Chapter 9 Practice Problems

(p9.01) The stream from a gas well consists of 90 mol% methane, 5% ethane, 3% propane and 2% n-butane. This stream is flashed isothermally at 233 K and 70 bar. Use the shortcut K-ratio method to estimate the L/F fraction and liquid vapor composisitons. (ANS. L/F = 0.181) …

Solution

By short-cut vapor pressure eqn.

$$\frac{y_i}{x_i} = K_i \cong \frac{\left[10\text{^}\left[\frac{7}{3}(1+\omega_i)\left(1-\frac{1}{T_{?,i}}\right)\right]\right]}{P_{r,i}}$$

$$y_i = x_i K_i$$

Though not required, the table below also shows bubble T and dew T calculations at 70 bar.

For the bubble calculations, in each column, the temperature at the top of the column is used to calculate the K-ratio. Then $y_i = x_i K_i$. The temperature is adjusted until the sum of y's is unity. This is an iterature calculation.

For the dew T calculations, in each column, the temperature at the top of the column is used to calculate the K-ratio. Then $x_i = y_i/K_i$. The temperature is adjusted until the sum of x's is unity. This is an iterative calculation.

For the isothermal flash calculation, the T = 233K and the pressure is 70 bar, so the K-ratio is fixed, as tabulated in the column under '233'. Equation 9.63 is programmed in the cells below the value of L/F=0.181 below the 'Flash' title. Each row holds the value of the term '$D_i = z_i(1-K_i)/[K_i + (L/F)(1-K_i)]$' from equation 9.63. These values are summed at the bottom of the column. The criteria for the isothermal flash is that L/F is adjusted until the sum goes to zero, as is shown at L/F = 0.181. Once the value of L/F is found, the xi values and yi values in the last columns are generated separately using equations 9.57 and 9.58 respectively.

pMPa=	7.000				BUBT		DEWT		FLASH			
	z	Tc	Pc	w	210.9	y	300.5	x	233	0.181	x	y
C1	0.9	190.6	4.6	0.011	1.108	0.997	4.7949	0.188	1.767	-0.424	0.553	0.977
C2	0.05	305.4	4.88	0.099	0.049	0.002	0.6332	0.079	0.111	0.1632	0.184	0.020
C3	0.03	369.8	4.25	0.152	0.006	0.000	0.1456	0.206	0.016	0.152	0.155	0.002
nC4	0.02	425.2	3.8	0.193	8E-04	0.000	0.0379	0.527	0.003	0.1088	0.109	0.000
						1.0000		0.9997		5E-07	1.000	1.000

(p9.2) An equimolar mixture of n-butane and n-hexane at pressure is isothermally flashed at 373K. The liquid-to-feed ratio is 0.35. Use the shortcut K-ratio method to estimate the pressure and liquid and vapor compositions. (ANS. P=0.533MPa; xC6=0.78).

Solution

By short-cut vapor pressure eqn.

$$\frac{y_i}{x_i} = K_i \cong \frac{\left[10\text{^}\left[\frac{7}{3}(1+\omega_i)\left(1-\frac{1}{T_{?,i}}\right)\right]\right]}{P_{r,i}}$$

$$y_i = x_i K_i$$

For the isothermal flash calculation, the T = 373K. Equation 9.63 is programmed in the cells below the value of L/F=0.35 below the 'Flash' title. Each row holds the value of the term '$D_i = z_i(1-K_i)/[K_i + (L/F)(1-K_i)]$' from equation 9.63. The value of K_i requires P which is to the left of the table. These values are summed at the bottom of the column. The criteria for the isothermal flash is that P is adjusted until the sum goes to zero, as is shown at P = 0.533. Once the value of P is found, the xi values and yi values in the last columns are generated separately using equations 9.57 and 9.58 respectively.

Though not required, the table below also shows the bubble T and dew T calculations for P = 0.533 MPa.

For the bubble calculations, in each column, the temperature at the top of the column is used to calculate the K-ratio. Then $y_i = x_i K_i$. The temperature is adjusted until the sum of y's is unity. This is an iterature calculation.

For the dew T calculations, in each column, the temperature at the top of the column is used to calculate the K-ratio. Then $x_i = y_i/K_i$. The temperature is adjusted until the sum of x's is unity. This is an iterative calculation.

pMPa=	0.533				BUBT		DEWT		FLASH			
	z	Tc	Pc	w	349.2	y	383.2	x	373	0.35	x	y
nC4	0.5	425.2	3.8	0.193	1.766	0.883	3.5299	0.142	2.906	-0.426	0.223	0.649
nC5	0	469.7	3.37	0.249	0.624	0.000	1.3902	0.000	1.11	0	0.000	0.000
nC6	0.5	507.4	3.01	0.305	0.236	0.118	0.5826	0.858	0.452	0.4257	0.777	0.351
nC7	0	540.3	2.74	0.349	0.097	0.000	0.2631	0.000	0.199	0	0.000	0.000
						1.0010		0.9999		1E-06	1.000	1.000

(p9.3) A mixture of 25 mol% n-pentane, 45% n-hexane, and 30% n-heptane is flashed isothermally at 365.9K and 2 bar. Use the shortcut K-ratio method to estimate the L/F fraction and liquid and vapor compositions (ANS. L/F = 0.56) …

By short-cut vapor pressure eqn.

$$\frac{y_i}{x_i} = K_i \cong \frac{\left[10\text{^}\left[\frac{7}{3}(1+\omega_i)\left(1-\frac{1}{T_{?,i}}\right)\right]\right]}{P_{r,i}}$$

$$y_i = x_i K_i$$

Though not required, the table below also shows bubble T and dew T calculations at 2 bar.

