

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)

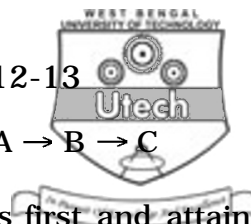
1. Choose the correct alternatives from the following :

10 × 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.

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- iii) In a consecutive elementary reaction $A \rightarrow B \rightarrow C$
- The concentration of B increases first and attains a maximum and then decreases
 - The concentration of B decreases first and attains a minimum and then increases
 - The concentration of B does not vary with time from initially
 - None of these.
- iv) The degree of freedom for calcinations of limestone at 900°C is
- Zero
 - One
 - Two
 - None of these.
- v) The stability of thermodynamically controlled product over kinetically controlled product is
- More
 - Less
 - Euqal
 - None of these.
- vi) Solid solution is a
- Compound
 - Mixture
 - Compound with a fixed composition range
 - None of these.



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

- a) $S_{\text{solid}} < S_{\text{liquid}} < S_{\text{gas}}$
- b) $S_{\text{solid}} = S_{\text{liquid}} = S_{\text{gas}}$
- c) $S_{\text{solid}} > S_{\text{liquid}} > S_{\text{gas}}$
- 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. $3 \times 5 = 15$

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 free energy change for decomposition of MgCO_3 is $\Delta G = 26000 - 39.4T$ (in cal/mole). Calculate the minimum partial pressure of CO_2 required for decomposition of MgCO_3 at 800°C .
5. The heat capacity of a system may be expressed as $C_p = 2.081 + 41.87/(t + 100) \text{ J/}^\circ\text{C}$, where t is the temperature of the system in $^\circ\text{C}$. 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 ?



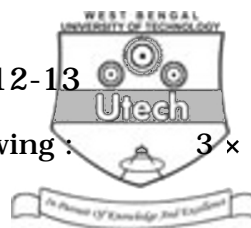
6. At the inlet of a nozzle, the enthalpy of the fluid is 3100 kJ/kg and at the discharge the value is 2800 kJ/kg. The fluid is entering the system at 55 m/s. Find the velocity at the outlet. If at the inlet area of the opening is 0.1 m^2 and specific volume is $0.186 \text{ m}^3 / \text{kg}$, calculate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

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

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 than 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 ($m = 5 \text{ kg}$), 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 $C_p = 4180 \text{ J/kg-K}$. 8

