1T00533 - S.E.(Chemical Engineering)(SEM-III)(Choice Base Credit Grading System) (R-2020-21) (C Scheme) / 50724 - Chemical Engineering Thermodynamics I
QP CODE: 10012763 DATE: 29/11/2022

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.

Q 1 Answer any Four. 20

(a) State and explain in brief the first law of thermodynamics.

(b) A heat engine operates between a heat source at 700 k and a heat sink at 300 k. What is the maximum efficiency of the engine?

(c) Explain concept of Exergy.

(d) For reversible isothermal compression, Prove that

$$W_s = RT\ ln\frac{P_1}{P_2}$$

(e) Explain the procedure to prepare Enthalpy-Temperature diagram.

Q 2 (a) One kmol of an ideal gas at 298 K and 150 kPa is compressed adiabatically to a temperature 363.3 K and cooled isobarically to 298 K and finally expanded isothermally to its original pressure of 150 kPa. Find Q, ΔU, ΔH for the cycle 12
Cp = 29.17 kJ/kmol,K Cv = 20.857 kJ/kmol,K

(b) A steel casting at a temperature 725 K and weighing 35 kg is quenched in 150 kg Oil at 275 K. If there are no heat losses, determine the change in entropy a) the casting b) the oil c) both considered together. The specific heat (Cp) of steel is 0.88 kJ/kgK and that of oil is 2.5 kJ/kg K. 08

Q 3 (a) State Carnot principle and derive efficiency of Carnot Engine**.** 10

(b) Derive the expression to calculate exergy loss when the system changes its state. 10

Q4 (a) Derive the van der Waals equation of state in terms of reduced parameters. 10

E1ECE34BC95251E12D10E8CEBABA3C7D

(b) Find the volume of n pentane at 500 K and 20 bar for the following cases i) Ideal gas ii) 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:

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

Data:

Tc = 469.6 K, Pc= 33.7 bar

Q5 (a) 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. 10

(b) A reversible heat engine operates between source temperature of 900 K and the sink temperature of 315 K. The engine is coupled with the heat pump working between the temperature of source at 253 K and the sink of 315 K. The net work done during the process is 320 KJ and the energy supplied by the higher temperature source at 900 K is 2000 KJ. Find the work done by the engine and the amount of energy rejected to the sinks by both the devices. 10

Q 6 (a) Show that the fugacity of a van der Waals gas is given by the equation: 10

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

(b) Derive an equation for entropy departure of a gas obeying Redlich Kwong equation of state. 10

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

E1ECE34BC95251E12D10E8CEBABA3C7D