Registration No. :

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B. Tech

PCCH 4401

Seventh Semester Examination – 2013

CHEMICAL ENGINEERING THERMODYNAMICS

BRANCH : CHEM

QUESTION CODE : C-155

Full Marks – 70

Time : 3 Hours

Answer Question No. 1 which is compulsory and any five from the rest.
The figures in the right-hand margin indicate marks.
Assume suitable notations and any missing data wherever necessary.
Use of Steam Table is permitted.

1. Answer the following questions :   2 ×10

    (a) Differentiate between extensive and intensive properties with examples.

    (b) Comment on the feasibility of cooling your kitchen in the summer by opening the door of the electrically powered refrigerator.

    (c) Define volume expansivity and isothermal compressibility with their equations. Mention their values for compressible and incompressible fluids.

    (d) Draw the four paths of polytropic processes characterized by specific values of δ.

    (e) An egg, initially at rest, is dropped onto a concrete; it breaks. Prove that the process is irreversible. In modelling this process, treat the egg as the system and assume the passage of sufficient time for the egg to return to its initial temperature.

    (f) An equilibrium liquid/vapour system described by Raoult's law cannot exhibit an azeotrope. Comment on the statement.

    (g) What is partial molar temperature ? What is the partial molar pressure ? Express results in relation to the T and P of the mixture.

P.T.O.

(h) Even though air is cheap and non-toxic compared to carbon dioxide, it is not used for making soda water. Using the concept of Henry's law, justify the statement.

(i) Define and explain fugacity and fugacity coefficient.

(j) What do you understand by reaction coordinate ?

2. (a) A laboratory reports quadruple-point coordinates of 10.2 Mbar and 24.1^{0}C for four-phase equilibrium of allotropic solid forms of the exotic chemical β-miasmone. Evaluate the claim.   4

   (b) A tank containing 20 kg of water at 20^{0}C is fitted with a stirrer that delivers work to the water at the rate of 0.25 kW. How long does it take for the temperature of the water to rise to 30^{0}C if no heat is lost from the water ? For water, $C_p = 4.18$ kJ/kg.^{0}C.   6

3. One mole of an ideal gas with $C_p = (7/2)\,R$ and $C_v = (5/2)\,R$ expands from $P_1 = 8$ bar and $T_1 = 600$ K to $P_2 = 1$ bar by each of the following paths :

   (a) Constant volume,

   (b) Constant temperature, and

   (c) Adiabatically.

   Assuming mechanically reversibility, calculate W, Q, ΔU, and ΔH for each process. Sketch each path on a single PV diagram.   10

4. For an ideal gas prove that :   10

$$\frac{\Delta S}{R} = \int_{T_0}^{T} \frac{C_v^{ig}}{R} \frac{dT}{T} + \ln \frac{V}{V_0}$$

5. (a) Binary system of acetonitrile(1)/nitromethane (2) conforms closely to Raoult's law. Vapour pressures for the pure species are given by the following Antoine equations :

   $$\ln P_1^{sat} = 14.3 - \frac{2945.5}{T - 49.2}$$

   $$\ln P_2^{sat} = 14.2 - \frac{2972.6}{T - 64.2}$$

   Prepare a graph showing P vs. X_1 and P vs. y_1 for a temperature of 70°C.   7

(b) A soft drinks bottle contains only $CO_2(1)$ and $H_2O(2)$. Determine the compositions of the vapour and liquid phases in the sealed bottle and the pressure exerted on the bottle at 15°C. Henry's law constant for CO_2 in water at 15°C is about 1000 bar.   3

6. Why the ideal gas mixture model is an important property model ? Based upon this derive the expression for chemical potential.   10

7. A system formed initially of 2 mol CO_2, 5 mol H_2, and 1 mol CO undergoes the reactions :

$$CO_2(g) + 3H_2(g) \rightarrow CH_3OH(g) + H_2O(g)$$
$$CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O(g)$$

Develop expressions for the mole fractions of the reacting species as functions of the reaction coordinates for the two reactions.   10

8. Write short notes on any **two** :   5×2

   (a) Applications of the Virial equations

   (b) Qualitative behavior of VLE

   (c) Partial properties in binary solutions

   (d) Gibb's theorem.