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

IV SEMESTER B.TECH. (BIOTECHNOLOGY)
END SEMESTER EXAMINATIONS, APRIL 2019
SUBJECT: CHEMICAL AND BIOCHEMICAL ENGINEERING THERMODYNAMICS [BIO 2001]

Time: 3 Hours MAX. MARKS: 50

1A.	A horizontal piston/cylinder arrangement is placed in a constant-temperature bath. The piston slides in the cylinder with negligible friction and an external force holds it in place against an initial gas pressure of 14 bar. The initial gas volume is 0.03 m^3. The external force on the piston is reduced gradually and the gas expands isothermally as its volume doubles. If the volume of the gas is related to its pressure so that the product PV is constant, what is the work done by the gas in moving the external force? How much work would be done if the external force were suddenly reduced to half its initial value instead of being gradually reduced?	**4**
1B.	An ideal gas, initially at 30°C and 100 kPa, undergoes the following cyclic Processes in a closed system: *(a)* In mechanically reversible processes, it is first compressed adiabatically to *500* kPa, then cooled at a constant pressure of *500* kPa to *303.15* K *(30°C),* and finally expanded isothermally to its original state. *(b)* The cycle traverses exactly the same changes of state, but each step is irreversible with an efficiency of *80%* compared with the corresponding mechanically reversible process. Calculate Q, W, ΔU, and ΔH for each step of the process and for the cycle. Take C_P = (7/2) R and C_V = (5/2) R.	**6**
2A.	A particular power plant operates with a heat source reservoir at 623.15 K and the heat sink reservoir at 303.15 K. It has a thermal efficiency equal to 55% of the Carnot engine thermal efficiency for the same temperatures. (a) What is the thermal efficiency of the plant? (b) To what temperature must the heat source reservoir be raised to increase the thermal efficiency of the plant to 35%? Again efficiency is 55% of the Carnot engine value.	**3**
2B.	Water at 93.5° 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?	**4**
2C.	2 kg of liquid water at 0^0 C is heated to 30^0 C by contact with a heat reservoir at 30^0 C and then to 90^0 C by contact with a reservoir at 90^0 C. what is total change in entropy (water and reservoir)?	**3**
3A.	A process stream contains light species 1 and heavy species 2. A relatively pure liquid stream containing mostly 2 is desired, obtained by a single-stage liquid/vapor separation. Specifications on the equilibrium composition are: x_1= 0.003 and y_1= 0.940. Use data given below to determine T(K) and P(bar) for the separator. Assume that modified Raoult's law $Y_iP= X_i\nu_iP_i^{sat}$ applies; the calculated P should validate this assumption.	**4**

	Data: For the liquid phase, $\ln\nu_1 = 0.93X_2^2$ $\ln\nu_2 = 0.93X_1^2$ $\ln P_i^{sat} = A_i - B_i/T$ $A_1 = 10.08$, $B_1 = 2{,}572.0$, $A_2 = 11.63$, $B_2 = 6{,}254.0$	
3B.	The sublimation pressure of solid CO_2 is 133 Pa at -134.3^0 C and at 2660 Pa at -114.4^0 C. Calculate the enthalpy of sublimation	**2**
3C.	A stream of nitrogen flowing at the rate of 4 kg/s and a stream of oxygen flowing at the rate of 1.5 kg/s mix adiabatically in a steady-flow process. If the gases are assumed ideal, what is the rate of entropy increase as a result of the process? Molecular weight of nitrogen and oxygen are 28 and 32 respectively	**4**
4A.	A system initially containing 2 mol C_2H_4 and 3 mol O_2 undergoes the reactions: $C_2H_4(g) + ½\ O_2(g) \rightarrow ((CH_2)_2)O\ (g)$ $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O\ (g)$ Develop expressions for the mole fractions of the each species in the reaction as the functions of the reaction coordinates of the two reactions.	**4**
4B.	Butadiene is prepared by the gas phase catalytic dehydrogenation of 1-butene, at 900 K and 1 bar. $C_4H_8(`g) \rightarrow C_4H_6(g) + H_2(g)$ a. In order to suppress side reactions, the butene is diluted with steam before it passes into the reactor. Estimate the conversion of 1-butene for a feed consisting of 10 moles of steam per mole of 1-butene. b. Find the conversion if the inert were absent and side reactions are ignored c. Find the total pressure that would be required to obtain the same conversion as in case a. if no inert were present. ΔG^o at 900 K = 10.62 KJ/mole	**6** `
5A.	Compute the equilibrium mole fraction of each of the species in the gas – phase reaction $CO_2 + H_2 \rightarrow CO + H_2O$ At 1000 K and (a) 1 bar total pressure and (b) 500 bar total pressure. The equilibrium constant for this reaction is 0.693 at 1000 K and 1 bar. Initially there are equal amounts of carbon dioxide and hydrogen present. Assume gases behaves ideally.	**2**
5B.	A protein is soluble in water. At 25^0 C it is found that if a solution with 2 g of protein per liter of solvent is placed in an osmometer, the height h to which the water rises is 0.85 cm. Use the information to estimate the molecular weight of the protein. The density of water is 0.98 g/cm^3	**4**
5C	How living cells uses two tricks and modifies energetically unfavorable reaction to a favorable reaction in any biochemical pathways? Explain In Glycolysis, the enzyme Phosphofructokinase I catalyzes the reaction Fructose 6-phosphate + ATP → fructose 1,6-bisphosphate + ADP Given the data below, calculate the equilibrium constant for this reaction. Data: ATP → ADP + P_i $\Delta G'^o = -30.5$ KJ/mol Fructose 1, 6-bisphosphate → fructose 6-phosphate + P_i $\Delta G'^o = -16.0$ KJ/mol	**2** **+** **2**