Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL

IV SEMESTER B.TECH (BIOTECHNOLOGY)
END SEMESTER EXAMINATIONS, APRIL/MAY 2017

SUBJECT: **CHEMICAL AND BIOCHEMICAL ENGINEERING THERMODYNAMICS**

[BIO 2201]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A	An ideal gas initially at 600K 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 a 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. (a) Sketch the cycle on a PV diagram. (b) Determine (where unknown) both T and P for states 1, 2, 3, and 4. (c) Calculate Q, W, ΔU and ΔH for each step of the cycle	8
1B	Identify extensive and intensive properties (a) chemical potential (c) entropy (b) Gibb's energy (d) pressure	2
2A	Why Carnot Engine is the most efficient engine anyone can construct. Illustrate with proper example	3
2B	Why Gibb's free energy calculation is very important in Biological thermodynamics and how it is derived using first and second law of thermodynamics?	3
2C	A 50 kg steel casting ($C_P = 0.5$ KJ/Kg. K) at a temperature of 400°C is quenched in 200 kg of oil ($C_P = 2.5$ KJ/Kg.K) at 25°C. If there are no heat losses, what is the change in entropy of (a) the casting (b) the oil and (c) both considered together?	4
3A	A vessel divided into two parts by a partition, contains 8mol of nitrogen gas at 65^{0}C and 40 bar on one side and 4mol of argon gas at 140^{0}C 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.	6

3B	A liquid mixture of cyclohexane (1)/phenol(2) for which $X_1 = 0.6$ is in its equilibrium with its vapor at 144^{0}C. Determine the equilibrium pressure P and vapor composition Y_1fom the following information: $\ln \nu_1 = -2.0998\ X_2^2$ $\ln \nu_2 = -2.0998\ X_1^2$ At 144^{0}C, $P_1^{sat} = 75.20$ KPa $P_2^{sat} = 31.66$ KPa Assume non ideality in the liquid phase.	2
3C	How fugacity concept is created? How chemical potential is related to it?	2
4A	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
4B	A system initially containing 2 mol C_2H_4 and 3 mol O_2 undergoes the reactions: $C_2H_4(g) + \frac{1}{2}\ O_2(g) \rightarrow ((CH_2)_2)O(g)$ $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O\ (g)$ 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
5A.	How living cells uses two tricks and modifies energetically unfavorable reaction to a favorable reaction in any biochemical pathways? Explain	2
5B.	A protein BSA is soluble in water. At 25^0 C it is found that if a solution with 10 g of protein per liter of solvent is placed in an osmometer, the height h to which the water rises is 11.6 cm. Use the information to estimate the molecular weight of the protein, assuming the solution is ideal. The density of water is 0.98 g/cm^3.	4
5C.	Nitrogen and Hydrogen react to form ammonia in the presence of a catalyst $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ The reactor in which the reaction is to be run is maintained at 450 K and has a sufficiently long residence time that the equilibrium is achieved at the reactor exit a. What will be the mole fraction of nitrogen, hydrogen and ammonia exiting the reactor if stoichiometric amount of nitrogen and hydrogen enter the reactor, which is kept at 4 bar? b. What will be the exit mole fractions if the reactor operates at 4 bar and the feed consists of equal amounts of nitrogen, hydrogen and an inert diluent? ΔH^o_{NH3} at 298 K = -46100 J/mol, ΔG^o_{NH3} at 298 K = -16500 J/mol. Assume for the reaction, change in enthalpy due to change in temperature is negligible.	4

----- ALL THE BEST -----