

Syllabus template

Semester: 1	
Course: Multi Dis-1	
Paper Title: Biological Thermodynamics and Kinetics	
Paper code: M1BT230111T	Credits: 3
Hours/week: 3	
Category: Core/MDC/SEC/VAC: MDC	
Theory / Practical / Composite: Theory	
No of Modules: 1	
Course Overview:	
<p>1. Understanding fundamental laws of thermodynamics and their application to living systems.</p> <p>2. Acquiring information about Chemical Bonding applicable to inorganic molecules and biological macromolecules.</p> <p>3. Understanding the basic principles of chemical kinetics that include the rates of chemical reactions, the factors affecting these rates (concentration, temperature, pressure, catalysts), and the specific mechanisms or steps by which reactants transform into products. A brief overview of enzyme kinetics, which is part and parcel of Biotechnology.</p>	
Course Outcome:	
<p>1. Remember (i) the Principles of first and second law thermodynamics and its importance in biological system, Carnot cycle and refrigeration, double salts and complex salts, Werner's theory of co-ordination, ligand and its classifications, coordination number, chelate complexes.</p> <p>(ii) The Definitions of reaction rates, rate constants, order of reaction, molecularity, activation energy.</p>	
<p>2. Understand (i) reversible and irreversible processes and work done, isothermal and adiabatic processes, enthalpy, heat capacities, entropy change during isothermal mixing of ideal gases, isomerism in respect of co-ordination number 4 and 6, stability constants of co-ordination complexes.</p> <p>(ii) Theories of Collision Theory, transition state theory, Arrhenius Equation components.</p>	
<p>3. Apply (i) thermochemistry in physicochemical and biochemical reactions, entropy change of systems and surroundings for various processes, co-ordination compounds in industry, chelation therapy.</p> <p>(ii) Calculate Reaction rates, rate constants, order of chemical reactions, half-lives and concentrations at specific times using integrated rate laws.</p>	
<p>4. Analyze (i) Gibbs Helmholtz equations and its applications, Clausius-Clapeyron equation and phase transition, equilibrium constant and standard free energy change, entropy and unavailable work, spontaneity and equilibrium, Valence Bond Theory and its drawbacks, spectrochemical series.</p> <p>(ii) How temperature, concentration, surface area, and catalysts affect rates of chemical reactions. Interpret potential energy diagrams (exothermic vs. endothermic, role of catalysts).</p>	
<p>5. Evaluate (i) chemical potential, Donnan equilibrium, activity and activity coefficient, splitting of d^n configurations in octahedral and tetrahedral fields, Crystal Field Stabilisation Energy (CFSE) in weak and strong fields.</p>	

(ii) Different reaction mechanisms, including Michaelis mention kinetics of enzymes and application of steady state theory.

6. Create (i) a concept of thermodynamic requirements of chemical and biochemical reactions, a comprehensive overview of square planar coordination and a concept of qualitative aspect of Molecular Orbital Theory.

(ii) a concept on how to analyze experimental data to interpret chemical reactions.

SYLLABUS

UNIT/Module	CONTENT	HOURS or NUMBER OF CLASSES	CO Mapping	COGNITIVE LEVEL
UNIT I to UNIT III	<p>SECTION-1: Unit I: Principles of Thermodynamics and Applications in Biology: Importance and scope of thermodynamics, Systems and surroundings, Types of systems (closed, isolated and open), Extensive and intensive properties, State and path functions, Steady state and equilibrium state. First law of thermodynamics: Internal energy, Reversible and irreversible processes and work done, Isothermal and adiabatic processes, Enthalpy, Heat capacities, Thermochemistry-enthalpy changes in physicochemical and biochemical reactions, Kirchoff's law. Second law of Thermodynamics: Carnot cycle and refrigeration, Physical concept of entropy, Entropy and irreversibility, Entropy change of systems and surroundings for various processes, Entropy change during isothermal mixing of ideal gases, Entropy and unavailable work, Helmholtz free energy and Gibbs free energy, Spontaneity and equilibrium, Gibbs Helmholtz equations and</p>	3 classes per week	CO1-CO6	K1-K6

