

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.

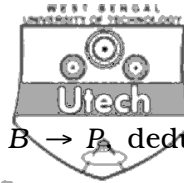
GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 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 $T_C = 647.3\text{ K}$, $P_C = 221.2\text{ Bar}$. Calculate the acentric factor of water.
6. A vessel contains 6 m^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 : $R = 0.287\text{ kJ/kg} \cdot \text{K}$.

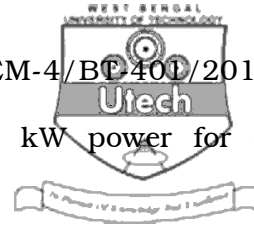
GROUP – C

(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 $T = 300\text{ K}$ and $P = 1.0133\text{ bar}$ to $T = 800\text{ K}$ and $P = 50\text{ bar}$.

Given for N_2 : $C_p / R = 3.280 + 0.593 \times 10^{-3} T$ 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

$\ln P^{\text{sat}}/K P_a = A - [B/(T + C)]$, 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 $x_1 = 0.33$ and $T = 373\text{K}$

- i) y_1 (the vapour composition)
- ii) P (bubble point pressure)



- b) A liquid mixture of cyclohexane (1)/Phenol (2) for which $x_1 = 0.6$ is in equilibrium with its vapour at 417K. Determine the equilibrium pressure, P and vapour composition (y_1) from the following information :

$$\ln y_1 = Ax_2^2 \text{ and } \ln y_2 = Ax_1^2 \text{ and}$$

at 417K, $P_1^{sat} = 75.20$ kPa, and $P_2^{sat} = 31.66$ kPa. The system forms an azeotrope at 417K for $x_1^{az} = y_1^{az} = 0.294$. 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 glycylglycine.

[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 : $C_{p_{H_2O}} = 4.2 \text{ kJ/kg} \cdot \text{K}$.
