7. At room temperature sucrose is hydrolyzed by the catalytic action of the enzyme sucrase as follows: sucrose + sucrase → products + sucrase
Starting with a sucrose concentration C_{A0} = 1mM and enzyme concentration C_{E0} = 0.01mM, the following kinetic data are obtained in a batch reactor.

C_A, mM	0.84	0.68	0.53	0.38	0.27	0.16	0.09	0.04	0.018	0.006	0.0025
t, h	1	2	3	4	5	6	7	8	9	10	11

Determine whether these data can be reasonably fitted by the following kinetic equation:

$$-r_A = \frac{k_2 . C_{E0} . C_A}{C_A + C_M},$$

where k_2 and C_M are kinetic constants. If the fit is reasonable, find the value of k_2 and C_M.

12

Group – E

8. Enzyme E catalyzes the decomposition of substrate S. To see whether substance B acts as inhibitor we make two kinetic runs in a batch reactor, one with B present, the other without B. From the data recorded below
(i) find a rate equation to represent the decomposition of S.
(ii) what is the role of B in this decomposition?
(iii) suggest a mechanism for the reaction.
Run 1: S_0=600mol / m^3, E_0= 8gm / m^3, no B present

S, moL/m^3	350	160	40	10
t, h	1	2	3	4

Run 2: S_0 = 800mol / m^3, E_0 = 8 gm / m^3, C_B = C_{B0} = 100 mol / m^3

4 + 4 + 4 = 12

9. (a) Derive a kinetic equation for non-competitive inhibition

(b) The following data were obtained for an enzyme catalyzed reaction. Determine V_{max} and K_m' by inspection. Additionally, plot the data using Eadie-Hofstee method and determine these constants graphically. Explain the discrepancy between the corresponding results. The initial rate data for the enzyme catalyzed reaction are as follows:

[S], µmol/L	500	200	60	40	30	20	16	10	8
v, mol/L.min	125	125	121	111	96.5	62.5	42.7	13.9	7.5

4 + 8 = 12

B.TECH/BT/4TH SEM/BIOT 2201/2017
THERMODYNAMICS & KINETICS
(BIOT 2201)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The change in internal energy of a closed system during a certain reversible process equals the net heat transferred, provided the process is
(a) isothermal (b) isobaric (c) isochoric (d) isenthalpic.

(ii) A reversible heat engine operating between two reservoirs of heat at temperature of 600K and 300K respectively, absorbs 300 kJ/s of heat and rejects Q_2 of heat to the sink
(a) Q_2 = 75 kJ / s (b) Q_2 = 100 kJ / s
(c) Q_2 = 150 kJ/ s (d) Q_2 = 200 kJ/ s

(iii) An elementary reaction has the kinetic equation – rA = $kCA^{2.5}CB^{-2.5}$. What is the order of reaction?
(a) 0 (b) 2.5 (c) 5 (d) none of these.

(iv) The Gibbs potential is an extensive property that depends on
(a) pressure only (b) temperature only
(c) number of moles of species in the system (d) all of the above.

(v) For the enzyme substrate reaction, the rate of disappearance of substrate is given by $-r_A = \frac{k[A][E_0]}{M+[A]}$, mol/$m^3$.s. What are the units of the k and M?
(a) s^{-1}, mol /m^3 (b) mol/m^3.s, mol /m^3 (c) mol/L, s^{-1} (d) none.

(vi) A batch reactor is a reactor
(a) at steady state
(b) where composition changes with location and time
(c) at an unsteady state
(d) none of these.

(vii) Milk is pastuerized if it is heated to 63°C for 30min, but if it is heated to 74°C it only needs 15s for the same result. How much slower the process is at 63°C than at 74°C?(E=422kJ/mol, R=8.314J/mol.K)
(a) 2 times (b) 120 times (c) 0.008 times (d) 0.5 times.

(viii) Reactions with order n<1
(a) can go to completion within a finite time
(b) never go to completion within a finite time
(c) do not have any limiting reactant
(d) none of the above.

(ix) Inhibitors that are substrate analogues, inhibit an enzyme substrate reaction
(a) competitively (b) non-competitively
(c) uncompetitively (d) none of the above.

(x) Rate of a reaction is a function of
(a) reaction time (b) concentration, reaction time
(c) concentration, temperature (d) temperature.

Group – B

2. (a) Draw the PT diagram for a pure substance.

(b) Prove that a heat pump is more efficient than a refrigerator, operating between two heat reservoirs with temperatures T_H and T_C respectively.

(c) A heat engine, a heat pump and a refrigerator receive 500 KJ of heat each. But they reject 250 kJ, 600 kJ and 700 kJ of heat, respectively. Determine (i) the efficiency of the heat engine (ii) the COP of the heat pump (iii) the COP of the refrigerator.

4 + 2 + 6 = 12

3. Binary system acetonitrile(1) / nitromethane (2) conforms closely to Raoult's law. Vapor pressures for the pure species are given by the following Antoine equations

$$\ln P_1^{sat} / kPa = 14.2724 - \frac{2945.47}{T - 49.15}$$

$$\ln P_2^{sat} / kPa = 14.2043 - \frac{2972.64}{T - 64.15}$$

Prepare a graph showing P vs. x_1 and P vs. y_1 for a temperature of 75°C (348.15 K).

12

Group – C

4. The equilibrium constant of temperature induced reversible denaturation of the protein chymotrypsinogen:

Native state (N) ⇌ Denatured state (D); $K_{eq} = \frac{[D]}{[N]}$

has been measured over a range of p_H and temperature. The experimental data are as follows:

T(K)	324.4	326.1	327.5	329.0	330.7	332.0	333.8
K_{eq}	0.041	0.12	0.27	0.68	1.9	5.0	21

What is the value of enthalpy change for the biochemical process at 54.5°C?

12

5. (a) How the group transfer potentials quantify the reactivity of functional groups?

(b) What are the complex equilibria involved in ATP hydrolysis?

6 + 6 = 12

Group – D

6. (a) A 10 minute experimental run shows that 75% of liquid reactant is converted to product by a ½ - order rate. What would be the fraction converted in a one-hour run?

(b) In the mid-nineteenth century the entomologist Henri Fabre noted that French ants busily bustled about their business on hot days but were rather sluggish on cool days. Checking his results with Oregon ants, I find

Running speed, m/h	150	160	230	295	370
Temperature, °C	13	16	22	24	28

What activation energy represents this change in bustliness?

4 + 8 = 12