| Reg. No. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|

# Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

## IV SEMESTER B.TECH (CHEMICAL ENGINEERING)

## END SEMESTER MAKEUP EXAMINATIONS, JUN/JUL 2016

SUBJECT: CHEMICAL ENGINEERING THERMODYNAMICS-II [CHE 2201]

**REVISED CREDIT SYSTEM**

Time: 3 Hours MAX. MARKS: 100

**Instructions to Candidates:**

- Answer **ALL** questions.
- Missing data, if any, may be suitably assumed.

| | | |
|---|---|---|
| **1A.** | Calculate the fugacity of propane at 12 bar and 310 K using the following data.<br>P, bar: 1.7, 3.4, 6.8, 10.2, 11.7, 13.6<br>V, $m^3$/kg: 0.3313, 0.1609, 0.0754, 0.0468, 0.0382, 0.021<br>Given the molecular weight of propane is 44. | **08** |
| **1B.** | The molar enthalpy of a binary solution at constant T and P is given by the relation $H = 400x_1 + 600x_2 + (40x_1 + 20x_2)x_1x_2$ where $H$ is in J/mol. Determine $\overline{H_1}$ and $\overline{H_2}$ as functions of $x_1$ and the numerical values of the pure component enthalpies $H_1$ and $H_2$ . | **08** |
| **1C.** | Discuss the tangent-intercept method for determining partial molar property. | **04** |
| **2A.** | The activity coefficient of thallium in amalgams at 298 K are given below.<br>$x_2$: 0, 0.00326, 0.01675, 0.04856, 0.0986, 0.168, 0.2701, 0.424<br>$\gamma_2$: 1.0, 1.042, 1.231, 1.776, 2.811, 4.321, 6.196, 7.707<br>Determine the activity coefficient of mercury (component 1) in the solution. | **10** |
| **2B.** | Prove that if Henry's law is obeyed by component 1 in a binary solution over certain concentration range, Lewis-Randall rule (Raoult's law) will be obeyed by component 2 over the same concentration range. | **06** |
| **2C.** | Derive the expression for the effect of temperature and pressure on activity. | **04** |
| **3A.** | Discuss with a sketch, maximum and minimum boiling azeotrope. | **06** |

**3B.** Mixtures of n-Heptane (A) and n-Octane (B) are expected to behave ideally. The total pressure over the system is 101.3 kPa. Using the vapour pressure data given below draw the boiling point diagram. **07**

| T, k | 371.4 | 378 | 383 | 388 | 393 | 398.6 |
|---|---|---|---|---|---|---|
| $P_A, kPa$ | 101.3 | 125.3 | 140.0 | 160.0 | 179.9 | 205.5 |
| $P_B, kPa$ | 44.4 | 55.6 | 64.5 | 74.8 | 86.6 | 101.3 |

**3C.** 2-propanol and 1-propanol forms an ideal solution. Prepare P-x-y diagram at $90^0$C. The Antoine constants are **07**

| | A | B | C |
|---|---|---|---|
| 2-propanol (1) | 8.87829 | 2010.330 | 252.636 |
| 1-propanol (2) | 8.37895 | 1788.020 | 227.438 |

**4A.** A mixture contains 45% (mol) methanol (A), 30% (mol) ethanol (B) and the rest n-propanol (C). Liquid solution may be assumed to be ideal and perfect gas law is valid for the vapour phase. Calculate at a total pressure of 101.3 kPa, the bubble point and the vapour composition. **10**

The vapour pressures of the pure liquids are given below.

| Temperature, K | 333 | 343 | 353 | 363 |
|---|---|---|---|---|
| $P_A, kPa$ | 81.97 | 133.29 | 186.61 | 266.58 |
| $P_B, kPa$ | 49.32 | 73.31 | 106.63 | 166.61 |
| $P_C, kPa$ | 39.32 | 62.65 | 93.30 | 133.29 |

**4B.** The following VLE data were obtained for ethanol – water system at 298 K. Test whether the data are thermodynamically consistent by slope of ln γ method. **10**

| $X_1$ | 0.122 | 0.163 | 0.226 | 0.320 | 0.337 | 0.437 | 0.440 | 0.579 | 0.830 |
|---|---|---|---|---|---|---|---|---|---|
| $Y_1$ | 0.474 | 0.531 | 0.562 | 0.582 | 0.589 | 0.620 | 0.619 | 0.685 | 0.849 |
| P,kPa | 5.57 | 6.02 | 6.38 | 6.76 | 6.80 | 7.02 | 7.04 | 7.30 | 7.78 |

The vapour pressures of ethanol and water are, respectively, 7.86 kPa and 3.17 kPa.

**5A.** Derive van't Hoff equation for showing the effect of temperature on equilibrium constant. **08**

**5B.** For the vapour phase hydration of ethylene to ethanol according to **12**

$C_2H_4 + H_2O \rightarrow C_2H_5OH$

The equilibrium constants were measured at temperature 420 K and 600 K. They are $6.8 \times 10^{-2}$ and $1.9 \times 10^{-3}$ respectively. The specific heat data is as follows.

| | $c_p$, J/mol K |
|---|---|
| Ethylene | $11.886 + 120.12 \times 10^{-3}T - 36.649 \times 10^{-6}T^2$ |
| Water | $30.475 + 9.652 \times 10^{-3}T + 1.189 \times 10^{-6}T^2$ |
| Ethanol | $29.358 + 166.9 \times 10^{-3}T - 50.09 \times 10^{-6}T^2$ |

Develop general expressions for the equilibrium constant and standard free energy change as functions of temperature.