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18BT45

## Fourth Semester B.E. Degree Examination, Dec.2023/Jan.2024

### Biochemical Thermodynamics

Time: 3 hrs.

Max. Marks: 100

**Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.  
2. Missing data can be assumed suitably.**

#### Module-1

- 1 a. Distinguish between reversible and irreversible, process. What are the salient characteristics of reversible process? Are all the real processes reversible? (08 Marks)
- b. Nitrogen gas is confined in a cylinder and the pressure of the gas is maintained by a weight placed on the piston mass of (piston + weight) is 50kg. Assume frictionless piston. Determine:
  - i) Force exerted by the atmosphere, the (piston + weight) in the gas if piston is 100mm diameter.
  - ii) Pressure of gas.
  - iii) If gas is allowed to expand on pulling up the (piston + weight) assembly by 400mm, what is the work done by the gas in KJ?
  - iv) What is the change in the potential energy of the (piston + weight) after the (piston + weight) assembly is subjected to expansion as defined in (iii). (12 Marks)

**OR**

- 2 a. Derive the mathematical relation for flow process based on first law of thermodynamics. (12 Marks)
- b. Show the equivalence of Kelvin-Planck and Clausius statements of second law of thermodynamics. (08 Marks)

#### Module-2

- 3 a. Explain the general behavior of pure fluids using P-V and P-T diagram. (08 Marks)
- b. For the constant temperature show that  $Q = RT \ln (v_2/v_1)$ . (06 Marks)
- c. Calculate the compressibility factor and molar volume of methanol vapour at 500K and 10 bar using i) Virial equation ii) Redlich kwong equation of state. Constants a and b of Redlich are as follows:  $a = 21.7181 \text{ Nm}^4 \text{ K}^{0.5} / \text{mol}^2$   $b = 4.5617 \times 10^{-5} \text{ m}^3 / \text{mol}$ .  
Also experimental values of virial co-efficients are  $B = -2.19 \times 10^{-4} \text{ m}^3 / \text{m}^3$   
 $C = -1.73 \times 10^{-8} \text{ m}^6 / \text{mol}^2$ . (06 Marks)

**OR**

- 4 a. Define with examples
  - i) Standard heat of reaction
  - ii) Standard heat of formation
  - iii) Standard heat of combustion
  - iv) Hess law of constant heat summation. (08 Marks)
- b. Calculate the change in internal energy, enthalpy, work done and heat supplied for the process in which an ideal gas is contained in a vessel of  $0.1 \text{ m}^3$  capacity, it is initially at 1 bar and 298K. It is heated at constant volume to 400K. Assume  $C_p = 30 \text{ J/mol. K}$ . (12 Marks)

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.  
2. Any revealing of identification, appeal to evaluator and /or equations written eg.  $42+8=50$ , will be treated as malpractice.

**Module-3**

- 5 a. Derive Maxwell's equations from thermodynamic. (12 Marks)  
 b. Explain the methods indicating the relationship among thermodynamic properties. (08 Marks)

**OR**

- 6 a. Derive Gibb's Helmholtz equation. (06 Marks)  
 b. Define fugacity and explain the effect of temperature and pressure on fugacity for pure substances. (08 Marks)  
 c. Differentiate between reference properties, energy properties and derived properties. (06 Marks)

**Module-4**

- 7 a. Derive Gibbs-Duhem equation and state its uses. (12 Marks)  
 b. 30% kg-mole methanol-water solution is to be prepared. How many cubic meters of pure methanol (molar volume is  $40.727 \times 10^{-6} \text{ m}^3/\text{mol}$ ) and pure water (molar volume is  $18.068 \times 10^{-6} \text{ m}^3/\text{mol}$ ) are to be mixed to prepare  $2 \text{ m}^3$  of the desired solution? The partial molar volume of methanol and water in a 30% solution are  $38.632 \times 10^{-6} \text{ m}^3/\text{mol}$  and  $17.765 \times 10^{-6} \text{ m}^3/\text{mol}$  respectively. (08 Marks)

**OR**

- 8 a. Explain the Tangent-Intercept method to determine the partial molar properties in a binary solution. (12 Marks)  
 b. Define chemical potential. Explain the effect of temperature and pressure on chemical potential. (08 Marks)

**Module-5**

- 9 a. Derive the Van't Hoff equation to relate temperature and equilibrium constant. (10 Marks)  
 b. Standard heat of formation and standard free energy of formation of ammonia at 298K are -46100J/mol and -16500J/mol respectively, calculate equilibrium constant (K) for the reaction:  $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightarrow 3\text{NH}_{3(g)}$  at 500K. Assume that standard heat of reaction is constant in the temperature range of 298K and 500K. (10 Marks)

**OR**

- 10 a. Discuss the effect of i) Pressure ii) Presence of inerts iii) Presence of excess reactants iv) Presence of products on equilibrium constant / equilibrium composition. (16 Marks)  
 b. Explain the  
 i) Phase rule for reacting systems  
 ii) Equilibrium for heterogeneous bioreaction. (04 Marks)

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