Properties of Reservoir Fluids (PGE 362)

Quantitative Phase Behavior

BY
DR. MOHAMMED A. KHAMIS
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Ideal Solutions

Solution:

Homogenous mixtures of two or more substances which has the same chemical composition and the same physical properties throughout.

Examples:

- Gases (why?)
- Alcohol and water

What about a liquid HC and water?

Rule:

The more closely two substances resemble one another chemically, the more likely to form a solution.

Ideal Solutions

Solute & Solvent:

Small amount of one component + large amount of another component ⟹ solution.

Solute? Solvent?

Is it a general rule?

Two components are completely miscible and present in nearly equal amounts?

Ways to designate the composition of a solution:

- Mole % , mole fraction.
- Weight % , weight fraction.
- Volume % , volume fraction.

Ideal Solutions

Ideal Solution:

In chemistry, an ideal solution or ideal mixture is a solution with thermodynamic properties analogous to those of a mixture of ideal gases.

Homogeneous mixture of substances that has physical properties linearly related to the properties of the pure components. $\Rightarrow$ Raoult's Law.

In ideal solution composed of molecules A & B, the forces of attraction between a molecule of A and a molecule of B is the same on the average as that between two molecules of A or two of B. also, there is no heating effect when the components of ideal solutions are mixed.

Ideal Solutions

Ideal Solution implies:

- No heating effect when the components of ideal solutions are mixed.
- Solution volume is equal to the sum of the volumes of its components:

$$V = \sum V_i$$

Solution density:

$$\rho_{solution} = \sum volume\ fraction_i \times \rho_i^{\circ}$$

ρ_i° : the density of the pure i[th] component.

Ideal Solutions

Vapor Pressure:

Raoult's Law:

The partial pressure of a component in the vapor is equal to mole fraction of that component in the liquid multiplied by the vapor pressure of the pure component.

$$P_A = x_A P_A^{\circ}$$

P_A: the partial pressure of component A in the vapor.

x_A: mole fraction of component A in the liquid solution.

P_A°: vapor pressure of pure A.

$$P_i = x_i P_i^{\circ}$$

Ideal Solutions

Vapor Pressure:

The total pressure exerted by the vapor is equal to the sum of the partial pressure of its components.

$$P_T = \sum x_i P_i^{\circ}$$

P_T: total pressure (the vapor pressure of the solution)

: bubble point pressure.

If the infinitesimal (tiny) amount of vapor which exists at bubble point is assumed to be a perfect gas, Dalton's law can be applied.

$$P_i = y_i P_T \quad \text{or} \quad y_i = \frac{P_i}{P_T}$$

y_i: mole fraction of the i^{th} component in the vapor.

P_i: partial pressure of the i^{th} component in the vapor.

Ideal Solutions

Vapor Pressure:

Bubble point pressure of a solution can be calculated using.

$$P_T = \sum x_i P_i^{\circ}$$

The composition of the vapor at bubble point can be estimated using:

$$P_i = y_i P_T \quad \text{or} \quad y_i = \frac{P_i}{P_T}$$

Ideal Solutions

Example:

At 0° F calculate the bubble point pressure and the composition of the vapor at bubble point for two-component solution having a mole fraction of propane equal to 0.5 and 0.5 for butane. Repeat these calculations for solution whose mole fraction of propane is 0.25 and 0.75 for butane.

The vapor pressure of pure propane and butane at 0° F are 38.2 psia and 7.3 psia respectively.

Ideal Solutions

Solution:

Bubble point pressure = 22.75 psia.

Component	P_i^0	x_i	$P_i = x_i P_i^0$	$y_i = P_i/P_T$
C_3H_8	38.20	0.50	19.10	0.840
C_4H_{10}	7.30	0.50	3.65	0.160

$$P_T = 22.75 \text{ psia}$$

Ideal Solutions

Solution:

Bubble point pressure = 15.03 psia.

Component	P_i^0	x_i	$P_i = x_i P_i^0$	$y_i = P_i/P_T$
C_3H_8	38.20	0.25	9.55	0.635
C_4H_{10}	7.30	0.75	5.48	0.365
			$P_T = 15.03$ psia	

Ideal Solutions

Solution: