

M.Sc. (Chemistry) Programme



School of Sciences

Indira Gandhi National Open University
Maidan Garhi. New Delhi-110068

PROGRAMME GUIDE

for

M.Sc. (Chemistry)

(MSCCHEM)

IMPORTANT

The Programme Guide contains key information about the programme including the details of courses on offer, the syllabi of courses, advice on choice of courses and how to study the courses, assessment methods, rules and regulations, important forms, lists of Study Centres/Regional Centres of IGNOU. It will help you study the programme and progress in it.

Keep the Programme Guide safe, read it carefully before studying the courses, refer to it for rules and procedures and let it guide you throughout this phase of your student life in IGNOU.

**School of Sciences
Indira Gandhi National Open University
New Delhi - 110068**

IMPORTANT

Our course materials are prepared in such a way that you can study them on your own. If you do not understand any part, take help from your counsellor at your Study Centre or from us. **Please do not use any guides for studying the IGNOU MSCCHEM courses or for solving assignments.** Such guides will neither help you in understanding the subject matter nor in passing the examinations.

OUR TERMINOLOGY

In IGNOU, we use terms different from the ones used in conventional Colleges or Universities. So do please learn them. The terms used in IGNOU and their conventional equivalents are

- Programme stands for Course,
- Course for Paper, and
- Discipline for Subject.

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*Soft copy updated as on February 2024 (with reference to MSCCHEM programme only). Please refer to the IGNOU website www.ignou.ac.in for latest information.

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Further information on Indira Gandhi National Open University courses may be obtained from the University's office at Maidan Garhi, New Delhi - 110068.

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WELCOME MESSAGE

Dear Learner,

Welcome to the family of distance learners and **M.Sc. in Chemistry (MSCCHEM) programme** offered by the Chemistry Discipline of the School of Sciences, Indira Gandhi National Open University, New Delhi. The programme is designed and developed by experts spread across length and breadth of the country and is pitched at a level at par with any central University. It provides a strong foundation of fundamental and advanced aspects of chemistry and their applications in industry and research. It addresses the desire and demand of many students of the BSc/BSc (Hons. / Major) in Chemistry looking for job prospects in teaching / research / industry and R&D laboratories. In addition, the programme would also help many in-service people to upgrade their qualifications for mobility in their career. This includes thousands of the TGTs in the Schools spread across the country, who can improve their qualifications by earning a credible master's degree in chemistry and become eligible for the post of a PGT.

The broad objectives of the programme are as under:

- Provide an opportunity for higher education in Chemistry to science graduates.
- Provide an opportunity to the learners to upgrade their qualifications.
- Provide the opportunities to the learners in building / upgrading their careers in teaching / research and industry.

It is a 2-year programme during which you will study a wide range of topics related to different domains of Chemistry. The course material (Self Learning Material, SLM) for the programme is designed and developed in a way that the learner can learn on one's own without the help of any teacher. Nonetheless, there may be occasions where you may need some intervention and hand holding. For this you will be attached to a Learner's Support Centre (LSC) and a regional centre (RC). These will provide you the academic and other support. We expect you to be directly in contact with yours RC and LSC. In addition, you are advised to keep visiting IGNOU's website (<http://www.ignou.ac.in/>) for the regular updates. This Programme Guide contains the information like instructional system, syllabi of the programme, details of evaluation scheme etc. related to the MSCCHEM programme. Besides, it contains other important information. Remember that your registration for this programme will be valid for four years from the date of initial registration.

The self-learning material (SLM) for MSCCHEM programme will reach you after you get admitted in this programme. The self-instructional course material will also be uploaded on **eGyankosh Website** (<https://egyankosh.ac.in/handle/123456789/100840>) and is available through **IGNOU eContent App** that can be installed from Google's play store. Each course contains prescribed number of assignments that will be assessed by a counsellor at your study centre. These are the continuous assessment tools and carry a weightage of 30%. You can download the assignments from IGNOU website (<https://webservices.ignou.ac.in/assignments/Master-Degree/Master.htm>). You need to submit the solved assignments at your study centre within the stipulated time mentioned against last date of submission. *You will not be allowed to appear in the Term-end Exam unless the assignments have been submitted.* All the details pertaining to the assignments will be given in the assignment booklet itself and will be uploaded on the IGNOU website. In case, you need the assignments of previous semesters, you can obtain a copy of the same from the IGNOU website.

