Reg. No.										

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

V SEMESTER B.TECH (BIOTECHNOLOGY)

END SEMESTER EXAMINATIONS, NOV/DEC 2015

SUBJECT: CHEMICAL AND BIOCHEMICAL ENGINEERING THERMODYNAMICS [BIO 301]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ANY FIVE FULL** the questions.
- Missing data may be suitable assumed.

1A.	Air at 1 bar and 298.15 K is compressed to 5 bar and 298.15K by a mechanically reversible process: heating at constant volume followed by cooling at constant pressure. Calculate the heat and work requirements and ΔU and ΔH of air. The following heat capacities for air may be assumed independent of temperature. C_V = 20.78 J/mol K and Cp = 29.10 J/mol K. Also assume PV/T is a constant regardless of the changes it undergoes. At 298.15 K and 1 bar the molar volume of air is 0.02479 m^3/mol	**5**
1B.	Nitrogen gas is confined in a cylinder and the pressure of the gas is maintained by a weight placed on the piston. The mass of the piston and the weight together is 50 kg. The acceleration due to gravity is 9.81 m/s^2 and the atmospheric pressure is 1.01325 bar. Assume frictionless piston. Determine: (i) The force exerted by the atmosphere, the piston, and the weight on the gas if the piston is 100 mm in diameter. (ii) The pressure of the gas. (iii) If the gas is allowed to expand pushing up the piston and the weight by 400 mm, What is the work done by the gas in kJ. What is the change in the potential energy of the piston and the weight after the expansion in part (iii)?	**5**
2A.	Calculate the absolute entropy of water vapour at 473 K and 101.3 kPa above 273 K base temperature. Compare this with the value reported in the steam tables (S = 7.829 kJ/kg K). The average heat capacity of water is 4.2 kJ/kg K and that of water vapour between 373 K and 473 K is 1.9 kJ/kg K. The latent heat of vaporization at 373 K is 2257 kJ/kg.	**5**
2B.	The potential energy of a body of mass 10 kg is 1.5 kJ. What is the height of the body from the ground? If a body of 10 kg is moving at a velocity of 50 m/s, what is its kinetic energy?	**3**
2C.	A tank comprising a fluid is stirred by a paddle driven by 2 HP motor. Heat losses from the tank are 378 Kcal/hr. Does the internal energy of the system	**2**

	comprising of 10 kg of the fluid in the tank, increase or decrease? By how much?	
3A.	An ideal gas is undergoing a series of three operations: The gas is heated at constant volume from 300 K and 1 bar to a pressure of 2 bar. It is expanded in a reversible adiabatic process of 1 bar. It is cooled at constant pressure of 1 bar to 300 K. Determine the heat and work effects for each step. Assume CP = 29.3 kJ/kmol K.	**5**
3B.	A 800MW thermal power plant uses steam at 600K and discards heat to a river at 295K. Determine the heat discarded to the river if the thermal efficiency of the plant is 70% of the maximum possible value	**3**
3C.	Show that any device that violates the Kelvin–Planck statement also violates the Clausius statement.	**2**
4A.	For a homogeneous phase, derive Gibbs/Duhem equation	**5**
4B.	What is the change in entropy when 0.7 m^3 of CO_2 and 0.3 m^3 of N_2 each at 1 bar and 25°C blend to form a gas mixture at the same condition? Assume ideal gases.	**3**
4C.	What is activity and activity coefficient?	**2**
5A.	The gas phase oxidation of SO_2 to SO_3 is carried out at a pressure of 1 bar and temperature of 855 K with 20% excess air in an adiabatic reactor. Determine the equilibrium composition. Data: $SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$ $\quad \Delta H^o_{298} = -98890\ J$ $\quad \Delta G^o_{298} = -70866\ J$	**6**
5B.	n-Butane is isomerised to i-butane by the action of catalyst at moderate temperatures. It is found that the equilibrium is attained at the following compositions Temperature, K: 317 — Mol%, n-butane: 31.00 Temperature, K: 391 — Mol%, n-butane: 43.00 Assuming that activities are equal to the mole fractions, calculate standard free energy of the reaction at 317 K and 391 K and average value of heat of reaction over this temperature range.	**4**
6A.	Calculate standard heat of reaction and free energy change at 37°C for the following reaction, if the equilibrium constant is 5.3 fold higher than standard state equilibrium constant $ATP + H_2O \rightleftharpoons ADP + P_i + H^+$ $\quad (\Delta G° = -30.5\ kJ/mol)$	**5**
6B.	Discuss the thermodynamic equilibrium with chemical potential and free energy changes for an osmosis process.	**3**
6C.	Living things are highly ordered, low entropy, structures. Is the second law of thermodynamics violated in the living cells? Explain?	**2**