Seat No.: _____ Enrolment No._____

# GUJARAT TECHNOLOGICAL UNIVERSITY

**ME - SEMESTER–I(New course)• EXAMINATION – WINTER- 2015**

**Subject Code: 2711601** **Date: 01/01/2016**

**Subject Name: Advanced Thermodynamics**

**Time:2:30 pm to 5:00 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)** What are equilibrium conversion charts? Elaborate the procedure for obtaining equilibrium conversion chart. Depict and discuss generalized nature of these charts for reaction of type A→B+C being **exothermic in nature** and occurring under different sets of conditions. **(07)**

**(b)** Production methanol proceeds as follows:- **(07)**

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

The reaction under consideration is carried out at temperature (t) = 390 ºC and pressure (p) = 300 atm. The value of ratio's of activity coefficients ($K\gamma$) is 0.434 and the value of free energy change for reaction at 663.2 K is + 14,700 cal/gmol. Show that the values of yield of methanol and equilibrium conversion are 21% and 45% respectively.

**Q-2(a)** Explain calculations of equilibrium conversion values under isothermal conditions for the following **two reactions proceeding simultaneously:** A→B+C & A→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)** Starting from first principals, derive an expression for Heat of Reaction for a reaction of type $a \cdot A + b \cdot B \rightleftarrows c \cdot C + d \cdot D$ occurring at any temperature (T) and any pressure (p) **under non-ideal conditions.** **(07)**

**OR**

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

**Q-3 (a)** Starting from first principles, derive an equation $\Delta G^o = -RT \ln K$ wherein all the symbols used have conventional meaning. **(07)**

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

OR

**Q-3(a)** The following isomerization reaction occurs in liquid phase. **(07)**

$$A \rightarrow B$$

Where A and B are miscible liquids for which

$$G^E / RT = 0.1\, x_A\, x_B$$

If $\Delta G^o_{298}$ = – 1000 kJ/kmol what is the equilibrium composition of mixture at 25º C? How much error is introduced if one assumes that A and B form an ideal solution?

**(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.

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

**Q.4** Given a plant process that requires cooling of 54.5 m³/h of water from 12.6 to $7^0$C, assume that the cooler heat transfer area will enable a $5^0$C differential between the chilled water leaving the cooler and the R-12 evaporating temperature. Also assume that the condenser heat transfer area enable a $5^0$C differential between the condenser water out and R-12 condensing temperature. Water is available for the condensing medium at $30^0$C inlet and $35^0$C outlet. Assume no liquid subcooling or suction gas superheating. Find **(14)**

(a) Tons of refrigeration.
(b) Evaporator pressure.
(c) Condenser operating pressure.
(d) Refrigeration effect.
(e) Mass flowrate of R-12 circulated.
(f) Compression ratio.
(g) Coefficient of performance.
(h) Condenser water quantity.

Exponential Coefficient for isentropic compression of R-12 is n = 1.19.

Properties of R-12

| T, K | P, bar | $h_l$, kJ/kg | $h_g$, kJ/kg |
|---|---|---|---|
| 260 | 1.959 | 387.7 | 546.1 |
| 270 | 2.784 | 397 | 550.7 |
| 280 | 3.825 | 406.5 | 555.1 |
| 290 | 5.184 | 416.1 | 559.4 |
| 300 | 6.84 | 426 | 563.5 |
| 310 | 8.86 | 436 | 567.3 |
| 320 | 11.29 | 446.2 | 570.9 |

Specific heat of water = 4.1868 kJ / (kg.$^0$C)

Specific heat of R-12 in gas phase = 0.25 kJ / (kg.$^0$C)

OR

**Q4(a)** Explain with neat sketch the working of Lithium Bromide water Vapour absorption refrigeration cycle. **(07)**

**(b)** Explain with neat sketch the working of modified Vapour Compression refrigeration cycle. **(07)**

**Q5(a)** Explain method for DEWT calculation with the help of block diagram and all supportive equations. **(07)**

**(b)** A saturated liquid mixture, containing 45.1% propane, 18.3% iso-butane and 36.6% *n*-butane (by mole), is available at 40.8 bar a and 125.6º C (398.78 K). It is adiabatically flashed at 22 bar a and 93.1ºC (366.25 K). At these conditions, K values are 1.42, 0.86 and 0.72, respectively. **(07)**

OR

**Q5(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 method for BUBLT calculation with the help of block diagram and all supportive equations. **(07)**

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