CBCS SCHEME

USN | | | | | | | | | | |

18BT45

Fourth Semester B.E. Degree Examination, Dec.2024/Jan.2025
Biochemical Thermodynamics

Time: 3 hrs. Max. Marks: 100

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

Module-1

1 a. Distinguish between
   i) Intensive and Extensive properties
   ii) Mechanical and Thermal equilibrium
   iii) Closed and Open system
   iv) System and surroundings **(10 Marks)**

b. Consider a closed system (piston and cylinder) with constant pressure process suffix 1 and 2 represents initial and final state respectively.
$P_1 = 2$ bar, $V_1 = 0.5\ m^3/Kg$, $V_2 = 0.75\ m^3/Kg$
$T_1 = 25°C$, $T_2 = 300°C$
$C_p = \left[0.5 + \frac{20}{T+30}\right]$ KJ/Kg.K where T is in °C.
Calculate:
i) Heat added ii) Work done iii) ΔU iv) ΔH. **(10 Marks)**

OR

2 a. A reversible heat engine takes heat at the rate of 500 kJ/sec from a heat source at 700 K. The work done by the cyclic device is 200 kJ/sec and rejects heat to two sinks at 400 K and 500 K. Calculate :
   i) The engine thermal efficiency
   ii) Amount of heat rejected to each sink **(10 Marks)**

b. Show the equivalence of both the statements of second law of thermodynamics. **(10 Marks)**

Module-2

3 a. Determine the pressure exerted by oxygen in a contain of 2 m^3 capacity when it contains 5 Kg at 27° C using
   i) Ideal gas equation
   ii) Vander Waals equation **(10 Marks)**

b. Write a note on a PVT behaviour of pure fluids and explain the physical significance triple point and critical point. **(10 Marks)**

OR

4 a. The equation of state of certain substance of given by the expression, $V = \frac{RT}{P} - \frac{C}{T^3}$, and the specific heat is given by the relation $C_P = A + BT$ where A, B and C are constants. Derive an expressions for changes in internal energy ΔU, enthalpy (ΔH) and entropy for
   i) An isothermal process
   ii) Isobaric process **(10 Marks)**

b. Using Hess's law calculate the heat of format of methane gas from the following data :

i) $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O$, $\Delta^{\circ}_{e\,(CH_4)} = -890.94\,kJ$

ii) $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$; $\Delta H^{\circ}_{f\,(CO_2)} = -393.78\,kJ$

iii) $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(\ell)}$; $\Delta H^{\circ}_{f\,(H_2O)} = -286.03$ kJ. **(10 Marks)**

Module-3

5 a. Derive Maxwell's equations starting from fundamental property relations. **(10 Marks)**

b. Using the relationship between C_p and C_V, show that $C_P - C_V = \frac{\beta^2 VT}{K}$. **(10 Marks)**

OR

6 a. Define fugacity and fugacity coefficient. Explain the effect of temperature and pressure on fugacity. **(10 Marks)**

b. Calculate the fugacity of liquid water at 303 K and 10 bar if the saturation pressure at 303 K is 4.241 KPa and specific volume of liquid water at 303 K is 1.004×10^{-3}/Kg. **(05 Marks)**

c. Define Activity. Explain the effect of temperature on activity. **(05 Marks)**

Module-4

7 a. Explain how partial motor properties can be measured by graphical method. **(10 Marks)**

b. Derive Gibb's – Duhem equation. **(10 Marks)**

OR

8 a. The activity coefficients for component 1 in a binary solution can be represented by $\ell n\,\gamma_1 = ax_2^2 + bx_2^3 + cx^4$, where a, b and c are concentration independent parameters. Derive an expression for $\ell n\,\gamma_2$. **(10 Marks)**

b. Explain Lewis – Randall rule and Henry's law. **(06 Marks)**

c. Explain the criteria for phase equilibria. **(04 Marks)**

Module-5

9 a. Write a note on coupled reactions. **(05 Marks)**

b. Discuss briefly about feasibility of chemical reaction. **(06 Marks)**

c. Calculate the equilibrium constant at 298K of the reaction $N_2O_{4(g)} \rightarrow 2NO_2$. Gives that the standard free energies of formation at 298 K are 97,540 J/K mol for N_2O_4 and 51,310 J/K mol for NO_2. **(09 Marks)**

OR

10 a. Derive Van't Hoff equation and show that $\ell n\,\frac{K_2}{K_1} = \frac{\Delta H^{\circ}}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$. **(10 Marks)**

b. With a short notes on the following :

i) Phase rule for reacting system

ii) Factors affecting equilibrium conversion **(10 Marks)**

* * * * *