Mangalore University
Department of Studies in Chemistry
M. Sc. Degree Programme
(CHOICE BASED CREDIT SYSTEM - SEMESTER SCHEME)

Syllabi for M.Sc., Courses in

ANALYTICAL CHEMISTRY

(From the Academic Year 2016-17 onwards)
Mangalore University

M. Sc. Degree Programme in Analytical Chemistry:

CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER SCHEME

COURSE PATTERN AND SCHEME OF EXAMINATION

(Year 2016-2017 onwards)

PREAMBLE

Revision of Syllabi for the Two years Master Degree (Choice Based Credit System-Semester Scheme) Programmes in Chemistry, Applied Chemistry, Organic Chemistry and Analytical Chemistry.

PG BOS in Chemistry has revised and prepared the Syllabi (CBCS based) for all the Four Courses -Chemistry, Applied Chemistry, Organic Chemistry and Analytical Chemistry in its meeting held on 24th July 2014 and the University implemented it from the same academic year. Now the University has asked the PG BOS in Chemistry to revise the syllabi by giving certain Guidelines (Ref:-No: MU/ACC/CR.38/ CBCS (PG)/2015-16 dt.05-05-2016 bse on UGC letter) for all the four Courses (Programmes) to offer Hard Core, Soft Core and Open Elective course papers with credits to each course amounting to 92 credits for the entire programme.

Accordingly, the PG BOS in Chemistry prepared the syllabi for all the four programmes. It has prepared course pattern by proposing 12 Hard Core theory courses (3 in each semester) and 5 practical courses (in 3rd and 4th semester), one Project work (in 4th Semester with 4 credits) with a provision to have One Project Work in lieu of one of the practicals in 4th semester in each programme with 3 credits each (project work - 4 credits) with total of 55 Credits. BOS is offering 3, 2, 2 and 3 (Total 10 courses) Soft core courses respectively in 1st, 2nd, 3rd and 4th semesters of a programme. Student shall opt any 2, 1, 1 and 2 (Total 6 courses) courses respectively in 1st, 2nd, 3rd, 4th Semesters. All the soft core papers are of 3 credits. Programma consists of 6 Soft Core practical courses (3 courses each in 1st and 2nd semesters of the Programme with 2 credits each) with a total of 30 credits (6 theory x 3 credits + 6 practicals x 2 credits). BOS has also proposed 2 open electives (1 each in 2nd & 3rd Semesters of the programme) with 3 credits each (6 credits). All together total credits come to 91 from teaching. I have prepared a draft course pattern by considering all the points mentioned in the above said letter from the Registrar and placing it before the BOS meeting.

Detailed syllabi for 1st and 2nd Semesters are prepared and enclosed, whereas the syllabi for the 3rd and 4th Semesters will be prepared in forthcoming BOS meeting.
**Course/credit pattern:**

<table>
<thead>
<tr>
<th>Semester</th>
<th>Hard Core(H)(T)</th>
<th>Soft Core (S)(T)</th>
<th>Elective E(T)</th>
<th>Practical</th>
<th>Tutorial</th>
<th>Total Credits</th>
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<tbody>
<tr>
<td>First</td>
<td>9</td>
<td>6</td>
<td>--</td>
<td>6 (S)</td>
<td>--</td>
<td>21</td>
</tr>
<tr>
<td>Second</td>
<td>9</td>
<td>3</td>
<td>3</td>
<td>6 (S)</td>
<td>--</td>
<td>21</td>
</tr>
<tr>
<td>Third</td>
<td>9</td>
<td>3</td>
<td>3</td>
<td>9 (H)</td>
<td>--</td>
<td>24</td>
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<tr>
<td>Fourth</td>
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<td>6</td>
<td>--</td>
<td>10(H)</td>
<td>--</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>18</td>
<td>6*</td>
<td>12(S) + 19(H)</td>
<td>--</td>
<td>91</td>
</tr>
</tbody>
</table>

Total Credits from all the Four Semesters (1st, 2nd, 3rd and 4th): 21+21+24+25 = 91

Total Hard Core credits = 36 (T) + 19 (P) = 55 = 60.4%

Total Soft Core credits = 18 (T) + 12(P) = 30 = 33.0%

*Open Elective Credits = 6 = 6.6% (Not to considered for calculating the CGPA)