	<p>applications, Clausius-Clapeyron equation and phase transition, equilibrium constant and standard free energy change, Coupled reactions, Chemical potential, Partial molar quantities, Donnan equilibrium, Concept of activity and activity coefficient, Fugacity, Thermodynamic requirements of chemical and biochemical reactions.</p> <p>Unit II: Chemical Bonding: Co-ordinate bonding and co-ordination compounds: Lewis acid base adducts, Double salts and complex salts, Werner's theory of co-ordination, Ligand and its classifications, Coordination number, Chelate complexes, Inner metallic complexes, Chelate effect, Applications of co-ordination compounds (analytical application, industrial application, chelation therapy), IUPAC nomenclature, Isomerism in respect of co-ordination number 4 and 6, Determination of configurations of cis- and trans-isomers by chemical methods, Stability constants of co-ordination complexes. Structure and bonding in co-ordination compounds: Valence Bond Theory and its drawbacks, Crystal Field Theory- splitting of d^n configurations in octahedral and tetrahedral fields, Crystal Field Stabilisation Energy (CFSE) in weak and strong fields, Pairing energy, Factors affecting the magnitude of $10Dq$, Spectrochemical series, Tetragonal distortion</p>			
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	<p>of octahedral complexes, Jahn-Teller theorem, Square planar coordination, Qualitative aspect of Molecular Orbital Theory- σ- and π-bonding in octahedral complexes.</p> <p>SECTION-2: Unit III: Chemical Kinetics and applications in Biology: Concepts of rate, rate constant, order and molecularity of a reaction, Rate equations and rate constants for 1st, 2nd and 3rd order reactions, Pseudo unimolecular reaction, Half value period and its significance, Rate determining step, Zero and fractional orders, Steady state approximations, Overview of collision and Transition state Theories, Kinetically controlled and thermodynamically controlled reactions, Temperature dependence of chemical reactions, Arrhenius equation, Activation energy, Enzyme kinetics, Catalysis-homogeneous and heterogeneous, Enzyme catalysis, Michelis- Menten equation.</p>			
Text Books				
1. G.W. Castellan, Physical Chemistry, Narosa, 4th edition, 2004.				
2. P. C. Rakshit, Physical Chemistry, Sarat Book House, Revised & enlarged 7th edition, 2014.				
3. R. P. Sarkar, General and Inorganic Chemistry (Part-II), New Central Book Agency (P) Limited, 3rd Revised edition, 2011.				
4. J. D. Lee, Concise Inorganic Chemistry, ELBS, 1991.				
5. Lehninger, Principles of Biochemistry.				
<p>Evaluation: Theory (50 marks) CIA- 13, Attendance – 02, Semester Exam- 35</p>				

Paper Structure for Theory Semester Exam:**SECTION-1:**

Any two from three questions with subparts: $5 \times 2 = 10$ marks.

Any two from three questions with subparts: $7.5 \times 2 = 15$ marks.

[No sub-part will be of more than 5 marks]

SECTION-2: Any two from three questions with subparts: $5 \times 2 = 10$ marks.

Course outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive levels
CO1	Remember (i) the Principles of first and second law thermodynamics and its importance in biological system, Carnot cycle and refrigeration, double salts and complex salts, Werner's theory of co-ordination, ligand and its classifications, coordination number, chelate complexes. (ii) The Definitions of reaction rates, rate constants, order of reaction, molecularity, activation energy.	K1
CO2	Understand (i) reversible and irreversible processes and work done, isothermal and adiabatic processes, enthalpy, heat capacities, entropy change during isothermal mixing of ideal gases, isomerism in respect of co-ordination number 4 and 6, stability constants of co-ordination complexes. (ii) Theories of Collision Theory, transition state theory, Arrhenius Equation components.	K2
CO3	Apply (i) thermochemistry in physicochemical and biochemical reactions, entropy change of systems and surroundings for various processes, co-ordination compounds in industry, chelation therapy. (ii) Calculate Reaction rates, rate constants, order of chemical reactions, half-lives and concentrations at specific times using integrated rate laws.	K3
CO4	Analyze (i) Gibbs Helmholtz equations and its applications, Clausius-Clapeyron equation and phase transition, equilibrium constant and standard free energy change, entropy and unavailable work, spontaneity and equilibrium, Valence Bond Theory and its drawbacks, spectrochemical series. (ii) How temperature, concentration, surface area, and catalysts affect rates of chemical reactions. Interpret potential energy diagrams (exothermic vs. endothermic, role of catalysts).	K4
CO5	Evaluate (i) chemical potential, Donnan equilibrium, activity and activity coefficient, splitting of d^n configurations in octahedral and tetrahedral fields, Crystal Field Stabilisation Energy (CFSE) in weak and strong fields. (ii) Different reaction mechanisms, including Michaelis mention kinetics of enzymes and application of steady state theory.	K5
CO6	Create (i) a concept of thermodynamic requirements of chemical and biochemical reactions, a comprehensive	K6

	overview of square planar coordination and a concept of qualitative aspect of Molecular Orbital Theory. (ii) a concept on how to analyze experimental data to interpret chemical reactions.	
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