To facilitate your learning, there is a provision of **face-to-face** counselling for all courses. You need to attend practical counselling sessions compulsorily to be eligible for appearing for the Term-end Practical Examinations. **Please note that the counselling schedules for the theory as well as lab courses will**

be provided by the coordinator of the Programme/Learner Support Centre/Study Centre. Therefore, you are advised to be in constant touch with the Learner Support Centre.

You are supposed to pay the examination fee and the re-registration fee online. It is to be noted that the payments that are mentioned in various proformas/formats/forms are as on date and are subject to revision from time to time. You are advised to check these proformas/formats/forms from IGNOU website/LSC/RC for any revision/modification. Some useful forms and formats (or the link to useful forms and formats) are also given at the end of this booklet. The Programme Guide, forms and formats are also available on the IGNOU website. Please confirm the fees with the RC / LSC / Website before you pay. As a distance learner, you may have several queries. You will find answers to many of them in this booklet. This booklet is a very important guide for you.

Please read this Programme Guide very carefully and keep it handy until you successfully complete the MSCCHEM programme.

However, during your studies, if you have any feedback, suggestions, and comments to make, please send an Email to the programme coordinators at: sanjiv_sos@ignou.ac.in or kamalika@ignou.ac.in . In case, you have any specific query, you can write to us on iGRAM (<http://igram.ignou.ac.in>).

You can communicate through post also. Write to us at

The Programme Coordinator(s)
MSc in Chemistry Programme
School of Sciences, Raman Bhavan, D-Block, Academic Complex,
IGNOU, Maidan Garhi, New Delhi – 110068

You may visit the IGNOU website for more information at: <http://www.ignou.ac.in>

Important Dates (Re-registration / registration for TEE)

The Re-registration (registration to new semester (s)) and registration for term-end examination are to be done online only. The last date of registration / re-registration is announced on the IGNOU website. In general, these are about 2-3 months prior to the start of Session. You must visit IGNOU website for actual dates.

e-version of the learning material

The soft copy of the learning material for MSCCHEM programme can be downloaded from e-Gyankosh (the e-Content repository of education resources)

<https://egyankosh.ac.in/handle/123456789/100840>

It can also be assessed through IGNOU e-Content mobile App (can be downloaded from Google Play Store:

<https://play.google.com/store/apps/details?id=ac.in.ignou.Viewer&hl=en>

We wish you success in pursuing the MSCCHEM programme.

THE UNIVERSITY

The Indira Gandhi National Open University (IGNOU) was established in September 1985 by an Act of Parliament to provide opportunities of higher education to large segments of population, vocations and professions. The primary emphasis is on innovation, flexibility, and cost-effectiveness. It is a university with a difference!

The major objectives of the university are to:

- promote the educational well-being of the community;
- democratise higher education by providing equitable access to all those who desire to improve their qualifications, skills and competence by taking education to the doorsteps of people living even in remote rural areas;
- disseminate knowledge through an innovative multiple media instructional package for self-learning; and
- provide high quality education at all levels.

In IGNOU, you can study:

- at your own pace and convenience;
- at your own chosen place; and
- courses of your choice from a wide range of Disciplines.

The University uses a variety of communication technologies for teaching-learning. **Student Support services** are provided at **Learner Support Centres** located all over the country. These Centres are in educational institutions and function on all holidays and Sundays. Some Study Centres open in the evenings on working days and Saturdays. Each Study Centre is supervised by a **Coordinator**. The functioning of Study Centres is monitored by **IGNOU Regional Centres**.

School of Sciences

The School of Sciences was established in 1985 and has been offering Science programmes successfully through the distance mode of education. Presently, there are eight disciplines, namely, Biochemistry, Chemistry, Geography, Geology, Life Sciences, Mathematics, Physics and Statistics in the School. At present, there are 42 faculty members and 15 administrative staff members in the School of Sciences.

The functions of the School are to:

- plan, develop and offer academic programmes at the Awareness, Certificate, Diploma, Under-Graduate, Post-Graduate and Research levels;
- collaborate with the other Schools of the University in the development of various programmes/courses;
- participate in the development and academic monitoring of the student services; and
- carry out research in systemic and discipline-based areas of Science.