H= Hard Core, S= Soft Core, P =Pratical/Project

Programme : M.Sc in Analytical Chemistry
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA H 401</td>
<td>Inorganic Chemistry</td>
<td>CA H 451</td>
<td>Advanced Inorganic Chemistry</td>
</tr>
<tr>
<td>CA H 402</td>
<td>Organic Chemistry</td>
<td>CA H 452</td>
<td>Advanced Organic Chemistry</td>
</tr>
<tr>
<td>CA H 403</td>
<td>Physical Chemistry</td>
<td>CA H 453</td>
<td>Advanced Physical Chemistry</td>
</tr>
<tr>
<td>CAS 404</td>
<td>Inorganic Spectroscopy and Analytical Techniques</td>
<td>CA S 454</td>
<td>Organic Spectroscopic Techniques</td>
</tr>
<tr>
<td>Or</td>
<td>Or Environmental Chemistry</td>
<td>CA S 455</td>
<td>Or Chemistry of Bio-molecules</td>
</tr>
<tr>
<td>CA S 406</td>
<td>Molecular Spectroscopy and Diffraction Techniques</td>
<td>CA E 456</td>
<td>Environmental, Electro- and Surface Chemistry</td>
</tr>
<tr>
<td>CA P 407</td>
<td>Inorganic Chemistry Practicals-1</td>
<td>CA P 457</td>
<td>Inorganic Chemistry Practicals-II</td>
</tr>
<tr>
<td>CA P 408</td>
<td>Organic Chemistry Practicals-1</td>
<td>CA P 458</td>
<td>Organic Chemistry Practicals-II</td>
</tr>
<tr>
<td>CA P 409</td>
<td>Physical Chemistry Practicals-1</td>
<td>CA P 459</td>
<td>Physical Chemistry Practicals-II</td>
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<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA H 501</td>
<td>Principles of Analytical Chemistry</td>
<td>CA H 551</td>
<td>Applied Analysis</td>
</tr>
<tr>
<td>CA H 502</td>
<td>Bioanalytical &amp; Radiochemical Techniques</td>
<td>CA H 552</td>
<td>Optical Methods of Analysis</td>
</tr>
<tr>
<td>CA H 503</td>
<td>Chromatographic Separation Techniques</td>
<td>CA H 553</td>
<td>Process Analytical Chemistry</td>
</tr>
<tr>
<td>CA S 504</td>
<td>Thermoanalytical Techniques Or Analytical</td>
<td>CA H 554</td>
<td>Environmental Chemistry Or Pharmacokinetics &amp; Nanimaterials</td>
</tr>
<tr>
<td>Or</td>
<td>Chemistry of Polymers</td>
<td>Or</td>
<td></td>
</tr>
<tr>
<td>CA S 505</td>
<td>Or O C A n a l y t i c S e p a r a t i o n T e c h n i q u e s</td>
<td>CA S 555</td>
<td></td>
</tr>
<tr>
<td>CA E 506</td>
<td>Analytical and Green Chemistry</td>
<td>CA S 555</td>
<td>Separation Techniques</td>
</tr>
<tr>
<td>CA P 507</td>
<td>Analytical Chemistry Practicals-III</td>
<td>CA P 557</td>
<td>Analytical Chemistry Practicals-VI</td>
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<tr>
<td>CA P 508</td>
<td>Analytical Chemistry Practicals -IV</td>
<td>AC P 558</td>
<td>Analytical Chemistry Practicals-VII</td>
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<tr>
<td>CA P 509</td>
<td>Analytical Chemistry Practicals -V</td>
<td>CA P 559</td>
<td>Project Work &amp; Dissertation</td>
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</table>
## Detailed distribution of Course & Credits:

**Programme: Analytical Chemistry:**

### 1st Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>No of Units</th>
<th>Evaluation IA + Exam</th>
<th>Teaching hrs week Sem</th>
<th>Exam hrs</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA H 401</td>
<td>Inorganic Chemistry</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td>CA H 402</td>
<td>Organic Chemistry</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td>CA H 403</td>
<td>Physical Chemistry</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td>CAS 404 or CA S 405</td>
<td>Inorganic Spectroscopy and Analytical Techniques or Environmental Chemistry</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>36</td>
<td>3</td>
</tr>
<tr>
<td>CA S 406</td>
<td>Molecular Spectroscopy and Diffraction Techniques</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>36</td>
<td>3</td>
</tr>
<tr>
<td>CA P 407</td>
<td>Inorganic Chemistry Practicals-1</td>
<td>4 Hrs</td>
<td>30 + 70</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>CA P 408</td>
<td>Organic Chemistry Practicals-1</td>
<td>4 Hrs</td>
<td>30 + 70</td>
<td>4</td>
<td>4</td>
<td>2</td>
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<tr>
<td>CA P 409</td>
<td>Physical Chemistry Practicals-1</td>
<td>4 Hrs</td>
<td>30 + 70</td>
<td>4</td>
<td>4</td>
<td>2</td>
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</tbody>
</table>

Total credits from 1st Semester: 21 (Hard Core-9, Soft Core-12)

### 2nd Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>No. of Units</th>
<th>Evaluation IA + Exam</th>
<th>Teaching hrs week Sem</th>
<th>Exam Hrs</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CA H 451</td>
<td>Advanced Inorganic Chemistry</td>
<td>3</td>
<td>30 + 70</td>
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<tr>
<td>CA H 452</td>
<td>Advanced Organic Chemistry</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td>CA H 453</td>
<td>Advanced Physical Chemistry</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td>CA S 454 or CA S 455</td>
<td>Organic Spectroscopic Techniques or Chemistry of Bio-molecules</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>36</td>
<td>3</td>
</tr>
<tr>
<td>CA E 456</td>
<td>Environmental, Electro- and Surface Chemistry</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>36</td>
<td>3</td>
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</table>
Total credits from 2nd Semester: 21 (Hard Core-9, Soft Core-9, Elective-3)

