Problem 4 ; Week 3.

Main Desired Reaction: $CH_3OH + \frac{1}{2}O_2 \longrightarrow CH_2O + H_2O$ (1)

side undesired reaction: $CH_2O + \frac{1}{2}O_2 \longrightarrow CO + H_2O$ (2)

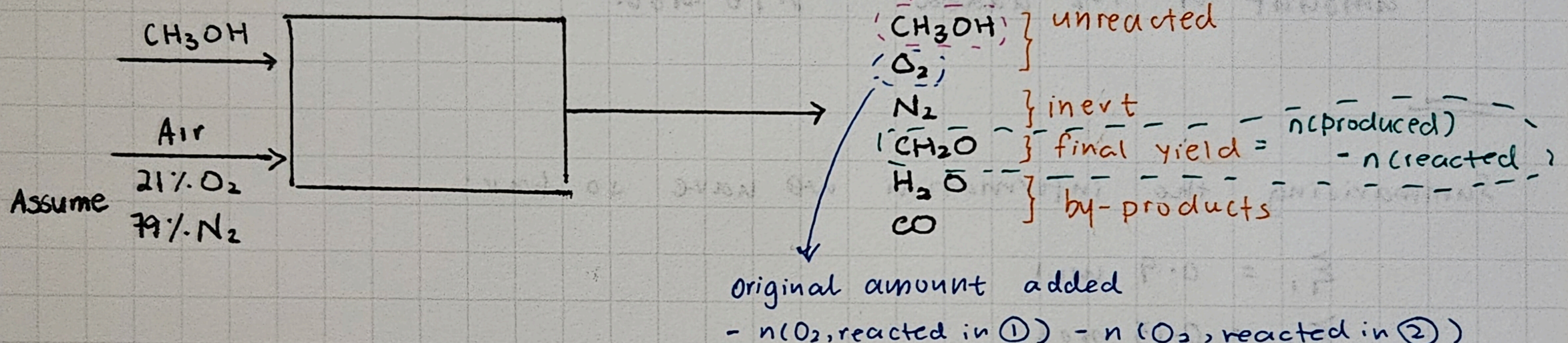
Key information from text:

A 1) "Assume MeOH is twice stoichiometric amount of air needed for complete conversion of MeOH to CH_2O & H_2O".

B 2) "90% CH_3OH conversion of CH_3OH results

C 3) "75% of formaldehyde yields".

Process diagram



Let the basis be 1 mol MeOH, ξ_1 be extent of reaction for ①, ξ_2 be extent of reaction for ②, with respect to 1 mol MeOH.

(from information B: 90% CH_3OH conversion results)

this indirectly implies the extent of reaction

$$\xi_1 = \frac{-0.9}{-1}(1) = 0.9 \text{ mol.}$$

From information 3, 75% of formaldehyde yields based on theoretical production of ①

Theoretical production implies 100% of Methanol reacted.

By reaction ① $n^{out,1}_{CH_2O} = \xi_1 = \xi_1$

② $n^{out,2}_{CH_2O} = n^{in,2}_{CH_2O} - 1(\xi_2) = \xi_2' - \xi_2$

$$\text{Yield} = \frac{\xi_1 - \xi_2}{1} = \frac{0.9 - \xi_2}{1} = 0.75$$

$$\xi_2 = 0.15.$$

Back to information A

" MeOH twice stoichiometric amount of Air required for the reaction".

2 mol MeOH reacts with 1 mol of O_2.

Stoichiometric amount of air required for the reaction depends on the amount of O_2 required

Since we have assumed ↑ Stoichiometric amount needed MeOH to be 1 mol for our basis, twice Stoichiometric amount

mol of O_2 = $(\frac{1}{2} \times 1) \times 2$

= (0.5) mol of ~~air~~ O2 is added.

Since we assumed air to contain 21% ~~Air~~ O2,

amount of air added = 4.76 mol

amount of N_2 added = 3.76 mol.

Summarising the information we have so far:

ξ_1 = 0.9 mol

ξ_2 = 0.15 mol

Added n_{O_2} = 1.00 mol

Added n_{N_2} = 3.76 mol

Now if we do the material balances;

Initial amount change from reaction 1 change from Reaction 2.

n^{final}_{MeOH} = 1 − 0.9 + 0 = 0.10 mol

$n^{final}_{O_2}$ = $1.00 - 0.9(\frac{1}{2}) - 0.15(\frac{1}{3})$ = 0.475 mol

$n^{final}_{CH_2O}$ = 0 + (0.9) + (−0.15) = 0.75 mol

$n^{final}_{H_2O}$ = 0 + 0.9 + 0.15 = 1.05 mol.

n^{final}_{CO} = 0 + 0 + 0.15 = 0.15 mol.

$n^{final}_{N_2}$ = 3.76 + 0 + 0 = 3.76 mol.

Total amount exiting system = 6.28 mol.

	CH_3OH	CH_2O	O_2	H_2O	N_2	CO
composition (%)	1.6	11.9	7.6	16.7	59.8	2.4