Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – WINTER 2012

Subject code: 711601N **Date: 08-01-2013**

Subject Name: Advanced Thermodynamics

Time: 02.30 pm – 05.00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q-(1) Acetic acid is manufactured by carbonylation of methanol by following reaction. **14**

$CH_3OH(l) + CO(g) = CH_3\ COOH(l)$

Continous reaction is carried out at 180°C (453.15 K) and 50 atm. Composition of liquid within the reactor remains uniform throughout and does not change with time. Liquid within the reactor contains 85% methanol and 15% acetic acid (by mole). Gas mixture leaves from the top of the reactor which contains 65 kmol/h of carbon monoxide and 35 kmol/h of hydrogen and are accompanied by vapours of acetic acid and methanol. Calculate the flow rate of organic vapours in the real gas mixture (i.e. non-deal behaviour of gas mixture) and in ideal gas mixture.

Data : Vapour pressures of acetic acid and methanol at 180°C (453.15 K) are 5 bar and 27 bar, respectively. Critical pressures of acetic acid and methanol are 57.86 bar and 80.92 bar, respectively. Critical tempratures of acetic acid and methanol are 592.7 K and 512.64 K, respectively.

Acentric factor (ω) for acetic acid and methanol are 0.467 and 0564, respectively.

For evaluation of Φ and Φ^{sat}generlized correlation in the form of virial equal equation

$$\Phi = \exp\{(p_r/T_r)(B^0 + \omega B^1)\}$$

where p_r = reduced pressure

T_r = reduced temperature

ω= acentric factor (pitzer correlation)

B^0 and B^1 are function of generalized reduced second virial coefficient correlation and are dependent on temperature only.

$$B^0 = 0.083 - (0.422/\boldsymbol{T_r}^{1.6})$$

$$B^1 = 0.139 - (0.172/\boldsymbol{T_r}^{4.2})$$

Q-(2)(a) Starting from first principals, derive an expression for Heat of Reaction for a reaction of type $a \cdot A + b \cdot B \leftrightarrows c \cdot C + d \cdot D$ occurring at any temperature (T) and any pressure (p) **under non-ideal conditions.** **07**

(b) Describe with the help of appropriate data and equations and relevant graphs, the calculation of equilibrium conversion **under adiabatic conditions** for a reaction of type $A \rightarrow B$ being highly reversible and **exothermic in nature.** **07**

OR

(b) Describe with the help of appropriate data and equations and relevant graphs, the calculation of equilibrium conversion **under adiabatic conditions** for a reaction of type $A \rightarrow B$ being highly reversible and **endothermic in nature.** **07**

Q-3 (a) Describe with the help of appropriate data and equations and relevant graphs, the calculation of equilibrium conversion **under non-isothermal & non-adiabatic conditions** for a reaction of type $A \rightarrow B$ being highly reversible and **exothermic or endothermic in nature.** **07**

(b) Explain the adiabatic flash calculations with block diagram and supporting equations. **07**

OR

Q-3(a) Explain the P-T flash calculations with block diagram and supporting equations. **07**

(b) Explain calculations of equilibrium conversion values under isothermal conditions for the following **two reactions proceeding simultaneously:** $A \rightarrow B+C$ & $A \rightarrow D+E$. Derive relevant equations for equilibrium constant (K) as a function of P, n_t & x_e. Also briefly decribe stepwise procedure for calculation of values of x_e **when both reactions proceed simultaneously.** **07**

Q-4(a) Show that the yield of methanol at t =390 ^oC, p = 300 atm is 21% for the reaction proceeds as follows:- **07**

$$CO + 2H_2 \rightarrow CH_3OH.$$

Deta: Free Energy change under std.condition at T=663.2 K is + 14700 cal/gmol and value of K_γ = 0.434

(b) A feed stock of n-butane is cracked at 750 K and 1.2 bar to produce olefins. Only two reactions have favourable equilibrium conversions at these conditions. **07**

$C_4H_{10} \rightarrow C_2H_4 + C_2H_6$ (I)

$C_4H_{10} \rightarrow C_3H_6 + CH_4$ (II)

If these reactions reach equilibrium what is product composition? At 750 K equilibrium constants for both reactions are

$K_I = 3.856$, $K_{II} = 268.4$

OR

Q-4(a) For the ammonia synthesis reaction **07**

$0.5\ N_2 + 1.5\ H_2 \rightarrow NH_3$

With 0.5 mol N_2 and 1.5 mol H_2 as the initial amounts of reactants and with the assumption that the equilibrium mixture is an ideal gas.

Show that

3 f!>!2.)2!,!2/3::!L)Q0Q1** 1/6!

where 3 f!>! Equilibrium extent of reaction

P = Absolute pressure

P^0 = Standard state pressure

L = Equilibrium constant

(b) Explain the BUBLT Calculations with block diagram and supporting equations **07**

Q-5 (a) Explain with neat sketch the working of Lithium Bromide water Vapour absorption refrigeration cycle.

(b) Explain with neat sketch the working of modified Vapour Compression refrigeration cycle.

OR

Q-5 For 200 kW (56.87 TR) ammonia water absorption referigeration plant determine the followings. **14**

a. Flow rate of ammonia required in cycle. Consider 2.5 % heat loss.
b. Calculate the heat duty of absorber.Heat of solution of ammonia= 2000 kJ/kg of NH_3
c. Calculate the heat duty of condenser of distillation column.Reflux ratio of distillation column is 0.3137.Condensation temprature of ammonia vapour in condenser = 40 ^oC.
d. Calculate the heat duty of generator (reboiler) of distillation column.
e. Calculate the COP.

DATA:

Temprature,^oC	Saturation Pressure,kPa	H_L, **kJ/kg**	H_V, **kJ/kg**
-10	290.75	301.4	1597.8
40	1555.5	538.5	1637.2

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