8 + 2 = 10.

SHAHEED BHAGAT SINGH STATE TECHNICAL CAMPUS, FEROZEPUR

ROLL No: | | | | | | | | | | | | | **Total number of pages:[3]**

B.Tech. || CHE || 3rd Sem. RP

Chemical Engineering Thermodynamics

Subject Code:BTCH-304A /305 2011 onwards

Paper ID: May, 2018.

Time allowed: 3 Hrs **Max Marks: 60**

Important Instructions:

- **All questions are compulsory**
- **Assume any missing data**
- **Additional instructions, if any**

PART –A (10 X2 marks)

Ques 1 Short Answer Questions:

a) State the principle of corresponding states.
b) Give the properties of a good refrigerant.
c) Define throttling process.
d) Discuss Lewis-Randall Rule.
e) Define extrinsic and intrinsic properties and give examples .
f) Kelvin-planck statement of second law of thermodynamics.
g) Calculate the degree of freedom for a system prepared by partially decomposing $CaCO_3$ into an evacuated space.
h) Discuss the effect of temperature on equilibrium constant.
i) Define chemical potential. Write its mathematical formula.
j) Define State and Path Functions with examples

PART –B (5X8 marks)

Ques 2 a) Derive an equation for the work done for the adiabatic process. CO1

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

a) Constant Volume Process

b) Constant Pressure Process

Assume that air is an ideal gas following $PV=nRT.C_p=29.099KJ/Kmol$ and $C_v=20.785KJ/Kmol$, molecular weight of air =29

OR

a) Mercury has a density of $13.69 \times 10^3\ kg/m^3$ in the liquid state and $14.193 \times 10^3\ kg/m^3$ in the solid stateboth measured at melting point of 234.33 K at 1 bar. If the heat of fusion of mercury is 9.7876kJ/kg. What is the melting point of mercury at 10 bar.

b) Derive the Maxwell's equations

Ques 3 Define excess properties. Give its fundamametal equation. Derive various excess properties relationships. Explain the nature of excess properties. CO2

OR

a) Define activity coefficient discuss the effects of temperature and pressure on activity coefficient.

b) Derive an equation for fugacity and fugacity coefficient for pure species.

Ques 4 Derive Gibbs-Duhem equation and give its application to vapor- liquid equilibria.

OR CO3

A) The fugacity of component 1 in a binary liquid mixture of components 1 and 2 at 298 K and 20 bar is given by

$$\bar{f_1} = 40\, x_1 - 60\, x_1^2 + 70\, x_1^3$$

Where $\bar{f_1}$ is in bar and x_1 is mole fraction of 1 component. Determine

a) The fugacity of pure component
b) The fugacity Coefficient
c) The Hennery's law constant K1
d) The activity Coefficient

B) Derive lewis Randall rule.

Ques 5 Five moles of steam reacts with one mole methane at 850K and 1 bar as follows:

$CH_4 + H_2O \Rightarrow CO + 3\,H_2$ $\quad K_1=0.574$

$CO + H_2O \Rightarrow CO_2 + H_2$ $\quad K_2= 2.21$

Calculate the composition at equilibrium assuming ideal gas behavior. CO4

Or

a) The standard heat of formation and standard free energy of formation of ammonia at 298 K-46,100J/mol and 16,500J/mol calculate the equilibrium constant for the reaction.

$$N_2\,(g) + 3H_2\,(g) \rightarrow 2NH_3(g)$$

At 500K assuming that the standard heat of reaction is constant in the temperature range 298 to 500 K (6)

b) Discuss the various factors affecting the equilibrium conversion. (2)

Ques 6 a) calculate the decomposition pressure of lime stone at 1000 K CO5

$$CaCO_3(s) \rightarrow CaO\,(s) + CO_2\,(g)$$

The standard free energy for this reaction as function of temperature is

$$\Delta G^0 = 1.8856 \times 10^5 - 243.42\,T + 11.8478\,T\ln T - 3.1045 \times 10^{-3}\,T^2 + 1.7271 \times 10^{-6}\,T^3 - 4.1784 \times 10^5/T$$ (6)

b) Discuss heterogeneous reaction equilibria. (2)

Or

a) Prove that solute in a dilute solution obeys henrys law and the solvent obeys Raoults law and show this using a figure. (4)

b) In the synthesis of ammonia stoichiometric amounts of nitrogen and hydrogen are sent to a reactor where the following reaction occurs (4)

$$N_2 + 3H_2 \rightarrow 2NH_3$$

The equilibrium constant for the reaction at 675 K may be taken equal to 2×10^{-4}

a) Determine the present conversion of nitrogen to ammonia at 675 K and 20 bar.
b) What would be the conversion at 675K and 200 bar?