Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH/BT(OLD)/SEM-4/BT-401/2013

2013

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 × 1 = 10

i) The degree of freedom of water at its triple point is

a) 0 b) 1

c) 2 d) 3.

ii) Henry's law is applicable for

a) Gas-liquid system b) Gas-gas system

c) Liquid-liquid system d) Solid-liquid system

iii) Compressibility factor for a non-ideal gas at higher pressure is

a) > 1 b) < 1

c) 1 d) none of these.

iv) The order of the reation whose rate equation is $r = kC_A^{1\cdot7} C_B^{1\cdot3}$, is

a) 1·7 b) 1·3

c) 3 d) 0·4.

v) At inversion temperature, the Joule-Thomson coefficient is

a) zero b) positive

c) negative d) infinity.

vi) For ideal gas, Fugacity coefficient is

a) 0 b) 1

c) < 1 d) > 1.

vii) The Michaelis-Menten constant K_m is a measure of

a) the rate of the reaction

b) the affinity of the enzyme for the substrate

c) the concentration of the enzyme (ES) intermediate

d) none of these.

viii) Allosteric enzymes contain

a) one substrate binding site

b) no substrate binding site

c) more than one substrate binding sites

d) none of these.

ix) Cubic equation of state can calculate molar volume of

a) gas

b) liquid

c) both (a) and (b)

d) none of these.

x) The plot of reaction velocity and pH for an enzymatic reaction is

a) a straight line through origin

b) a bell-shaped curve

c) an asymptotic curve

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

GROUP – B

(Short Answer Type Questions)

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

2. Prove that $C_p - C_v = R$.

3. Air at 1 bar and 298·15 K is compressed to 5 bar and 298·15 K by cooling at constant pressure followed by heating at constant volume. Calculate the head and work requirements for each path. The following heat capacities for air may be assumed independent of temperature :

$$C_v = 20{\cdot}78 \text{ and } C_p = 29{\cdot}10 \text{ J mol}^{-1}\text{K}^{-1}.$$

4. Prove that $V_c = (3/8)\, RT_c / P_c$.

5. The activation energy for pyrolysis of ethane is 298 kJ/mole. How faster is the decomposition at 600°C than at 550°C ?

6. Liquid *A* decomposes by 1st order kinetic and in a batch reactor 50% of *A* is converted in a 10 minute run. How much it will take to reach 75% conversion ?

GROUP – C

(Long Answer Type Questions)

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

7. a) Deduce an expression for entropy change for mixing of different ideal gases. 7

b) Atmospheric air is a mixture of nitrogen and oxygen in the mole ratio of 79 : 21. Calculate the minimum work to be done to separate 1 k mol air at 0·1 MPa and 300 K into pure nitrogen and oxygen at the same temperature and pressure. Assume air as an ideal gas. 8

8. a) What is the significance of Joule-Thomson coefficient, $\mu_{jT} = \left(\frac{\partial T}{\partial P}\right)_H$? Deduce an expression for μ_{jT} in terms of T, P and Z. 7

b) Draw a flow diagram of Linde liquefaction process and show the mass and energy balance for the cyclic process. 8

9. a) Find the first-order rate constant for the disappearance of A in the gas reaction $2A \rightarrow R$ if, on holding the pressure constant, the volume of the reaction mixture, starting with 80% A, decreases by 20% in 03 min.

   b) Find the first-order rate constant for the disappearance of A in the gas reaction $A \rightarrow 1{\cdot}6\ R$ if the volume of the reaction mixture, starting with pure A increases by 50% in 4 min. The total pressure within the system stays constant at 1·2 atm and the temperature is 25°C.

10. a) State phase rule. For a closed system how this rule gets modified ? Explain with deduction. 2 + 4

   b) For acetone at 293·150 K and 1 bar,

   $$\beta = 1{\cdot}487 \times 10^{-3}\ K^{-1}$$

   $$\kappa = 62 \times 10^{-6}\ bar^{-1}$$

   $$V = 1{\cdot}287 \times 10^{-3}\ m^3 kg^{-1}$$

   find

   i) the value of $\left(\frac{\partial P}{\partial T}\right)_V$

   ii) the pressure generated when acetone is heated at constant volume from 293·150 K and 1 bar to 303·15 K.

   iii) the volume change when acetone is changed from 293·150 K and 1 bar to 273·15 K and 10 bar. 6

   c) Explain Boiling Point Diagram. 3

11. The following data were obtained from enzymatic oxidation of phenol by phenol oxidase at different phenol concentrations :

S (mg / l)	10	20	30	50	60	80
Rate (mg/l-h)	5	7·5	10	12·5	13·7	15

90	110	130	140	150
15	12·5	9·5	7·5	5·7

a) Identify the type of inhibition.

b) Determine the constants V_m , K_m , K_{si} .