June 12, 2024 02:30 pm - 05:30 pm 1T00533 - S.E.(Chemical Engineering)(SEM-III) (Choice Base Credit Grading System) (R- 19) (C Scheme) / 50724 - Chemical Engineering Thermodynamics I QP CODE: 10057246

(3 Hours) **Total Marks: 80**

N.B.: 1. Question No.1.iscompulsory.

2. Attempt any three questions out of the remaining five questions.

3. Assume suitable data wherever required.

4. Figures to the right indicates full marks.

Q.1] Solve any four of the following. 20

a) Write short note on Joule-Thomson coefficient.

b) Explain concept of heat engine, heat pump and refrigerator.

c) Calculate the volume occupied by one mole of oxygen at 300K and 100 bar using the van der Waals equation of state.

Given data: a = 0.1378 Nm^4/mol^2 , b = 3.18×10^{-5} m^3/mole.

d) Discuss the concept of Entropy.

e) Write short note on ejectors.

f) A steam turbine using steam at 1368 kPa and 645 K and discharging saturated steam at 137 kPa is used to generate power for certain chemical plant. The turbine acts adiabatically and the feed and discharge velocities may be considered equal. Determine the theoretical horsepower developed by the turbine if it uses 1650 kg steam per hour. From the steam tables,

Enthalpy of superheated steam at 1368 kPa and 645 K = 3200 kJ/kg ,and Enthalpy of saturated steam at 137 kPa = 2690 kJ/kg.

Q.2] a) Show that the fugacity of a gas obeying the van der Waals equation of state is given by, 10

$$\ln f = \frac{b}{V-b} - \frac{2a}{RTV} + ln\frac{RT}{V-b}$$

Where a and b are van der Waals constants.

b) State Carnot principle and derive efficiency of Carnot Engine**.** 10

Q.3] a) A reversible engine receives 75 kJ/s of energy from a source at 750 K and does 12 kJ/s of work. The heat is rejected to the two sinks at 650 K and 550 K respectively. Find the amount of heat rejected to the two sinks. 10

b) Derive the relation to estimate the enthalpy departure and entropy departure for gas obeying Redlich-Kwong Equation of state. 10

Q.4] a) Steam at 1800 kPa and 673.15 K steadily enters a nozzle at a rate of 5 kg/s and leaves the nozzle at 1400 kPa with a velocity of 300 m/s. The inlet area of the nozzle is 0.02 m^2. Heat losses from the nozzle per unit mass of the steam are estimated to be 3.3 kJ/kg. Determine the exit temperature of the steam. 10

b) Explain the Concept of exergy and get the expression to calculate exergy loss when system changes its state. 10

Q.5] a) A vessel is divided into two parts by a partition, on one side 4 kmol of nitrogen gas at 80 ^oC and 40 bar and on the other side 2kmol of Argon at 120 ^oC and 20 bar are kept. If the partition is removed and the gases are mixed adiabatically and completely, what is the change in entropy? Assume Nitrogen and Argon as Ideal gases with c_v values 2.5 R and 1.5R respectively. 10

b) Derive the equation for first Law of Thermodynamics for flow processes. 10

Q.6] a) Calculate the volume of one mole liquid n-Pentane at 500 K and 20 bar for the vander waals equation. Given data: T_c = 469.6 K, P_c = 33.7 bar. 10

b) An ideal gas is undergoing a series of three operations : The gas is heated at constant volume from 300 K and 1 bar to apressure 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 300 K. Determine the heat and work effects for each step. Assume Cp = 29.3 kJ/kmol K 10

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