B.Tech. Third Semester (Chemical Engineering) (CGS)

10986 : Chemical Engineering Thermodynamics - I

3 CH 04 / 3 PP 04

P. Pages : 2 **AW - 2997**

Time : Three Hours Max. Marks : 80

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Notes :
1. Answer **three** question from Section A and **three** question from Section B.
2. Due credit will be given to neatness and adequate dimensions.
3. Assume suitable data wherever necessary.
4. Diagrams and chemical equations should be given wherever necessary.
5. Retain the construction lines.
6. Illustrate your answer necessary with the help of neat sketches.
7. Use of slide rule logarithmic tables, Steam tables, Moller's Chart, Drawing instrument, Thermodynamic table for moist air, Psychrometric Charts and Refrigeration charts is permitted.
8. Discuss the reaction, mechanism wherever necessary.
9. Use of pen Blue/Black ink/refill only for writing the answer book.

SECTION - A

1. a) Explain in detail the concept of Reversible and Irreversible process. **6**

b) State and explain the phase rule. Compute the degree of freedom if. **8**
i) liquid water in equilibrium with its vapour.
ii) liquid water in equilibrium with a mixture of water vapour and nitrogen.
iii) A liquid solution of alcohol in water in equilibrium with its vapour.
iv) System is made by partial decomposition of NH_4Cl.

OR

2. a) Explain the following : **8**
i) Heat Reservoir ii) Heat Engine
iii) Heat Pump

b) Explain with example state and path functions. **6**

3. a) Explain the first law of thermodynamics for non flow process. What are its limitations ? **6**

b) Calculate ΔU and ΔH for 1 kg of water when it is vaporized at the constant pressure of 101.325 kPa. The specific volume of liquids and vapour water at these conditions are 0.00104 and 1.673 m^3/kg for this change, heat in the amount of 2256.9 kJ is added to the water. **7**

OR

4. a) One Kilomole of gas for which PV = nRT (R = 8.31 kJ/kmol k) is originally at 320 k of 1 bar. It is then heated at constant pressure to a temperature of 420 k and compressed isothermally to volume equal to its initial volume. Assume C_P = 25 kJ/kmol k. Find ΔV, ΔH, Q & W. **7**

b) Show that $\Delta E = q_V$ of $\Delta H = q_p$ in this equation q_V & q_p are state function. **6**

5. a) Show the equivalence of : 6
   i) Kelvin Planck statement ii) Clausius statement

   b) Explain in detail the concept of Carnot cycle with propositions. 7

OR

6. a) From a reservoir at 600 k, 1000 J of heat is transferred to an engine that operates on the Carnot cycle. The engine rejects heat to a reservoir at 300 k. Determine the thermal efficiency of the cycle and the work done by the engine. 7

   b) Derive the equation for calculation of entropy changes for the processes involving ideal gases. 6

SECTION - B

7. a) Explain in detail the vapour compression cycle with neat sketch and T-S and P-H diagrams. 8

   b) A vapour compression refrigeration system with ammonia as the working fluid is to operate between 266 k and 300 k. Determine COP, given that the enthalpy of saturated vapour at 266 k = 656 kJ/kg and enthalpy of superheated vapour leaving the compressor is 724 kJ/kg, enthalpy of saturated liquid at 300 k = 144 kJ/kg. 6

OR

8. a) Explain in detail the Linde process for gas liquefaction. 8

   b) Show that a 1 kw heat pump working between an indoor temperature of 300 k and an outside temperature of 290 k is equivalent to a 30 kw heater. 6

9. a) Explain in detail the classification of thermodynamic properties. 6

   b) Derive the expression for Gibbs free energy and show that decrease in Gibbs free energy is equal to the amount of maximum work which a system can do isothermally and isobarically over and above the mechanical work. 7

OR

10. a) Explain the fundamental property relations and show. 6
    i) $d_A = -Sd_T - Pd_V$ ii) $d_G = -Sd_T + Vd_P$

    b) Explain Clausius - Clapeyron equation. 7

11. Derive the following equations : 13

    i) $\frac{dA}{du} = \frac{A}{u}(M^2 - 1)$ ii) $\frac{P_C}{P_O} = \left(\frac{2}{\gamma + 1}\right)^{\gamma(\gamma-1)}$

OR

12. a) Explain in detail the Throttling process (Joule Thomson Expansion). 7

    b) Steam at 600 kPa and 573 k (H = 3062 kJ/kg) enters a nozzle at a rate of 10 kg/s and discharges it at 100 kPa and 473 k (H = 2875 kJ/kg). Heat loss to the surroundings is estimated to be 100 kw. Assuming that the inlet velocity of steam is negligible determine the discharge velocity. 6

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