1. Propose an example to rationalize pseudo-steady state hypothesis and its limitation. 15%

2. The hydrolysis of ethylnitrobenzene (A) by hydroxyl ions at 15 °C can be represented by A + B → C + D, where B is hydroxyl ion.

   In one experiment using a batch reactor, the initial concentration for both reactants is 0.05 mol/L, please use the data listed as follows to estimate the reaction order and rate constant for the reaction. 15%

Reaction time, sec	120	180	240	330	530	600
% hydrolysis	32.95	41.75	48.8	58.05	69.0	70.4

3. Propose suitable method to examine the existence of external and internal mass transfer limitation and to determine adsorption capability of a solid metal catalyst. 10%

4. A first order reaction is carried out to a given conversion in isothermal stirred tank reactors. You have available N such reactors, all of equal volume V. In order to process the maximum amount of feed F_A (kmol/s), determine the optimal arrangement of m-parallel processing lines, each with n-reactors (i.e., nm=N) 10%

5. Initially, 1 mole of an unknown gas was kept at 1 bar and 80°C. The gas was found to behave ideally and the value of $C_p/C_v = 1.37$. The gas is allowed to expand reversibly and adiabatically to 0.1 bar. Now answer the following questions:

a. What are the initial and final volumes of the gas (6%)?

b. What is the final temperature of the gas (3%)?

c. Calculate ΔU and ΔH, respectively, for the process (6%)?

(R = 0.083145 bar $dm^3K^{-1}mol^{-1}$ = 8.3145 $J\,K^{-1}mol^{-1}$)

6. For the equilibrium $NH_4Cl(s) \rightleftharpoons HCl\ (g) + NH_3\ (g)$

Estimates the temperature at which the dissociation of solid ammonium chloride reaches 1 atm, by using the following values at 25 °C (10%)

	ΔH^o_f(kJ/mol)	ΔG^o_f(kJ/mol)
$NH_4Cl(s)$	-315.4	-203.9
HCl (g)	-92.3	-95.3
NH_3 (g)	-46.2	-16.6

7. The molar heat of vaporization of a liquid solvent at its normal boiling point is approximated by the Trouton's law:

$\Delta H^{vap}/T_B = 88\ J\,K^{-1}mol^{-1}$ where T_B is the normal boiling temperature of the liquid. Now we have a solvent with $T_B = 313\ K$ and with the molecular weight of 72g/mol. Now

a. Assuming that the heat of vaporization is temperature independent, estimate the vapor pressure of the solvent at T = 293 *K*. (6%)

b. The solvent is vaporized into air at 293 *K* and at a total of 1 atm. Estimate the weight of the solvent vaporized per unit volume (g/m^3). Assume that the vaporized solvent is a ideal gas.(7%)

8. The values of H and S for steam at 400 °C are listed below. Use these data to calculate the fugacity of 10% steam at 400 °C and 15 MPa. (12%)

State 1 (Low pressure)	State 2
T_1 = 400 °C	T_2 = 400 °C
P_1 = 0.01 MPa	P_2 = 15 MPa
H_1 = 3279.9 kJ/kg	H_2 = 2975.9 kJ/kg
S_1 = 9.609 kJ/kg.K	S_1 = 9.609 kJ/kg.K