RABINDRANATH TAGORE UNIVERSITY

Department of Chemistry

PROPOSED STRUCTURE OF SYLLABUS OF SEMESTER III & SEMESTER IV OF THE FOUR YEARS UNDERGRADUATE PRORAMME (FYUGP) IN CHEMISTRY AS PER NEP 2020.

Board of Studies (BoS) Committee

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5	Dr Jayanta K Sarmah, Member	Associate Professor	Rabindranath Tagore University
6	Mrs. Shilpi Mitra *Special Invitee*	Assistant Professor	Rabindranath Tagore University

B.Sc. in Chemistry

Course Structure (Semester – III & IV)

Semester	Category of Course	Course Code	Course Title	Total Credit
III	Core-3 (Major)	MAJ-CHM-3.1	Foundation Course Chemistry-III	4
	Core-4 (Major)	MAJ-CHM-3.2	Foundation Course Chemistry-IV	4
	Minor-3	MIN-CHM-3.1	Introductory Chemistry-III	4
	GE/MD – III	MD-CHM-3.1	Pesticide Chemistry	3
	SEC - III	SEC-CHM-3.1	Industrial Chemistry	3
	AECC – III			2
			Total Credit	**20**
IV	Core-5 (Major)	MAJ-CHM-4.1	Inorganic Chemistry-I	4
	Core-6 (Major)	MAJ-CHM-4.2	Organic Chemistry-I	4
	Core-7 (Major)	MAJ-CHM-4.3	Physical Chemistry-I	4
	Minor-4	MIN-CHM-4.1	Introductory Chemistry-IV	4
	AECC – IV			2
	Summer Internship			2
			Total Credit	**20**

DETAILED SYLLABUS OF FYUGP III SEMESTER

Course Title: Foundation Course Chemistry- III

Course Code: MAJ-CHM-3.1

Total Credit: 4 (3 Credit Theory + 1 Credit Practical)

Distribution of marks: (60 T+25 P) + 15 (In-Semester)

Course objective:

The course aims to equip students with foundational chemistry knowledge, focusing on acids, bases, metallurgical principles, stereochemistry, and organic synthesis, phase equilibria, solid-state chemistry, fostering analytical and practical chemical skills.

Theory: 3 credits **Total course hour: 45 hr** **Duration of examination: 3 hr**

Unit-1: Acids and bases **(8L+ 10 marks)**

Bronsted-Lowry concept of acid-base reaction, solvated proton, relative strength of acids, types of acids-base reactions, leveling solvents, Lewis acid-base concept, classification of Lewis acids, Hard & soft acids and bases (HSAB), Pearson's concept, bonding in hard-hard and soft-soft combinations, application of (HSAB) principle, Symbiosis, theoretical basis of hardness and softness, electro negativity and hardness and softness.

Unit-2: Oxidation-Reduction and general principle of metallurgy **(7L+ 10 marks)**

Redox equation, standard electrode potential and its application to Inorganic reactions, principles involved in volumetric analysis to be carried out in class. Principles and applications of Ellingham diagram, General methods of isolation and purification of Electrolytic process and Mond's process, Zone refining.

Unit-3: Prostereoisomerism **(8L+ 10 marks)**

Prostereogenic centre, Topicity of ligands and faces, Enantiotopic and Diastereotopic atoms, groups and faces, Pro-*R* and Pro-*S* designation of enantiotopic groups and atoms, *Re* and *Si* designation of enantiotopic and diastereotopic faces.

Stability of cycloalkanes, Baeyer strain theory. Conformational analysis of cyclic systems: mono- and di-substituted cyclohexanes. Stereochemistry of fused ring systems (Decalin).

Unit-4: Chemistry of alkyl and aryl halides **(7L+10 marks)**

Alkyl Halides: Preparation from alkenes and alcohols. Nucleophilic substitution reaction and its types (SN_1, SN_2 and SN_i reactions), solvolysis, halide displacement reactions. Williamson's ether synthesis and elimination vs substitution. Aryl Halides: Preparation: from phenol, Sandmeyer & Gattermann reactions. Reactions: aromatic nucleophilic substitutions. Benzyne formation and reactions.

Unit-5: Phase Equilibrium **(9 L+ 12 marks)**

Concept of phases, components and degree of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive system; Clausius - Claperyon equation and its application to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component system with applications. Phase diagram for system of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions.

Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation.

Nernst distribution law: its derivation and applications.

Unit-6: Basic Crystallography **(6 L+ 8 marks)**

Basic law of crystallography, crystal system, crystal lattice, Miller indices and simple face centered and body centered cubic lattice, number of points in a unit cell. X-Ray diffraction study of crystals, Bragg's law, determination of crystal structure- introduction to powder and single crystal methods of structure analysis, crystal structure of NaCl and KCl, packing of crystals, closed packed structure, radius ratio.

