Dealing with Gas Mixtures

1 MASS FRACTIONS

Mass fraction, portion of the mass of mixture ‘m’ that is made up of component ‘i’

\[ m_f = \frac{m_i}{m_m} \]

2 MOLE FRACTIONS

Mole fraction, portion of the number of molecules of ‘m’ that is made up of molecules of component ‘i’

\[ y_i = \frac{N_i}{N_m} \]

3 MOLAR MASSES

Molar mass, ratio of mass to number of moles

\[ M = \frac{m}{N} \]

Can be provided for a mixture as well as for just one substance. For mixtures it is called apparent (average) molar mass:

\[ M_m = \frac{m_m}{N_m} \]

The specific gas constant for a mixture can be obtained by the ratio of the universal gas constant (per unit mol) to the molecular mass (per unit mass).

\[ R_m = \frac{R_u}{M_m} \]

4 ADDITIVE PRESSURES (DALTON’S LAW)

This is a model of gas behavior that says pressures add to create the total pressure of the mixture.

\[ P_m = \sum P_i(T_m, V_m) \]

For this to work, the component pressure (or partial pressure of a component in an ideal gas mixture) must be evaluated at the mixture temperature and mixture volume.

Dalton’s Law will be a better model if the gas mixture is at a lower pressure. The additive pressure model breaks down at high pressures because the molecules are interacting with each other more.

5 ADDITIVE VOLUMES (AMAGAT’S LAW)

This is a model of gas behavior that says volumes add to create the total volume of the mixture.

\[ V_m = \sum V_i(T_m, P_m) \]

For this to work, the component volume (or partial volume of a component in an ideal gas mixture) must be evaluated at the mixture temperature and mixture pressure, which gives the volume that the individual gas would take up if it were at those conditions alone.

IDEAL v. REAL GASES

If your gas behaves as ideal, Dalton’s Law and Amagat’s Law are identical! This is because the mole fraction will be the same as the pressure fraction for each component, and the mole fraction will also be the same as the volume fraction for each component.

See “Can I use the ideal gas law?” for an overview of some alternatives to the ideal gas model that can be used to predict the behavior of real gas mixtures.

NOTATION:

- \( m \) Mass
- \( m_f \) Mass fraction
- \( y \) Mole fraction
- \( N \) Number of moles
- \( P \) Pressure
- \( m_m \) mixture
- \( m_i \) individual component
- \( R \) Gas constant, unique to the substance
- \( R_u \) Gas constant, universal
- \( T \) ABSOLUTE temperature
- \( V \) volume

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