CHE 211 BASIC PRINCIPLES IN CHEMICAL ENGINEERING
2021 - 2022 Fall Semester

17.11.2021

Problem Set III

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1. Hydrogen is produced from steam by water gas shift reaction

   $CO + H_2O \longrightarrow CO_2 + H_2$

   If the feed to the reactor contains 30 moles of CO, 12 moles of CO_2 and 35 moles of steam per hour and 18 moles of hydrogen are produced per hour, Calculate
   a) The limiting reactant
   b) The excess reactant
   c) The fractional conversion of steam to H_2
   d) The degree of completion oft he reaction
   e) The kg of hydrogen to be yield per kg of steam fed
   f) The composition of the product

2. The reaction between ethylene (C_2H_4) and HBr to form ethyl bromide (C_2H_5Br) is carried out in a continous reactor. The product stream is analyzed and is found to contain 50% C_2H_5Br an 33.3% HBr by mole. The feed to the reactor contains only ethylene and hydrogen bromide. Calculate:
   a) The fractional conversion of the limiting reactant
   b) The percentage of the excess reactant

3. Methan (CH_4) and oxygen react to form formaldehyde (CH_2O). In a side reaction, some of methane is oxidized to carbon dioxide and water

   $CH_4 + O_2 \longrightarrow CH_2O + H_2O$

   $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

   The feed to the reactor contains 50% methane and 50% oxygen in moles. The fractional conversion of methane is 0.95 and the fractional yield of formaldehyde is 0.90.
   a) Calculate the molar composition of the reactor output stream and the selectivity of formaldehyde production relative to carbon dioxide production.
   b) Calculate conversion of O_2

4. Five kilograms of bismuth (MW= 209) is reacted with one kilogram of sulfur (MW= 32) to form Bi_2S_3 (MW= 514). At the end of the reaction, output is taken out of the reactor and is found to contain 5 wt % free sulfur. Reaction is,

   $2\,Bi + 3S \longrightarrow Bi_2S_3$

   Determine:
   a) the limiting reactant,
   b) the percent excess reactant,
   c) the percent conversion of sulfur to Bi_2S_3 ,
   d) percent conversion of Bi to Bi_2S_3.

5. When propylene(C_3H_6) is mixed with chlorine(Cl_2), the following reactions take place.

$C_3H_6(g) + Cl_2(g) \rightarrow C_3H_5Cl(g) + HCl(g)$ (a)

$C_3H_6(g) + Cl_2(g) \rightarrow C_3H_6Cl_2(g)$ (b)

Molecular weights of C_3H_6, C_3H_5Cl, and $C_3H_6Cl_2$ are 42.0, 76.5, and 113.0 respectively. The species in the product are listed in the following table.

Species	gmol
Cl_2	141.0
C_3H_6	651.0
C_3H_5Cl	4.6
$C_3H_4Cl_2$	24.5
HCl	4.6

assuming that there are only propylene and chlorine in feed, calculate the following:

(a) How much propylene and chlorine are fed to the reactor in gmol?
(b) What was the limiting reactant?
(c) What was the excess reactant and excess percentage of the excess reactant on the basis of reaction (a) ?
(d) What was the fractional conversion of C_3H_6 to C_3H_5Cl ?
(e) What was the selectivity of C_3H_5Cl relative to $C_3H_6Cl_2$?
(f) What was the yield of C_3H_5Cl expressed in gmol C_3H_5Cl to the gmol of C_3H_6 fed to the reactor?
(g) What was the extent of reaction of the first and second reactions?

6. In a process for the manufacture of chlorine by direct oxidation of HCl with air over a catalyst to form Cl_2 and H_2O (only), the exit product is composed of HCl (4.4%), Cl_2 (19.8%), O_2 (4.0%), and N_2 (52.0%). What was

(a) The limiting reactant?
(b) The percent excess air?
(c) The degree of completion of the reaction?

7.Consider a continous, steady –state process in which the following reactions take place :

$C_6H_{12} + 6\ H_2O \rightarrow 6CO + 12\ H_2$

$C_6H_{12} + H_2 \rightarrow C_6H_{14}$

In the process 250 moles/h of C_6H_{12} and 800 moles/h of H_2O are fed into reactor . The yield of H_2 is 40% . Yield is defined as the mole of H_2 obtained divided by the theoretical maximum H_2 that would be obtained based on the limiting reactant being comletely consumed). The selectivity of H_2 relative to C_6H_{14} is 12.

(a) What is limiting reactant?
(b) Calculate the molar flow rates of all five components in output stream.
Note**: Use extent of reaction method.**
(c) Calculate the fractional conversion of H_2O.
(d) What was the conversion of C_6H_{12} to C_6H_{14} ?