Practical: 1 Credit **Total course hour: 30 hr** **Duration of Examination: 3 hr**

List of experiments:

1. Volumetric estimation of water of crystallization in Mohr's salt by titrating with KMnO4.
2. Volumetric estimation of Na_2CO_3 and $NaHCO_3$ present together in a mixture.
3. Detection of functional groups in organic compounds.
4. Preparation of organic compounds using classical organic reactions like nitration, bromination, acetylation, and condensation.

5. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
6. Construction of the phase diagram using cooling curves or ignition tube method:
   i. simple eutectic method,
   ii. congruently melting point
7. Distribution of acetic/benzoic acid between water and cyclohexane.
8. Study the equilibrium of at least one of the following reactions by the distribution method
   i. I_2 (aq) + I → I_2 (aq)
   ii. Cu^{2+} (aq) + nNH_3 → $Cu(NH_3)_n$

 # Expt no 1-4 are compulsory and any two from expt no 5-8

Learning outcome:

Upon completing this foundation course in Chemistry, students will be able to understand and apply key chemical concepts such as redox chemistry in metallurgical processes and strengths of acids and bases. phase equilibria, solid-state chemistry, prostereoisomerism, and the chemistry of alkyl and aryl halides. Students will gain proficiency in interpreting redox reactions in metallurgical processes, stereochemistry, phase diagrams and, crystallography. Additionally, students will develop practical skills in analysing X-ray diffraction data and synthesizing chemical compounds, preparing them for advanced studies and research in chemical sciences.

Suggested reading:

1. Physical Chemistry by Atkins & Paula

2. Principles of Physical Chemistry by Puri, Sharma & Pathania

3. A text book of Physical Chemistry by Negi & Anand

4. Inorganic Chemistry by Puri, Sharma & Kalia

5. Inorganic Chemistry by J E Huheey

6. Basic Inorganic Chemistry by Cotton and Wilkinson

7. Stereochemistry of Organic Compounds: Principles and Applications by D. Nasipuri,4th Ed., New Age International Publishers.

8. Organic Chemistry by Janice Gorzynski Smith, 2nd Ed., The McGraw Hill Com.

9. Comprehensive Practical Organic Chemistry: Qualitative Analysis by V. K. Ahluwalia and Sunita Dhingra

Course title: Foundation Course Chemistry – IV

Course Code: MAJ-CHM-3.2

Total Credit: 4 (3 credit Theory + 1 Credit Practical)

Distribution of marks: (60T+25P) + 15 (In-Semester)

Course objective:

This course aims to deepen understanding of chemistry of S, P- block elements, noble gases, chemical reactions involved in alcohols, phenols and ethers as well as chemical equilibrium, and ionic behaviour.

Theory: 3 credits **Total course hour:** 45 hr **Duration of examination:** 3 hr

Unit -1: Main group elements, Chemistry of S and P block elements (10 L+ 10 marks)

Diagonal relationship and anomalous behavior of first member of each group. Inert pair effect, Relative stability of different oxidation states. Reaction of alkali and alkaline earth metals with oxygen, hydrogen and water. Catenation and allotropy. Allotropes of carbon, phosphorous. Oxides of nitrogen, phosphorous sulphur and chlorine. Borohydrides (diborane) and carboranes, Wades rule, Interhalogen compounds, polyhalide ions and pseudohalogens. Hydrides and their classification: ionic, covalent and interstitial. Basic properties of halogens.

Unit-2: Noble gages: (5 L+ 10 marks)

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2). Molecular shapes of noble gas compound (VSEPR theory).

Unit-3: Alcohols, Phenols and Ethers (15 L + 20 marks)

Alcohols: Preparation of 1°, 2° & 3° alcohols and 1,2-diols: using Grignard reagent, ester hydrolysis, reduction of aldehydes, ketones, carboxylic acid and esters. Reactions with alkali metals, HX (Lucas test), esterification, oxidation (with PCC, alkaline $KMnO_4$, acidic

dichromate, conc. HNO_3). Oppeneauer oxidation. Diols: oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: Preparation - Cumene hydroperoxide method, from diazonium salts. Reactions - Electrophilic substitution and name reactions (Kolbe-Schmidt reaction, Riemer Tieman reaction, Lederer- Manasse reaction)

Ethers: (aliphatic and aromatic): Important methods of preparation, important reactions.

Unit-4: Chemical Equilibrium: (6 L+ 8 marks)

Criteria of thermodynamics equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamics derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p, K_c and K_x. Le Chatelier principle (quantitative treatment).

