Lesson Plan (2020-2021)

Subject: Chemistry Honours

Teacher: Dr Sanjukta Mukhopadhyay

Mode of teaching: Online

UG 5th Semester(up to Examination Study Leave)

Course Title: Inorganic Materials of Industrial Importance

Course Code: BCEMDSHC2

(Three classes each of one hour per week is available in Routine)

Relevant texts and videos will be uploaded after each lecture. One interactive session is planned after each class.

If any Problem (mostly network problem) remedial classes will be arranged.

Topics from Syllabus

Cements (4 Lectures)

Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

Alloys (6 Lectures)

Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (Ar and heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

Batteries (8 Lectures)

Primary and **secondary batteries, battery components and their role, Characteristics** of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

Plan

Lecture 1 : Cement Composition and types

Lecture 2 : Role of ingredients

Lecture 3 : Manufacturing process

Lecture 4 : Setting of cement

Online Examination of 20 marks for 1 hour for Internal Assessment. (Date to be notified as per convenience)

Lecture 5 : Definition and Classification of Alloys

Lecture 6 : Roles of elements present in Alloys

Lecture 7 : Manufacture of Steel

Lecture 8 : Continued..

Lecture 9 : Composition of Steel

Lecture 10 : Properties of different types of steels

Internal Assessment

Lecture 11 : Battery Chemistry and Arrangement

Lecture 12 : Types with Internal Structures

Lecture 13 : Role of required components for various types of Batteries.

Lecture 14 : Pd Acid Battery

Lecture 15 : Li-Battery and Solid state electrolyte Battery

Lecture 16 : Fuel Cell

Lecture 17 : Polymer cell

Lecture 18 : Solar cell

Internal Assessment

Course Title: Advanced Physical Chemistry

Course Code: BCEMDSHC1

Statistical Thermodynamics (12L)

1. Configuration: Macrostates, microstates and configuration; calculation with harmonic oscillator; variation of W with E; equilibrium configuration
2. Boltzmann distribution: Thermodynamic probability, entropy and probability, Boltzmann distribution formula (with derivation); Applications to barometric distribution
3. Partition function: molecular partition function and thermodynamic properties, Maxwell's speed distribution; Gibbs' paradox

Plan

Lecture 1 : Introduction with specific interaction, Concept of Phase Space, some basic concepts of mathematics eg Probability and statistics.

Lecture 2 : Different terms and their significance and density of states

Lecture 3 : Statistical postulates and Calculations of number of microstates for various systems and related problems

Lecture 4 : Derivation of Maxwell – Boltzmann Distribution law.

Lecture 5 : Degeneracy with examples

Lecture 6 : Entropy, W and randomness

Lecture 7 : Evaluation of constants in Boltzmann Distribution Formula

Lecture 8 : Barometric distribution and related numerical problems.

Lecture 9 : Partition Function, Different expressions

Lecture 10 : Harmonic Oscillator and Statistical Thermodynamics

Lecture 11 : Calculation of thermodynamic properties in terms of molecular partition function

Lecture 12 : Maxwell speed distribution derivation and Equipartition principle and other problems.

Extra class

Lecture 13 : Gibbs Paradox and its origin

Lecture 14 : Resolution/Settlement for Gibbs Paradox and Sachur-Tetrode Equation

Lecture 15 : Correction for E, H, G and A.

Lecture 17 : Statistical method of averaging and its applications.

Internal Assessment

Third law of thermodynamics and properties near 0K (15L)

1. Specific heat of solid: Coefficient of thermal expansion, thermal compressibility of solids; Dulong –Petit's law; Equipartition theorem and heat capacities; Perfect Crystal model, Einstein's theory – derivation from partition function, limitations; Debye's T3 law – analysis at the two extremes
2. 3rd law: Absolute entropy, Plank's law, Calculation of entropy, Nernst heat theorem
3. Adiabatic demagnetization: Approach to zero Kelvin.

Plan

Lecture 1 : Nernst Heat Theorem and its applications and limitations

Lecture 2 : Arrival at the third law in the context of S, C_v etc.

Lecture 3 : Different statements of third law and modifications

Lecture 4 : Absolute Entropy, related graphs and calculations

Lecture 5 : Apparent Limitations of third law, residual entropies of various systems

Lecture 6 : Approach to zero Kelvin : many ways qualitative ideas, principle of Adiabatic Demagnetization

Lecture 7 : Adiabatic Demagnetization continued…

Lecture 8 : Perfect Crystal Model of Solids, Dulong-Petit law and its agreement with Classical Mechanics

Lecture 9 : Failure of Dulong-Petit law in some cases, Cause and approach towards Quantum Mechanics

Lecture 10 : Planck's Quantum Hypothesis and its application to derive Einstein's Formula.

