Seat No.: _____ *Enrolment No._____*

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – SUMMER • 2014

Subject code: 711601N **Date: 13-06-2014**

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 mark.**

Q-(1) (a) Show that the yield of methanol at t =390 ^{o}C, p = 300 atm is 21% for the reaction proceeds as follows:- 07

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

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

(b) Write briefly about criteria of chemical reaction equilibria and standard conditions. Hence or otherwise, discuss about ranges of the following:- 07

ΔG : Free Energy Change for reaction under actual conditions.

ΔG^o : Free Energy Change for reaction under standard conditions.

K : Equilibrium constant for chemical reaction equilibria.

X_e : Equilibrium constant for reaction under actual conditions.

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) Elaborate the procedure for obtaining equilibrium conversion charts.Depict and discuss generalised nature of these charts for a reaction of type A== B+C being highly reversible and **exothermic in nature** occuring under different sets of conditions**.** **07**

OR

(b) Elaborate the procedure for obtaining equilibrium conversion charts.Depict and discuss generalised nature of these charts for a reaction of type A== B+C being highly reversible and **endothermic in nature** occuring under different sets of conditions**.** **07**

Q-3(a) 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**

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

OR

Q-3(a) With reference to a generalized reaction of type. 07

aA + bB Ÿ cC + dD

evaluate equilibrium constant for chemical reaction equilibria from basic thermodynamics data, ΔH_f^e, ΔG_f^e and Cp equations for reactants and products. Derive the necessary equation from first principles.

(b) Explain the BUBL T calculations with block diagram and supporting equations. **07**

Q-4(a) A feed to a column has the composition given in the table below, and is 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	K_i
ethane	20	3.8
propane	20	1.3
isobutene	20	0.43
n-pentane	20	0.16
Total:	80	

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

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

OR

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

$0.5\ N_2 + 1.5\ H_2$ Ÿ 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

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

where ε_e = Equilibrium extent of reaction

P = Absolute pressure

P^0 = Standard state pressure

K = Equilibrium constant

(b) Explain the DEW P 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. **07**

OR

Q-5 For 2000 kW (568.7TR) Lithium bromide water absorption refrigeration plants following data are given. **14**

i) Chilled water entering temperature = 12° C

ii) Chilled water leaving temperature = 9° C

iii) Cooling water supply temperature = 32° C

iv) Cooling water leaving temperature = 40° C

v) Saturated steam pressure in generator = 83 k*Pa* g

vi) Operating pressure in evaporator and absorber = 7 mmHg a

vii) Boiling temperature of pure water at 7 mmHg a pressure = 6º C

viii) Latent heat of vaporization of water at 6º C = 2490 kJ/kg

ix) Heat of dilution of Li-Br solution = 470 kJ/kg of water (Heat evolved)

x) Strength of Li-Br solution at inlet to absorber = 63.3% (by mass)

xi) Strength of Li-Br solution at outlet from absorber = 59.5% (by mass)

xii) Entering temperature of Li-Br solution to absorber = 48.9º C

xiii) Outlet temperature of Li-Br solution from absorber = 40º C

xiv) Average specific heat of Li-Br solution in the range of 59.5% to 63.3% (by mass) = 1.842 kJ/(kg. K).

xv) Inlet temperature of weak solution of Li-Br (59.5%) to generator = 75º C

xvi) Boiling point of weak solution in generator = 88.9º C.

xvii) Condensation temperature of water vapour in condenser = 46.1º C.

xviii) Latent heat of vaporization of water at 46.1º C = 2393 kJ/kg.

xix) Boiling point of strong solution (63.3%) leaving the generator = 101.6º C

xx) Specific heat of water vapour = 1.884 kJ/kg.

xxi) Saturated steam supplied to generator at 82.7 kPa g.
Its latent heat of condensation = 2210 kJ/kg.

Calculate:

a) Chilled water flow rate

b) Evaporation rate of water in chiller

c) Flow rates of strong solution and weak solution of Li-Br

d) Heat duty of absorber

e) Heat duty of generator

f) COP of refrigeration cycle

g) Heat duty of condenser

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