**3rd Semester**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>No. of Units</th>
<th>Evaluation IA + Exam</th>
<th>Teaching hrs week</th>
<th>Exam Hrs.</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA H 501</td>
<td>Principles of Analytical Chemistry</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>CA H 502</td>
<td>Bioanalytical &amp; Radiochemical Techniques</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>CA H 503</td>
<td>Chromatographic Separation Techniques</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>3</td>
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<tr>
<td>CA S 504 Or</td>
<td>Thermoanalytical Techniques</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>CA S 505</td>
<td>Analytical Chemistry of Polymers</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>CA E 506</td>
<td>Analytical &amp; Green Chemistry</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>CA P 507</td>
<td>Analytical Chemistry Practicals-III</td>
<td>6 Hrs</td>
<td>30 + 70</td>
<td>6</td>
<td>6</td>
<td>3</td>
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<tr>
<td>CA P 508</td>
<td>Analytical Chemistry Practicals -IV</td>
<td>6 Hrs</td>
<td>30 + 70</td>
<td>6</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>CA P 509</td>
<td>Analytical Chemistry Practicals - V</td>
<td>6 Hrs</td>
<td>30 + 70</td>
<td>6</td>
<td>--</td>
<td>3</td>
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</tbody>
</table>

Total Credits from 3rd Semester = 24 (Hard Core-18, Soft Core-3 and Elective-3)

**4th Semester**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>No. of Units</th>
<th>Evaluation IA + Exam</th>
<th>Teaching hrs week</th>
<th>Exam Hrs</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA H 551</td>
<td>Applied Analysis</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td>CA H 552</td>
<td>Optical Methods of Analysis</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td>CA H 553</td>
<td>Process Analytical Chemistry</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td>CA H 554 Or</td>
<td>Environmental Chemistry Or</td>
<td>3</td>
<td>30 + 70</td>
<td>3</td>
<td>36</td>
<td>3</td>
</tr>
</tbody>
</table>
Question Paper Setting:

A) BASIS FOR INTERNAL ASSESSMENT: Internal assessment marks in theory papers shall be based on two tests. The tests may be conducted 8 and 14 weeks after the start of a semester. Average of two test marks will be considered as internal assessment marks. Practical internal assessment marks shall be based on test and records. 20 marks for experiment and 10 marks for record. The practical tests may be conducted 12 weeks after the start of a semester. Internal Assessment marks on Project work-Dissertation is based on Two seminars of 45 minutes duration each carrying 15 marks. The Seminar is to be delivered in 3rd semester on the subject and 4th semester on their project work.

B) THEORY QUESTION PAPERS PATTERN: The Syllabus of each hard core course shall be grouped into units of 15 teaching hours and that of soft core and open Elective shall be of 12 teaching hours. All the papers shall contain three units each. Question Papers in all the four semesters hall consist of Two Parts A and B. Part A is shall contain Nine (09) very short answer objective type questions carrying 2 marks each drawn from all the Three units of the syllabus. All the nine subdivisions are to be answered. Part B shall contain Six (06) brief and/or long answer questions carrying 13 marks each drawn from all the Three units of the syllabus (2 questions per unit). There may be a maximum of three sub-divisions per question, carrying 3 or more marks per sub-division. Four (04) out of Six (06) questions are to be answered.

C) PRACTICAL EXAMINATION PATTERN

Practical Examination course papers out of 70 marks 15 marks shall be allotted for Viva voce and 55 marks for practical proper. In the 4th semester there shall project work/dissertation in lieu of one of the practicals for all the programmes (Chemistry, Applied Chemistry, Organic Chemistry and Analytical Chemistry) consisting of 70 marks. The Project work may be conducted either in the department or in an Institution or Industry. Project report shall be valued for 70 marks.
FIRST SEMESTER

CA H 401 : INORGANIC CHEMISTRY

UNIT- I: [15 Hours]

Ionic bond: Properties of ionic substances, coordination number of an ion, structures of crystal lattices- NaCl, CsCl, ZnS and rutile. Lattice energy- Born Lande equation, Born-Haber cycle, Uses of Born-Haber type of calculations. Ionic radii, methods of determining ionic radii, factors affecting ionic radii, radius ratio rule, covalent character in ionic bonds, hydration energy and solubility of ionic solids.

Covalent bond: valence bond theory, resonance, hybridisation, Bent’s rules and energetics of hybridization, Deduction of molecular shapes – VSEPR theory.

M.O.theory, application to homo- and hetero-diatomic and -triatomic molecules.

UNIT -II: [15 Hours]

Alkali and alkaline earth metal complexes of crown ethers, cryptands and calixarenes and their biological significance.

Halogens and Noble gas chemistry –interhalogens, psuedohalogens, polyhalide ions, oxyhalogen species, xenon oxides and fluorides. Oxy- and peroxy acids of N, P and S.

Graphitic compounds, carbides, pure silicon, silica and silicates, zeolites.

HSAB concept, super acids. Reactions in non-aqueous media: Liquid ammonia, anhydrous sulphuric acid, glacial acetic acid, anhydrous HF, bromine trifluoride, liquid sulphur dioxide and dinitrogen tetroxide. Reactions in molten salts.

UNIT- III: [15 Hours]

Precipitation phenomena: precipitation from homogeneous solutions, organic precipitants in inorganic analysis. Solvent extraction of metal ions, nature of extractant, distribution law, partition coefficients, types of extractions and applications.

Theories of redox indicators, titration curves, feasibility of redox titrations.

Chelometric titrations- titration curves with EDTA, feasibility of EDTA titrations, indicators for chelometric titrations, selective masking and demasking techniques, industrial applications of masking.