Lecture 11 : Derivation of Einstein Formula using Statistical Thermodynamics, Explanation of the Atomic heat curves,

Lecture 12 : Limitations of Einstein's Graph, Cause, Approach towards Debye formula

Lecture 13 : Derivation of Debye T^3 law and better explanation of curves.

Lecture 14 : Thermal Expansion and Compressibility of Solids.

Lecture 15 : Derivation of their expressions in 1D, 2D and 3D systems and interrelations

UG 3rd Semester (up to Examination Study Leave)

Course Title : Physical Chemistry II

Course Code : BCEMCCHC301

(Two classes per week are available in routine)

Applications of Thermodynamics – I (24L)

1. Second Law: Need for a Second law; statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle; Physical concept of Entropy; Carnot engine and refrigerator; Kelvin – Planck and Clausius statements and equivalence of the two statements with entropic formulation; Carnot's theorem; Values of §dQ/T and Clausius inequality; Entropy change of systems and surroundings for various processes and transformations; Entropy and unavailable work; Auxiliary state functions (G and A) and their variation with T, P and V. Criteria for spontaneity and equilibrium.
2. Thermodynamic relations: Maxwell's relations; Gibbs- Helmholtz equation, Joule-Thomson experiment and its consequences; inversion temperature; Joule-Thomson coefficient for a van der Waals gas; General heat capacity relations

3. Partial properties and Chemical potential: Chemical potential and activity, partial molar quantities, relation between Chemical potential and Gibb's free energy and other thermodynamic state functions; variation of Chemical potential (μ) with temperature and pressure; Gibbs-Duhem equation; fugacity and fugacity coefficient; Variation of thermodynamic functions for systems with variable composition; Equations of states for these systems, Change in G, S H and V during mixing for binary solutions
4. Chemical Equilibrium: Thermodynamic conditions for equilibrium, degree of advancement; van't Hoff's reaction isotherm (deduction from chemical potential); Variation of free energy with degree of advancement; Equilibrium constant and standard Gibbs free energy change; Definitions of KP, KC and KX; van't Hoff's reaction isobar and isochore from different standard states; Shifting of equilibrium due to change in external parameters e.g. temperature and pressure; variation of equilibrium constant with addition to inert gas; Le Chatelier's principle and its derivation
5. Dissociation of weak electrolyte. Solubility equilibrium
6. Nernst's distribution law; Application- (finding out Keq using Nernst dist law for KI+I2 = KI3 and dimerization of benzene

Plan

Lecture 1 : Need for the second law

Lecture 2 : Different statements and their equivalence

Lecture 3 : Carnot cycle in P-V diagram, Calculation of work and efficiency

Lecture 4 : Refrigerator and its coefficient of performance, Heat pump

Lecture 5 : Numerical problems

Lecture 6 : Carnot theorem and its proof

Lecture 7 : Thermodynamic scale of temperature

Lecture 8 : Introduction of Entropy, Its properties

Lecture 9 : Entropy changes in various processes, physical concept of entropy

Lecture 10 : Carnot cycle in T-S diagram

Lecture 11 : Entropy and available work, Clausius inequality

Lecture 12 : Numerical problems

Lecture 13 : Free energy functions and their dependence on parameters of a system

Lecture 14 : Gibbs-Helmholtz equation, its various forms, thermodynamic equation of states

Lecture 15 : Concept of fugacity and activity coefficient for real gases

Lecture 16 : ΔG_{mix}, Numerical calculations, Maxwell Relations

Lecture 17 : Condition of spontaneity and equilibrium

Lecture 18 : Joule-Thomson Experiment and calculations with μ for an ideal gas

Lecture 19 : Inversion temperature, Calculations for van der Waals' gas

Lecture 20 : Partial molar quantities, their determination and Chemical potential

Lecture 21 : Gibbs-Duhem Relations and applications

Lecture 22 : Chemical potential with activity and fugacity

Lecture 23 : Discussion on thermodynamic properties and their changes in systems of variable composition specially in Binary solutions

Lecture 24 : Dissociation equilibrium of weak electrolytes, different types

Extra class

Lecture 25 : Solubility Equilibrium

Lecture 26 : Law of Mass action and arrival of different types of equilibrium constants, their determinations and interrelations

Lecture 27 : Calculations of equilibrium constants of different kinds of chemical equilibria, numerical problems

