4th sem End sem Q.P (2016) BRG

Reg. No. | | | | | | | | | | |

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

INSPIRED BY LIFE

IV SEMESTER B.TECH (BIOTECHNOLOGY)

END SEMESTER EXAMINATIONS, May 2016

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	One mole of an ideal gas, initially at *303.15* K *(30°C)* and *1* bar, is changed to *403.15*K *(130°C)* and *10* bar by three different mechanically reversible processes: • The gas is first heated at constant volume until its temperature is 403.15 K ; then it is compressed isothermally until its pressure is 10 bar. • The gas is first heated at constant pressure until its temperature is 403.15 K (130°C); then it is compressed isothermally to *10* bar. • The gas is first compressed isothermally to *10* bar; then it is heated at constant pressure to *403.15* K *(130°C)*. Calculate Q, W, ΔU, and ΔH in each case. Take $C_p = (7/2)$ R and $C_v = (5/2)$ R.	6
1B	Identify extensive and intensive properties (a) chemical potential (c) molar enthalpy (b) Helmholtz free energy (d) pressure	2
1C	An incompressible (p = constant) liquid flows steadily through a conduit of circular Cross-section and increasing diameter. At location 1, the diameter is 2.5 cm and the velocity is 2 m/ s; at location 2, the diameter is 5 cm. *(a)* What is the velocity at location 2? (b) What is the kinetic-energy change (J/ kg) of the fluid between locations 1 and 2?	2
2A	Using Carnot engine cycle, prove that entropy is a state function	4
2B	Why Gibb's free energy calculation is very important in Biological thermodynamics and how it is derived?	2
2C	With respect to 1 kg of liquid water: a) Initially at 0^0C, it is heated to 100^0C by contact with a heat reservoir at 100^0C. What is the entropy change of the water? Of the heat reservoir? What is ΔS_{total}? b) Initially at 0^0C, it is first heated to 50^0C by contact with a heat reservoir at 50^0C and then to 100^0C by contact with a reservoir at 100^0C. What is ΔS_{total}?	4

	c) Explain how the water might be heated from 0^0C to 100^0C so that $\Delta S_{total} = 0$.	
3A	The sublimation pressure of solid CO_2 is 133 Pa at -134.3°C and at 2660 Pa at -114.4°C Calculate the enthalpy of sublimation	2
3B	Nitrogen and argon are inert gases used in particular industry. Nitrogen was used regularly (cheap compared to argon) but the stock of nitrogen was not sufficient to use it fully so they decided to mix it with argon for usage. Since entropy and Gibb's free energy are the properties they are worried about, they wanted to see the change in entropy and Gibb's free energy when they mix 2 kg/s of nitrogen with 0.5 kg/s of argon adiabatically at steady flow condition and at considerable low pressure. What is the value they have come up with? Molecular weight of Nitrogen and Argon are 28 and 40 gm/mole respectively.	4
3C	With proper explanation and equations explain Chemical potential of species i in a mixture of ideal gases. Express chemical potential of species i in an ideal solution mixture using Lewis/Randall rule. If the solution is real, how to express chemical potential of species i in a mixture?	4
4A	The following reaction is carried out at 1 atmosphere $SO_2 (g) + 1/2O_2 (g) \rightarrow SO_3 (g)$ The reaction is carried out at a temperature of 855 K, using 20% excess air. Calculate K. At 25°C $\Delta H° = -98,890$ J/mol and $\Delta G° = -70,866$ J/mol Calculate equilibrium composition. Assume ideal gas and the process is at constant ΔH.	6
4B	A system formed initially of 2 mol of CO_2, 5 mol H_2, and 1 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
4C.	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
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 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.	10 gms of BSA (protein) of molecular weight 30000 Da is added to 1 kg of water. What is the elevation of boiling point of water due to addition of BSA? Derive the expression required for substitution.	4

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