G/E/TX

Reg. No: 23BCM0059

Final Assessment Test – May 2024

VIT
Vellore Institute of Technology

Course: BCHE202L - Chemical Engineering Thermodynamics

Class NBR(s):1183

Slot: A2+TA2+TAA2

Time: Three Hours

Max. Marks: 100

- KEEPING MOBILE PHONE/ELECTRONIC DEVICES EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE
- DON'T WRITE ANYTHING ON THE QUESTION PAPER

General Instructions:

(i) Compressibility chart and Steam tables are permitted

(ii) Graph sheets provided

Answer any TEN Questions

(10 X 10 = 100 Marks)

1. (a) Calculate the degree of freedom of water (i) at 100°C and 1atm and (ii) at its triple point. [5]

   (a) In an autoclave the pressure is 2 atm. Calculate the saturation temperature using Antoine equation. For water the Antoine equation is [5]

   $\ln P^{sat} = 16.262 - \frac{3799.89}{T^{sat}+226.35}$ where T^{sat} is in °C and P^{sat} is in kPa.

2. Determine the mass of N_2 contained in a $30m^3$ vessel at 20 MPa and 200 K by using (a) the ideal gas equation and (b) the generalized compressibility chart.

3. (i) Find the second and third virial coefficients of the vander waals equation when expressed in the form of virial equation of state. [5]

   (ii) Calculate change in internal energy, change in enthalpy, work done and heat supplied in the following processes. [5]

   a) An ideal gas is expanded from 5 bar to 4 bar isothermally at 600 K.

   b) An ideal gas contained in a vessel of 0.1 m^3 capacity is initially at 1 bar and 298 K. It is heated at constant volume to 400 K. Assume Cp = 30 J/ molK.

4. Heat is transferred to 10 kg of air which is initially at 100 kPa and 300 K until its temperature reaches 600 K. Determine the change in internal energy, the change in enthalpy, the heat supplied, and the work done in the following processes:

   (a) Constant volume process

   (b) Constant pressure process.

   Assume that air is an ideal gas for which the P V T relationship is PV = nRT , where n is the number of moles of the gas and R is the ideal gas constant.

   R = 8.314 kmol K. Take C_P = 29.099 kJ/ kmol K , C_V = 20.785 kJ/ kmol K and molecular weight of air = 29.

5. The standard heat of combustion of benzene at 298 K is -3269.5 kJ/mol when burnt completely to CO_2 and liquid water. The standard heat of combustion of hydrogen to liquid water -286.04 kJ/mol and that of carbon dioxide is -393.78 kJ/mol. Calculate the standard heat of formation of benzene.

6. Estimate the change in enthalpy and entropy when liquid ammonia at 270 K is compressed from its vapour pressure of 381 kPa to 1200 kPa. For saturated liquid ammonia at 270 K, V^L=1.55 $\times 10^{-3}$ m^3/kg and $\beta = 2.095 \times 10^{-3}$ K^{-1}.

7. Given that for an ideal mixture, $\Delta G_{mix}^{id} = RT\sum x_i ln x_i$, show that partial molar Gibb's free energy of a component in an ideal mixture is given by $\overline{G_i^{id}} = G_i + RTln x_i$.

8. At 200K, the compressibility factor of oxygen varies with pressure as given below. Evaluate the fugacity at 200K and 100 bar.

p, bar	z
1	0.99701
4	0.98796
7	0.9788
10	0.96956
40	0.8734
70	0.7764
100	0.6871

9. For the system acetone(1)-water (2), the vapour pressure of the pure components are given by

$$\ln P_1^{sat} = 14.39155 - \frac{2795.817}{t + 230.002}$$

$$lnP_2^{sat} = 16.26205 - \frac{3799.887}{t + 226.346}$$

Where P^{sat} is in KPa and t is in °C.

Assuming Raoult's law to be true, determine

(a) *P and y_1, given $x_1 = 0.43$ and t = 76°C*
(b) *P and x_1, given $y_1 = 0.43$ and t = 76°C*
(c) *T and y_1, given $x_1 = 0.32$ and P= 101.33 kPa*
(d) *T and x_1, given $y_1 = 0.57$and P = 101.33 kPa*

10. Explain the T-x-y and P-x-y diagram of binary VLE mixtures with neat graph.

11. Consider the reaction

$$\frac{1}{2}N_2 + \frac{3}{2}H_2 \rightarrow NH_3$$

Initially the number of moles of N_2 is 1, H_2 is 3 and NH_3 is 0. The equilibrium constant is 1.175 and the pressure in the reactor is kept constant at 4 atm.

Determine the values of K_p and K_y and hence the equilibrium mole fraction of NH_3. If the reaction is carried out at constant temperature and volume,

what is the equilibrium pressure of the reactor and equilibrium mole fraction of ammonia in the reactor? Assume ideal gas phase reaction.

12. A liquid phase isomerization reaction occurs as follows: $A\,(l) \rightarrow B(l)$ where A and B are miscible liquids for which the excess Gibb's free energy per mol is given by

$$\frac{G^E}{RT} = x_1 x_2$$

Where x_1 is the mol fraction of A and x_2 is the mol fraction of B in the liquid mixture. If $\Delta G^0_{rxn,298.15} = -1000J$, what is the equilibrium composition of the mixture at 25°C if the liquid mixture is assumed (i) ideal (ii) non-ideal.

⇔⇔⇔ G/E/TX ⇔⇔⇔