

**THERMODYNAMICS & KINETICS  
(BTC2102)**

**Time Allotted : 2½ hrs**

**Full Marks : 60**

*Figures out of the right margin indicate full marks.*

*Candidates are required to answer Group A and  
any 4 (four) from Group B to E, taking one from each group.*

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

**Group – A**

1. Answer any twelve:

**12 × 1 = 12**

*Choose the correct alternative for the following*

- (i) Carnot engine has an efficiency of 50% when its source is at a temperature of 327°C. The temperature of the sink is  
(a) 27°C                      (b) 15°C                      (c) 100°C                      (d) 200°C
- (ii) 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
- (iii) Which of the following best characterizes the free energy change  $\Delta G$  for an endothermic reaction under physiological conditions?  
(a) The sign of  $\Delta G$  is positive  
(b) The sign of  $\Delta G$  is negative  
(c) The sign of  $\Delta G$  cannot be determined without knowing more information  
(d)  $\Delta G$  is zero
- (iv) What is the significance of triple point in phase diagram?  
(a) It represents highest temperature in the system.  
(b) It is the point where all phases coexists.  
(c) It marks the lowest pressure at which a gas phase can exist.  
(d) It is unrelated to the equilibrium condition.
- (v) Find the correct statement for a solution of two components A and B showing positive deviation from ideal solution behaviour  
(a) Intermolecular attractive force between A-A and B-B are stronger than those between A-B  
(b) Intermolecular attractive force between A-A and B-B are weaker than those between A-B  
(c)  $\Delta_{\text{mix}} H = 0$  at constant T and P  
(d)  $\Delta_{\text{mix}} V = 0$  at constant T and P

- (vi) Conversion of a reactant is independent of initial concentration of the reactant for  
 (a) First order reaction (b) Second order reaction  
 (c) Half order reaction (d) Zero order reaction
- (vii) The relationship between rate constant and temperature is given by  
 (a) Raoult's law (b) Arrhenius' law  
 (c) Henry's law (d) Boyle's law.
- (viii) 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
- (ix) Higher value of Michaelis constant signifies  
 (a) increased substrate affinity of the enzyme  
 (b) reduced substrate affinity of the enzyme  
 (c) decreased enzyme reaction rate  
 (d) none of the above.
- (x)  $K_m$  and  $V_m$  both are changed in value in presence of inhibitor for  
 (a) Competitive inhibition (b) Uncompetitive inhibition  
 (c) Non-competitive inhibition (d) All the above.

*Fill in the blanks with the correct word*

- (xi) Polytropic process represented by the equation \_\_\_\_\_
- (xii) The first law of thermodynamics is conservation of \_\_\_\_\_.
- (xiii) Reactions that go into completion within a finite time are of order \_\_\_\_\_.
- (xiv) First order reaction is characterized by conversion ( $X_A$ ) independent of \_\_\_\_\_.
- (xv) The point of intersection of the straight line for inhibition  $>0$ , the straight line for inhibition  $=0$  and the y-axis is \_\_\_\_\_

### Group - B

2. (a) A spherical balloon of diameter 0.5m contain a gas at 2 bar and 300K. The gas is heated and the balloon is allowed to expand. The pressure inside the balloon varies linearly with diameter. What will be the work done by the gas when the pressure inside the balloon reached to 10 bar? [[CO1](Calculate/IOCQ)]
- (b) State 1<sup>st</sup> law of thermodynamics. [[CO1](Remember/LOCQ)]
- 10 + 2 = 12**
3. (a) Difference between heat engine and heat pump. [[CO2](Analyse/IOCQ)]
- (b) Briefly explain the steps of a refrigeration cycle with diagram. [[CO2](Remember/IOCQ)]
- 5 + 7 = 12**

### Group - C

4. (a) Derive Gibbs Duhem relation for multicomponent system. [[CO3](Analyse/IOCQ)]  
 (b) State Raoult's law for ideal solution. [[CO3](Remember/LOCQ)]  
 (c) A mixture of ethanol and water liquid is in equilibrium with ethanol-water vapour at certain temperature and pressure. If the change in number of moles of ethanol is 0.4 and water is 0.6 and chemical potential of ethanol is -52.5 J/mol, find the chemical potential of water. [[CO3](Apply/IOCQ)]  
**6 + 3 + 3 = 12**
5. (a) Write van-der -Walls equation and explain significance of each term in it. State the applicability of the equation? [[CO3](Analyse/HOCQ)]  
 (b) Explain why a non ideal solution show positive deviation from ideality. Give two examples of such solution. [[CO3](Remember/LOCQ)]  
**(6 + 2) + (2 + 2) = 12**

### Group - D

6. (a) The maximum allowable temperature for a reactor is 800K. At present our operating set point is 780K, the 20K margin of safety to account for fluctuating feed, sluggish controls etc. Now with a more sophisticated control system we would be able to raise our set point to 792K with the same margin of safety that we now have. By how much can the reaction rate, be raised by this change if the reaction taking place in the reactor has activation energy of 175kJ/mol? [[CO4](Understand/LOCQ)]  
 (b) Derive a kinetic equation for a second order reaction. [[CO4](Understand/LOCQ)]  
**7 + 5 = 12**
7. (a) Derive the general rate equation for n<sup>th</sup> order reaction. [[CO4](Remember/LOCQ)]  
 (b) The pyrolysis of ethane proceeds with an activation energy of about 300KJ/mol. How much faster is the decomposition at 650°C than at 500°C? [[CO4](Calculate/IOCQ)]  
**5 + 7 = 12**

### Group - E

8. Decarboxylation of glyoxalate(S) by mitochondria is inhibited by malonate(I). Using the following data obtained in batch experiments, determine the following:

S, mM		0.25	0.33	0.4	0.5	0.6	0.75	1.00
V, mM/h	I=0	1.02	1.39	1.67	1.89	2.08	2.44	2.5
V, mM/h	I=1.26mM	0.73	0.87	1.09	1.3	1.41	1.82	2.17

- (i) What type of inhibition is this?  
 (ii) Determine the constants  $V_{max}$ ,  $K_m'$  and  $K_i$ .

[[CO6](Analyse/IOCQ)]  
**[3 + (3 + 3 + 3)] = 12**

9. (a) Derive Briggs and Haldane equation for enzyme substrate reaction. *[[CO5)(Analyse/HOCQ)]*
- (b) Graphically differentiate among the different types of inhibition reactions. *[[CO6)(Differentiate/IOCQ)]*
- 6 + 6 = 12**
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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	27.08	58.33	14.58