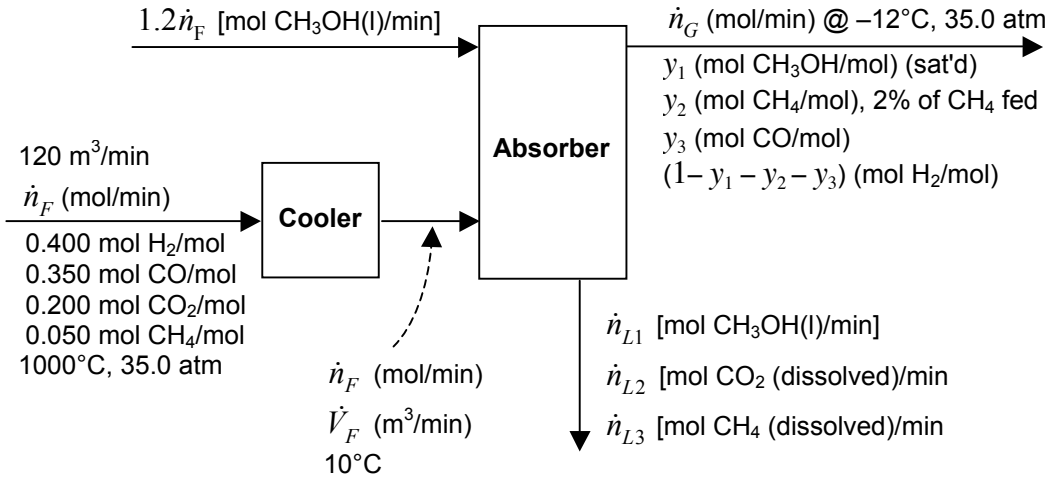
PROBLEM 6.32

A gas stream containing 40.0 mole% hydrogen, 35.0% carbon monoxide, 20.0% carbon dioxide, and 5.0% methane is cooled from 1000°C to 10°C at a constant absolute pressure of 35.0 atm. Gas enters the cooler at 120 m^3/min and upon leaving the cooler is fed to an absorber, where it is contacted with refrigerated liquid methanol. The methanol is fed to the absorber at a molar flow rate 1.2 times that of the inlet gas and absorbs essentially all of the CO_2, 98% of the methane, and none of the other components of the feed gas. The gas leaving the absorber, which is saturated with methanol at –12°C, is fed to a cross-country pipeline.

(a) Calculate the volumetric flow rate of methanol entering the absorber (m^3/min) and the molar flow rate of methanol in the gas leaving the absorber. *Do not assume ideal gas behavior when doing PVT calculations.*



Strategy

- We will first do a degree-of-freedom analysis on the overall system to make sure we have enough information to determine the requested quantities ($\dot{V}_F, \dot{n}_G, y_1$).
- Assuming we do, we will then use an equation of state to convert the volumetric flow rate of the feed stream (120 m^3/min) to a molar flow rate and the latter to the volumetric flow rate of the cooler outlet stream ($\dot{V}_F$). Since each stream is a mixture of species and Chapter 5 only presents one way to do PVT calculations for mixtures (the compressibility factor equation of state with Kay's rule), we'll use that one.
- Finally, we'll write and solve the equations listed in the DOF analysis.

Solution

(6.32-1)

DEGREE-OF-FREEDOM ANALYSIS: OVERALL SYSTEM		
UNKNOWNS AND INFORMATION		JUSTIFICATION/ CONCLUSION
+ 8 unknowns	_____	
– 5 material balances	_____	
– 1 eq. of state at cooler inlet	Calculate _____	
– 1 Raoult's law for CH_3OH	Calculate _____	
– 1 98% CH_4 absorption		_____
0 DOF		Problem is solvable