U.S.N.										

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

Autonomous Institute Affiliated to VTU

September / October 2023 Semester End Main 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)	How would you define extensive and intensive properties? State whether the following properties are intensive or extensive: (a) volume, (b) density, (c) specific volume, (d) heat capacity, (e) specific heat, (f) potential energy, (g) pressure.	CO 1	PO 1	**06**
	b)	Derive the equation for first law of thermodynamics for flow process.	CO 1	PO1	**08**
	c)	Nutrients in the soil are absorbed by the root system of a tree and then rise to reach the leaves through a complex vascular system in its trunk and branches. Calculate the work required to raise 10 g of liquid water (corresponding to a volume of about 10 mL) through the trunk of a 20 m tree from its roots to its top most leaves.	CO 1	PO1	**06**
		OR			
2	a)	Derive the equation for Carnot efficiency of reversible heat engine. Write the propositions of Carnot principle.	CO1	PO1	**10**
	b)	Two Carnot engines A and B are connected in series between the two thermal reservoirs at 1000 K and 200 K respectively. Engine A receives 500 kJ of heat from the higher temperature reservoir and rejects heat to the engine B. Engine B takes in heat rejected by engine A and rejects heat to the low temperature reservoir. If the engines A and B deliver equal work, draw a neat schematic for the flow of energy and determine i. The amount of heat taken in by the engine B ii. Efficiencies of engine A and B	CO1	PO1	**10**
		UNIT - II			
3	a)	Prove that all gases when compared at the same reduced temperature and the reduced pressure, have approximately the	CO1	PO1	**06**

			same compressibility factor and all deviate from the ideal behavior to the same extent.			
		b)	Explain PVT behavior of pure fluids with PV diagram.	*CO1*	*PO1*	**06**
		c)	Calculate the pressure developed by 1 mol of gaseous ammonia contained in a vessel of $0.6x10^{-3}$ m^3 capacity at a constant temperature of 473 K by the following methods: 1) using ideal gas equation 2) using Vander Waals equation given that a=0.4233 Nm^4/mol^2 b=3.73 x 10^{-5} m^3/mol 3) using Redlich Kwong equation given that P_c=112.8 bar T_c=405.5 K.	*CO1*	*PO1*	**08**
			UNIT - III			
	4	a)	Derive Maxwells equation using fundamental property relations.	*CO1*	*PO1*	**10**
		b)	Prove that $dS = \frac{C_V}{T} dT - \frac{(\partial V/\partial T)_P}{(\partial V/\partial P)_T} dV$	*CO1*	*PO1*	**10**
			OR			
	5	a)	How are the partial molar volumes of the constituents of a binary mixture related to their mole fractions of the constituents and molar volume of the solution? Explain how these equations are useful for the determination of partial molar volumes by tangent intercept method.	*CO1*	*PO1*	**06**
		b)	Deduce the equation for the effect of temperature and pressure on chemical potential.	*CO1*	*PO1*	**08**
		c)	A 30% by mole methanol-water solution is to be prepared. How many cubic metres of pure methanol (molar volume, 40.727 x 10^{-6} m^3/mol) and pure water (molar volume, 18.068 x 10^{-6} m^3/mol) are to be mixed to prepare 2 m^3 of the desired solution? The partial molar volumes of methanol and water in a 30 percent solution are 38.632 x 10^{-6} m^3/mol and 17.765 x 10^{-6} m^3/mol, respectively.	*CO1*	*PO1*	**06**
			UNIT - IV			
	6	a)	What do you mean by positive and negative deviation from ideality? "A solution formed exhibiting positive deviation from ideality is accompanied by absorption of heat and a solution formed exhibiting negative deviation from ideal behavior is accompanied by an evolution of heat". Explain.	*CO2*	*PO 2*	**08**
		b)	n-heptane and toluene form ideal solution. At 373 K, their vapor pressures are 106 and 74 kPa respectively. Determine the composition of the liquid and vapor in equilibrium at 373 K and 101.3 kPa.	*CO2*	*PO2*	**04**

		c)	Show that the following equations provide the criteria of equilibrium under certain constraints. $dU_{S,V} = 0$, $dS_{H,P} = 0$, and $dH_{S,P} = 0$	*CO2*	*PO2*	**08**
			UNIT - V			
	7	a)	Derive the equation representing the effect of temperature on equilibrium constant.	*CO2*	*PO 2*	**08**
		b)	The standard Gibbs energy change for the reaction $C_2H_4 + H_2O \rightarrow C_2H_5OH$ at 25ºC is -9500 J/mol. The heat of reaction at 25ºC is -50000 J/mol. Estimate the equilibrium constant for the reaction at 400ºC.	*CO 2*	*PO 2*	**06**
		c)	Explain oxygen consumption rate and heat evolution in aerobic cultures.	*CO1*	*PO1*	**06**

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