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

IV SEMESTER B.TECH (BIOTECHNOLOGY)

END-SEMESTER EXAMINATION, 03/05/2024 (2:30-5:30PM)

SUBJECT: CHEMICAL AND BIOCHEMICAL ENGINEERING THERMODYNAMICS

(BIO 2221)

REVISED CREDIT SYSTEM

ANSWER ALL QUESTIONS

TIME: 3 HOURS **MAX. MARKS: 50**

Q. NO		MARKS	CO	BTL
1A	Identify extensive and intensive properties • Chemical potential • pressure • Gibb's energy • Molar enthalpy	**2**	1	4
1B	An ideal gas initially at 600 K and 10 bar undergoes a four-step mechanically reversible cycle in a closed system. In step 12, pressure decreases isothermally to 3 bar; in step 23, pressure decreases at constant volume to 2 bar; in step 34, volume decreases at constant pressure; and in step 41, the gas returns adiabatically to its initial state. Take $C_P = (7/2)R$ and $C_V = (5/2)R$. • Sketch the cycle on a PV diagram • Determine (where unknown) both T and P for states 1, 2, 3 and 4 • Calculate Q, W, ΔU and ΔH for each step of the cycle.	**5**	1	3
1C	Water at 93.5^o C with density 958 kg/m^3 is pumped from a storage tank at the rate of 3.15 x 10^{-3} m^3/s. The motor for the pump supplies work at the rate of 1.5 KW. The water goes through a heat exchanger, giving up heat at the rate of 700 KW and is delivered to a second storage tank at an elevation 15 m above the first tank. What is the temperature of the water delivered to the second tank?	**3**	1	3
2A	• Prove that change in entropy from one state to another state is always positive or equal to zero. • Why Gibb's free energy calculation is very important in Biological thermodynamics and how it is derived?	**4**	2	4
2B	Find the change in entropy if 500 g of water at 80^0 C is added to 500 g of water at 20^0 C and assume no heat is lost from the system. Specific heat of water is 4.18 J/kg.K	**2**	2	3
2C	MIT students went to see Shimla during December holidays, the Temperature was very cold outside (4^O C), but they were in a hotel which maintains the temperature of 24^O C all the time. They bought 10-liter container of drinking water from a local grocery shop, which was kept overnight outside without heater. Students brought the container inside and they realized it is cold to drink and they kept it in hotel room to	**4**	2	3

	reach it to room temperature. Calculate the entropy change of water in the container, the entropy changes of the surrounding and the entropy change of the universe. Neglect the heat capacity of container and take heat capacity of water as 4.18 J/g.K			
3A	For the system ethyl ethanoate (1)/n-heptane (2) at 343.15 K. $\ln \nu_1 = 0.95\ X_2^2$ $\ln \nu_2 = 0.95\ X_1^2$ $P_1^{sat} = 79.80$ KPa $P_2^{sat} = 40.50$ KPa Assume non ideality in the liquid phase. Make a bubble point calculation for T = 343.15 K and $X_1 = 0.05$.	**2**	3	3
3B	Draw phase diagram for single component system and represent different phases. Derive from the fundamental equation how this diagram is mathematically proved. How Claperyon equation is modified to Clausious-Claperyon equation? Justify with the diagram. How phase diagram of water is different from other single component phase diagram of any solvent, due to which life exist on earth. Explain	**4**	3	3
3C	A Company was started in Manipal to produce carbonated drink called Biopop. Assuming that carbonated drink contains only CO_2 and water, determine the compositions of the vapor and liquid phases in sealed can of Biopop and the pressure exerted on the can at room temperature (25^{o}C) and at the refrigerated temperature (4^{o}C). The Henry's constant for CO_2 in water at 25^{o}C is 1250 bar and at 4^{o}C is 920 bar. One of the main criteria for carbonated drink is the pH; it should be 2.5. To get the pH 2.5, the mole fraction of CO_2 in liquid phase should be around 0.02. vapor pressure of water at 25^0 C and 4^0 C are 0.03166 and 0.00813 bar respectively	**4**	3	3
4A	A vessel divided into two parts by a partition, contains 4 mol of nitrogen gas at 75^0C and 40 bar on one side and 2.5 mol of argon gas at 130^0C and 20 bar on the other. If the partition is removed and the gases mix adiabatically and completely, what is the change in entropy? Assume nitrogen to be an ideal gas with $C_V = (5/2)$ R and argon to be an ideal gas with $C_V = (3/2)$ R. Molecular weight of Nitrogen = 28 and atomic weight of argon = 40.	**4**	4	3
4B	A system formed initially of 3 mol of CO_2, 6 mol H_2, and 2 mol CO undergoes the reactions: $CO_2\,(g) + 3H_2\,(g) \rightarrow CH_3OH\,(g) + H_2O\,(g)$ $CO_2\,(g) + H_2\,(g) \rightarrow CO\,(g) + H_2O\,(g)$ Develop expressions for the mole fractions of the reacting species and products as functions of the reacting coordinates for the two reactions.	**2**	4	3
4C	Consider the production of ammonia from the catalytic reaction of a stoichiometric feed of nitrogen and hydrogen. The reaction temperature is 500°C and the reactor pressure is 1 bar. $N_2 + 3H_2 = 2NH_3$ what is the possible conversion of the reaction? Assume the reaction happens at ideal gas condition	**4**	4	3

	If the conversion you got is very low, how do you proceed? which variable is suitable to change? And Why? b) increase the pressure to 300 bar and calculate the conversion of the reaction. Data: ΔG^0 = -32.9 KJ/mol at 25^{o}C and ΔH = -92.22 KJ/mol at all temperature.			
5A	20 gms of sodium chloride salt of molecular weight 58.44 gm/mol is added to 1 kg of water. What is the elevation of boiling point of water due to addition of salt? Derive the expression required for substitution. Heat of vaporization of water is 2250 KJ/kg	**4**	4	3
5B	15 gm of unknown protein is dissolved in 1000 gms of water. The vapor pressure of solution at 30^0 C is 0.03166 bar, the vapor pressure of pure water at 30^0 C is 0.04241 bar. The density of the solution is 998 kg/m^3. Calculate the molecular weight of the dissolved protein, the osmatic pressure exerted by the solution and the height it will show in osmometric scale.	**4**	5	3
5C	How living cells uses two tricks and modifies energetically unfavorable reaction to a favorable reaction in any biochemical pathways? Explain	**2**	5	4
CO: Course Outcome; BLOOM TAXONOMY LEVEL: 1-Remember, 2-Understand, 3-Apply, 4-Analyze, 5-Evaluate, 6-Create				