Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

IV SEMESTER B.TECH. (CHEMICAL ENGINEERING)

ENDSEM EXAMINATIONS, APR 2019

SUBJECT: CHEMICAL ENGINEERING THERMODYNAMICS-II [CHE 2201]

REVISED CREDIT SYSTEM
(24/04/2019)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A.	The molar volume of a binary solution at constant T and P is given by the relation $V = 120x_1 + 70x_2 + (15x_1 + 8x_2)x_1x_2$ where V is in m^3/mol. Determine the expression for $\bar{V}_2$ as a function of x_2 and calculate the value of $\bar{V}_2^{\infty}$.	**04**
1B.	Estimate the fugacity of gaseous propane at 12 bar and 310 K using the following data. (Solve using compressibility factor method) P, bar: 1.7, 3.4, 6.8, 10.2, 11.7, 13.6 V, m^3/kg: 0.3313, 0.1609, 0.0754, 0.0468, 0.0382, 0.021 The molecular weight of propane is 44	**06**
2A.	Justify the following statements. (a) The concept of ideal gaseous solution is less restrictive than that of an ideal gaseous mixture. (b) Raoult's law is a simplified form of Lewis-Randall rule.	**02**
2B.	Check whether the following equations satisfy Gibbs-Duhem equation. $ln\gamma_1 = Ax_2^2 + Bx_2^2(3x_1 - x_2)$ $ln\gamma_2 = Ax_1^2 + Bx_1^2(x_1 - 3x_2)$ Note: The final answer on both sides of the Gibbs-Duhem equation should be in terms of x_1.	**04**
2C.	Define the terms: chemical potential, Henry's law, residual volume, Lechatelier's principle.	**04**
3A.	Discuss the effect of pressure on T-x-y diagram.	**04**
3B.	The system n-pentane (1)- n-hexane(2) n-heptane(3) forms an ideal solution. Determine the composition of liquid which is in equilibrium with vapour of composition y_1 =0.45, y_2 =0.3 and y_3 =0.25 at 70°C. At 70°C, the vapour pressure of n-pentane, n-hexane and n-heptane are 2129.57 Torr, 785.82 Torr and 303.99 Torr respectively.	**03**

<table>
<tr><td>3C.</td><td>With the help of phase diagrams, discuss the maximum boiling azeotrope.</td><td>03</td></tr>
<tr><td>4A.</td><td>The following data were reported for VLE for ethanol (1)- water (2) system at 298 K. Test whether the following data are consistent by zero area method.
<table>
<tr><td>x_1</td><td>0.163</td><td>0.226</td><td>0.337</td><td>0.440</td><td>0.579</td><td>0.830</td></tr>
<tr><td>y_1</td><td>0.531</td><td>0.562</td><td>0.589</td><td>0.619</td><td>0.685</td><td>0.849</td></tr>
<tr><td>P, kPa</td><td>6.02</td><td>6.38</td><td>6.80</td><td>7.04</td><td>7.30</td><td>7.78</td></tr>
</table>
The vapour pressure of ethanol and water are 7.86 and 3.17 kPa respectively.</td><td>06</td></tr>
<tr><td>4B.</td><td>The binary system having component (1) and component (2) forms an azeotrope at x_1=0.7390 at 25°C and 262 Torr. Calculate the P-x-y data at 25°C. (any 2 sets of data). The system follows van Laar equation. The vapour pressure varies with respect to temperature as
$\log_{10} P_1^S = 7.11714 - \frac{1210.595}{T+229.664}$
$\log_{10} P_2^S = 6.85146 - \frac{1206.470}{T+223.136}$</td><td>04</td></tr>
<tr><td>5A.</td><td>For the vapour phase hydration of ethylene to ethanol according to
$C_2H_4 + H_2O \rightarrow C_2H_5OH$
the equilibrium constants at 420 K and 600 K were found to be 6.8×10^{-2} and 1.9×10^{-3} .The specific heat data is as follows.
<table>
<tr><td></td><td>c_p, J/mol K</td></tr>
<tr><td>Ethylene</td><td>$11.886 + 120.12 \times 10^{-3}T - 36.649 \times 10^{-6}T^2$</td></tr>
<tr><td>Water</td><td>$30.475 + 9.652 \times 10^{-3}T + 1.189 \times 10^{-6}T^2$</td></tr>
<tr><td>Ethanol</td><td>$29.358 + 166.9 \times 10^{-3}T - 50.09 \times 10^{-6}T^2$</td></tr>
</table>
Develop the general expressions for equilibrium constant and standard free energy change as functions of temperature.</td><td>06</td></tr>
<tr><td>5B.</td><td>The reaction $N_2 + O_2 \rightarrow 2NO$ takes place in the gas phase at 2700°C and 2025 kPa. The reaction mixture initially comprises 15 % oxygen, 77 % nitrogen and the rest inerts. The standard Gibbs free energy change for the reaction is 113.83 kJ/mol at this temperature. Assuming ideal gas behavior, calculate the composition of all the components in the product stream.</td><td>04</td></tr>
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