Reg. No.										

INTERNATIONAL CENTRE FOR APPLIED SCIENCES

(Manipal University)

IV SEMESTER B.S. DEGREE EXAMINATION – APRIL / MAY 2017

SUBJECT: THERMODYNAMICS FOR BIOPROCESSING (BT 241)

(BRANCH: IND. BIOTECH)

Saturday, 29 April 2017

Time: 3 Hours **Max. Marks: 100**

✓ **Answer ANY FIVE full Questions.**

1A. (i) Distinguish between intensive and extensive properties with suitable example.
(ii) What are state and path functions? Explain with examples.
(iii) What is heat engine and thermal efficiency of a heat engine?
(iv) What are the various steps involved in a Carnot cycle?

1B. An astronaut weighs 730 N in Houston, Texas, where the local acceleration of gravity is g= 9.792 ms^{-2}. What are the astronaut's mass and weight on the moon where g = 1.67 ms^{-2}.

(16+4)

2A. What is an adiabatic process? Write the expression for work done during reversible adiabatic process

2B. Water flows over a waterfall 100 m in height. Consider 1 kg of the water, and assume that no energy is exchanged between the 1 kg and its surroundings
(i) What is the potential energy of the water at the top of the falls with respect to the base of the falls?
(ii) What is the kinetic energy of the water just before it strikes bottom?
(iii) After the 1 kg of water enters the river below the falls, what change has occurred in its state?

2C. Prove that $C_P - C_V = R$ for an ideal gas **(2+12+6)**

3A. An ideal gas is undergoing a serious 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 to a pressure 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 C_P = 29.3 kJ/kmol K

3B. What are limitations of First law of thermodynamics? Enlist the statements of the second law of thermodynamics. **(12+8)**

4A. 140 kg of nitrogen at a pressure 4.052×10^5 Pa is stored in a cylinder of volume 30 m^3. It is desired to keep the gas temperature below 25°C. Does the cylinder need cooling if nitrogen behaves like an ideal gas

4B. Obtain expression to relate vander Waal's constant 'a' and 'b' in terms of critical properties.

4C. 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 **(6+8+6)**

5A. Determine the increase in entropy of solid magnesium when the temperature is increased from 300 K to 800 K. The heat capacity is given by the following relation

$$C_P = 26.04 + 5.586 \times 10^{-3} T, \frac{J}{mol\ K}$$

5B. The coefficient of compressibility and coefficient of volume expansion of mercury at 273 K and 1 bar are 3.9×10^{-6} bar^{-1} and 1.8×10^{-4} K^{-1} respectively. Calculate C_V for mercury. (C_P = 0.14 kJ/kg K; $\rho = 13.596 \times 10^3$ kg/m^3)

5C. State the importance of Maxwell's relations and derive the Maxwell's equations from fundamental property relations for homogeneous phase. **(6+6+8)**

6A. Derive an expression for the fugacity co-efficient of a gas obeying the equation of state, P(V- b) = RT. Estimate the fugacity of ammonia at 10 bar and 298 K, given that b=3.707×10^{-5} $m^3/gmol$

6B. Derive the Gibbs-Duhem equation from fundamentals. **(10+10)**

7A. Acetic acid is esterified in the liquid phase with ethanol at 100°C and atmospheric pressure to produce ethyl acetate and water according to the reaction:

$$CH_3COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O$$

$$\Delta H^o_{298} = -3640\ J; \Delta G^o_{298} = -4650\ J$$

If initially there is 1 mol of each of acetic acid and ethanol, estimate the mole fraction of ethyl acetate in the reacting mixture at equilibrium.

7B. The standard heat of formation and standard free energy of formation of ammonia at 298 K are - 46,100 J/mol and - 16,500 J/mol respectively. Calculate the equilibrium constant for the reaction At 500 K. Assuming that the standard heat of reaction is constant in the temperature range 298 K to 500 K. **(10+10)**

$$N_2 + 3\ H_2 \rightarrow 2NH_3$$

8A. Explain the osmosis process. Discuss the thermodynamic equilibrium with chemical potential and free energy changes

8B. Calculate K_{eq} for the hydrolysis of the following compounds at neutral pH and 298 K

(i) Phosphoenolpyruvate ($\Delta G° = -61.9$ kJ/mol)

(ii) Pyrophosphate ($\Delta G° = -33.5$ kJ/mol)

(iii) Glucose-1-phosphate ($\Delta G° = -20.9$ kJ/mol)

8C. Calculate free energy change at 37°C for the following reaction

$$ATP + H_2O \rightleftharpoons ADP + P_i + H^+ \qquad (\Delta G° = -30.5\ kJ/mol)$$

(10+6+4)