U.S.N.										

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

Autonomous Institute Affiliated to VTU

February 2025 Semester End Main Examinations

Programme: B.E. **Semester:IV**
Branch: Biotechnology **Duration: 3 hrs.**
Course Code: 23BT4ESPET / 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)		Enumerate extensive and intensive properties? State whether the following properties are intensive or extensive: (a) volume, (b) density, (c) specific volume, (d) heat capacity,	CO 1	PO 1	**06**
	b)		Prove that $dH = Cp\,dT$.	CO1	PO1	**04**
	c)		Derive the equation for first law thermodynamics for an open system.	CO 1	PO2	**10**
			OR			
2	a)		Arrive at an equation for Carnot efficiency of reversible heat engine. Write the propositions of Carnot principle.	CO 1	PO2	**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 reject 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	CO 1	PO2	**10**
			UNIT - II			
3	a)		Prove that all gases when compared at the same reduced temperature and the reduced pressure, have approximately the same compressibility factor and all deviate from the ideal behavior to the same extent.	CO2	PO 2	**06**
	b)		With PV diagram, explain in detail about the PVT behavior of pure fluids.	CO2	PO2	**08**
	c)		Calculate the pressure developed by 1 mol of gaseous ammonia contained in a vessel of 0.6 x 10^{-3} m^3 capacity at a constant temperature of 473 K by the following methods: i. Using ideal gas equation	CO2	PO2	**06**

			ii. Using Vander Waals equation g iven that a=0.4233Nm^4/mol^2 b=3.73 x 10^{-5}m^3/mol			
			OR			
	4	a)	Prove that PV^{γ} = constant for adiabatic process	*CO2*	*PO 2*	**10**
		b)	Explain vander Waals equation of state in detail. Differentiate between ideal gas and real gas.	*CO2*	*PO 2*	**10**
			UNIT - III			
	5	a)	Using fundamental property relations, arrive at Maxwells equations.	*CO 1*	*PO 1*	**10**
		b)	Prove that $$dS = \frac{C_V}{T}dT - \frac{(\partial V/\partial T)_P}{(\partial V/\partial P)_T}dV$$	*CO 1*	*PO 1*	**10**
			OR			
	6	a)	Derive the equation representing the effect of temperature and pressure on chemical potential.	*CO2*	*PO2*	**10**
		b)	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.	*CO2*	*PO2*	**10**
			UNIT - IV			
	7	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". Justify.	*CO3*	*PO2*	**10**
		b)	Show that the following equations provide the criteria of equilibrium under certain constraints. $dU_{S,V} = 0$, $dS_{H,P} = 0$, and $dH_{S,P} = 0$	*CO3*	*PO2*	**10**
			OR			
	8	a)	Show that for equilibrium between phases of pure substance, the fugacities in both phases should be equal.	*CO1*	*PO 1*	**10**
		b)	The azeotrope of the ethanol-benzene system has composition of 44.8 % (mol) ethanol with boiling point of 341.4K and 101.3 kPa. At this temperature the vapor pressure of benzene is 68.9 kPa and the vapor pressure of ethanol is 67.4 kPa. Calculate the activity coefficients in a solution containing 10% alcohol.	*CO3*	*PO 2*	**10**
			UNIT - V			
	9	a)	Derive the equation representing the effect of temperature on equilibrium constant.	*CO3*	*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.	*CO3*	*PO2*	**08**
		c)	Explain the heat evolution in aerobic processes.	*CO4*	*PO2*	**04**
			OR			
	10	a)	Illustrate criteria for chemical reaction equilibrium with neat graph.	*CO1*	*PO 1*	**06**
		b)	Calculate the equilibrium constant at 298K of the reaction $N_2O_4(g) \rightarrow NO_2(g)$ Given that the standard free energies of formation at 298K are 97540 J/mol for N_2O_4 and 51310 J/mol for NO_2.	*CO4*	*PO 2*	**06**
		c)	Explain oxygen consumption and heat evolution in aerobic cultures.	*CO3*	*PO 1*	**08**

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