For the bubble calculations, in each column, the temperature at the top of the column is used to calculate the K-ratio. Then $y_i = x_i K_i$. The temperature is adjusted until the sum of y's is unity. This is an iterature calculation.

For the dew T calculations, in each column, the temperature at the top of the column is used to calculate the K-ratio. Then $x_i = y_i/K_i$. The temperature is adjusted until the sum of x's is unity. This is an iterative calculation.

For the isothermal flash calculation, the T = 365.9 K and the pressure is 2 bar, so the K-ratio is fixed, as tabulated in the column under '365.9'. Equation 9.63 is programmed in the cells below the value of L/F=0.56 below the 'Flash' title. Each row holds the value of the term '$D_i = z_i(1-K_i)/[K_i + (L/F)(1-K_i)]$' from equation 9.63. These values are summed at the bottom of the column. The criteria for the isothermal flash is that L/F is adjusted until the sum goes to zero, as is shown at L/F = 0.56. Once the value of L/F is found, the xi values and yi values in the last columns are generated separately using equations 9.57 and 9.58 respectively.

pMPa=	0.2				BUBT		DEWT		FLASH			
	z	Tc	Pc	w	358.6	y	312.48	x	365.9	0.56	x	y
nC4	0	425.2	38	0.193	57.73	0.000	18.804	0.000	67.18	0	0.000	0.000
nC5	0.25	469.7	3.37	0.249	2.107	0.527	0.5756	0.434	2.51	-0.227	0.150	0.377
nC6	0.45	507.4	3.01	0.305	0.821	0.369	0.1898	2.370	1.001	-2E-04	0.450	0.450
nC7	0.3	540.3	2.74	0.349	0.348	0.104	0.0694	4.324	0.432	0.227	0.400	0.173
						1		7.129		3E-08	1.000	1.000

(p9.04) A mixture containing 15 mol% ethane, 35% propane, and 50% n-butane is isothermally flashed at 9 bar and T. the liquid-to-feed ratio is 0.35. Use the shortcut K-ratio method to estimate the pressure and liquid and vapor compositions.

By short-cut vapor pressure eqn.

$$\frac{y_i}{x_i} = K_i \cong \frac{\left[10\text{^}\left[\frac{7}{3}(1+\omega_i)\left(1-\frac{1}{T_{?,i}}\right)\right]\right]}{P_{r,i}}$$

$$y_i = x_i K_i$$

For the isothermal flash calculation, the P=9 bar. Equation 9.63 is programmed in the cells below the value of L/F=0.35 below the 'Flash' title. Each row holds the value of the term '$D_i = z_i(1-K_i)/[K_i + (L/F)(1-K_i)]$' from equation 9.63. The value of K_i requires T which is to the left under the 'Flash' title. These values of D_i are summed at the bottom of the column. The criteria for the isothermal flash is that T is adjusted until the sum goes to zero, as is shown at T = 319.4K. Once the value of T is found, the xi values and yi values in the last columns are generated separately using equations 9.57 and 9.58 respectively.

Though not required, the table below also shows the bubble T and dew T calculations for P = 0.9 MPa.

For the bubble calculations, in each column, the temperature at the top of the column is used to calculate the K-ratio. Then $y_i = x_i K_i$. The temperature is adjusted until the sum of y's is unity. This is an iterature calculation.

For the dew T calculations, in each column, the temperature at the top of the column is used to calculate the K-ratio. Then $x_i = y_i/K_i$. The temperature is adjusted until the sum of x's is unity. This is an iterative calculation.

pMPa=	0.900				BUBT		DEWT		FLASH			
	z	Tc	Pc	w	290	y	326.9	x	319.4	0.35	x	y
C1	0	190.6	4.6	0.011	32.92	0.000	49.257	0.000	45.74	0	0.000	0.000
C2	0.15	305.4	4.88	0.099	3.963	0.594	7.9952	0.019	7.027	-0.184	0.031	0.214
C3	0.35	369.8	4.25	0.152	0.86	0.301	2.0955	0.167	1.779	-0.181	0.232	0.413
nC4	0.5	425.2	3.8	0.193	0.213	0.106	0.614	0.814	0.505	0.3648	0.737	0.372
						1.0016		1.0002		6E-08	1.000	1.000