Lecture 28 : ΔG and degree of advancement of a reaction, ΔG and K relations(van't Hoff isotherm, Isobar, Isochore), integration of van't Hoff equation and its applications

Lecture 29 : Influence of T, P, addition of inert gas etc. on equilibrium, Le-Chatelier's principle, its thermodynamic derivation

Lecture 30 : Standard states and related calculations

Internal Assessment

UG 1st Semester (up to Examination Study Leave)

Course Title: Physical Chemistry I

Course code: BCEMCCHC102

(Two classes per week are available in routine)

Chemical Thermodynamics (18 L)

1. Zeroth and 1st law of Thermodynamics: Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics; Concept of heat, work, internal energy and statement of first law; enthalpy, H; relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions; Joule's experiment and its consequence
2. Thermochemistry: Standard states; Heats of reaction; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; Laws of thermochemistry; bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchhoff's equations and effect of pressure on enthalpy of reactions; Adiabatic flame temperature; explosion temperature

Plan

Lecture 1 : Basic Mathematics required for studying thermodynamics

Lecture 2 : Zeroth law, introduction to first law of thermodynamics

Lecture 3 : Heat, work and energy, nature of their differentials, different useful terms and processes

Lecture 4 : Calculation of work done in various processes for ideal, real systems and van der Waals' gases

Lecture 5 : Joule's Experiment and consequences

Lecture 6 : Enthalpy, ΔH and ΔU, $C_p - C_v$, Numerical problems

Lecture 7 : Kirchhoff's Equations and related numerical problems

Lecture 8 : Adiabatic Process

Lecture 9 : Numerical problems

Lecture 10 : Introduction to Thermochemistry

Lecture 11 : Laws of Thermochemistry and their applications

Lecture 12 : Different kinds of ΔH and applications

Lecture 13 : Numerical problems

Lecture 14 : Bond energy and Dissociation energy and resonance energy

Lecture 15 : Adiabatic flame temperature and Explosion temperature

Internal Assessment

UG 6th Semester(up to Examination Study Leave)

Course Title: Analytical Methods in Chemistry

Course Code: BCEMDSHC4

(Two classes per week are available in routine)

Qualitative and quantitative aspects of analysis (10L)

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution of indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

Plan

Lecture 1 : Sampling of solids, liquids and gases

Lecture 2 : Treatment of Analytical data

Lecture 3 : Different types of errors

Lecture 4 : Accuracy and Precision, calculations, Numerical problems

Lecture 5 : Indeterminate errors

Lecture 6 : Analysis of data, different tests

Lecture 7 : Numerical problems

Lecture 8 : Rejection of data and confidence intervals

Internal Assessment

Thermal methods of analysis (5L)

Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

Plan

Lecture 1 : Introduction to Thermogravimetry

Lecture 2 : Basic principles of instrumentation

Lecture 3 : Different techniques of estimations elementary idea

Lecture 4 : Techniques for quantitative estimation of Ca and Mg from their mixture.

Lecture 5 : Numerical problems

Internal Assessment

Electroanalytical methods (10L)

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

Role of computers in instrumental methods of analysis.

Plan

Lecture 1 : Types of Electroanalytical methods

Lecture 2 : pH- metry

Lecture 3 : Conductometry

Lecture 4 : Potentiometry

Lecture 5 : Graphs and Equivalence points of different kinds of titrations

Lecture 6 : Determination of pK_a values of weak acids

Lecture 7 : Discussion about problems

Lecture 8 : Role of computers in instrumental methods of analysis.

Internal Assessment

UG 4^{th} Semester(up to Examination Study Leave)

Course Title: Physical Chemistry III

Course Code: BCEMCCHC401

(Two classes per week are available in routine)

Nanomaterials: Importance of nano-systems; confinement and dimensionality with example (dot, wire etc.); Different approaches for preparation of nanomaterials.

Plan

Lecture 1 : Introduction to Nanoscience

Lecture 2 : Different Nano systems and their applications

Lecture 3 : Quantum Confinement

Lecture 4 : Preparation of Nanomaterials

Internal Assessment

Applications of Thermodynamics – II

1. Binary mixture: Chemical potential of individual components. Thermodynamic parameters of mixing ideal solution; Colligative properties: Vapour pressure of solution; Ideal solutions, ideally diluted solutions and colligative properties; Raoult's law; Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) Osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution; Abnormal colligative properties
2. Binary solutions: Ideal solution; Positive and negative deviations from ideal behaviour; Principle of fractional distillation; Duhem-Margules equation; Henry's law; Konowaloff's rule; Azeotropic solution; Liquid-liquid phase diagram using phenol- water system; Solid-liquid phase diagram; Eutectic mixture

   Plan

Lecture 1 : Chemical potential of components in a binary mixture of gases, liquids in terms of pressure, concentration, activity and fugacity

Lecture 2 : ΔG_{mix}, ΔH_{mix}, ΔS_{mix}, ΔV_{mix} in an ideal solution

Lecture 3 : Ideal solution, Ideally diluted solution and real solution

Lecture 4 : Colligative Properties

Lecture 5 : Raoult's law and related graphs

Lecture 6 : Thermodynamic derivation of colligative properties

Lecture 7 : continued…..

