INDUSTRIAL ORGANIC CHEMISTRY- July 11th, 2017

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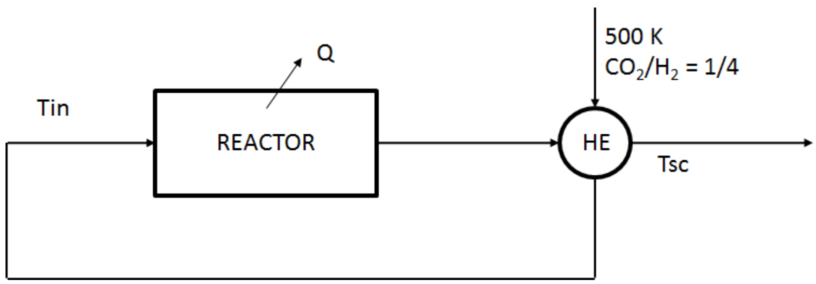
A possible way to exploit hydrogen produced by water hydrolysis is the production of methane according to the Sabatier reaction ($CO_2 + 4\,H_2 \rightarrow CH_4 + 2\,H_2O$). A simplified process layout consists of a heat exchanger (HE), where the fresh feed at 500 K is heated up using the reactor effluents, and of a reactor where a conversion of 95% of CO_2 is achieved when operated at 8 atm. The formation of CO is also experienced in the reactor.



By assuming that:

- The reacting mixture is an ideal mixture of ideal gases
- The thermodynamic equilibrium is reached at the outlet of the reactor (species present at equilibrium: $CO_2, H_2, CH_4, H_2O, CO$)
- The heat exchanger is ideal and the heat losses are negligible
- The reactor is designed to <u>remove</u> 7000 cal/mol of charge
- The fresh feed is at 500 K and the molar ratio between CO_2 and H_2 is $1:4$
- The pressure drop is negligible

1. Evaluate the composition and the temperature of the stream leaving the reactor

H_2O		H_2	
CH_4		CO	
CO_2		Temperature	

2. Evaluate the temperature of the stream entering the reactor (T_{in})

Temperature	

3. Evaluate the temperature of the stream leaving the heat exchanger (T_{sc})

Temperature	

Thermodynamic data:

Sabatier reaction:

$$K_{eq}(T) = \exp\left(\frac{1}{1.987}\left(\frac{56000}{T^2} + \frac{34633}{T} - 16.4\ln T + 0.00557\,T\right) + 33.165\right)$$

where T in [K]

Water gas shift reaction: $\Delta G^0_{WGS}(T) = -8514 + 7.71 \cdot T$ [cal/mol] where T in [K]

Reference state: ideal gas at 1 atm

	ΔH^0_F(298K) [cal/mol]	Cp [cal/mol]
H_2	0	2207
CO	-26420	2253
CO_2	-94050	3284
CH_4	-17890	3438
H_2O	-57800	2662

Heat capacity can be assumed constant in the range of temperature of interest.