Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech (BT)/SEM-4/BT-401/2011

2011

THERMODYNAMICS & KINETICS

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 : $10 \times 1 = 10$

   i) The Michaelis-Menton constant, K_m is a measure of

      a) the rate constant of the reaction

      b) the affinity of the enzyme for the substrate

      c) the concentration of the enzyme — substrate (ES) intermediate

      d) none of these.

   ii) For an enzymatic reaction the plot of reaction rate and pH is

      a) a straight line through its origin

      b) an asymptotic curve

      c) a bell shaped curve

      d) a straight line parallel to the x-axis.

iii) The enzymatic reactions occurring respectively at high and low substrate concentrations have the reaction orders respectively

a) First and Zero

b) Pseudo — First order

c) Second and First order

d) Zero and First order.

iv) Which of the following is not a property of the system ?

a) pressure b) volume

c) work d) temperature.

v) An enzyme does the following in catalyzing a reaction

a) stabilizes the substrate

b) decrease the equilibrium constant

c) increase the forward reaction rate

d) hastens the approach to equilibrium.

vi) The third law of thermodynamics states that

a) it is impossible to convert heat energy fully to work

b) it is impossible to destroy energy

c) it is impossible to attain absolute zero temperature

d) none of these.

vii) A heat pump works on the principle of the

a) first law of thermodynamics

b) second law of thermodynamics

c) zeroth law of thermodynamics

d) third law of thermodynamics.

viii) Which of the following is not an intensive property ?

a) temperature b) pressure

c) density d) enthalpy.

ix) The Molier chart is a

a) pressure — enthalpy chart

b) enthalpy — entropy chart

c) temperature — entropy chart

d) pressure volume chart.

x) Higher possible value of C.O.P is attained in

a) air cycle

b) vapour compression cycle by expansion value

c) Carnot cycle

d) vapour compression by expansion engine.

GROUP – B

(Short Answer Type Questions)

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

2. Derive a relation to calculate fugacity virial equation of state.

3. A reaction $A \rightarrow P$ is carried out in a batch reactor at different initial concentrations. Half-life for each run is noted and given in the table below. Calculate order of reaction and the rate constant.

C_{A0}, kmols/m^3	10	18·5	30
Half-life, secs	100·0	54·0	33·3

4. For an irreversible reaction of the type $A \rightarrow B \rightarrow P$, deduce the expression for maximum concentration of B and the time at which it is attained, from the general expression of C_B in terms of the reaction rates k_1 and k_2.

5. The saturation pressure of water at 180°C is 1·0027 MPa. The critical constant of water are $T_C = 647 \cdot 3$ K, $P_C = 221 \cdot 2$ Bar. Calculate the acentric factor of water.

6. A vessel contains $6m^3$ of air at a pressure of 500 kPa. If 1/5 of the air be removed by an air pump, what will be the pressure of the remaining air where the temperature is constant Given : $R = 0 \cdot 287$ kJ/kg – k.

GROUP – C

(Long Answer Type Questions)

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

7. a) What is the maximum work and entropy change for a steady state process when 1 mole of nitrogen is compressed from T = 300 K and P = 1·0133 bar to T = 800K and P = 50 bar.

   Given for N_2 : $C_p / R = 3{\cdot}280 + 0{\cdot}593 \times 10^{-3}\ T$ where T is in Kelvin. 7

b) A refrigeration system requires 1·5 kW power for a refrigeration rate of 4 kW

i) What is the coefficient of performance ?

ii) How much heat is rejected in the condenser ?

iii) If heat is rejected at 313 K, what is the lowest temperature the system can possibly maintain ? 8

8. a) For the benzene (1)/toluene (2) system, the Antoine equation is given as

In $P^{sat}/KP_a = A - [B/(T + C)]$, where A, B and C values benzene and toluene are as given below :

	A	B	C
Benzene (1)	13·8594	2773·78	– 53·08
Toluene (2)	14·0098	3103·01	– 53·36

Assuming the validity of Raoult's Law, calculate the following for $x_1 = 0 \cdot 33$ and $T = 373K$

i) y_1 (the vapour composition)

ii) P (bubble point pressure)

b) A liquid mixture of cyclohexane (1)/Phenol (2) for which $x_1 = 0{\cdot}6$ is in equilibrium with its vapour at 417K. Determine the equilibrium pressure, P and vapour composition (y_1) from the following information :

$ln\ y_1 = Ax_2^2$ and $ln\ y_2 = Ax_1^2$ and

at 417K, $P_1^{sat} = 75{\cdot}20$ kPa, and $P_2^{sat} = 31{\cdot}66$ kPa. The system forms an azeotrope at 417K for $x_1^{az} = y_1^{az} = 0{\cdot}294$. 7 + 8

9. Derive an expression to calculate the change in enthalpy and entropy of a real gas undergoing an isothermal compression and obeying the following equation of state :

$$V = \frac{RT}{P} + b - \frac{a}{RT}.$$

10. The following experimental data were calculated during a study of the catalytic activity of an intestinal peptidase with the substrate glycye glycine.

[S] mm	1·5	2	3	4	8	16
V μ mol/min	0·21	0·24	0·28	0·33	0·40	0·45

Use graphical analysis to determine the K_m and V_{max} for this enzyme preparation and substrate. 15

11. In a chemical process plant, water at 67°C is pumped from a storage tank at the rate of 20000 kg/hr. The motor for the pump expenses work at the rate of 1·5 hp. The water passes through a heat exchanger and rejects heat at the rate of 38000 kJ/min and is delivered to the next storage tank at an elevation of 20m above the first tank. Determine the temperature of the water delivered to the second tank.

Given : $C_{P_{H_2O}} = 4 \cdot 2 \text{ kJ/kg} - \text{K}$.