Sampling techniques, preparation of samples for analysis. Nature of errors, statistical treatment of errors, the t- and F-tests, significant figures, rejection of data.
References:


CA H 402 : ORGANIC CHEMISTRY

UNIT–I: [15 Hours]

Bonding in organic systems: Theories of bonding-Valence and molecular orbital approaches. Resonance, hyper-conjugation and tautomerism, Huckel molecular orbital theory and its application to simple systems- ethylene, allyl, cyclopropyl, butadienyl, cyclopentadienyl, pentadienyl, hexatrienyl, heptatrienyl systems. Calculation of the total energy and M.O. coefficients of the systems.

Aromaticity: Concept of aromaticity, Huckel’s rule, Polygon rule, Homo-aromatic, non-aromatic and anti-aromatic systems. Aromaticity in benzenoid and non-benzenoid molecules. Annulenes & hetero-annulenes. Physical methods to study aromaticity-UV, IR & ^1H NMR.

Bonds weaker than covalent: Addition compounds, crown ether complexes, cryptands, inclusion compounds, catenanes, fluxional molecules.

Structure and reactivity: Effects of hydrogen bonding, resonance, inductive and hyperconjugation on strengths of acids and bases.

UNIT-II: [15 Hours]

Methods of Determining Reaction Mechanism: Kinetic and non-kinetic methods, Identification of products, detection of intermediates, isotopic labeling, stereochemical evidences, cross-over experiments, Limitation of reactions, kinetic evidences and kinetic isotopic effects.

Reaction Intermediates: Generation, structure, stability, reactivity, detection, trapping and reactions of classical and non-classical carbocations, carbanions, free radicals, carbenes, nitrenes and arynes. Singlet oxygen-generation and reactions with organic molecules.
Aliphatic Nucleophilic Substitution Reactions: Mechanism and scope of aliphatic nucleophilic substitution reactions- $S_N^1$, $S_N^2$ and $S_N^i$. Stereochemistry of nucleophilic substitution reactions, allylic nucleophilic substitution reactions, Walden inversion, neighbouring group participation & anchimeric assistance. Factors influencing the rates of nucleophilic substitution reactions. 5 hrs

UNIT-III: Stereochemistry [15 Hours]

Optical Isomerism: Conformation and configuration of molecules, projection formulae, Fischer, Saw-horse, Newman and Flying wedge representations. Interconversion of these formulae. Absolute configuration (D,L) and (R,S) systems. Elements of symmetry, pseudoasymmetric centres, chirality, molecules with more than one chiral centre, threo and erythro isomers, methods of resolution, stereospecific and stereoselective synthesis, asymmetric synthesis, Cram’s and Prelog’s rules. Optical activity in the absence of chiral carbon-biphenyls, allenes and spiranes. Conformational analysis of cycloalkanes and decalins. Effect of conformation on reactivity. Acyclic & cyclic systems- Substituted cyclohexanes, cyclohexanones, cyclohexanols, Curtain-Hammet Principle. Stereochemistry of compounds containing nitrogen, sulphur and phosphorus. 12 hrs

Geometrical Isomerism: Cis-trans isomerism resulting from double bonds, monocyclic compounds & fused ring systems. E,Z-notations, determination of configuration of geometrical isomers, syn & anti isomers. 3 hrs

References:
CA H 403 : PHYSICAL CHEMISTRY

UNIT-I: Catalysis [15hours]


Acidity functions: Hammet acidity function, Zucker – Hammet hypothesis, and Bunnett hypothesis. 2hrs


UNIT – II [15 hours]

Chemical Kinetics:

Composite reactions: Rate equation for composite reaction mechanisms (simultaneous and consecutive reactions, steady state treatment, rate determining steps and microscopic reversibility), Chain reactions (hydrogen-halogen reactions with comparison). Auto catalytic reactions(Hydrogen-Oxygen reaction) and Oscillatory reactions. 6hrs.

Reactions in solution: Solvent effects on the reaction rates, Factors determining reaction rates in solution, reaction between ions (effect of dielectric constant and ionic strength), substitution and correlation effects (Hammet and Taft equations-linear free energy relations.) Ion-dipole and dipole-dipole reactions (Pre exp factors and influence of ionic strength) and diffusion controlled reactions. 4 hrs.

Fast reactions- Introduction, Study of fast reactions by-flow, relaxation, molecular beam, and spectroscopic and analytical methods. 3hrs.

Theory of reaction rates- Temperature dependence and the Arrhenius theory of reaction rates, collision theory of bimolecular reactions, its importance and limitations. Introduction to transition state theory. 2hrs.

UNIT-III: [15hours]

**Corrosion:** Introduction, Importance and principles, Forms of corrosion (Galvanic, Atmospheric, stress, microbial and soil). Techniques of Corrosion rate measurement (instrumental and non-instrumental). EMF series & Galvanic series and their limitations. Thermodynamics (Pourbaix diagram). Concept of mixed potential theory and its importance in terms of Kinetics (Tafel and Evans diagram), effect of oxidizer and passivity of corrosion. Protection against corrosion (Design improvement, Anodic and cathodic protection, inhibitors, coating).

6 hrs.

**Analytical Applications of Electrochemistry** - Principles and Applications of Polarography, Cyclic voltammetry, Coulometry, Amperometry and chrono systems. 5hrs.

