the system of interest through validation of the results against known data. If the answer is yes, then the calculation of mixture properties follows the same procedure as for pure components.

9.9 Problems

35 °C (<--degrees C)

Problem 9.1: A stream that contains a mixture of methane (25% by mol) and carbon monoxide is compressed from 1 bar, 35 to 12 bar. The compressor efficiency is 90%. Treating the mixture as an ideal gas, calculate the required work.
Additional data: $C_{PA} = 40.8$ J/mol K, $C_{PB} = 29.4$ J/mol K ($A = CH_4$, $B = CO$).

Problem 9.2: Air is compressed from 1 bar, 25°C to 50 bar, and subsequently is cooled to 300 K using cooling water. Assuming air to be an ideal-gas mixture and the compressor to be 100% efficient, calculate the work in the compressor and the heat removed in the heat exchanger per mol of air. Assume air to be ideal-gas mixture (79% N_2, 21% O_2) and use the heat capacities given in Perry's *Handbook*.

Problem 9.3: Streams A and B are mixed adiabatically to produce stream C. Stream A is at 1 bar, 50 °C, it contains pure methane and its flow rate is 0.2 mol/min. Stream B is at 1 bar, 100 °C, contains a methane-ethane mixture 50% in methane (by mol) and its flow rate is 0.8 mol/min. Stream C exits at 1 bar.