



Name :

Roll No. :

Invigilator's Signature :

CS/B. Tech (CT-N)/SEM-3/CH(CT)-303/2011-12

2011

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 for the following :

10 × 1 = 10

- i) Which of the following is the intensive property ?

- a) Enthalpy b) Free energy
c) Chemical potential d) None of these.

- ii) Diffusion controlled solid state reaction is characterized
by

- a) linear plot of X vs. t
b) parabolic plot of X vs. t
c) exponential plot of X vs. t with a maximum
d) none of these.



- iii) The stability of kinetically controlled product over thermodynamically controlled product is
- a) equal
 - b) more
 - c) less
 - d) none of these.
- iv) The half-life period of second order reaction is
- a) independent of initial concentration of reactant
 - b) inversely proportional to the initial concentration of reactant
 - c) equal to initial concentration of reactant
 - d) none of these.
- v) Glass transition is
- a) zero order phase transition
 - b) first order phase transition
 - c) second order phase transition
 - d) none of these.
- vi) The spontaneous process is characterized by
- a) $\Delta G^0_{P,T}$ equal to zero
 - b) $\Delta G^0_{P,T}$ greater than zero
 - c) $\Delta G^0_{P,T}$ less than zero
 - d) none of these.

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GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. A gas of mass 1.5 kg undergoes a quasi-static expansion which follows a relationship $p = a + b V$ where a and b are constants. The initial and final pressures are 1000 kPa and 200 kPa respectively and the corresponding volumes are 0.20 cu.m and 1.20 cu.m. Calculate the amount of work done. 5
3. A turbine operates under steady flow conditions, receiving steam at the following state : pressure 1.2 MPa, temperature 188 degree C, enthalpy 2785 kJ/kg, velocity 33.3 m/s and elevation 3 m. The steam leaves the turbine at the following state : pressure 20kPa, enthalpy 2512 kJ/kg, velocity 100 m/s, and elevation 0 m. Heat is lost to the surroundings at the rate of 0.29 kJ/s. If the rate of steam flow through the turbine is 0.42 kg/s, what is the power output of the turbine in kW? 5
4. Deduce Gibbs-Duhem relation and explain the significance of each equation. (3 + 2)
5. Discuss thermodynamically controlled and kinetically controlled reactions with mentioning energy profile diagram. Give example in ceramic system. (4 + 1)
6. Show that first order reaction never be completed but second order reaction is completed at a finite time. 5



GROUP – C

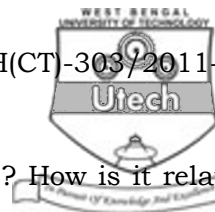
(Long Answer Type Questions)

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

7. a) A reversible heat engine operates between two reservoirs at temperatures of 600 degree C and 40 degree C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40 degree C and -20 degree C. The heat transfer to the heat engine is 2000 kJ and the net work output of the combined engine refrigerator plant is 360 kJ. Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40 degree C. 7
- b) Two identical bodies having mass m each of constant and same heat capacities are at the same initial temperature T_i . A refrigerator operates between these two bodies until one body is cooled to T_2 . If the bodies remain at constant pressure and undergoes no change of phase, find the minimum amount of work needed. 8



8. 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 Jender modify this equation ? 4 + 2 + 2
- b) Discuss Kirchhoff's equation and van't Hoff's equation. How enthalpy change for decomposition of limestone can be determined experimentally by measuring the partial pressure of CO_2 ? 4 + 3
9. a) For a first order elementary reaction of type $A \rightarrow B \rightarrow C$, Show that the rate of maximum accumulation of B at time $t = (\ln k_1 - \ln k_2) / (k_1 - k_2)$. If one of the reactions is very fast compared to other then find out the concentration of the product C . 5 + 3
- b) Discuss Eutectic and peritectic type reactions in ceramic system. What are congruent melting and incongruent melting ? 5 + 2



10. a) What is thermodynamics probability ? How is it related with entropy ? Calculate entropy change with introducing 10^{20} number of vacancies in a gram mole of a perfect crystal ($k = 1.38 \times 10^{-23}$). 2 + 1 + 4
- b) How is diffusion controlled solid state reaction characterized ? The activation energy for the formation of mullite from Al_2O_3 and SiO_2 is a diffusion controlled reaction. If the activation energy is 50 kcal / mole and the reaction proceeds to 10 % of completion at 1400°C in 1 hr, How far will it go in 1 hr at 1500°C ? 2 + 6
11. a) How is activation energy of decomposition of limestone measured by measuring the weight loss and equilibrium weight loss at different isotherm ? How is equilibrium weight loss experimentally measured ? 5 + 3
- b) The standard free energy change for decomposition of CaCO_3 is $40,200 - 35.6 T$ (in cal / mole). Calculate the partial pressure of CO_2 at 900°C . 7