**References**

**CAS 404 : SPECTROSCOPY AND ANALYTICAL TECHNIQUES**

**UNIT- I:**  [12 Hours]

**Electron Spin Resonance Spectroscopy:** Basic principles, hyperfine couplings, the ‘g’ values, factors affecting ‘g’ values, isotropic and anisotropic hyperfine coupling constants, Zero Field splitting and Kramer’s degeneracy. Measurement techniques and Applications to simple inorganic and organic free radicals and to inorganic complexes.

**NQR Spectroscopy:** Quadrupolar nuclei, electric field gradient, nuclear quadrupole coupling constants, energies of quadrupolar transitions, effect of magnetic field. Applications.

**Mössbauer Spectroscopy:** The Mössbauer effect, chemical isomer shifts, quadrupole interactions, measurement techniques and spectrum display, application to the study of Fe$^{2+}$ and Fe$^{3+}$ compounds, Sn$^{2+}$ and Sn$^{4+}$ compounds (nature of M-L bond, coordination number and structure), detection of oxidation states and inequivalent Mössbauer atoms.
Photoelectron spectroscopy: Basic principles, valence & core binding energies, shifts in energies due to chemical forces, Photoelectron spectra of simple molecules, Auger transitions, measurement techniques. Applications.

UNIT-II  

Ion Exchange Chromatography: Definitions, requirements for ion-exchange resin, synthesis and types of ion-exchange resins, Principles, basic features of ion-exchange reactions, resin properties, ion-exchange capacity, resin selectivity and factors affecting the selectivity, applications of IEC in preparative, purification and recovery process. Separation of lanthanides.

Exclusion Chromatography: Theory and principle of size exclusion chromatography, experimental techniques for gel-filtration chromatography (GFC) and gel-permeation chromatography (GPC), materials for packing-factors governing column efficiency, methodology and applications.

Thermal methods: Thermogravimetric analysis, Instrumentation, factors affecting the results and applications. Differential thermal analysis, simultaneous DTA-TGA curves. Differential scanning calorimetry, applications.

UNIT – III:  

Atomic Absorption Spectrometry: Principle, Theory, working of AAS instruments, analytical applications, interferences.

Emission Spectroscopy: Flame Emission Spectroscopy, plasma emission spectrometry, basic principles of flame photometry, evaluation methods in flame photometry, interferences.

Molecular Luminescence Spectroscopy: Theory of fluorescence and phosphorescence, fluorimetry in quantitative analysis, instruments, fluorescence and structure, fluorescence quenching, phosphorescence method, applications in quantitative analysis.

Light-Scattering methods: Nephelometry and turbidimetry- theory, effects of concentration, particle size and wavelength on scattering, instrumentation and applications. Activation analysis.

REFERENCES:

1. A. Salahuddin Kunju and G. Krishnan: Group Theory and its Applications in Chemistry, PHI Learning, N. Delhi, 2010


7. B.K. Sharma, Instrumental Methods of Chemical Analysis (Goel publishing), 2000.


CA S 405: ENVIRONMENTAL CHEMISTRY

UNIT-I [12 Hrs]


UNIT-II [12 Hrs]

Hydrologic cycle, sources, chemistry of sea water, criteria and standards of water quality- safe drinking water, maximum contamination levels of inorganic and organic chemicals, radiological contaminants, turbidity, microbial contaminants. Public health significance and measurement of colour, turbidity, total solids, acidity, alkalinity, hardness, chloride, residual chlorine, sulphate, fluoride, phosphate and different forms of nitrogen in natural and polluted water. Chemical sources of taste and odour, treatment for their removal, sampling and monitoring techniques. Determination and significance of DO, BOD, COD and TOC. Water purification for drinking and industrial purposes, disinfection techniques, demineralization, desalination processes and reverse osmosis.

UNIT – III [12hrs]

Toxic chemicals in the environment, impact of toxic chemicals on enzymes. Detergents-pollution aspects, eutrophication. Pesticides - pollution of surface water. Sewage and industrial effluent treatment, heavy metal pollution. Chemical speciation - biochemical effects of pesticides, insecticides, particulates, heavy metals (Hg, As, Pb, Se), carbon monoxide, nitrogen oxides, sulphur oxides, hydrocarbon, particulates, ozone, cyanide and PAN. Solid pollutants and its treatment and disposal. Radioactive waste management.
REFERENCES:


CA S 406: Molecular Spectroscopy & Diffraction Techniques

Unit-I [12 hours]
Introduction to spectroscopy, intensity of spectral lines, Natural line width and broadening, Rotational, vibrational and electronic energy levels, selection rules.

