Recycle Calculations

Problem 1: A simplified flowsheet for the Union Carbide oxo process is given in Figure 1. The reactor operates at a pressure of 200 psia and a temperature of 373 K. The reaction mechanism is as follows:

$$PL + CO + H_2 \rightarrow IBA + NBA \rightarrow HV$$

80% PL is converted and IBA/NBA ratio is 0.1.
1% of IBA is converted.

PL	Propylene
CO	Carbon Monoxide
H_2	Hydrogen
IBA	Isobutyraldehyde
NBA	n-butyraldehyde
HV	Heavy compounds
P	Propane

Propane is an inert component that does not take part in the reaction. The feed is available at 1 atm and 298 K and has the following composition:

CO	0.5 kgmol/s
H_2	0.5 kgmol/s
PL	0.47 kgmol/s
P	0.03 kgmol/s

- Determine the overall conversion of propylene to n-butyraldehyde for purge rates of 1% and 0.1%. Assume that all the separation steps (distillation) give perfect splits for the components shown.
- How does the propane flowrate change at the reactor inlet when the purge rate goes from 0.1% to 1%?

Problem 2: Consider the ammonia process shown in Figure 2. A feed of 20% N_2, 78% H_2, and 2% CH_4 is mixed with two recycle streams and enters a reactor. Here, conversion per pass of N_2 to NH_3 is 45% according to the reaction:

$$N_2 + 3H_2 \rightarrow 2NH_3$$

The ammonia product is recovered by flashing the reactor effluent in two stages and recycling the overhead vapor. If the purge fraction is 5% for the high pressure recycle, what is the methane concentration in the reactor feed?

The split fractions for Flash 1 and Flash 2 are given below

	ξ_{H_2}	ξ_{N_2}	ξ_{CH_4}	ξ_{NH_3}
Flash 1	0.995	0.99	0.99	0.01
Flash 2	1.000	1.00	1.00	0.02

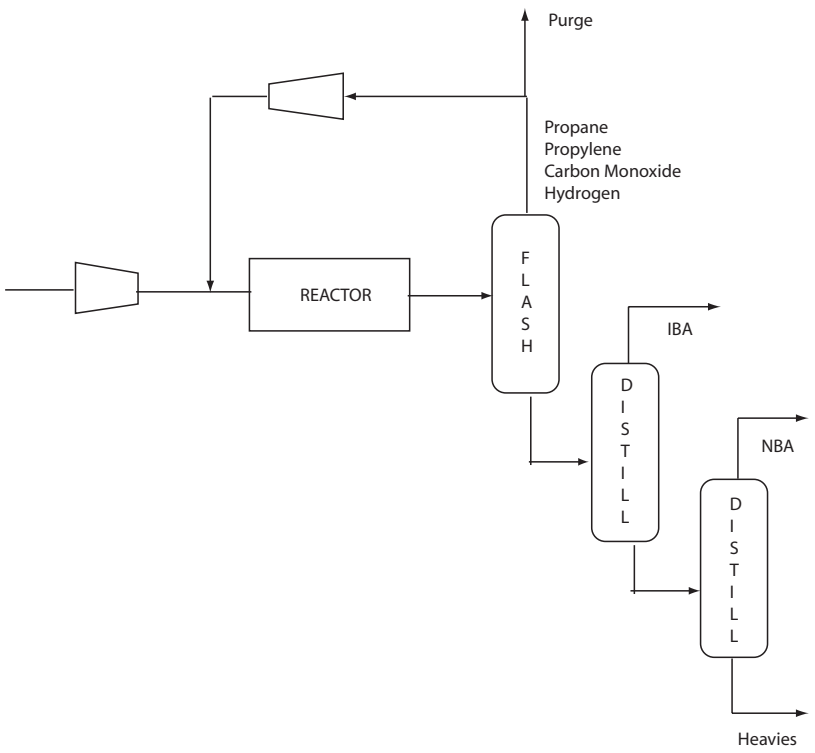
Purge
Propane
Propylene
Carbon Monoxide
Hydrogen
REACTOR
FLASH
IBA
DISTILL
NBA
DISTILL
Heavies

Figure 1:

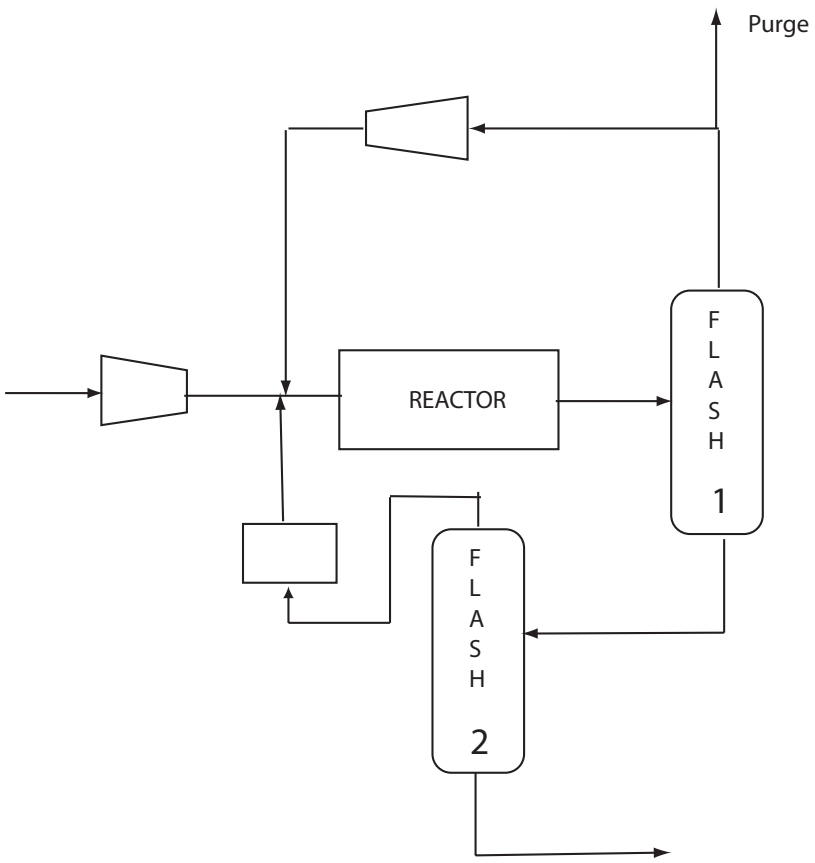

Figure 2: