Time: 3 Hours **Total Marks: 80**

N.B.:
(i) Question No.1. is compulsory.
(ii) Attempt any three questions out of remaining five questions.
(iii) Assume suitable data and justify the same.
(iv) Figures to the right indicate full marks.

1. (a) Distinguish between reversible and irreversible processes by giving 2 examples of each. **05**
   (b) Derive an expression to estimate entropy change of an ideal gas. **05**
   (c) Explain the physical significance of the triple point and the critical point. **05**
   (d) What are the Maxwell's equations? **05**

2. One kmol of an ideal gas at 0.2 MPa and 500 K undergoes the following reversible changes: **20**
   (i) Compressed isothermally to 3 MPa.
   (ii) Cooled at constant pressure to 300 K.
   (iii) Expanded adiabatically to 1 MPa.
   (iv) Expanded isothermally to its initial pressure.
   (v) Heated isobarically to 500 K.

   Determine ΔU, ΔH, Q and W for the individual stage and for the entire cycle.
   Data:
   C_p = 3.5 R J/(mol.K), C_v = 2.5 R J/(mol.K)

3. (a) A reversible heat engine operates with three reservoirs at 300 K, 400 K and 500 K. It absorbs 900 kJ energy as heat from the reservoir at 500 K and delivers 300 kJ work. Determine the heat interaction with other two reservoirs. **10**
   (b) Calculate the compressibility factor & molar volume for methanol vapor at 500 K & 10 bar by using pressure explicit form & volume explicit form of Virial Equation of State. **10**
   Data:
   B = -2.19×10^{-4} m^3/mol & C = -1.73×10^{-8} m^6/mol^2 for methanol.

4. (a) Derive an expression for Joule Thomson inversion temperature for a gas obeying **v**an der Waals equation of state in terms of reduced properties. **10**
   (b) Derive an expression for fugacity coefficient of ammonia vapor. Ammonia vapor obeys Redlich Kwong equation of state. **10**
   Redlich Kwong equation of state is given by:

$$P = \frac{RT}{(V-b)} - \frac{a}{\sqrt{T}V(V+b)}$$

Where:

$$a = 0.42748\frac{R^2T_c^{2.5}}{P_c} \quad \text{and} \quad b = 0.08664\frac{RT_c}{P_c}$$

5. (a) Explain and derive Exergy balance for a closed system. **10**
   (b) Calculate the enthalpy and entropy departures for ethane at 400 K and 1 MPa using van der Waals equation of state. **10**

Data:
T_c = 305.43 K, P_c = 48.84 bar, V = 3.21×10^{-3} m^3/mol

6. Write short notes on the following: **20**
   (i) Law of corresponding states
   (ii) Carnot principle
   (iii) Joule Thomson effect
   (iv) T-S diagram
