B.TECH SEM - IV (2007 COURSE) (CHEMICAL ENGG.) :
WINTER - 2017
SUBJECT: CHEMICAL ENGINEERING THERMODYNAMICS - I

Day : **Friday** Time **02.30 PM TO 05.30 PM**
Date : **24/11/2017** **W-2017-2399** Max. Marks: 80

N.B.

1) **Q.1** and **Q.5** are **COMPULSORY**. Out of the remaining attempt any **TWO** questions from each Section.
2) Figures to the right indicate **FULL** marks.
3) Answers to both the sections should be written in **SEPARATE** answer book.
4) Use of non-programmable calculator is allowed.
5) Assume suitable data if necessary.

SECTION – I

Q.1 **a)** Explain the Carnot principle. **(05)**

b) Why is the specific heat at constant pressure (C_p) always greater than that at constant volume (C_v). **(04)**

c) Write short notes on: **(05)**
- **i)** Virial equation of state
- **ii)** Compressibility factor

Q.2 **a)** Define phase rule. Using phase rule calculate the degree of freedom for following system: **(06)**
- **i)** System consist of liquid solution of alcohol and water in equilibrium with its vapour.
- **ii)** System is made up of liquid water in equilibrium with its vapour.
- **iii)** System consisting of solid carbon CO, CO_2 in chemical equilibrium.

b) Water is flowing in a straight horizontal pipe of 25 mm id. There is no device present for adding or removing energy as work. The upstream velocity is 10 m/s . The water flows in a section where the diameter is suddenly increased. **(07)**
- **i)** What is the change in enthalpy if the down stream diameter is 50 mm?
- **ii)** What is the maximum enthalpy change for a sudden enlargement in pipe?

Q.3 **a)** Calculate W, Q, ΔU and ΔH for the process : **(07)**
One kg. of air is heated reversibly at constant pressure from an initial state of 300K and 1 bar until its volume triples.
Assume for air $PV/T = 83.14$ bar $cm^3/mol\ ^0K$. $C_P = 29\ J/mol^0\ K$

b) Explain the following: **(06)**
- **i)** First law of thermodynamics with mathematical expression.
- **ii)** Reversible process and irreversible process.

P.T.O.

Q.4 **a)** The equation of state of a certain substance is given by the expression: **(07)**

$$V=\frac{RT}{P}-\frac{C}{T^3}$$

The specific heat is given by the relation $C_P = A–BT$.
Where A, B and C are constants. Derive expression for change in internal energy, enthalpy and entropy for :

i) An isothermal process
ii) An isobaric process

b) Explain PVT behaviour of pure substance with neat diagrams of PT and PV. **(06)**

SECTION – II

Q.5 **a)** What is fugacity? Explain Lewis Randall rule. **(05)**
b) State physical significance of chemical potential and obtain an equation for chemical potential at constant T and P. **(05)**
c) Write short note on second law of thermodynamics. **(04)**

Q.6 **a)** n-Heptane and toluene form an ideal solution. At 373 K, its vapour pressures are 106 and 74 KPa respectively. Determine the composition of the liquid and vapour in equilibrium at 373 K and 101.325 KPa. **(07)**
b) Derive an expression of entropy change for an ideal gas. **(06)**

Q.7 **a)** Estimate the enthalpy change of vaporization of benzene at 500^0C using Clausius Clapeyron equation. The vapour pressure of benzene is given by the equation. **(06)**

$$\ln P^{sat} = 13.88 - \left[\frac{2788.51}{T+220.9}\right]$$

Where P^{sat} is in KPa and T in ^{0}C.

b) A gas obeys the relation P(V-b)=RT and has a constant C_V show that : **(07)**

i) U is a function of temperature only.
ii) γ is constant
iii) $P(V-b)^{\gamma}$ is constant for an adiabatic reversible process.

Q.8 **a)** Derive fundamental property relations for a system of varying composition. **(06)**
b) The enthalpy of a binary liquid system of species 1 and 2 at fixed T & P is represented by the equation. **(07)**

$H = 400x_1 + 600\,x_2 + x_1x_2(40x_1 + 20x_2)$.

Where H is in J/mol. Determine expressions for $\overline{H_1}$ and $\overline{H_2}$ as function of x_1.

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