Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

IV SEMESTER B.TECH. (CHEMICAL ENGINEERING)

ENDSEM EXAMINATIONS, JUN 2022

SUBJECT: CHEMICAL ENGINEERING THERMODYNAMICS-II [CHE 2251]

REVISED CREDIT SYSTEM
(11/06/2022)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

<table>
<tr><td>1A</td><td>Calculate the fugacity of nitrogen at 800 bar from the following data at 273 K. (Use compressibility factor method).
<table>
<tr><td>P, bar</td><td>50</td><td>100</td><td>200</td><td>400</td><td>800</td></tr>
<tr><td>PV/RT</td><td>0.9846</td><td>0.9846</td><td>1.0365</td><td>1.2557</td><td>1.7959</td></tr>
</table></td><td>5</td></tr>
<tr><td>1B</td><td>The molar enthalpy of a binary solution at constant T and P is given by the relation
$H = 120x_1 + 70x_2 + (15x_1 + 8x_2)x_1x_2$
where H is in J/mol. Calculate $\overline{H_2}$ as a function of x_1.</td><td>3</td></tr>
<tr><td>1C</td><td>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.</td><td>2</td></tr>
<tr><td>2A</td><td>Check whether the given equations satisfy Gibbs Duhem equation.
$ln\gamma_1 = 500 + 140x_1 - 60x_1x_2 - 20x_2^2 + 20x_1x_2^2$
$ln\gamma_2 = -120x_2 - 90x_1x_2 - 20x_2^2 + 20x_1x_2^2$ (Note: The final answer on both sides of the Gibbs Duhem equation should be in terms of x_1.)</td><td>4</td></tr>
<tr><td>2B</td><td>With the help of phase diagram, explain the effect of pressure on constant pressure equilibria.</td><td>3</td></tr>
<tr><td>2C</td><td>Define Henry’s law, Duhem theorem, Critical envelope</td><td>3</td></tr>
</table>

<table>
<tr>
<td>3A</td>
<td>
<p>Using the RK equation of state, determine the values of RK parameters for a gas mixture containing 30% propane and 70% n-pentane at 500 K and 12 bar.</p>
<p>Given the properties of the components</p>
<table>
<tr><th></th><th>Critical temperature (K)</th><th>Critical pressure (bar)</th></tr>
<tr><td>Propane</td><td>369.9</td><td>42.57</td></tr>
<tr><td>n-pentane</td><td>469.8</td><td>33.75</td></tr>
</table>
</td>
<td>3</td>
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<tr>
<td>3B</td>
<td>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.</td>
<td>3</td>
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<tr>
<td>3C</td>
<td>With the help of phase diagrams, discuss the maximum boiling azeotrope.</td>
<td>4</td>
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<tr>
<td>4A</td>
<td>Methanol(1)- acetone(2) forms an azeotrope at 760 Torr with x_1=0.2 and t=55.7°C. The vapour pressures at 55.7°C are P_1^S=530.97 Torr and P_2^S=749.65 Torr. Predict the P-x-y data (any two sets of data) at 55.7°C. Assume that van Laar equation is applicable to the system.</td>
<td>4</td>
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<tr>
<td>4B</td>
<td>A vapour mixture of 20 mole percent methane, 30 mole percent ethane and 50 mole percent propane is available at 30°C. Making use of the K factor chart determine the percent at which condensation begins if the mixture is isothermally compressed. Also estimate the composition of the first drop of liquid that forms.</td>
<td>3</td>
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<tr>
<td>4C</td>
<td>
<p>Vapour liquid equilibrium data for the system methanol (1)- benzene (2) at 313 K are given below. Calculate the values of $ln(\gamma_1/\gamma_2)$.</p>
<table>
<tr><td>x_1</td><td>0</td><td>0.141</td><td>0.304</td><td>0.468</td><td>0.643</td><td>0.702</td><td>0.878</td><td>1.00</td></tr>
<tr><td>y_1</td><td>0</td><td>0.507</td><td>0.531</td><td>0.543</td><td>0.566</td><td>0.578</td><td>0.670</td><td>1.000</td></tr>
<tr><td>P, kPa</td><td>24.46</td><td>46.52</td><td>48.32</td><td>48.73</td><td>48.81</td><td>47.61</td><td>44.52</td><td>35.12</td></tr>
</table>
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<tr>
<td>5A.</td>
<td>
<p>For the following reaction the data are given at 298 K.</p>
<p>$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$</p>
<table>
<tr><th></th><th>$\Delta H^o_{f,298} \times 10^{-3}$, J/mol</th><th>$\Delta G^o_{f,298} \times 10^{-3}$, J/mol</th><th>$c_p$, J/mol K</th></tr>
<tr><td>Methane</td><td>-74.943</td><td>-50.66</td><td>$17.449 + 60.449 \times 10^{-3}T + 1.117 \times 10^{-6}T^2$</td></tr>
<tr><td>Water</td><td>-241.99</td><td>-228.60</td><td>$28.850 + 12.055 \times 10^{-3}T$</td></tr>
<tr><td>Carbon dioxide</td><td>-393.97</td><td>-394.81</td><td>$45.369 + 8.688 \times 10^{-3}T$</td></tr>
<tr><td>Hydrogen</td><td></td><td></td><td>$27.012 + 3.509 \times 10^{-3}T$</td></tr>
</table>
<p>Calculate the values of integration constants.</p>
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<td>4</td>
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<tr>
<td>5B.</td>
<td>Estimate the maximum conversion of ethylene to alcohol by vapour-phase hydration at 523 K and 34 bar.</td>
<td>4</td>
</tr>
</table>

	C_2H_4 (g) + H_2O (g) → C_2H_5OH (g) The equilibrium constant varies with temperature as $lnK = \frac{4760}{T} - 1.558 \ln T + 2.22 \times 10^{-3} T - 0.29 \times 10^{-6} T^2 - 5.56$ The steam to ethylene ratio in the initial mixture is 5.0. The equilibrium constant in terms of fugacity coefficient is 0.9419.	
5C.	Define reaction coordinate, Lechatelier's principle	**2**