Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH/CT(N)/SEM-3/CH(CT)-303/2012-13

2012

CHEMICAL & ENGINEERING THERMODYNAMICS

Time Allotted : 3 Hours *Full Marks :* 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives from the following : $10 \times 1 = 10$

i) The spontaneous process is characterized by

a) $\Delta G^\circ < 0$ b) $\Delta G^\circ_{P,T} < 0$

c) $\Delta G^\circ_{P,T} = 0$ d) None of these.

ii) Half life period of first order reaction is characterized by

a) Inversely proportional to initial concentration of reactant

b) Directly proportional to initial concentration of reactant

c) Independent of initial concentration of reactant

d) None of these.

iii) In a consecutive elementary reaction $A \rightarrow B \rightarrow C$

a) The concentration of B increases first and attains a maximum and then decreases

b) The concentration of B decreases first and attains a minimum and then increases

c) The concentration of B does not vary with time from initially

d) None of these.

iv) The degree of freedom for calcinations of limestone at 900˚C is

a) Zero b) One

c) Two d) None of these.

v) The stability of thermodynamically controlled product over kinetically controlled product is

a) More b) Less

c) Euqal d) None of these.

vi) Solid solution is a

a) Compound

b) Mixture

c) Compound with a fixed composition range

d) None of these.

vii) The specific entropy (S) of a substance in solid, liquid and gaseous state is in the order of

a) $S_{solid} < S_{liquid} < S_{gas}$

b) $S_{solid} = S_{liquid} = S_{gas}$

c) $S_{solid} > S_{liquid} > S_{gas}$

d) None of these.

viii) The order of a reaction is equal to

a) Number of moles of species involved in a chemical reaction

b) Experimentally determined number but not necessarily equal to the number of moles of species involved in a chemical reaction

c) Totally arbitrary number

d) None of these.

ix) The plot of $ln\ k_a$ *vs.* $1/T$ for exothermic reaction gives

a) Positive slope b) Negative slope

c) Constant slope d) None of these.

x) Chemical potential is

a) Intensive property b) Extensive property

c) Surface property d) None of these.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. Deduce Gibbs-Duhem relation and explain the physical significance of each equation. 3 + 2

3. Discuss thermodynamically controlled and kinetically controlled product of a chemical reaction mentioning the energy profile diagram.

4. The standard feee energy change for decomposition of $MgCO_3$ is $\Delta G = 26000 - 39{\cdot}4T$ (in cal/mole). Calculate the minimum partical pressure of CO_2 required for decomposition of Mg CO_3 at 800°C.

5. The heat capacity of a system may be expressed as

   $C_p = 2.081 + 41.87/(t + 100)$ J/°C, where t is the temperature of the system in °C. The system is heated while it is maintained at a pressure of 1 atmosphere until its volume increases from 2000 m^3 to 2300 m^3 and its temperature from 0°C to 100°C.

   a) Find the amount of heat transfer

   b) How much is the increase of internal energy of the system ?

6. At the inlet of a nozzle, the enthalpy of the fluid is 3100 kJ/kg and at the discharge the value is 2800 kJ/kg. The fluid is entering the system at 55 m/s. Find the velocity at the outlet. If at the inlet area of the opening is 0.1 m^2 and specific volume is 0.186 m^3 / kg, calculate the mass flow rate.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Discuss thermodynamic probability and its relation with entropy. Calculate the Configurational entropy with a perfect crystal containing 1×10^{12} numbers of vacancy in per mole of crystal. 3 + 4

   b) How would you prove that the spinelisation from MgO and Al_2O_3 is diffusion controlled solid state reaction. If the activation energy is 100 kcal/ mole and reaction proceed to 10% of completion at 1450˚C in 1 hour, how far it will go in 4 hrs. at 1550˚C. 2 + 6

8. Write short notes on any *three* of the following : 3 × 5

   a) Eutectic and Peritectic Reaction

   b) Ellingham Diagram

   c) Interdiffusion of solid

   d) Kirchhoff's equation & its significance

   e) Third Law of Thermodynamics.

9. a) Derive a relation between thickness of converted layer and fraction conversion for a solid particle with spherical geometry. How is it related with activation energy of such conversion. How did Jander modify this equation ? 4 + 2 + 2

   b) What is free energy diagram. How would you explain the spontaneity of decomposition of limestone related with partial pressure of CO_2 at different temperatures ? 2 + 5

10. a) Discuss Van't Hoff equation. How enthalpy change for decomposition of limestone can be determined experimentally by measuring the partial pressure of CO_2 ? 2 + 5

    b) For a first order elementary reaction of type $A \rightarrow B \rightarrow C$, show that the rate of maximum accumulation of B at time $t = (\ln k_1 - \ln k_2) / (k_1 - k_2)$. Also find out the concentration of *C* if one of the reaction is very fast han other. Show their concentration profile diagram. 5 + 2 + 1

11. a) A refrigerator is maintained at 2°C. Every time the door is opened, 420 kJ of heat is introduced without appreciably changing the temperature of the refrigerator.The door is opened 20 times a day and the refrigerator runs at 15% of ideal COP. The cost of electricity is Rs. 2.50 per kWh. What is the monthly bill for this refrigerator ? The atmosphere maintains a steady temperature of 30°C. 7

b) A mass of liquid water (m = 5 kg), initially in thermal equilibrium with the atmosphere at 295 K is cooled at constant pressure to 280 K by means of a refrigerator. What is the minimum work required ? For water take C_p = 4180 J/kg-K. 8