Lecture 8 : Applications of colligative properties

Lecture 9 : Numerical problems

Lecture 10 : Abnormal Colligative Properties

Lecture 11 : Henry's law

Lecture 12 : Positive and negative deviations from Raoult's law, drawing of graphs, comparison with ideal case

Lecture 13 : Fractional distillation principles and techniques

Lecture 14 : Duhem-Margules Equation, Konowaloff's rule and derivations

Lecture 15 : Azeotropic solutions and their distillations, graphs

Lecture 16 : Liquid-Liquid phase diagram, different systems, graphs

Lecture 17 : Phenol-water system

Lecture 18 : Numerical problems

Lecture 19 : Solid mixture, thermal analysis

Lecture 20 : Solid-Liquid equilibrium, Eutectic

Internal Assessment

Applications of Thermodynamics – III

1. Electromotive Force: Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry; Chemical cells, reversible and irreversible cells with examples; Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb2O3 electrodes
2. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers; Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation)

Plan

Lecture 1 : Faraday's laws of Electrolysis

Lecture 2 : Concept of half cell and associated oxidation – reduction potential

Lecture 3 : Application of Electrolysis

Lecture 4 : Chemical cells, types and reactions inside

Lecture 5 : Discussion on problems

Lecture 6 : EMF and its measurement

Lecture 7 : Different types of electrodes and their reactions

Lecture 8 : Construction of cell using cell reaction or vice versa

Lecture 9 : Discussion on Problems

Lecture 10 : Application of EMF measurements to obtain thermodynamic parameters

Lecture 11 : Determination of pH using different types electrodes

Lecture 12 : Glass electrode

Lecture 13 : Concentration cell

Lecture 14 : Liquid Junction Potential

Lecture 15 : Application and corresponding calculations

Lecture 16 : Potentiometric Titrations

Lecture 17 : continued…

Lecture 18 : Numerical problems

Internal Assessment

UG 2^{nd} Semester(up to Examination Study Leave)

No classes available in Routine

Extra class

Inorganic chemistry and Basic principles of chemistry

Plan

Theoretical discussion on

Lecture 1 : Permanganatometry

Lecture 2 : Acid-Base reactions

Lecture 3 : Dichromatometry

Lecture 4 : Spectroscopy, nature of waves, wave nature of light

Lecture 5 : Dissociation equilibrium

Lecture 6 : Different kinds of solvents, factors affecting chemical reactions

Lecture 7 : Solubility

Lecture 8 : Idea of Buffer

Lecture 9 : Numerical Problems

Lesson Plan (2020-2021)

Subject: Chemistry Honours

Teacher: Dr. Tanushree Sen

Course Title:	**Organic Chemistry I**
Course Code:	**BCEMCCHC101**
Module Name:	**Bonding and Physical Properties**
Allotted Lectures:	**25**

L1	Introduction: Valence Bond Theory
L2	Concept of Hybridization: Background and Origin
L3	Orbital Pictures and Shapes of molecules
L4	Calculation of Formal Charge and DBE, s-cis and s-trans Geometry
L5	Electronic Displacements: Inductive Effect and Field Effect
L6	Resonance and Hyperconjugation
L7	Electromeric Effect, Bond Polarization and Polarizability
T-1	Discussion of different electronic effects upon physical and chemical properties of molecules
L8	Influence of hybridization on bond properties: (e.g. BDE, BE)
L9	Effect of covalent and non-covalent forces
L10	Dipole Moment and relative stabilities of isomeric hydrocarbons
L11	MO Theory: Qualitative idea about molecular orbitals
L12	Bonding and Antibonding interactions: idea about Frontier MOs
L13	FMO interactions, Sketch and Energy Levels of pi MOs: C=C, Conjugated Diene system

