PROBLEM SET 6-1

1) Find F for the following systems
   a) a gaseous mixture of N_2, H_2 and NH_3 with no catalyst present (so the rate of reaction is zero); **b)** A gaseous mixture of N_2, H_2 and NH_3 with a catalyst present to establish reaction equilibrium; **c)** the system of (b) with the added condition that all the N_2 and H_2 must come from the dissociation of the NH_3; **d)** a system formed by heating pure $CaCO_3(s)$ to give $CaCO_3(s)$, $CaO(s)$, $CO_2(g)$, $CaCO_3(g)$ and $CaO(g)$.

2) The following table gives mole percent acetic acid in aqueous solutions and in the equilibrium vapor at the boiling point of the solution at 1.013 bar.

b.p., ºC	118.1	113.8	107.5	104.4	102.1	100
Mole% of acetic acid						
In liquid	100	90	70	50	30	0
In vapor	100	83.3	57.5	37.4	18.5	0

Calculate the minimum number of the theoretical plates for the column required to produce an initial distillate of 28 mole acetic acid from a solution 80 mol % acetic acid.

3) From the data given in the following table, construct a complete temperature-composition diagram for the system ethanol-ethyl acetate for 1.013 bar. A solution containing 0.80 mole fraction ethanol is distilled completely at 1.013 bar.

   a) What is the composition of the first vapor to come off?
   b) What is the composition of the last drop of liquid to evaporate?
   c) What would be the values of these quantities if the distillation were carried out in a cylinder provided with a piston so that none of the vapor escapes?

X_{EtOH}	Y_{EtOH}	b.p., ºC	X_{EtOH}	Y_{EtOH}	b.p., ºC
0	0	77.15	0.563	0.507	72
0.025	0.07	76.7	0.71	0.6	72.8
0.1	0.164	75	0.833	0.735	74.2
0.24	0.295	72.6	0.942	0.88	76.4
0.36	0.398	71.8	0.982	0.965	77.7
0.462	0.462	71.6	1.00	1.00	78.3

4) Plot the following boiling point data for benzene-ethanol solutions.
   a) Estimate the azeotropic composition.
   b) State the range of mole fraction of benzene for which pure benzene could be obtained by fractional distillation at 1 atm.

b.p., ºC	78	75	70	70	75	80
Mole% of acetic acid						
In liquid	0	0.04	0.21	0.86	0.96	1.00
In vapor	0	0.18	0.42	0.66	0.83	1.00