CBCS SCHEME

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18BT45

Fourth Semester B.E. Degree Examination, June/July 2023
Biochemical Thermodynamics

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

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-1

1 a. Calculate the total internal energy of the three given states 1, 2 and 3 which is given below in the Fig.Q1(a). Given $Q_{1231} = -2000$ J.

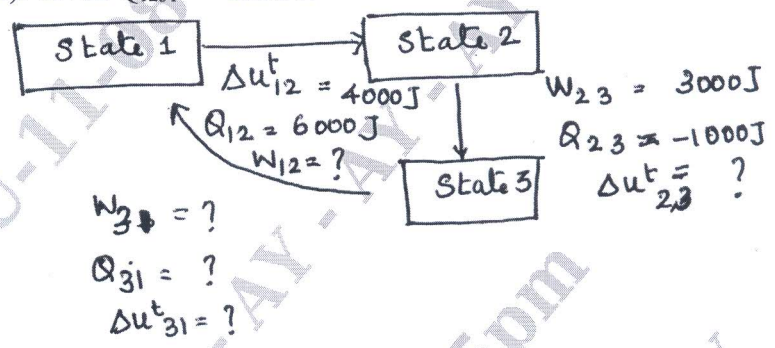

Fig.Q1(a) **(10 Marks)**

b. Explain about the process of Carnot cycle with mathematically as well as graphically. In addition to that, justify the disadvantage of Carnot cycle by the graphical representation (P-V diagram). **(10 Marks)**

OR

2 a. An insulated, electrically heated tank for hot water contains 190 kg of liquid water at 333.15 K (60°C) where power outage occurs. If water is withdrawn from a tank at a steady state rate of $\dot{m} = 0.2$ kg/s, how long will it take for the temperature of the water in the tank to drop from 333.15 to 308.15 K? Assume that cold water enters the tank at 283.15 K (10°C) and that heat losses from the tank are negligible. For liquid water let $C_V = C_p = C$, independent of T and P. **(10 Marks)**

b. 10 mol/s of air is compressed from 1 bar to 10 bar. The inlet temperature and 300 K and the temperature at the outlet of compressor is 450 K. The velocity at inlet and outlet of the compressor are 6 and 0.9 ms^{-1}. The compressor delivers power at 75 kW. Assume that the enthalpy does not depend on pressure and $C_p = 3.5$ R. Find the rate of heat transfer. **(10 Marks)**

Module-2

3 a. Explain graphically about characterized by:
(i) Superheated vapour compared to saturated vapour.
(ii) Super heated vapour compared to compressed liquid. **(10 Marks)**

b. An 80 L vessel contains 4 kg of refrigerant –134 a at a pressure of 160 kPa. Determine:
(i) Temperature (ii) Quality
(iii) The enthalpy of the refrigerant (iv) The volume occupied by the vapour phase.
Data: (i) At 160 kPa; $V_f = 0.0007437$ m^3/kg; $V_g = 0.12348$ m^3/kg
(ii) The temperature at saturation at 160 kPa = –15.60°C
(iii) At 160 kPa; $h_f = 31.21$ kJ/kg; $h_{fg} = 209.90$ kJ/kg. **(10 Marks)**

OR

4 a. The viral coefficients of isopropanol vapour at 473.15 K (200°C) are:
$B = -0.388\ m^3/Kmol$, $C = -26 \times 10^{-3}\ m^6/Kmol^2$
Calculate V and Z for isopropanol vapour at 473.15 K (200°C) and 10 bar by
(i) The ideal gas equation
(ii) $V = \frac{RT}{P} + B$
(iii) $V_{i+1} = \frac{RT}{P}\left(1 + \frac{B}{V_i} + \frac{C}{V_1^2}\right)$ **(10 Marks)**

b. Explain about the PVT behaviour of liquid and gases using cubic state of equation. **(10 Marks)**

Module-3

5 a. Explain about the importance of Maxwell equations relations to evaluate thermodynamic properties by using partial derivatives. **(10 Marks)**

b. The molar volume of an organic liquid at 300 K and 1 bar is 0.1 m^3/Kmol and its coefficient of expansion is 1.25×10^{-3}/K. What would be the change in entropy if the pressure is increased to 20 bar at 300 K? What assumption is involved in the solution? **(05 Marks)**

c. Calculate the vapour pressure of water at 363 K. If the vapour pressure at 373 K is 101.3 kPa. The mean heat of vapourization in this temperature range is 2275 kJ/kg. **(05 Marks)**

OR

6 a. Derive the differential equations of entropy as a function of S = f(P, T) and V = f(P, T). **(10 Marks)**

b. Show that C_p and C_v of ideal gas are independent of pressure and volume. **(10 Marks)**

Module-4

7 a. Explain about the various methods for determination of Partial Molar properties. **(08 Marks)**

b. The enthalpy at 300 K and 1 bar of binary liquid mixture is
$H = 400x_1 + 600x_2 + x_1x_2(40x_1 + 20x_2)$ where H is in J/mol
For the stated temperature and pressure, determine:
(i) Expression for $\overline{H}_1$ and $\overline{H}_2$ interms of x_1
(ii) Numerical values for the pure component enthalpies H_1 and H_2
(iii) Numerical values for the partial molar enthalpies at indefinite dilution $\overline{H}_1^{\infty}$ and $\overline{H}_2^{\infty}$. **(12 Marks)**

OR

8 a. The partial pressure of acetone (A) and chloroform (B) are measured at 298 K and reported below:

X_A	0	0.2	0.4	0.6	0.8	1.0
P_A, bar	0	0.049	0.134	0.243	0.355	0.457
P_B, bar	0.386	0.288	0.187	0.108	0.046	0

Calculate the activity and activity coefficient of chloroform in acetone at 298 K.
(i) Based on the standard state as per Levis-Randall rule.
(ii) Based on Henry law. **(10 Marks)**

b. Derive the expression for Gibbs-Duhem equation for a binary solution made up of components 1 and 2 whose mole fractions in the solution are x_1 and x_2. **(10 Marks)**

Module-5

9 a. A gas mixture containing 3 mole CO_2, 5 mole H_2 and 1 mole water is undergoing the following reactions.

$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$

$CO_2 + H_2 \rightarrow CO + H_2O$

Derive expressions for the mole fraction of the species in terms of extent of reaction. **(10 Marks)**

b. Write about the criteria of chemical reaction equilibrium condition. **(10 Marks)**

OR

10 a. What are various factors affecting equilibrium conversion in a chemical reaction? **(10 Marks)**

b. Ammonia synthesis reaction is represented by $N_2 + 3H_2 \rightarrow 2NH_3$ the reactant stream consist of 1 mol N_2, 3 mol H_2 and 2 mol organ. The temperature and pressure of the reaction are 675 K and 20 bar. The equilibrium constant for the reaction is 2×10^{-4}. Determine how the conversion of nitrogen is affected by the presence of organ. **(10 Marks)**

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