Reg. No.										

IV sem End Sem. QP (April 2018) BRG

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

IV SEMESTER B.TECH. (BIOTECHNOLOGY)
END SEMESTER EXAMINATIONS, APRIL 2018
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 suitable assumed.

1A. 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 $C_V = (5/2)\ R$. **2+3+**

- Sketch the cycle on a PV diagram **2**
- 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.

1B. Derive the expression for Joule-Thompson coefficient μ_{JT} and deduce μ_{JT} for ideal gas **3**

2A. One mole of an ideal gas initially at $P_1 = 4$ atm, T, and V_1 expands to $P_2 = 2$ atm, T, and $2V_1$. Consider two different paths: (a) the expansion occurs irreversibly into a vaccum, and (b) the expansion is reversible. Calculate Q_{irrev}, ΔS (system) and ΔS (surroundings) for (a) and ΔS (system) and ΔS (surroundings) for (b). **4**

2B. 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 reach it to room temperature. Calculate the entropy change of water in the container, the entropy change of the surroundings 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 **4**

2C. Show that entropy is a state function using Carnot's cycle **2**

3A. 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**

3B. 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°C) and at the refrigerated temperature (4°C). The Henry's constant for CO_2 in water at 25°C is 1250 bar and at 4°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**

3C. Define & derive chemical potential of species i in n number of species (in a system) in terms of change in internal energy **2**

4A. 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 oxygen and Nitrogen are 32 and 28 gm/mol respectively. **4**

4B. Consider the reaction for the production of methanol from CO and H_2

$$CO\ (g) + 2H_2\ (g) = CH_3OH\ (g)$$

The value of K at 500 K is 6.23×10^{-3}.

- A gas stream containing equimolar amounts of CO and H_2 is passed over a catalyst at 1 bar. What is the extent of reaction at equilibrium?
- To obtain a more complete reaction the pressure is raised to 100 bar and 2 mol of hydrogen is used per mole of CO. What is the equilibrium extent of reaction?
- If the reactant gases contain a mole of nitrogen in addition to 1 mol of CO and 2 mol of hydrogen, what is the equilibrium extent of reaction at 100 bar?

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5A. A system initially containing 2 mol C_2H_4 and 3 mol of O_2 undergoes the reactions

$$C_2H_4(g) + 1/2O_2 \rightarrow \{(CH_2)_2\}O\ (g)$$

$$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2\ (g) + 2H_2O\ (g)$$

Develop expressions for the mole fractions of the each species as functions of the reaction coordinates for the two reactions **4**

5B. Assuming as ideal solution, derive expression for osmotic pressure in semipermeable membrane. To determine the molecular weight of protein dissolved in pure water, a sample was made as solution containing 0.1 g/L. This solution exhibited an osmotic pressure of 0.0171 atm against pure water at 25^0 C. What is the molecular weight of protein? Using this result, calculate the vapor pressure lowering of water above the solution. The vapor pressure of pure water at 25^0 C is 0.0313 atm. **2+2**

5C How living cells uses two tricks and modifies energetically unfavorable reaction to a favorable reaction in any biochemical pathways? Explain **2**