Unit-5: Ionic equilibria (9 L+ 12 marks)

Strong, moderate and weak electrolyte, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constant of mono, di and triprotic acids (exact treatment).

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body.

Practical: 1 Credit Total course hour: 30 hr Duration of Examination: 3 hr

List of experiments:

1. **Inorganic Preparation (A minimum of two experiments are to be performed):**
    a) Tetramminecopper (II) sulphate, $[Cu(NH_3)4]SO_4.H_2O$
    b) Cis and trans $K[Cr(C_2O_4)_2.(H_2O_2]$ Potassium dioxalatodiaquachromate (III)
    c) Tetramminecarbonatocobalt (III) ion
    d) Potassium tris (oxalate) ferrate (III)

2. **Chromatography of metal ions:**

Principles involved in chromatographic separation. Paper chromatographic separation of following metal ions:

a) Ni(II) and Co (II)
b) Fe(III) and Al(III)

3. **Systematic qualitative analysis of organic compounds.**
    a. Identification of functional groups in a given organic sample: Simple functional groups such as alcohols, phenols, amines, nitro, carbonyl and carboxylic acid groups.
    b. Prepare derivatives of a given organic sample containing single functional group (alcohols, phenols, amines, nitro, carbonyl and carboxylic acid groups)
4. **pH metric titration (Any one)**
    a) strong acid vs. strong base
    b) weak acid vs. strong base
5. P**reparation of buffer solutions of different pH (Any one)**
    a) Sodium acetate-acetic acid
    b) Ammonium chloride- ammonium hydroxide

Learning outcome:

Upon completing this foundation course in Chemistry, students will be adept at understanding and applying

1. inorganic compounds with emphasis on their structure, bonding, preparation and properties
2. principles of chemical and ionic equilibria, thermodynamics, and the preparation and reactions of alcohols, phenols, and ethers.
3. students will be proficient at calculating equilibrium constants, pH values, and buffer capacities, and develop clear understanding of preparation and chemical reactivity of alcohols, phenols and ethers. This knowledge will enable them to tackle advanced topics in chemistry and apply their skills in various scientific and industrial settings.

Suggested reading:

1. Physical Chemistry by Atkins & Paula

2. Principles of Physical Chemistry by Puri, Sharma & Pathania

3. A text book of Physical Chemistry by Negi & Anand

4. Inorganic Chemistry by Puri, Sharma & Kalia

5. Inorganic Chemistry by J E Huheey

6. Basic Inorganic Chemistry by Cotton and Wilkinson

7. Organic Chemistry, Vol – I, by I L Finar, PEARSON.

Title of the course: Industrial Chemistry **(SEC-3, Major)**

Course Code: SEC-CHM-3.1

Total Credit: 3 (2 credit Theory + 1 Credit Practical)

Distribution of marks: (50 T + 25 P)

Course objective: To provide understanding of materials in industrial applications, fertilizers, drugs and energy devices.

Theory: 2 credits **Total course hours: 30** **Duration of examination: 2 hr.**

Unit – 1: Industrial applications **(5L, 8 marks)**

Water purification methods - zeolites, ion-exchange resins and reverse osmosis; Protective coatings for corrosion control: cathodic and anodic protection - PVD technique.

Unit – 2: Functional materials **(10L, 15 marks)**

Oxides of AB, AB_2, ABO_3 type (specific examples); Composites - types and properties; Polymers - thermosetting and thermoplastic polymers – synthesis and application (TEFLON, BAKELITE); Conducting polymers- polyacetylene and effect of doping – chemistry of display devices specific to OLEDs; Nano materials – introduction, bulk *vs* nano (quantum dots), top-down and bottom-up approaches for synthesis, and properties of nano Au.

Unit – 3: Fertilizers **(5L, 7 marks)**

Chemical fertilizers and organic manures-types of chemical fertilizers, nitrogenous fertilizers-methods of production of ammonia and urea, phosphatic fertilizers, potassic fertilizers and their applications.

Unit – 4: Energy Devices **(7L, 15 marks)**

Electrochemical and electrolytic cells – electrode materials with examples (semi-conductors), electrode-electrolyte interface- chemistry of Li ion secondary batteries, supercapacitors; Fuel cells: H_2-O_2 and solid oxide fuel cell (SOFC); Solar cells - photovoltaic cell (silicon based), photoelectrochemical cells and dye-sensitized cells.

Unit – 5: Drugs **(3L, 5 marks)**

Synthetic drug, synthesis of aspirin and paracetamol. Importance of chiral drugs.

