1. Please define /explain the following items (a) Adiabatic condition, (b) Joule-Thomson effect, (c)Enthalpy, (d)Closed System, (e) Intensive properties. **(10%)**

2. Determine expressions for G^R and H^R implied by the equation of state, PV=ZRT. **(5%)**

3. A block of metal of total heat capacity Cp is initially at a temperature of T_1, which is higher than the ambient temperature T_2.

   (a) Determine the maximum amount of work that can be obtained on cooling process to the ambient temperature if the nature heat transfer between the metal and surrounding is observed? **(5%)**

   (b) Determine the maximum amount of work that can be obtained on cooling this block to ambient temperature if the temperature of metal drop to T_2 in a very short time? **(5%)**

   (c) Also the same as (b), if the temperature of metal decrease to T_3 ($T_3 < T_2$) in a short time, Can we obtain the work output? If we can, what is the maximum value of the work? You can discuss your answer using the reasonable assumption. **(5 %)**

4. In a binary system where activity coefficients can be represented by the sample equations

$$\ln \gamma_1 = Bx_2^2$$
$$\ln \gamma_2 = Bx_1^2$$

(a)Assuming that these equations are valid, derive expressions relating the activity coefficient base on Henry's law γ^*, to composition. **(5%)**

(b) Show that an azeotrope occurs when $|B| \geq \left| \ln \dfrac{P_1^0}{P_2^0} \right|$, where P_1^0 and P_2^0 are the vapor pressure of component (1) and (2) at the temperature of azeotrope point. **(5 %)**

(c) Also show that for $\left| \ln \dfrac{P_1^0}{P_2^0} \right| < |B|$ and $B < 2$, the azeotrope composition is give

by $x_1 = \dfrac{1}{2}(1 + \dfrac{1}{B} \ln \dfrac{P_1^0}{P_2^0})$ **(10 %)**

5. Define or explain the following items:
   (a) Continuous stirred tank reactor. **(4%)**
   (b) Space time **(4%)**
   (c) Steps in a catalytic reaction process **(4%)**
   (d) Selectivity **(4%)**

6. For the two reactors in series, 40% conversion is achieved in the first reactor. Calculate the total volume of the two reactors necessary to achieve 80% overall conversion of the entering species A.

X	0.0	0.2	0.4	0.6	0.8
$F_{A0}/-r_A \, (m^3)$	1	1.5	2	3.5	8

   (a) If the two reactors are CSTR in series. **(8%)**
   (b) If the two reactors are PFR in series. **(8%)**

7. Tests were run on a small experimental reactor used for decomposing nitrogen oxides in an automobile exhaust stream. Each point represents one complete run. The reactor operates essentially as a **CSTR**. What can you deduce about the apparent order of the reaction over the temperature range studied? **(10%)**
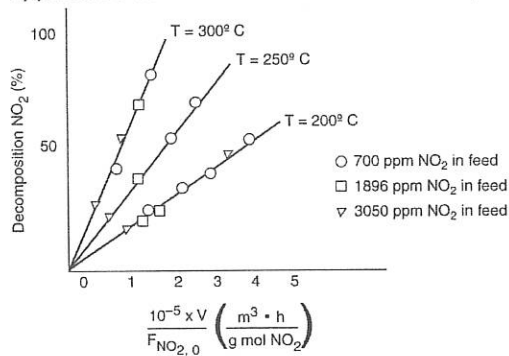
8. For the following sets of reaction describe your reactor type and conditions (T, C_A) to maximize the selectivity to D. Make sketches where necessary to support your choices. The rates are in $(mol/dm^3 \cdot s)$, and concentrations are in (mol/dm^3). **(8%)**

$$A \rightarrow D \quad -r_{1A} = 4280 \exp\left(-\frac{12000K}{T}\right) C_A^2$$

$$D \rightarrow U_1 \quad -r_{2D} = 10100 \exp\left(-\frac{15000K}{T}\right) C_D$$

$$A \rightarrow U_2 \quad -r_{3A} = 26 \exp\left(-\frac{18800K}{T}\right) C_A$$