

Seat No.: _____

Enrolment No. _____

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E Sem-I Regular Examination January / February 2011

Subject code: 711601N

Subject Name: Advanced Thermodynamics

Date: 31 /01 /2011

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 (a) Derive an expression for Heat of Reaction for a reaction of type $a.A + b.B \rightarrow c.C + d.D$ occurring at any temperature (T) and pressure (P) under non-ideal conditions. Hence or otherwise derive an expression for Heat of Reaction under ideal conditions. **07**

(b) The free energy change under standard conditions for ethyl benzene to styrene and hydrogen is given by $\Delta G^\circ_I = 29720 - 31.1 (T)$ And for ethyl benzene to benzene and ethylene reaction is given by $\Delta G^\circ_{II} = 27550 - 33.03 (T)$. Calculate the values of X_e at 800 K and 1 atm if both the reactions proceed simultaneously.
Note: ΔG° is in cal/gmol and T is in K. **07**

Q.2 (a) Derive an expression $\Delta G^\circ = - RT \ln K$ for a reaction of type $a.A + b.B \rightarrow c.C + d.D$ occurring at any temperature (T) and pressure (P). **07**

(b) A feed to a column has the composition given in the table below, and is at a pressure of 14 bar and a temperature 60° C. Based on calculations verify that the given mixture is a Vapour-liquid mixture at given conditions. **07**

Feed	kmol/h	Ki
ethane	20	3.8
propane	20	1.3
isobutene	20	0.43
n-pentane	<u>20</u>	0.16
	<u>80</u>	

Also determine the flow rates and composition of vapour and liquid phases.

OR

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

Q.3 Explain with neat sketch the working of Lithium Bromide water Vapour absorption refrigeration cycle. Also discuss the importance of “Economizer” in the same cycle. **14**

OR

Q.3 For 200 kW (56.87 TR) ammonia water absorption refrigeration plant determine the followings. **14**

- Flow rate of ammonia required in cycle. Consider 2.5 % heat loss.
- Calculate the heat duty of absorber. Heat of solution of ammonia = 2000 kJ/kg of NH_3
- Calculate the heat duty of condenser of distillation column. Reflux ratio of distillation column is 0.3137. Condensation temperature of ammonia vapour in condenser = 40 °C.
- Calculate the heat duty of generator (reboiler) of distillation column.
- Calculate the COP.

DATA:

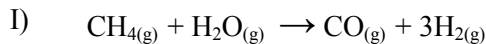
Temperature, °C	Saturation Pressure, kPa	H_L , kJ/kg	H_V , kJ/kg
-10	290.75	301.4	1597.8
40	1555.5	538.5	1637.2

Q.4 Explain the BUBL P Calculations and DEW P Calculations with block diagram and supporting equations **14**

OR

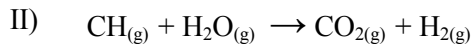
Q.4 Explain the BUBL T Calculations and DEW T Calculations with block diagram and supporting equations **14**

Q.5 Synthesis gas for methanol may be produced by the catalytic reforming of methane with steam. The reactions are: **14**



Equilibrium constant K_I of this reaction at 1300 K and 1 bar pressure.

$$K_I = 13845$$



Equilibrium constant K_{II} of this reaction at 1300 K and 1 bar pressure.

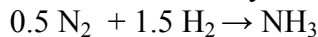
$$K_{II} = 0.5798$$

- Would it be better to carry out the reaction at pressures above 1 bar?
- Would it be better to carry out the reaction at temperatures below 1300 K ?
(Note : Give justification for your answers of (a) and (b).)
- Estimate the molar ratio of hydrogen to carbon monoxide in the synthesis gas if the feed consists of an Equimolar mixture of steam and methane.
- Repeat part (c) for a steam to methane mole ratio in the feed of 2.
- How could the feed composition be altered to yield a lower ratio of hydrogen to carbon monoxide in the synthesis gas than is obtained in part (c) ?
- How could the feed be altered to prevent carbon deposition?

OR

Q.5 (a) Write short notes on Equilibrium conversion charts. **07**

(b) For the ammonia synthesis reaction **07**



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

$$\epsilon_e = 1 - (1 + 1.299 K(P/P^0))^{-0.5}$$

where ϵ_e = Equilibrium extent of reaction

P = Absolute pressure

P^0 = Standard state pressure
