मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज – 211004 [भारत]

Motilal Nehru National Institute of Technology Allahabad
Prayagraj - 211004, [India]

End Semester Examination Odd Semester (Session 2020-21)

Programme Name: B.Tech. **Semester: V**

Course Code: CH15104 **Course Name: Chemical Engineering Thermodynamics-II**

Branch: Chemical Engineering **Student Reg. No.:**

Duration: 2 Hours **Max. Marks: 40**

Instructions:

1. **Solve the questions as per the given sequence**
2. **Attempt all the questions**

Question 1:

a) A gas expansion process takes place in a piston-cylinder assembly from an initial pressure of 3.75 bar and initial volume of 0.75 m^3 to a final volume of 1.85 m^3. During this expansion process the relationship between pressure and volume is given by PV^n=constant. Calculate the work done if (a) n=1.7 (b) n=1.0

2 Marks

b) Why does a slight change in molar volume take place in initial stage of boiling? Justify your answer with the help of TV diagram.

2 Marks

c) Air is compressed steadily from 150 kPa and 250 K to 550 kPa and 450 K. During this process, mass flow rate of air is 0.03 kg/s with the heat loss of 15kJ/kg. Changes is kinetic and potential energies are considered as negligible. Calculate the change in enthalpy and work done per mole of air. Assume air to behave as an ideal gas. For air

$$C_p^0 = 28.13 + 0.1966 * 10^{-2}T + 0.4804 * 10^{-5}T^2 - 1.963 * 10^{-9}T^3$$

[T in K, C_p^0 in J/molK]

2 Marks

d) What will be the criteria to reach at equilibrium stage for a closed system at constant T and P?

2 Marks

Question 2:

a) The vapour pressure of methanol can be estimated from the following equation:

$$log_{10}P^{sat} = 7.1212 - \frac{1581.824}{t + 221.184}$$

where P^{sat} is in mmHg and temperature is in $°C$. The critical constants for methanol are T_c=523.2 K and P_c=55.48 bar. Calculate the acentric factor for methanol.

2 Marks

b) What are the major findings of virial equations of state?

2 Marks

c) Calculate the mass of propane contained in a 0.4 m^3 cylinder at $50°C$ and 120 bar using virial equation of state Z=1+BP/RT for gases and compare it with the ideal gas law. For propane, T_c=302.4 K, P_c=45.71 bar, ω=0.100.

4 Marks

Question 3:

a) Prove that:

$$\left(\frac{\partial P}{\partial T}\right)_V = \frac{\beta}{k_T}$$

2 Marks

b) Prove that:

$$ln\phi = \int_0^P (Z-1)\frac{dP}{P}$$

2 Marks

c) What is the criteria for equilibrium between two phases? Justify with the help of fundamental relations for a multicomponent system.

2 Marks

d) Determine the change in enthalpy and entropy when liquid ammonia at 250 K is compressed from its vapour pressure of 379 kPa to 1150 kPa. For saturated liquid ammonia at 250 K, V_L=1.5*$10^{-3}$$m^3$/kg and β=2.075*10^{-3} K^{-1}.

2 Marks

Question 4:

a) What is a criteria of chemical equilibrium? What will be the effect of change in T and P?

2 Marks

b) Calculate the equilibrium composition for the gas phase reaction $CO+2H_2 \rightarrow CH_3OH$ at 500 K, 250 atm for a feed ratio of 1 mol of CO to 4 mol of H_2. Fugacity coefficients for CO, H_2 and CH_3OH in equilibrium reaction mixture are 1.02, 1.4 and 0.57, respectively. The reaction equilibrium constant at 500 K is $0.81*10^{-4}$.

2 Marks

c) For the ideal gas phase reaction

$$SO_2 + \frac{1}{2}O_2 = SO_3$$

(i) Calculate the standard heat of reaction as a function of temperature, (ii) calculate the equilibrium constant as a function of temperature, (iii) Given the pressure of 1 atm and temperature is 850 K and SO_2 and O_2 are fed in stoichiometric amounts determine the mole fraction of SO_3 at equilibrium. The following data are given:

$\Delta H^o_{f,SO_2,298.15}$=-70.90 kcal/mol, $\Delta H^o_{f,SO_3,298.15}$=-94.05 kcal/mol, $\Delta G^o_{f,SO_2,298.15}$=-70.70 kcal/mol, $\Delta G^o_{f,SO_3,298.15}$=-80.50 kcal/mol. The standard heat ca[acity as a function of temperature is given by C^o_P=a+bT+cT^2+dT^3 where T is in K and C^o_P in cal/mol-K and is

4 Marks

component	a	b*10^2	c*10^5	d*10^9
SO_2	6.157	1.384	-0.9103	2.057
SO_3	3.918	3.483	-2.675	7.744
O_2	6.085	0.3631	-0.1709	0.3133

Question 5:

a) Why rankine cycle is useful in place of carnot cycle? Justify your answer with cyclic diagram.

4 Marks

b) How absorption refrigeration cycle is different from vapour-compression cycle? Justify your answer.

4 Marks