Practical: 1 Credit **Total course hour**: 30 hr **Duration of Examination**: 3 hr

List of Experiments (Minimum three)

1. Determination of hardness of water sample by complexometric titration before and after ion-exchange process

2. Preparation of tin oxide by sol- gel method and its characterization

3. Laboratory scale preparation of important drug intermediate - para aminophenol for the synthesis for acetaminophen

4. Determination of Chemical Oxygen Demand (COD) of waste water

5. Colorimetric estimation of Ni^{2+} using conventional and smart phone digital-imaging methods.

Learning outcome: Following this course, students will have an understanding of both the most recent and historical advancements in industrial chemistry.

Suggested reading:

1. Theodore E. Brown, H Eugene, LeMay Bruce E. Bursten, Catherine Murphy, Patrick Woodward, Matthew E. Stoltzfus, Chemistry: The Central Science, 2017, 14th edition, Pearson Publishers, 2017. UK
2. Solid State Chemistry and its Applications, Anthony R. West. 2014, 2nd edition, Wiley, UK.
3. AngÃ¨le Reinders, Pierre Verlinden, Wilfried van Sark, Alexandre Freundlich, Photovoltaic solar energy: From fundamentals to Applications, 2017, Wiley publishers, UK.
4. Lawrence S. Brown and Thomas Holme, Chemistry for engineering students, 2018, 4th edition – Open access version.

Course Title: Introductory Chemistry – III

Course Code: MIN-CHM-3.1

Total Credit: 4 (3 credit Theory + 1 Credit Practical)

Distribution of marks: (60T+25P) + 15 (In-Semester)

Course objective:

Theory: 3 credits **Total course hour: 45 hr** **Duration of examination: 3 hr**

Unit-1: s and p-block elements **(10 L+12 marks)**

Inert pair effect, Relative stability of different oxidation states. Diagonal relationship. Allotropes of carbon, Sulphur and Phosphorous. Anomalous behavior of first member of each group. Complex formation tendency of s- and p-block elements. Hydrides and their classifications. Boronhydrides (Diborane). Boron nitride. Oxides and oxyacids of nitrogen, phosphorous and chlorine. Interhalogen compounds and pseudohalogens.

Unit-2: Transition Series (3d Series) **(5 L+8 marks)**

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn and Cu. Frost Ebsworth diagram.

Unit-3: Chemistry of alkyl and aryl halides **(7L+10 marks)**

Alkyl Halides: Preparation from alkenes and alcohols. Nucleophilic substitution reaction and its types (SN_1, SN_2 reactions), solvolysis. Elimination vs substitution.

Aryl Halides: Preparation: from phenol, Sandmeyer & Gattermann reactions. Reactions: aromatic nucleophilic substitutions. Benzyne formation and reactions.

Unit-4: Alcohol, Phenol and Ether **(8 L+10 marks)**

Alcohols: General methods of preparation alcohols. Reactions with HX (Lucas test), esterification, oxidation (with PCC, alkaline $KMnO_4$, acidic dichromate, conc. HNO_3). Diols: Pinacol-Pinacolone rearrangement.

Phenols: Preparation - Cumene hydroperoxide method, from diazonium salts. Reactions - Electrophilic substitution and important named reactions.

Ethers: Williamson's synthesis of ethers, important reactions of ether.

Unit-5: First Law of Thermodynamics **(8 L+10 marks)**

Thermal equilibrium and zeroth law of thermodynamics- concept of temperature, Mechanical work, SI sign convention. 1st law of thermodynamics, internal energy, enthalpy, reversible and irreversible processes, calculation of W, Q, ΔU, ΔH for expansion of ideal gas, isothermal work and enthalpy, relation between enthalpy change, and entropy change, molar heat capacities, relation between C_p and C_v, adiabatic processes- relation between P, V and T, Joule-Thomson effect, liquefication of gases, Enthalpy of reaction, enthalpy of different processes. Hess law calculations based on Hess law.

Unit-6: Second Law of Thermodynamics **(7L+10 marks)**

Second law of thermodynamics, Spontaneous and Non-Spontaneous processes cyclic process- Carnot cycle, Entropy, Entropy change in reversible and irreversible processes and for ideal gas, concept of work function and free energy.

Practical: 1 Credit **Total course hour**: 30 hr **Duration of Examination**: 3 hr

List of experiments:

1. Semi-micro qualitative analysis using H_2S of mixture-not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

CO_3^{2-},NO_2^-,S^{2-},SO_3^{2-}, $S_2O_3^-$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^-, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+},Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}.

(*Spot tests to be carried out wherever feasible*)

2. Acid-base Titrations: (Any one)

a) Estimation of Carbonate and hydroxide present together in a mixture.
b) Estimation of Carbonate and bicarbonate present together in a mixture.

