Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

III SEMESTER B.TECH. END SEMESTER EXAMINATIONS

9 December 2023

SUBJECT: CHEMICAL ENGINEERING THERMODYNAMICS [CHE 2121]

Time: 3 h **Max. Marks: 50**

Instructions to Candidates:

- Answer ALL questions & missing data may be suitably assumed

1A	What is enthalpy of a system? How is it related to the internal energy?	**2**
1B	How would you define extensive and intensive properties? State whether the following properties are intensive or extensive: (a) specific volume (b) heat capacity	**3**
1C	Water at 368 K is pumped from a storage tank at the rate of 25 m^3/hr. The motor for the pump supplies work at the rate of 2 hp. The water passes through a heat exchanger, where it gives up heat at the rate of 42000 kJ/min and is delivered to a second storage tank at an elevation of 20 m above the first tank. What is the temperature of the water delivered to the second storage tank? Assume that the enthalpy of water is zero at 273 K and the specific heat of water is constant at 4.2 kJ/kg K.	**5**
2A	A system consisting of some fluid is stirred in a tank. The rate of work done on the system by the stirrer is 2.25 hp. The heat generated due to stirring is dissipated to the surroundings. If the heat transferred to the surroundings is 3400 kJ/hr, determine the change in internal energy.	**3**
2B	The partial molar volumes of acetone (MW: 58) and chloroform (MW:119.4) in a mixture at 0.5307 mole fraction of acetone are 74.166 cm^3/mol and 80.235 cm^3/mol respectively. What is the volume of 1 kg of the solution?	**3**
2C	Calculate the change in internal energy, change in enthalpy, work done, and heat supplied in the process where an ideal gas, initially at 1 bar and 298 K and contained in a vessel of 0.1 m^3 capacity, is heated at constant volume to 400 K. (Assume that C_P = 30 J/mol K.).	**4**
3A	The food compartment of a refrigerator is maintained at 4°C by removing heat from it at a rate of 360 kJ/min. If the required power input to the refrigerator is 2 kW, determine the coefficient of performance of the refrigerator and the rate of heat rejection to the room that houses the refrigerator?	**3**
3B	Calculate the volume occupied by 1 mol of saturated n-octane vapor at 427.85 K at a saturation pressure of 0.215 MPa by van der Waals equation. Take van der Waals equation constants a = 3.789 Nm^4/mol^2 and b = 2.37×10^{-4} m^3/mol.	**3**
3C	Do the following equations satisfy Gibbs–Duhem equations? $\ln \gamma_1 = Ax_2^2 + Bx_2^2(3x_1 - x_2)$ $\ln \gamma_2 = Ax_1^2 + Bx_1^2(x_1 - 3x_2)$	**4**

4A	A gas obeys the relation P(V – b) = RT and has a constant C_V. Show that (i) U is a function of temperature alone (ii) γ is constant.	**4**
4B	For a simple compressible system, prove that, $dH=Cp\,dT+(1-\beta T)V\,dP$	**3**
4C	Calculate the fugacity of pure ethylene at 100 bar and 373 K. The van der Waals constants are a = 0.453 J m^3/mol^2, b = 0.571×10^{-4} m^3/mol, molar volume at 100 bar and 373 K = 2.072×10^{-4} m^3/mol.	**3**
5A	State Carnot principles.	**2**
5B	Consider a vessel which initially contains only n_0 mol of water vapor. If decomposition occurs according to the reaction, $$H_2O \rightarrow H_2 + \frac{1}{2}O_2$$ find expressions which relate the number of moles and the mole fraction of each chemical species to the reaction coordinate ε.	**3**
5C	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: $$CH_3COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O$$ 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. $$\Delta H^o_{298} = -3640\ J$$ $$\Delta G^o_{298} = -4650\ J$$	**5**