HW7_2

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1 Homework 7

1.1 Problem 2.1

Derive the equation for bubble point pressure as a function of temperature assuming Raoult's law holds.

Starting with the Rachford-Rice equation,

$$\sum_{i=1}^{C} \frac{z_i(K_i - 1)}{1 + (K_i - 1)\Psi} = 0 \tag{1}$$

where $\Psi = \frac{V}{F}$

At the bubble point, $V = 0$ so (1) is simplified to

$$\sum_{i=1}^{C} z_i(K_i - 1) = 0$$

or

$$\sum_{i=1}^{C} z_i K_i = 1 \tag{1.1}$$

Using Raoult's law as the model for K_i

$$K_i = \frac{P_i^s}{P} \tag{2}$$

(2) can be substituted in for (1.1) as

$$\sum_{i=1}^{C} z_i \frac{P_i^s}{P} = 1 \tag{3}$$

P can be factored out and the bubble point equation is

$$P = \sum_{i=1}^{C} z_i P_i^s \tag{4}$$

1.2 Problem 2.2

Derive the equation for the dew point pressure as a function of T assuming Raoult's law holds.

Starting with the Rachford-Rice equation again, at the dew point, $V = F$ so (1) becomes

$$\sum_{i=1}^{C} \frac{z_i(K_i - 1)}{1 + (K_i - 1)} = 0 = \sum_{i=1}^{C} \frac{z_i(K_i - 1)}{K_i} = \sum_{i=1}^{C} (z_i - \frac{z_i}{K_i}) \tag{1.2}$$

Since $\sum_{i=1}^{C} z_i = 1$, (1.2) becomes

$$\sum_{i=1}^{C} \frac{z_i}{K_i} = 1 \tag{5}$$

K_i can be simplified using (2)

$$\sum_{i=1}^{C} \frac{z_i}{\frac{P_i^s}{P}} = 1 = \sum_{i=1}^{C} \frac{z_i P}{P_i^s} \tag{6}$$

Which is further simplified to

$$P = \frac{1}{\sum_{i=1}^{C} \frac{z_i}{P_i^s}} \tag{7}$$