3. Detection of functional groups in organic compounds.

4. Determination of heat capacity and enthalpy of reactions (Minimum three):

a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

c) Calculation of the enthalpy of ionization of ethanoic acid.
d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
f) Determination of enthalpy of hydration of copper sulphate.
g) Study of the solubility of benzoic acid in water and determination of ΔH.

Learning outcome: After completion of this course, students will be able to understand and apply concepts of s and p-block elements, Transition Series, Alcohol, Phenol and Ethers and thermodynamics in real life applications.

Suggested reading:

1. Physical Chemistry by Atkins & Paula

2. Principles of Physical Chemistry by Puri, Sharma & Pathania

3. A text book of Physical Chemistry by Negi & Anand

4. Inorganic Chemistry by Puri, Sharma & Kalia

5. Inorganic Chemistry: Principles of Structure and Reactivity by J E Huheey, E A Keiter, R L Keiter & O K Medhi.

6. Basic Inorganic Chemistry by Cotton and Wilkinson

7. A Text Book of Organic Chemistry by Arun Bahl and B. S. Bhal, S CHAND.

8. Comprehensive Practical Organic Chemistry: Qualitative Analysis by V. K. Ahluwalia and Sunita Dhingra

Course Title: Pesticide Chemistry

Course Code: MD-CHM-3.1

Total Credit: 3

Distribution of marks: 60 (End Semester) + 15 (In-Semester)

Course objective: This course is aimed at providing students with the basic understanding of pesticides, types, benefits and environmental hazards as well as knowledge of pesticides formulation and packaging.

Theory: 3 credits **Total course hour: 30 hr** **Duration of examination: 3 hr**

Unit-1: **(8 L + 10 marks)**

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship. Chemical and Botanical pesticides, Classification of pesticides based on chemicals, nature, types of targets, Systemic and non-systemic Pesticides

Unit-2: **(10 L + 20 marks)**

Synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor). Ecofriendly pesticides. Degradation, mode of actions and toxicity.

Safety measures: Environmental aspects and degradability

Unit-3: **(12 L + 30 marks)**

Introduction of pesticide formulations: Definition, History, Purpose. Brief account of main types. Study of conventional formulations: Dusting, Powders/ Dust Formulations (DP), Granules (GR), Water Dispersible Powders/Wettable powders (WDP/WP), Soluble Concentrates (SC), Emulsifiable concentrates (EC), Ultra Low volume (ULV) with respect to their ingredients, advantages and disadvantages.

Current trends in single trip containers, Liquid Formulations: Rigid plastics, High Density Polyethylene, (HDPE), Polyethylene Terephathalate (PET), Ethylene Vinyl Alcohol (EVOH), and Polyamide (PA). Solid Formulations: Polyethylene, Laminates–Low Density Polyethylene (LDPE), Aluminum foil, LDPE plus ether, Polypropylene (PP), Polyester (PET), Polyamide (PA) Paper, Water soluble Films Paper on packaging material used to pack pesticides (technical and formulation) like Dust, EC, SC, WP, WDG).

Recent insect attractants, Chemosterilants and Repellents, Applications of Neem in plant protection: Introduction, Chemical constituents and Mode of action, Bio-efficacy of neem preparations.

Learning Outcome:

Upon completion of the course the students will

1. Understand the types of pesticides, mode of actions, degradability and associated toxicity with the use of pesticides
2. Know about the pesticide formulations and packaging styles.
3. be able to correlate the classroom knowledge with the real-life applications.

Suggested reading:

1. R. Cremlyn: Pesticides, Preparation and Mode of Action, John Wiley & Sons, New York, 1978.
2. RPBateman, Pesticide Applications, AAB Press, 2004.
3. Principles of Pesticide chemistry: S K Handa, Ed. by Agrobios (India), 2008.
4. Pesticide Science & Biotechnology: R Greenhalgh and T R Robers, IUPAC, Blackwell Scientific Publications, 1987.
5. The Chemical Process Industries: D N Shreve
6. Pesticide Chemistry: G Matolesy, M. Nadasy, V. Andriska, Elsevier Sc. Publisher, USA, 1988.

B.Sc. in Chemistry

DETAILED SYLLABUS OF FYUGP IV SEMESTER

Title of the course: Inorganic Chemistry – I

Course Code: MAJ-CHM-4.1

Total Credit: 4 (3 credit Theory + 1 Credit Practical)

Distribution of marks: (60 T+25 P) +15 (In-Semester)

Course objective:

To give the students a fundamental understanding of Inorganic Polymers, structure and applications connected to it. To educate students about the nature of Transition elements, Lanthanoides and Actinoides, Coordination Chemistry and give some knowledge about Bioinorganic Chemistry. To make students aware of the Principles of Qualitative and Quantitative analysis

Prerequisite: Basic inorganic chemistry.