UNIT-II: [12 hours] Vibration-rotation spectra of diatomic and polyatomic molecules, selection rules, PQR branches. IR Spectrophotometer-Instrumentation

Unit III [12 Hours]


References:


CA P 407 : INORGANIC CHEMISTRY PRACTICALS - I

1. Analysis of Hematite-insoluble residue by gravimetry and Iron by volumetry using Ce⁴⁺.
2. Analysis of Dolomite - insoluble residue by gravimetry and Ca, Mg by complexometry.
3. Pyrolusite - Insoluble residue by gravimetry and Manganese content by oxalate method.
4. Analysis of solder - Pb and Sn by EDTA method.
5. Complexometric determination of Mn, Cu, Ni and Fe-Cr mixture
6. Hardness of water
7. Analysis of Halide Mixture - Iodide by KIO₃ and total halide by gravimetrically.
10. Statistical Analysis of Data.
Reference:


CA P 408 : ORGANIC CHEMISTRY PRACTICALS - I

Single and two stage organic preparations

1. Electrophilic substitution reactions–Preparations of p-bromoaniline, p-nitroaniline, 2,4,6-tribromophenol and picric acid.
2. Alkylations–Preparation of nerolin and N-methyl anthranilic acid.
4. Reactions with ring formation–Preparations of 1,2,3,4-tetrahydrocarbazole, 1-phenyl-3-methyl-5-pyrazolone and 7-hydroxy-4-methyl-coumarin.
5. Diazotisation reactions–Preparations of iodo, chloro and azo compounds.
6. Dehydration reactions–Preparations of cyclohexene and succinic anhydride
7. Condensation reactions–Condensations involving diethylmalonate and ethyl aetoacetate.
9. Reduction reactions–Reductions of nitro compounds and carbonyl compounds.

References:

CA S 409 : PHYSICAL CHEMISTRY PRACTICALS - I

(Any 12 experiments are to be carried out)

1. (a) Determination of transport number of Cd$^{2+}$ and SO$_4^{2-}$ ions by EMF method.
   
   (b) Determination of thermodynamic parameters of a cell reaction by EMF method.

2. Determination of pK values phosphoric acid by potentiometric/pH metric method

3. Potentiometric titration of halides in mixtures (Cl$^-$, Br$^-$ and I$^-$) with silver nitrate

4. Verification of Nernst equation for Ag$^+$, Cu$^{2+}$ and Zn$^{2+}$ species.

5. Determination of Solubility product and the Instability constant by potentiometric method.

6. Potentiometric determination of solubility of insoluble silver halide and the standard electrode potential using quinhydrone electrode.

7. Conductometric titrations of displacement and precipitation reactions.

8. Determination of equivalent conductance and dissociation constants of weak acid and base.

9. Determination of solubility of lead iodide at different T & hence molar heat of solution

10. Determination of hydrolysis constant of aniline hydrochloride.

11. Determination of degree of hydrolysis of CH$_3$COONa and NH$_4$Cl by conductivity method.


13. Determination of pH of buffer solutions with a pH meter & evaluation of pK$_a$ of acids

14. Verification of Walden's rule (relation between viscosity of a solution and the electrical conductivity.

15. Study of variation of viscosity of a liquid with temperature

16. Determination of parachor value for CH$_2$ group and some elements by Surface Tension method.

17. Determination of the composition of a solution by S.T measurement.

18. Determination of the Critical Micelle Concentration by surface tension/spectrophotometric measurements.

19. Determination of the composition of Zinc Ferrocyanide complex by Potentiometric titrations.

20. Determination of Specific and molar refractivity of liquids and parachor value of a species by refractometric method.
Any other relevant experiments of interest.

References:

3. Experimental Physical Chemistry - Daniels et al.
UNIT - I: [15 Hours]
Symmetry and Group Theory


UNIT - II: [15 Hours]
Chemistry of higher boranes, classification, structures and M.O. description of bonding, framework electron counting, Wade’s rules, chemistry of \( \text{B}_3\text{H}_9 \), \( \text{B}_{10}\text{H}_{14} \) and \( \text{B}_8\text{H}_{12}^2 \). Carboranes and metallocarboranes. Cyclophosphazenes, phosphazene polymers, S-N compounds. Coordination numbers 2-10 and their geometry, crystal field theory of coordination compounds, d-orbital splittings in octahedral, square planar and tetrahedral fields, spectrochemical series, and Jahn-Teller effect. Structural evidences for ligand field splittings – hydration, ligation and lattice energies, site preference energies. MO theory of coordination compounds- MO energy level diagrams for octahedral and tetrahedral complexes.

UNIT - III: [15 Hours]
Trends in oxidations states, stereochemistry and ionic sizes of metals, comparison of 3d, 4d and 5d series by taking Ti and Ni subgroups as examples. Lanthanides and actinides: electronic structure, oxidation states, extraction and separation of lanthanides, stereochemistry, spectral and magnetic properties of lanthanide and actinide complexes, lanthanide complexes as NMR shift reagents. Comparison with d-block ions.

Methods of reduction of oxide ores, Ellingham diagram, chemical and electrolytic reductions, reduction potentials, Latimer and Frost diagrams, effect of complexation on potential.

