U.S.N.										

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

Autonomous Institute Affiliated to VTU

December / January 2024 Supplementary Examinations

Programme: B.E. **Semester: IV**
Branch: Biotechnology **Duration: 3 hrs.**
Course Code: 22BT4ESPET **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.

		UNIT - I	CO	PO	Marks
1	a)	What are intensive and extensive properties? Segregate the following based on the type of properties. Temperature, specific heat, density, pressure, heat capacity, and molar volume.	CO1	PO 1	**05**
	b)	Derive an equation for the first law of thermodynamics for the flow process with a neat sketch.	CO1	PO1	**08**
	c)	Hydrocarbon oil is to be cooled from 425 K to 340 K at a rate of 5000 kg/h in a parallel flow heat exchanger. Cooling water at a rate of 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) 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, how much work would be available?	CO1	PO1	**07**
		OR			
2	a)	State and explain the zeroth and the first law of thermodynamics.	CO1	PO1	**04**
	b)	Heat is transferred to 10 kg of air which is initially at 100 kPa and 300 K until its temperature reaches 600 K. Determine the change in internal energy, the change in enthalpy, the heat supplied, and the work done in the constant volume process. Assume: Air is an ideal gas, C_P = 29,099 J/kmol K and C_V = 20,785 J/kmol K	CO1	PO1	**08**
	c)	Explain the Carnot principle with a neat figure.	CO1	PO1	**08**
		UNIT - II			
3	a)	What is the significance of the compressibility factor?	CO1	PO1	**04**

		b)	One kmol of CO_2 occupies a volume of 0.381 m^3 at 313 K. Compare the pressures given by (i) the ideal gas equation and (ii) the van der Waals equation. Express the answer in units of bar. Assume the van der Waals constants as, a = 0.365 Nm^4/mol^2 and b = 4.28×10^{-5} m^3/mol.	*CO2*	*PO2*	**06**
		c)	Elucidate the PVT behavior of pure fluids, with a neat PT and PV diagram.	*CO2*	*PO1*	**10**
			UNIT - III			
	4	a)	The fugacity of component 1 in a binary liquid mixture of components 1 and 2 at 298 K and 20 bar is given by $\overline{f}_1 = 50x_1 - 80x_1^2 + 40x_1^3$. Where $\overline{f}_1$ is in bar and x_1 is the mole fraction of component 1. Determine (i) The fugacity f_1 of pure component (ii) The fugacity coefficient φ_1 (iii) The Henry's law constant K_1 (iv) The activity coefficient γ_1	*CO1*	*PO1*	**08**
		b)	Derive an equation to determine the fugacity of pure gases using the compressibility factor.	*CO 1*	*PO1*	**07**
		c)	What is the application of the Clapeyron equation?	*CO 1*	*PO1*	**05**
			OR			
	5	a)	Write the Gibbs-Duhem equation in terms of activity coefficient. Discuss its significance.	*CO1*	*PO1*	**05**
		b)	Calculate the vapour pressure of water at 90°C if the vapour pressure at 100°C is 101325 Pa, and the mean heat of vaporizing in this temperature range is 2275 kJ/kg.	*CO1*	*PO1*	**07**
		c)	Discuss the importance of Raoult's law.	*CO1*	*PO1*	**04**
		d)	The Henry's law constant for oxygen in water at 298 K is 4.4×10^4 bar. Estimate the solubility of oxygen (g oxygen/g water) in water at 298 K for partial pressure of oxygen at 0.25 bar.	*CO 1*	*PO1*	**04**
			UNIT - IV			
	6	a)	An equimolar solution of benzene and toluene is totally evaporated at a constant temperature of 363 K. At this temperature, the vapor pressures of benzene and toluene are 135.4 and 54 kPa, respectively. What are the pressures at the beginning and at the end of the vaporization process?	*CO 2*	*PO2*	**08**
		b)	Discuss positive and negative deviation from ideality with figures.	*CO2*	*PO1*	**08**
		c)	Draw T-x-y diagram. Explain its significance.	*CO2*	*PO1*	**04**

<table>
<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>Explain the criteria for Biochemical reaction equilibrium. From this, derive the relationship between the standard Gibbs energy and equilibrium constant, $\Delta G^{\circ} = -RT \ln K$.</td><td>CO2</td><td>PO2</td><td>08</td></tr>
<tr><td></td><td></td><td>b)</td><td>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.</td><td>CO2</td><td>PO2</td><td>08</td></tr>
<tr><td></td><td></td><td>c)</td><td>Explain the oxygen consumption and heat evolution in aerobic cultures.</td><td>CO1</td><td>PO1</td><td>04</td></tr>
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