B.E. MECHANICAL ENGINEERING FOURTH YEAR SECOND SEMESTER – 2024

ADVANCED THERMODYNAMICS (HONS)

Time : Three hours **Full Marks : 100**

Assume any data, if not furnished, consistent with the problem. Use of relevant tables and charts are permitted.

All parts of a question must be answered together. If answers of different parts are scatterd, marks shall be deducted.

Answer Q No. 1 and any four (4) from the rest

1. a) Show the law of cyclic differentiations holds true for ideal gas.
   b) A cyclic engine operating between two thermal reservoirs has a thermal efficiency of 0.8. What is the COP of the same system if reversed to use as a refrigerator?
   c) State the equipartition theorem. Explain how energy varies with the degrees of freedom of the constituent particle.
   d) All adiabatic processes are isentropic – do you agree? Support your answer with proper reasons.
   e) An inventor claims to have a hat engine that is capable of developing 9 kW while working between the temperature limits of 20 ^{0} C and 40 ^{0} C. It receives 1047 kJ/minute of heat. Discuss the possibility of the claim.
   f) Plot the Carnot cycle in h-s and T-V plane. Explain why such a cycle is not used in real life.

   2+3+4+2+4+5

2. a) Explain the concept of chemical potential.
   b) A piston-cylinder arrangement contains 1 kg of saturated water at 30^0 C . The piston has cross-sectional area of 0.065 m^2, a mass of 40 Kg and is resting on two stops. The volume at this point is 0.1 m^3. Atmospheric pressure is 94 kPa and the local gravitational acceleration is 9.75 m/s^2. Heat is now transferred to the system until the cylinder is filled up with saturated vapor. What is the temperature and dryness fraction of the water when the piston rises from the stop? Calculate the work done by the water during the overall process.

   8+12

3. a)Starting from van-dar Wale's equation of state, show the expression reduces to 8 times reduced temperature

$$\left(p_r + \frac{3}{v_r^2}\right)(3v_r - 1) = 8T_r$$

   b) For Maxwell velocity distribution, derive the ratio of most probable speed, rms of speed and average speed. 10+10

4. (a) Using Maxwell's relationship show

$c_p - c_v = Tv\beta^2/k$

b) Find out an expression for Joule Thompson coefficient using Maxwell's relations

12+8

5. (a) Discuss the statistical interpretation of work and heat starting from large number of molecules in a cubical box of volume V

b) Derive the number of microstates for one of the three distributions Maxwell Statistics, Fermi Dirac statistics or Bose statistics (any one).

c) Compare the three distributions mentioned above.

8+8+4

6. (a) In a reaction two chemical species A and B react to form species C and D. Show the criterion for chemical equilibrium is

$$\nu_C \bar{g}_C + \nu_D \bar{g}_D - \nu_A \bar{g}_A - \nu_B \bar{g}_B = 0$$

(b) Develop an expression for equilibrium constant K_P for the above reaction

6+14

7.(a) From quantum mechanical law, show that $n_x^2 + n_y^2 + n_z^2$ = constant.

When the value of this constant is 66, find out the number of macrostates by developing an appropriate table.

(b) In the vicinity of triple point, the vapor pressure of liquid NH_3 is given by

$\ln p = 15.16 - 3060/T$

For solid ammonia vapor pressure curve is given by $\ln p = 18.70 - 3750/T$

Find out the values of pressure and temperature at triple point. Also find out the latent heats of sublimation, vaporization and fusion

(6+6)+8