References:
CA H 452 : ADVANCED ORGANIC CHEMISTRY

UNIT - I: [15 Hours]

Aliphatic Electrophilic Substitution Reactions: Bimolecular mechanisms-S_E1, S_E2 and S_Ei mechanism. Electrophilic substitution reactions accompanied by double bond shifts. 3 hrs

Aromatic Electrophilic and Nucleophilic Substitution Reactions: Mechanism of aromatic electrophilic substitution reactions-nitration, halogenation, sulphonation, Friedel-Crafts alkylation and acylation, orientation and reactivity, energy profile diagram. The ortho/para ratio, ipso attack, orientation in other ring systems. Mechanism of Vilsmeir-Haack reaction, Mannich reaction, Diazonium coupling, Pechmann reaction and Fries rearrangement. Mechanisms of aromatic nucleophilic substitution reactions- S_NAr, S_N1 & aryne mechanism. Von-Richter rearrangement, Sommelet-Houser rearrangement, Smiles rearrangement. 12 hrs

UNIT - II: [15 Hours]


Elimination Reactions: Discussions of E1, E2 and E1cB mechanisms. Orientation during elimination reactions. Saytzeff and Hofmann rules. Reactivity-effects of substrate structures, attacking base, leaving group and solvent medium. 5 hrs

Pyrolytic Eliminations: Mechanisms of pyrolysis of esters of carboxylic acids. Chugaev reactions, Hofmann degradation, Cope elimination and xanthate pyrolysis. 5 hrs

UNIT - III: [15 Hours]

Formation and Hydrolysis of Esters: Plurality of mechanism. Mechanism of esterification reactions. Ester hydrolysis-A_AC2, B_AC2, A_AC1 & A_AL1 mechanism. Transesterification.4 hrs

Addition to Carbon-Hetero Multiple Bonds: Electrophilic, nucleophilic and free radical additions to C=O and C=N systems. Addition of Grignard reagents. Reformasky reaction, aldol condensation, Knoevenagel condensation, Perkin reaction and Wittig reactions. 6 hrs

References:

CA H 453 : ADVANCED PHYSICAL CHEMISTRY

UNIT I: [15 hours]

Chemical Thermodynamics:
Free energy, Maxwell’s relations and significance. Helmholtz’s and Gibbs free energies, Gibbs – Helmholtz equation and its applications.
Chemical affinity and thermodynamic functions. Effect of temperature and pressure on chemical equilibrium- van’t Hoff reaction isochore and isotherms.
Thermodynamic functions of mixing, Gibbs – Duhem – Margules equation.
Fugacity: Relationship between fugacity and pressure. Determination of fugacity- graphical method and Lewis Randall rule.
Activity and activity coefficient: Variation of activity and fugacity with temperature and pressure. Determination of activity by vapour pressure method.

**UNIT - II: Statistical and Irreversible thermodynamics**  
[15 hours]


**Law of equipartition principle. Partition function and equilibrium constant.**


6hrs.

**UNIT III: Quantum Chemistry**  
[15 hours]

Postulates of quantum Mechanics. Particle waves, its character and significance. Normalization and orthogonality of wave functions. Operators and their algebra, types and applications, operators for the dynamic variables of a system (position, linear momentum, angular momentum, Kinetic energy, potential energy and total energy). Eigen values and Eigen functions. Quantum numbers and their characteristics. Shrodinger wave equation- significance and derivation. Statistical interpretation of $\psi$.

7hrs

Solution of SWE for simple systems-particle in a box (1D & 3D), particle in a ring, simple harmonic oscillator, rigid rotor, the H atom (solution of $r, \theta, \Phi$ equations). Chemical Bonding in diatomics: Covalent bond-Valence bond and molecular orbital approaches with comparison.
Molecular orbital theory applied to homonuclear and heteronuclear diatomic molecules. Introduction to Hückel molecular orbital theory of conjugated systems and its applications. 8hrs

References:
1. Thermodynamics for Chemists - S Glasstone (East West press)
2. Physical Chemistry - P W Atkins.

CA S 454: ORGANIC SPECTROSCOPIC TECHNIQUES

UNIT–I: [12 hours]
UV/Electronic Spectroscopy: Basic principles, Chromophores, auxochromes, Instrumentation and application. Factors affecting the positions of UV bands. Electronic transitions and empirical correlations of predicting $\lambda_{\text{max}}$ of organic compounds. Woodward–Fieser rules. UV absorption of aromatic compounds - effect of substituents and solvent effects. Empirical rules to calculate $\lambda_{\text{max}}$. Application of UV spectroscopy in the structural study of organic molecules. 5 hrs

IR Spectroscopy: Basic principles, Application of infrared spectroscopy in the structural study-identity by finger printing and identification of functional groups. Characteristic vibrational frequencies of common functional groups (alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines). Study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, anhydrides and acids). Factors affecting band positions and intensities such as effect of hydrogen bonding, phase and solvent on vibrational frequencies, overtones, combination bands and Fermi resonance. 7 hrs

UNIT-II: Nuclear Magnetic Resonance Spectroscopy [12 hours]
Theory and principle, NMR spectrometer, FT NMR and its advantages. Solvents used, chemical shift and its measurements, factors affecting chemical shift. Integration of NMR signals, spin-spin coupling, coupling constant. Shielding and deshielding. Chemical shift assignment of major functional groups, Classification (ABX, AMX, ABC, $A_2B_2$), spin decoupling, effects of chemical exchange, fluxional molecules, Hindered rotation through NMR spectrum, Karplus relationships (Karplus curve–variation of coupling constant with dihedral angle), double resonance techniques,
NMR shift reagents, solvent effects and Nuclear Overhauser Effect. High resolution $^1$H NMR. Applications of NMR spectroscopy in structure elucidation of simple organic and inorganic molecules. Pulse techniques in NMR, two dimensional and solid state NMR. Use of NMR in Medical diagnostics.