Theory: 3 credits **Total course hour:** 45 hr **Duration of examination:** 3 hr

Unit 1: Inorganic Polymers (5 L+10 Marks)

Types of Inorganic polymers, Comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes, Borazines, Silicates and Phosphazenes and polysulphates.

Unit 2: Transition Elements (8L+10 Marks)

Characteristics of d-block elements, Oxides, hydroxides and salts of first row metals; General group trends with spectral reference to electronic configuration, Colour, variable valency, magnetic and catalytic properties, ability to form complexes, stability of various oxidation states and e.m.f. (latimer and Frost ebsworth diagrams). Difference between the first, second and third transition series.

Unit 3: Lanthanoids and Actinoids (8L+8 Marks)

Electronic configuration, Oxidation states, colour, spectral and magnetic properties, Lanthanide contraction, Causes and consequences. Separation of Lanthanides (Ion –exchange method only).

General features of Actinoids: Formation of complexes. Comparison with lanthanoids.

Unit 4: Coordination Chemistry (9L+12 Marks)

Coordination compounds, types of ligands, Werner's theory. IUPAC nomenclature and isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Valence bond theory (inner and outer orbital complexes), electroneutrality, principle and back bonding, Crystal field theory, measurement of 10 Dq (Δ_o), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq(Δ_0, Δ_t). Octahedral versus tetrahedral coordination, trigonal distortions from octahedral geometry. Jahn-Teller theorem, square planar geometry. Qualitative aspects of ligand field and Molecular orbital theory. Chelate effect. Lability and inertness.

Unit 5: Bioinorganic Chemistry (8L+10 Marks)

Metal ions present in biological systems, classification of elements according to their action in biological system. Sodium-Potassium pump, Carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals Toxicity of metal ions (Hg, Pb, Cd, As), reasons for toxicity, Use of metals in medicine: Use of chelating agents in medicine.

Iron and its application in bio-systems. Myoglobin and hemoglobin. Role of hemoglobin and myoglobin in biological systems. Cooperativity effect and Bohr effect.

Unit 6: Analytical Chemistry (7L+10 Marks)

Principles of qualitative and quantitative analysis. Acid-base, oxidation-reduction and complexometric titrations using EDTA; Precipitation reactions; use and types of indicators; use of organic reagents in inorganic analysis. Radioactivity. Nuclear reactions, applications of isotopes.

Practical: 1 Credit **Total course hour**: 30 hr **Duration of Examination**: 3 hr

List of experiments:

1. **Iodo/Iodimetric titration:**
   i. Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution iodimetrically
   ii. Estimation of available Chlorine in bleaching powder iodometrically.
2. **Inorganic Preparatios (minimum 2):**
   i. Preparation of Cuprous chloride, CuCl
   ii. Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.
   iii. Preparaton of Manganese (III) phosphate, $MnPO_4.H_2O$

Learning outcome:

Upon completion of this course the students will gain an understanding of

1. Structural aspects and applications of Inorganic polymer.
2. Predict the characteristics of d-block elements
3. Knowledge of Lanthanoids and Actinoids
4. Introduction to Coordination Chemistry, Valence bond theory, Crystal field theory, Molecular orbital theory.
5. Metal ions in Bioinorganic Chemistry and their applications .
6. Analytical Chemistry.

Suggested reading:

1. Inorganic Chemistry: Principles of Structure and Reactivity by J E Huheey, E A Keiter, R L Keiter & O K Medhi.
2. Basic Inorganic Chemistry by Cotton and Wilkinson
3. Advanced Inorganic Chemistry by Cotton and Wilkinson
4. Inorganic Chemistry by Puri, Sharma & Kalia.
5. A Text Book of Practical Chemistry by Sudarshan Barua

Title of the course: Organic Chemistry – I

Course Code: MAJ-CHM-4.2

Total Credit: 4 (3 credit Theory + 1 Credit Practical)

Distribution of marks: (60T+25P) +15 (In-Semester)

Course objective:

This course aims at introducing some important topics of organic chemistry, namely carbonyl compounds, carboxylic acids, amines and aromatic hydrocarbons.

Prerequisite: Basic organic chemistry reaction mechanism.

Theory: 3 credits **Total course hour:** 45 hr **Duration of examination:** 3 hr

Unit 1: Carbonyl Compounds (15L+20 Marks)

Preparation of carbonyl compounds from other functional groups. Reactions – with HCN, ROH, $NaHSO_3$, amine derivatives. Cannizzaro's reaction, Benzoin condensation. Chemistry of -carbon of carbonyls - pKa of C-H, keto-enol tautomerism. Halogenation, haloform reaction, aldol reaction. Reformatsky reaction, Michael reaction, Robinson annulation, Knoevenagel condensation, Claisen ester condensation, Perkin reaction, Stobbe condensation, Darzens reaction, acyloin condensation, McMurry coupling Wittig reaction and other named reactions. Malonic and acetoacetic esters: Characteristic reactions of active methylene group, synthetic uses of malonic, acetoacetic and cyanoacetic ester.

