Registration No : | | | | | | | | | | |

Total Number of Pages : 02 **B.Tech**
PCE4I003

4th Semester Regular / Back Examination 2018-19
CHEMICAL ENGINEERING THERMODYNAMICS
BRANCH : CHEM
Time : 3 Hours
Max Marks : 70
Q.CODE : F481

Answer Question No.1 which is compulsory and any five from the rest.
The figures in the right hand margin indicate marks.

Q1 **Answer the following questions :** **(2 x 10)**

a) State the limitations of first law of thermodynamics wit example.

b) An egg, initially at rest, is dropped onto a concrete surface and breaks. With the egg treated as the system, what is the sign of W, Q and ΔE_p.

c) Calculate ΔU and ΔH for 1 kg of water when it is vaporized at the constant temperature of 373.15 K and the constant pressure of 101.325 kPa. The specific volumes of liquid and vapour water at the conditions are 0.00104 and 1.673 m^3kg^{-1}. For this change, heat in the amount of 2256.9 kJ is added to the water.

d) One mole of an ideal gas is compressed in a piston cylinder assembly from the initial state 0.1MPa and 300 K till its volume is reduced to 1/15 of the original volume. The process of compression can be approximated as a polytropic process with n=1.2. Determine the final temperature, pressure and work done on the gas.

e) State Kelvin-plank and Clausius statement of second law of thermodynamics.

f) Define partial molar properties of a component in a solution.

g) Define activity and activity coefficients of a component in a solution.

h) Define Raoults law and its limitations.

i) State third law of thermodynamics.

j) Write the effect of temperature on equilibrium constant in a reaction mixture.

Q2 **a)** With neat sketch explain the PT and TV diagram of pure substance. **(5)**

b) Reported values for the virial coefficients of isopropanol vapor at 473.15K (200°C) are: **(5)**

$B=-0.3888 m^3kmol^{-1}$

$C=-26\times10^{-3}\ m^6kmol^{-2}$

Calculate V and Z for isopropanol vapour at 473.15K (200°C) and 10 bar by:

(i) The ideal gas equation

(ii) Virial equation with 2nd term

Virial equation with 3rd term

Q3 **a)** Derive the expression of Gibbs Duhem equation for a solution containing multi component mixture. **(5)**

b) The molar enthalpy of a binary solution at constant T and P is given by the relation **(5)**

$h=500x_1+1000x_2+(50x_1+40x_2)\,x_{12}$

where h is in J/mol. Determine $\bar{h}_1$ and $\bar{h}_2$ as function of x_1 and the numerical values of the pure component h_1 and h_2. Also determine the partial molar enthalpies at infinite dilution.

Q4 **a)** Write the effect of operating condition on degree of conversion at equilibrium. **(5)**

b) A system formed initially of 2 mol CO_2, 5 mol H_2 and 1 mol CO undergoes the reactions **(5)**

$$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$$
$$CO_2 + H_2 \rightarrow CO + H_2O$$

Develop expressions for the mole fractions of the reacting species as function of the reaction coordinates for the two reactions.

Q5 **a)** Derive the expression of fugacity and fugacity coefficient for a component in a mixture which obeys Van der waals equation of state. **(5)**

b) Calculate the fugacity and fugacity coefficient for one mole of n-octane vapor at 427.85 K and 0.215 MPa. Assume that n-octane follows the Vander Waals equation of state. The van der Waals constants a and b are 3.789 $Pa(m^3/mol)^2$ and $2.37\times10^{-4} m^3/mol$ respectively. **(5)**

Q6 Air is compressed from an initial condition of 1 bar and 298.15K (25°C) to a final state of 5 bar and 298.15K (25°C) by three different mechanically reversible processes in a closed system: **(10)**

(a) Heating at constant volume followed by cooling at constant pressure
(b) Isothermal compression
(c) Adiabatic compression followed by cooling at constant volume

Assume air to an ideal gas with the constant heat capacities, $C_v=(5/2)R$ and $C_p=(7/2)R$. Calculate the work required, heat transferred and the changes in internal energy and enthalpy of the air for each process. At 298.15 K and 1 bar the molar volume of air is 0.02479 m^3/mol.

Q7 Mixtures of Benzene (1) and Tolune (2) conform to ideal solution behaviour. The vapor pressures of pure components are adequately described by the Antoine equation. Prepare **(10)**

(a) P-x-y diagram at 95°C.
(b) T-x-y diagram at a pressure of 101.325kPa (760 Torr).

Antoine constant	A	B	C
Benzene	6.87987	1196.760	219.161
Tolune	6.95087	1342.310	219.187

Q8 **Write short answer on any TWO :** **(5 x 2)**

a) Virial equation of state
b) Carnot cycle & Carnot theorem
c) Accentric facor
d) Chemical Potential