NMR of nuclei other than proton: $^{13}$C chemical shift & factors affecting it. Decoupling-Noise decoupling & broad band decoupling. Off-resonanceproton decoupling-some representative examples. Introduction to $^{19}$F & $^{31}$P NMR.

UNIT-III: Mass Spectrometry [12 hours]


Composite problems involving the applications of UV, IR, $^1$H and $^{13}$C NMR and mass spectroscopic techniques. Structural elucidation of organic molecules.

REFERENCES:
5. Spectroscopic Methods in Organic Chemistry - Williams and Fleming, TMH.

**Lipids**: Fatty acids, essential fatty acids, structure and function of triacylglycerides, glycerophospholipids, sphingolipids, cholesterol, bile acids, prostaglandins.

**Lipoproteins**: composition and function, role in atherosclerosis, properties of lipid aggregates, micelles, bilayers, liposomes and their biological functions. Biological membranes – Fluid mosaic model of membrane structure. Lipid metabolism (oxidation of fatty acids).

**Unit II**: 12 Hours


**Coenzymes**: 12 Hours

Introduction. Co factors - cosubstrates - prosthetic groups. Classification-Vitamin derived coenzymes and metabolite coenzymes. Structure and biological functions of coenzyme A, thiamine pyrophosphate (TPP), pyridoxal phosphate (PLP), oxidized and reduced forms of nicotinamide adenine dinucleotide / their phosphates (NAD, NADH, NADP⁺, NADPH), Flavin adenine nucleotide (FAD, FADH2), Flavin mononucleotide (FMN, FMNH2) and tetrahydrofolate. Adenosine triphosphate (ATP) and adenosine diphosphate (ADP). Mechanism of reactions catalyzed by the above coenzymes.

**References**:
6. Enzyme structure and mechanism - Fersht and Freeman
7. Outlines of Biochemistry - Conn and Stumpf

UNIT-II Corrosion - Introduction, consequence, types, prevention and measurement. Conventional sources of energy, limitations, Importance of storage, Battery-Electrodes, Cell, battery Brief account of primary, secondary, lithium battery and fuel cells. Semiconductor electrodes and Solar energy system. Introduction to bioelectrochemistry, electrochemical communication in biological organisms. Theory and applications of Electroplating and electroless plating. 7hrs . Reaction Kinetics-Theory and applications of different types of reactions- Oscillatory, chain reaction, branched chain reaction. Energy of activation and thermodynamic parameters, Collision theory of reaction rates, limitations and basics of transition state theory. 5 hrs

UNIT- III Polymers: Introduction- Basic concepts and classification of polymers, Molecular weight and its distribution, Chemistry of polymerization- Step, chain, Coordination, Copolymerization. Polymerization techniques- bulk, solution, suspension, emulsion, poly-condensation, solid and gas phase polymerization. Chemical and geometrical structure of polymer molecules, Structure property relationship- Physical, Thermal and mechanical properties 6hrs

Synthesis, properties, structural features and applications of some important commercial polymers (PE, PP, PS, PVC, PMMA, PET, Nylon-6, Nylon-6,6) , Engineering polymers (Kevlar, Nomex, ABS, PC, Teflon). Applications of polymers in separations: reverse osmosis, ultra and nano-filtration. Applications in electronics- conducting polymers and electronic shielding, Applications of polymers in medicine. Management of plastics in environment- recycling, incineration and biodegradation. 6hrs
References:
8.. V.R. Gowariker, Polymer Science, New Age International (P) Ltd., New Delhi, 2012

CA P 457: INORGANIC CHEMISTRY PRACTICALS-II

Qualitative Analysis of mixtures of Inorganic Salts containing 3 cations and 2 anions (1 less common metal ions like Ti, W, Mo, V, Zr, Th, U, Ce, Ti and Li to be included among anions organic acid radicals, phosphate, borate and fluoride separation included).

References:

CA P 458: ORGANIC CHEMISTRY PRACTICALS-II

Separation and systematic qualitative analysis of binary mixtures of organic compounds containing both mono and bifunctional groups and preparation of suitable derivatives.

References:


**CAP 459: PHYSICAL CHEMISTRY PRACTICALS- II**

*(At least 12 experiments are to be carried out)*

1. Determination of cryoscopic constants of solvents and molecular weight of non volatile substances by thermal method.

2. Determination of degree of dissociation, Vant Hoff factor and molecular weight of an electrolyte by cryoscopy method using copper calorimeter/Dewar flask.


4. Phase diagram of two component systems by thermal analysis.

5. Phase diagram of three component system (a) 3 liquids with single binodal curve, and b) two liquids and one solid.

6. Kinetics of acid catalyzed hydrolysis of methyl acetate and determination of (a) order and rate constant and (b) Energy of activation.

7. Determination of a) Energy of activation & b) rate constant for the First and second order kinetics of reaction between potassium persulphate and potassium iodide.


11. Verification of F & L adsorption isotherms for acetic acid on activated charcoal.

12. To study the adsorption of iodine on charcoal from alcoholic solution.

13. To study the effects of gelatin solution on the precipitation values.


15. Thermodynamic prediction and measurement of the solubility of naphthalene in benzene.

16. Study of association of benzoic acid in benzene/toluene.

   Any other relevant experiments of interest.
References:-
4. Experimental Physical Chemistry - Daniels et al.