Unit 2: Carboxylic acids: (10L+15 Marks)

Preparation carboxylic acids by acid and base mediated hydrolysis of esters. Reactions: Hell–Vohlard-Zelinsky reaction and reactions involving carboxylic functionality. Carboxylic acid derivatives: acid chlorides, anhydrides, esters and amides from acids and their interconversion.

Unit 3: Amines: (10L+15 Marks)

Preparation of amines from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann bromamide reaction and by reduction reactions. Reactions - Hofmann degradation, qualitative tests for amines, Schotten – Baumann Reaction. Electrophilic substitution: nitration, bromination, sulfonation. Diazonium compounds – preparation and reactions.

Unit 4: Aromatic hydrocarbons: (10L+10 Marks)

Preparation of benzene from phenol, by decarboxylation and from acetylene. Reactions of benzene: electrophilic substitution: nitration, halogenation and sulfonation. Friedel-Craft's reaction - alkylation and acylation. Side chain oxidation of alkyl benzenes.

Practical: 1 Credit **Total course hour**: 30 hr **Duration of Examination**: 3 hr

List of experiments (Minimum four):

1. Estimation of Glycine
2. Estimation of hydroxyl group
3. Estimation of Carboxylic acid
4. Estimation of Glucose
5. Determination of saponification value of fats and oils.

Learning outcome:

After completing this course students will know how to synthesize carbonyl compounds, carboxylic acids, amines, and aromatic hydrocarbons, in addition to learning about their reactivity.

Suggested reading:

1. Organic Chemistry, Vol – I, by I L Finar, PEARSON.
2. Organic Chemistry by Janice Gorzynski Smith, 2nd Ed., The McGraw Hill Com.
3. Vogel's Text Book of Practical Organic Chemistry, 5th Ed., PEARSON.
4. Comprehensive Practical Organic Chemistry: Qualitative Analysis by V. K. Ahluwalia and Sunita Dhingra

Title of the course: Physical Chemistry – I

Course Code: MAJ-CHM-4.3

Total Credit: 4 (3 credit Theory + 1 Credit Practical)

Distribution of marks: (60 T+25 P) +15 (In-Semester)

Course objective: The course aims to provide a comprehensive understanding of electrochemistry and solution chemistry, emphasizing theoretical foundations, analytical techniques, and practical applications in both laboratory and industrial settings.

Prerequisite: Basic foundational knowledge in general chemistry, including chemical bonding, reaction kinetics, and thermodynamics.

Theory: 3 credits **Total course hour:** 45 hr **Duration of examination:** 3 hr

Unit 1: Electrochemistry I (15L+20 Marks)

Arrhenius theory of electrolytic dissociation, conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Huckel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. Ionic velocities, mobilities and their determinations, transfrerence number and their relation to ionic mobilities, determination of transference number using Hittorf and Moving Boundary methods. Applications of conductance mesurment: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) coductometric titrations, and (v) hydrolysis constants of salts.

Unit 2: Electrochemistry II (20L+25 Marks)

Quantitative aspects of Faraday's law of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, .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 mesurments in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constan, and (iii) pH values , using hydrogen , quinine-hydroquinone, glass and SbO/Sb_2O_3 electrodes. 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). Applications of electrolysis in metallurgy and industry.

Unit 3: Solution (10L+15 Marks)

Dilute solutions, lowering of vapour pressure, Raoults and Henry laws and their applications. Excess thermodynamic functions. Osmosis and osmotic pressure. Determination of molar mass for osmotic pressure measurement. Relation between osmotic pressure and vapour pressure lowring of an ideal solution, Theory of semi permeability, reverse osmosis, van't hoff law, van't hoff factor. 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. Application in calculating molar masses of normal, dissociated and associated solutes in solution.

Practical: **1 Credit** **Total course hour**: 30 hr **Duration of Examination**: 3 hr

List of experiments (Minimum four):

1. Determination of cell constant and hence the specific conductance of an electrolyte.
2. Conductometric titrations of i. strong acid vs strong base, ii. Weak acid vs strong base.
3. Determination of equivalent conductance of a strong electrolyte at various dilutions and verification of Onsager equation.
4. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
5. Potentiometric titration of a mixture of strong and weak acids vs strong base.
6. Potentiometric titration of ferrous ammonium sulphate against standard $K_2Cr_2O_7$, $KMnO_4$ and determination of redox potential of Fe (II)-Fe (III) system.