L14	Conjugated triene, Allyl and Pentadienyl system
L15	Cyclic p-orbital neutral systems
L16	3-, 4- and 5-membered charged ring systems
T-2	Sketch of Orbital pictures of different pi systems
L17	Huckel's Rule for Aromaticity
L18	Concept of Antiaromaticity and Homoaromaticity
L19	Non-aromatic molecules: discussion with examples
L20	Frost Diagram: Discrimination between aromatic, antiaromatic and non-aromatic molecules
L21	Idea about α and β: measurement of delocalization energies
R-1	Discussion on pi MOs and criteria for different types of aromaticity
T-3	Practice teaching on orbital pictures of cyclic and acyclic p orbital systems
L22	Reactive Intermediates: Concept and Classification
L23	Generation and Stability of Carbocation and Carbanions
L24	Generation and Stability of Carbon Radical and Carbenes
L25	Structure of various intermediates using orbital picture and elementary idea about their electrophilic and nucleophilic behavior
T-4	Discussion of problems related to Electronic Displacements and Aromaticity
T-5	Discussion of previous years' university questions

Subject : Physical Chemistry

Year: 2021 -2022

Semester II

Course Code : BCEMCCHC201

Course Title : Inorganic Chemistry I

Teacher: Jayanta Kumar Midya

L1	Acid-Base concept: Arrhenius concept
L2	Bronsted-Lowry's concept and Lux-Flood Concept
L3	theory of solvent system (in H2O, NH3, SO2 and HF),
L4	Remedial Class
L5	Relative strength of acids, Pauling's rules.
L6	Lewis concept
L7	Group characteristics of Lewis acids
L8	Solvent levelling and differentiating effects
L9	Remedial Class
L10 and L11	Thermodynamic acidity parameters, Drago-Wayland equation.
L12	Superacids, Gas phase acidity and proton affinity;
L13	Tutorial Class
L14	HSAB principle
L15	Acid-base equilibria in aqueous solution (Proton transfer equilibria in water)
L16	pH, buffer and Henderson equation
L17	Acid-base neutralisation curves; indicator, choice of indicators.
L18	Remedial Class

Course Code : BCEMCCHC401

Course Type: CC-8

Course Title : Physical Chemistry III

Syllabus : Applications of Thermodynamics – II (20L)

Teacher: Jayanta Kumar Midya

L1	Idea about binary mixtures
L2	Chemical potential of individual components of the mixture
L3	Thermodynamic parameters of mixing ideal solution;
L4 & L5	Vapour pressure of solution, Ideal solutions and ideally diluted solutions

L6	colligative properties and thermodynamical idea
L7	Remedial Class
L8	Raoult's law
L9	Four colligative properties [(i) relative lowering of V.P, (ii) elevation of B.P,
L10	Contd.. (iii) Depression of F.P and (iv) O.P]
L11	Abnormal colligative properties
L12	Applications in calculating molar masses of normal, dissociated and associated solutes in solution
L13	Remedial Class
L14	Introduction of Phase rule: Definitions of phase, component and degrees of freedom
L15 & L16	Derivation of Phase rule ; Definition of phase diagram (1 component)
L17 & L18	Phase diagram for water, CO2, Sulphur
L19	First order phase transition and Clapeyron equation
L20	Clausius-Clapeyron equation - derivation and use
L21	Liquid vapour equilibrium for two component systems; Phenol-water system
L22	Binary solutions and ideal solution; Positive and negative deviations
L23	Duhem-Margules equation
L24	Remedial Class
L25	Henry's law and Konowaloff's rule;
L26	Azeotropic solution; Liquid-liquid phase diagram using phenol- water system;
L27	Solid-liquid phase diagram and Eutectic mixture
L28	Principle of fractional distillation
L29	Remedial class

Semester VI

Course Code : BCEMCCHC602

Course Type: CC-14

Course Title : Physical Chemistry IV

Syllabus : Photochemistry (16L)

L1	Characteristics of electromagnetic radiation,
L2	Lambert-Beer’s law and its limitations,
L3	physical significance of absorption coefficients
L4	Laws of photochemistry
L5	Idea on quantum yield, actinometry, examples of low and high quantum yields
L6	Photochemical Processes and potential energy curves (diatomic

	molecules)
L7	Frank-Condon principle and vibrational structure of electronic spectra
L8	Bond dissociation and principle of determination of dissociation energy (ground state)
L9 and L10	Fluorescence and phosphorescence, Jablonskii diagram
L11	Kinetics of Photochemical processes
L12	Different photostationary state
L13	HI decomposition, H2-Br2 reaction and dimerisation of anthracene
L14	photosensitised reactions
L15	Role of quenching in photochemical reactions in biochemical processes
L16	Chemiluminescence
L17	Remedial/ Tutorial class