CBCS SCHEME

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18BT45

Fourth Semester B.E. Degree Examination, June/July 2024
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. Define i) First Law of Thermodynamic ii) Second Law of Thermodynamics . **(04 Marks)**

b. Calculate ΔU and ΔH in kJ for 1 Kmol of water, as it is vapourised at a constant temperature of 373K and constant pressure of 101.3 kPa. The specific volumes of liquid and vapour at these conditions are 1.04×10^{-3} and $1.675 m^3/k$ mol respectively. 1030 kJ of heat is added to water for this change. **(06 Marks)**

c. Calculate the change in internal energy, change in enthalpy, work done and the heat supplied in the process.
i) An ideal gas is expanded from 5 bar to 4 bar Isothermally at 600 K.
ii) An ideal gas contained in a vessel of $0.1 m^3$ capacity is initially at 1 bar and 298K. It is heated at constant volume to 400K. Assume Cp = 30J/mol. K. **(10 Marks)**

OR

2 a. Explain the principle of Carnot cycle and derive the relationship to determine the efficiency of Carnot cycle. **(10 Marks)**

b. One kg of superheated steam at 1.5MPa and 523K (H = 2923.5 kJ/kg , S = 6.71 kJ/kg. K) is contained in a Piston – Cylinder assembly. The unit is kept at ambient conditions of 300K and the steam condenses to saturated liquid (H = 845 kJ/kg , S = 2.32kJ/kg. k) at constant pressure. Calculate the change in entropy and check whether the process in reversible (or) not. **(10 Marks)**

Module-2

3 a. Show that the work done in an adiabatic process involving ideal gas is given by

$$W = \frac{P_1 V_1}{\gamma - 1}\left[1 - \left(\frac{P_2}{P_1}\right)^{(\gamma-1)/\gamma}\right]$$ **(10 Marks)**

b. An ideal gas is undergoing a series of three operations: The gas is heated at constant volume from 300K 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 300K. Determine the heat and work effects for each step. Assume C_p as 29.3kJ/K mol-K. **(10 Marks)**

OR

4 a. For the following reaction, the standard heat of reaction at 298K is -164.987 kJ.

$$CO_2(g) + 4H_2(g) \rightarrow 2H_2O(g) + CH_4(g)$$

The constants in the heat capacity (J/mol K) equations. $C_p = \alpha + \beta T + \gamma T^2$ are given below:

	α	β	γ
CO_2	26.75	42.26×10^{-3}	-14.25×10^{-6}
H_2	26.88	4.35×10^{-3}	-0.33×10^{-6}
H_2O	29.16	14.49×10^{-3}	-2.02×10^{-6}
CH_4	13.41	77.03×10^{-3}	-18.74×10^{-6}

Calculate the standard heat of reaction at 773K. **(08 Marks)**

b. Discuss Vander Waals equation and the correction factors introduced to explain the PVT behavior of real gases. (08 Marks)

c. Calculate the standard heat of reaction at 298K for the following reaction:

$$4HC\ell_{(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)} + 2C\ell_{2(g)}$$

The standard heats of formation are -92.307 kJ/mol for HCl (g) and -241.818 kJ/mol for H_2O(g). (04 Marks)

Module-3

5 a. Define fugacity co-efficient. Explain the effect of temperature and pressure on fugacity. (10 Marks)

b. Write a note on: i) Maxwell's equations ii) Clapeyron equations. (10 Marks)

OR

6 a. Discuss about:

i) Helmholtz free energy

ii) Gibb's free energy

iii) Energy properties. (10 Marks)

b. What are derived properties? Derive the Gibb's-Helmholtz equation. (10 Marks)

Module-4

7 a. A 30 percent by mole methanol – water solution is to be prepared. How many cubic meters of pure methanol (molar volume , 40.727×10^{-6} m^3/mol) and pure water (molar volume, 18.068×10^{-6} m^3/mol) are to be mixed to prepare $2m^3$ of the desired solution? The partial molar volumes of methanol and water in a 30 percent solution are 38.632×10^{-6} m^3/mol and 17.765×10^{-6} m^3/mol respectively. (10 Marks)

b. Explain and derive the relationship of Lewis – Randall rule. (10 Marks)

OR

8 a. Explain about Chemical potential with its physical significance. (10 Marks)

b. The fugacity of component 1 in binary liquid mixture of components 1 and [2] at 298 K and 20 bar is given by $\bar{f}_1 = 50x_1 - 80x_1^2 + 40x_1^3$. Where $\bar{f}_1$ is in bar and x_1 is the molar fraction of component 1. Determine i) The fugucity f_1 of the pure component 1.

ii) The Fugacity co-efficient ϕ_1 iii) The Henry's law constant K_1.

iv) The Activity co-efficient γ_1. (10 Marks)

Module-5

9 a. The following reaction occurs in a mixture consisting of 2 mol methane, 1 mol water, 1 mol carbon monoxide and 4 mol hydrogen initially $CH_4 + H_2O \rightarrow CO + 3H_2$ Deduce expression relating the mole fractions of various species to the extent of reaction. (06 Marks)

b. Define equilibrium constant 'K' of a chemical reaction. How is it related to k_f and k_p? (08 Marks)

c. Derive Van't Hoff's equation to predict the effect of temperature on the equilibrium constant. (06 Marks)

OR

10 a. 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)	Mole %, n-butane
317	31.00
391	43.00

Assuming that activities are equal to the mole fractions, calculate the standard free energy of the reaction at 317K and 391K and average value of heat of reaction over this temperature range. **(08 Marks)**

b. Show that $\Delta G° = -RT\,ln K$. **(08 Marks)**

c. Calculate the equilibrium constant at 298K of the reaction $N_2O_4(g) \rightarrow 2NO_2(g)$ given that the standard free energies of formation at 298K are 97,540 J/mol for N_2O_4 and 51,310 J/mol for NO_2. **(04 Marks)**

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