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 Explain **any Four.** 20

(a) Define Fugacity coefficient. What is its physical significance?

(b) Concept of Entropy with example.

(c) Explain the Procedure to prepare Enthalpy –Temperature diagram.

(d) Reversible and irreversible process with example.

(e) Calculate the coefficient of performance of carnot refrigerator operating between -20 ^{0}C and 30^{0}C.

Q 2 (a) 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 12

(b) Explain Clausius Inequality with equation. 08

Q 3 (a) A 40 kg steel casting (Cp = 0.5 kJ/kg K) at a temperature of 450 ^{0}C is quenched in 150 kg of oil (Cp = 2.5 kJ/kgK) at 25 ^{0}C. If there are no heat losses, what is the change in entropy of a) the casting b) the oil c) both considered together? 10

(b) Viral coefficient for ethane is B= -15.67x 10^{-2} m3/kmol and C = 9.65 x10^{-3} m^6/kmol^2. Calculate the isothermal work of compression for one kmol of a gas from 1 bar to 15 bar at 100^{0}C. Compressibility factor Z_1 = 0.9949 and Z_2 = 0.9203 .Viral equation of state is: 10

$$\frac{PV}{RT} = Z = 1 + \frac{B}{V} + \frac{C}{V2}$$

Q4 (a) Estimate the fugacity coefficient of n-hexane at 600 K and 800 Kpa using van der Waals equation of state 10

Data: T_c= 507.4 K, P_c= 2969 kPa

(b) Find the volume of n.pentane at 500 K and 20 bar for a gas which obeys Redlich Kwong Soave equation of state. 10

Redlich Kwong Soave equation of state is given by:

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

Where:

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

$\alpha = [\,1 + S\,(\,1 - \sqrt{T_r}\,)\,]^2$

$S = 0.48508 + 1.55171\,w - 0.15613\,w^2$

Tc = 469.9 K, Pc = 33.7 bar, ω = 0.251

Q5 (a) Explain the concept of exergy and get the expression to calculate exergy loss when the system changes its state. 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 both the engines and the energy supplied to other sources and the sink. 10

Q 6 (a) Derive an expression for Joule Thomson Coefficient for van der Waals gas and find the relation for inversion temperature and inversion pressure. 10

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

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

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