U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

October 2024 Supplementary Examinations

Programme: B.E. **Semester: IV**
Branch: Biotechnology **Duration: 3 hrs.**
Course Code: 23BT4ESPET **Max Marks: 100**
Course: Process Engineering Thermodynamics

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

			CO	*PO*	Marks
		UNIT - I			
1	a)	State the second law of thermodynamics. Derive an equation for the first law of thermodynamics for the flow process with a neat sketch.	*CO1*	*PO1*	**10**
	b)	What is the principle of the Carnot cycle? Derive the equation for Carnot efficiency.	*CO1*	*PO1*	**10**
		OR			
2	a)	Explain the zeroth and third law of thermodynamics with examples.	*CO1*	*PO1*	**04**
	b)	What are intensive and extensive properties? Segregate the following based on the type of properties. Temperature, internal energy, specific heat, density, pressure, heat capacity, volume, mass, and molar volume.	*CO1*	*PO1*	**06**
	c)	Hydrocarbon oil will be cooled from 425 K to 340 K at 5000 kg/h in a parallel flow heat exchanger. Cooling water at 10,000 kg/h at 295 K is available. The mean specific heats of the oil and water are 2.5 kJ/kg K and 4.2 kJ/kg K, respectively. (i) Determine the total change in entropy. Is the process reversible? (ii) How much work would be available if a reversible Carnot engine is to be operated, receiving the heat from the oil and rejecting the heat to the surroundings at 295 K?	*CO1*	*PO2*	**10**
		UNIT – II			
3	a)	Elucidate the importance of PT and PV diagrams in understanding the PVT behavior of pure fluids.	*CO1*	*PO1*	**10**
	b)	Prove that $Cp - Cv = R$.	*CO1*	*PO1*	**04**

<table>
<tr><td></td><td></td><td>c)</td><td>The molar volume of carbon dioxide is 0.381 m^3/kmol at 313 K. Calculate the pressure in bar using:
(i) ideal gas equation
(ii) van der Waals equation.
Assume the van der Waals constants: a = 0.365 Nm^4/mol^2 and b = 4.28×10^{-5} m^3/mol. Comment on the values obtained by both equations.</td><td>CO2</td><td>PO2</td><td>06</td></tr>
<tr><td></td><td></td><td></td><td>UNIT - III</td><td></td><td></td><td></td></tr>
<tr><td></td><td>4</td><td>a)</td><td>What is fugacity? How is the fugacity of pure gases determined?</td><td>CO2</td><td>PO1</td><td>06</td></tr>
<tr><td></td><td></td><td>b)</td><td>Calculate the fugacity of liquid water at 303 K and 10 bar if the saturation pressure at 303 K is 4.241 kPa and the specific volume of liquid water at 303 K is 1.004×10^{-3} m^3/kg.</td><td>CO2</td><td>PO2</td><td>06</td></tr>
<tr><td></td><td></td><td>c)</td><td>Derive the Clausius Clapeyron equation by stating suitable assumptions. Emphasize on its applications.</td><td>CO2</td><td>PO2</td><td>08</td></tr>
<tr><td></td><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td></td><td>5</td><td>a)</td><td>Derive the Maxwell equations using fundamental property relations.</td><td>CO2</td><td>PO2</td><td>08</td></tr>
<tr><td></td><td></td><td>b)</td><td>Explain the term fugacity coefficient. Deduce the relationship between the fugacity and fugacity coefficient.</td><td>CO2</td><td>PO1</td><td>06</td></tr>
<tr><td></td><td></td><td>c)</td><td>Elucidate the chemical potential and its importance in bioprocess applications.</td><td>CO2</td><td>PO1</td><td>06</td></tr>
<tr><td></td><td></td><td></td><td>UNIT - IV</td><td></td><td></td><td></td></tr>
<tr><td></td><td>6</td><td>a)</td><td>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,
(i) Construct the boiling point diagram
(ii) Construct the equilibrium diagram
(iii) Deduce an equation for the equilibrium diagram using an arithmetic average α value
<table>
<tr><td>T, K</td><td>371.4</td><td>378</td><td>383</td><td>388</td><td>393</td><td>398.6</td></tr>
<tr><td>P_A, kPa</td><td>101.3</td><td>125.3</td><td>140.0</td><td>160.0</td><td>179.9</td><td>205.3</td></tr>
<tr><td>P_B, kPa</td><td>44.4</td><td>55.6</td><td>64.5</td><td>74.8</td><td>86.6</td><td>101.3</td></tr>
</table></td><td>CO3</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>Discuss the criteria of phase equilibria.</td><td>CO3</td><td>PO2</td><td>06</td></tr>
<tr><td></td><td></td><td>c)</td><td>Briefly explain the VLE in non-ideal solutions.</td><td>CO3</td><td>PO2</td><td>04</td></tr>
<tr><td></td><td></td><td></td><td>UNIT - V</td><td></td><td></td><td></td></tr>
<tr><td></td><td>7</td><td>a)</td><td>Derive an expression between temperature and equilibrium constant.</td><td>CO3</td><td>PO2</td><td>08</td></tr>
</table>

		b)	*n*-Butane is isomerized to *i*-butane by the action of catalyst at moderate temperatures. It is found that the equilibrium is attained at the following compositions. <table><tr><td>Temperature (K)</td><td>Mol % of *n*-butane</td></tr><tr><td>317</td><td>31</td></tr><tr><td>391</td><td>43</td></tr></table> Assuming that activities are equal to the mole fractions, calculate the standard free energy of the reaction at 317 K and 391 K and the average value of heat of reaction over this temperature range.	***CO3***	***PO2***	**08**
		c)	Explain the thermodynamics of denaturation of proteins.	***CO4***	***PO2***	**04**

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