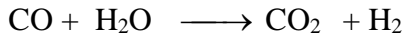


Problem Set III

---

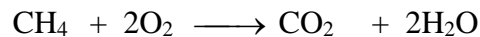
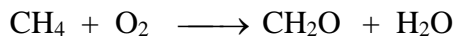
1. Hydrogen is produced from steam by water gas shift reaction



If the feed to the reactor contains 30 moles of CO, 12 moles of CO<sub>2</sub> and 35 moles of steam per hour and 18 moles of hydrogen are produced per hour, Calculate

- The limiting reactant
  - The excess reactant
  - The fractional conversion of steam to H<sub>2</sub>
  - The degree of completion of the reaction
  - The kg of hydrogen to be yield per kg of steam fed
  - The composition of the product
2. The reaction between ethylene (C<sub>2</sub>H<sub>4</sub>) and HBr to form ethyl bromide (C<sub>2</sub>H<sub>5</sub>Br) is carried out in a continuous reactor. The product stream is analyzed and is found to contain 50% C<sub>2</sub>H<sub>5</sub>Br and 33.3% HBr by mole. The feed to the reactor contains only ethylene and hydrogen bromide. Calculate:
- The fractional conversion of the limiting reactant
  - The percentage of the excess reactant

3. Methane (CH<sub>4</sub>) and oxygen react to form formaldehyde (CH<sub>2</sub>O). In a side reaction, some of methane is oxidized to carbon dioxide and water



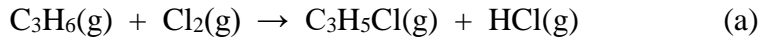
The feed to the reactor contains 50% methane and 50% oxygen in moles. The fractional conversion of methane is 0.95 and the fractional yield of formaldehyde is 0.90.

- Calculate the molar composition of the reactor output stream and the selectivity of formaldehyde production relative to carbon dioxide production.
  - Calculate conversion of O<sub>2</sub>
4. Five kilograms of bismuth (MW= 209) is reacted with one kilogram of sulfur (MW= 32) to form Bi<sub>2</sub>S<sub>3</sub> (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,



Determine:

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



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

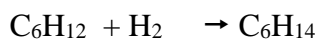
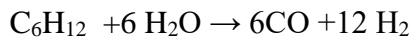
assuming that there are only propylene and chlorine in feed, calculate the following:

- How much propylene and chlorine are fed to the reactor in gmol?
- What was the limiting reactant?
- What was the excess reactant and excess percentage of the excess reactant on the basis of reaction (a) ?
- What was the fractional conversion of  $C_3H_6$  to  $C_3H_5Cl$  ?
- What was the selectivity of  $C_3H_5Cl$  relative to  $C_3H_6Cl_2$ ?
- 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?
- 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

- The limiting reactant?
- The percent excess air?
- The degree of completion of the reaction?

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



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 completely consumed). The selectivity of  $H_2$  relative to  $C_6H_{14}$  is 12.

- What is limiting reactant?
- Calculate the molar flow rates of all five components in output stream.

Note: Use extent of reaction method.

- Calculate the fractional conversion of  $H_2O$ .
- What was the conversion of  $C_6H_{12}$  to  $C_6H_{14}$  ?