Learning outcome:

Upon completing this course, students will be able to

1. understand key electrochemical concepts, including electrolytic dissociation, conductivity, and electrochemical cell dynamics.
2. apply principles such as Kohlrausch's Law and the Nernst equation to solve electrochemical problems.
3. conduct experiments to determine ionic mobilities, dissociation degrees, and thermodynamic properties.

4. analyze solution behavior using colligative properties and osmotic pressure.
5. integrate theoretical knowledge with practical applications in industry and laboratory settings.

Suggested reading:

1. Physical Chemistry by Atkins & Paula

2. Principles of Physical Chemistry by Puri, Sharma & Pathania

3. A text book of Physical Chemistry by Negi & Anand

4. Practical Chemistry by Yadav.

Course Title: Introductory Chemistry – IV

Course Code: MIN-CHM-4.1

Total Credit: 4 (3 credit Theory + 1 Credit Practical)

Distribution of marks: (60T+25P) + 15 (In-Semester)

Course objective: To provide knowledge and hands on experience of acids-bases, metallurgical processes, chemical reactions involving carbonyl compounds, carboxylic acids and amines, electrochemistry principles and applications.

Theory: 3 credits **Total course hour: 45 hr** **Duration of examination: 3 hr**

Unit-1: Acids and Bases, Oxidation-Reduction and general principles of metallurgy.

(15 L + 20 marks)

Bronsted-Lowry concept of acids base reaction, Solvated proton, relative strength of acids, types of acids-base reactions, leveling solvents, Lewis acid-base concept, classification of Lewis acids, Hard & soft acids and bases (HSAB). Pearson's concept. Bonding in hard-hard and soft-soft combinations. Application of (HSAB) principle. Symbiosis.

Redox equation, standard electrode potential and its application to Inorganic reactions, principles involved in volumetric analysis. Principles and applications of Ellingham diagram, General methods of isolation and purification of Electrolytic process and Mond's process, Zone refining.

Unit-2: Carbonyl compounds, Carboxylic acids and Amines (15 L + 20 marks)

Carbonyl Compounds: General methods of preparation of carbonyl compounds. Reactions – with HCN, ROH, $NaHSO_3$, amine derivatives. Important name reactions involving carbonyl compounds. Haloform reaction, aldol reaction, Cannizzaro reaction, Reformatsky reaction, Michael addition, Knoevenagel condensation, Perkin reaction, and Wittig reaction.

Carboxylic acids: Preparation carboxylic acids by acid and base mediated hydrolysis of esters. Hell-Vohlard-Zelinsky reaction. Carboxylic acid derivatives: acid chlorides, anhydrides, esters and amides from acids and their interconversion.

Amines: Preparation of amines from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann bromamide reaction. Reactions - Hofmann degradation, qualitative tests for amines, Schotten – Baumann Reaction. Electrophilic substitution: nitration. Diazonium compounds – preparation and Sandmeyer reaction.

Unit-3: Electrochemistry (10 L + 20 marks)

Conductivity, equivaent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using moving boundary methods. Ionic mobility. Conductometric titrations.

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data.

Unit-4: Solutions (5 L + 20 marks)

Thermodynamics of ideal solution: Ideal solutions and Raoult's law, deviations from Raoult's law, non-ideal solutions, vapour pressure-composition, temperature-composition curves for ideal and non-ideal solutions, distillation of solution and Lever rule.

Practical: 1 Credit **Total course hour: 30 hr** **Duration of Examination: 3 hr**

List of experiments:

1. Volumetric estimation of
    a) water of crystallization in Mohr's salt by titrating with $KMnO_4$.

or

b) Na_2CO_3 and $NaHCO_3$ present together in a mixture

2. Detection of functional groups in organic compounds.

3. Determination of cell constant and hence the specific conductance of an electrolyte.
4. Conductometric titrations
   a) strong acid vs strong base,

      or

   b) Weak acid vs strong base.

Learning outcome: After completion of this course students will be able to understand and apply the concepts of acids-bases, redox reactions involved in metallurgical processes, reactions involving carboxylic acids, amines and electrochemistry in real life applications.

Suggested reading:

1. A Text Book of Organic Chemistry by Arun Bahl and B. S. Bhal, S CHAND.
2. Comprehensive Practical Organic Chemistry: Qualitative Analysis by V. K. Ahluwalia and Sunita Dhingra.
3. Physical Chemistry by Atkins & Paula
4. Principles of Physical Chemistry by Puri, Sharma & Pathania
5. A text book of Physical Chemistry by Negi & Anand
6. Practical Chemistry by Yadav.

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