Quiz 11
Chemical Engineering Thermodynamics
March 25, 2021

A natural gas process stream contains the following composition. It is desirable to flash a feed liquid at 0.8 MPa and 298 K to produce liquid and vapor streams in order to partially separate the components prior to distillation.

	z_i	T_c, °K	P_c, Mpa	ω
METHANE	0.8800	190.6	4.604	0.011
ETHANE	0.0758	305.4	4.88	0.099
PROPANE	0.0442	369.8	4.249	0.152

a) -What is the bubble point temperature of this mixture at 0.8 MPa?
Use solver in excel and the shortcut method.
-Comment on if the method is appropriate after solving.
-What is the bubble point pressure at 298K?

b) -Compare the K-ratios for the three components for the bubble point temperature with that from PREOS.xls at the final temperature and pressure from the first part of "a" using equation 10.70: $y_i f_i^V = x_i f_i^L$. (The reference state doesn't matter for this calculation) When this method doesn't work because you are in the super-critical state find P^{sat} for the bubble point temperature and get the K-ratio from Raoult's law (use your shot-cut P^{sat} as the initial P value for solver).

c) -What is the dew point temperature of this mixture at 0.8 MPa?
-Use solver in excel and the shortcut method. Demonstrate that the method is appropriate after solving.
-What is the dew point pressure at 298K?

d) -If V/F is desired to be 50% at 0.8 MPa what is the flash temperature?
-How does this temperature compare to parts "a" and "b"?

e) -If the feed stream is liquid at 298 K and 0.8 MPa, **calculate the *Q* required per mole of feed** using the ideal gas heat capacities and enthalpies of vaporization given in the table below (the i.g. heat capacities are from the PREOS.xls file).
-Compare your resulting Q with that using PREOS.xls to determine the enthalpies using the feed stream conditions for $H = 0$ and a real liquid or super critical fluid reference state. If the state at 0.8 MPa and T_{flash} is super critical, then the vapor and liquid have the same super-critical enthalpy.

Please put your answers in the attached Answer Sheet which contains the data tables in separate tabs

It is suggested that you do calculations in Excel spreadsheets

$$\log_{10} P_r^{sat} = \frac{7}{3}(1+\omega)\left(1 - \frac{1}{T_r}\right) \quad 9.11$$

Shortcut vapor pressure equation. Use care with the shortcut equation below $T_r = 0.5$.

Note: *The shortcut vapor pressure equation must be regarded as an*

approximation for rapid estimates. The approximation is generally good above P = 0.5 bar; the percent error can become significant at lower pressures (and

$$\sum_i \frac{z_i(1-K_i)}{1_i + (V/F)(K_i - 1)} = 0$$

$$K_i = \frac{P_i^{sat}}{P} \approx \frac{P_{c,i} 10^{\frac{7}{3}(1+\omega)\left(1-\frac{1}{T_{r,i}}\right)}}{P}$$ Shortcut K-ratio

$$\sum_i x_i = \sum_i (y_i / K_i) = 1$$

$$\sum_i y_i = \sum_i K_i x_i = 1$$

Heat Capacity Constants		TK Cp in J/mol-K		
i.g.	A	B	C	D
METHANE	19.25	5.21E-02	1.20E-05	-1.13E-08
ETHANE	5.409	1.78E-01	-6.94E-05	8.71E-09
PROPANE	-4.224	3.06E-01	-1.59E-04	3.22E-08
Liquid				
METHANE	50	0	0	0
ETHANE	70	0	0	0
PROPANE	98	0	0	0
Heat of Vaporization at 760 mmHg				
	Tb, °C	DHvap kJ/mole	Tb at 50°C	Tb, K
METHANE		8.5		111
ETHANE		16.4		184.6
PROPANE		22.1		119.8

				Tr>0.5	
a)	Tb @ 0.8 MPa		K		METHANE
					ETHANE
					PROPANE
	Pb @ 298K		Mpa		
				PREOS	
b)	METHANE	K1			
	ETHANE	K2			
	PROPANE	K3			
c)	Tdp @ 0.8 Mpa		K	Tr>0.5	
					METHANE
					ETHANE
					PROPANE
	Pdp @ 298		Mpa		
d)	T Flash at V/F = 0.5		K		
	Compare:				
e)	Q		kJ/mole Feed		
	Q from PREOS.xls		kJ/mole Feed		

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			Tr>0.5	
Tb @ 0.8 MPa	147	K	0.77	METHANE
			0.48	ETHANE
			0.40	PROPANE
Pb @ 298K	29.1	Mpa		
			PREOS	
METHANE	K1	1.14	1.11	
ETHANE	K2	0.0103	0.0096	
PROPANE	K3	0.000436	0.000226	
Tdp @ 0.8 Mpa	214	K	Tr>0.5	
			1.12	METHANE
			0.70	ETHANE
			0.58	PROPANE
Pdp @ 298	11.0	Mpa		
T Flash at V/F = 0.5	150	K		
It is between the DP and BP				
Q	-4.14	kJ/mole Feed		
Q from PREOS.xls	-9.15	kJ/mole Feed		