1. M.SC. (CHEMISTRY) PROGRAMME

The programme is designed and developed by experts spread across the country and is pitched at a level at par with any central University. It provides a strong foundation of fundamental and advanced aspects of chemistry and their applications in industry and research. It addresses the desire and demand of many students of the BSc/BSc (Hons. / Major) in Chemistry looking for job prospects in teaching / research / industry and R&D labs. In addition, the programme would also help many in-service people to upgrade their qualifications for mobility in their career. This includes thousands of the TGTs in the Schools spread across the country, who can improve their qualifications by earning a credible master's degree in chemistry and become eligible for the post of a PGT.

The objectives of the programme are as to:

- ❖ provide an exposure to fundamental principles and advanced concepts of various domains of chemistry including organic, inorganic, physical, analytical, and interdisciplinary areas;
- ❖ to cultivate critical thinking skills to analyse and propose innovative solutions complex chemical problems;
- ❖ to provide hands-on experience in designing and conducting chemical experiments and interpreting experimental results;
- ❖ to encourage the learners for lifelong learning and equipping them with the knowledge & skill sets needed to adapt to fast changing trends in the field of chemistry throughout their careers; and
- ❖ provide the opportunities to the learner in building / upgrading their careers in teaching / research and industry.

1.1 Target Group:

- ❖ Science graduates with BSc/BSc (Hons. / Major) degree in Chemistry looking for job prospects in teaching / research / industry and R&D labs.
- ❖ In service science graduates, including TGTs working in the Schools across India.

1.2 Duration of Programme:

To fulfil the requirements for acquiring the MSCCHEM, a learner may successfully complete each course of the programme in a minimum of 2 years and a maximum of 4 years.

Minimum: 2 years and Maximum: 4 years.

1.3 Medium of Instruction

The medium of instruction is **English**. The course material is in English.

1.4 Eligibility

- Graduates with B.Sc. (Major/Honours) Degree in Chemistry from a recognised university.
- Graduates with a B.Sc. Degree (or equivalent) from a recognised university with Chemistry as one of three science subjects with equal weightage
- Graduates with a B.Sc. Degree from an Open University with a minimum of 20 Credits of Chemistry courses

1.5 Programme Fee

The total programme fee, exclusive of examination fee, is ₹ 40,400/-* which is to be paid annually @ ₹ 20,200/- per annum.

In addition, a registration fee of ₹ 300/- (Non-refundable) is to be paid at the time of admission. *(The University can revise the programme fee and the revised fee shall be payable by you as per schedule of payment notified by the University from time to time).* Timely payment of programme fees is the responsibility of the students. Students are expected to remit fee as early as possible without waiting for the last date. In case, you fail to remit the fee as per above schedule, you will have to wait for next cycle of fee payment schedule. Non-payment of fee results in discontinuation of the despatch of study material. Such students will not be permitted to write the examinations. In case any student wilfully appears in the examination without proper registration for a course(s), disciplinary action shall be taken against him as per rules of the University.

1.6 Credit System

The IGNOU follows the '**Credit System**' for its programmes. Each credit is equivalent to 30 study hours comprising all learning activities. Thus, a four-credit course involves 120 study hours. This helps learners to understand the academic effort he/she must put into successfully completing a course. **Successful Completion of the programme requires successful completion of continuous evaluation (assignments) and the Term-End Examination of each course in the programme.**

1.7 Recognition

IGNOU is a Central University established by an Act of Parliament in 1985 (Act No.50 of 1985) IGNOU Degrees/Diplomas/Certificates are recognized by all member Universities of Association of Indian Universities (AIU) and are at par with Degrees/Diplomas/Certificates of all Indian Universities/Deemed Universities/Institutions vide UGC Circular No. F1-52/2000 (CPP-II) dated 5 May, 2004 and AIU Circular No. EV/B (449)/94/177115 dated January 14, 1994, and UGC's letter no. UGC/DEB/2013 dated 14.10.2013, and UGC notification on UGC website F.No. 1-18/2018 (DEB-I) dated 21-02-2019, list Master of Computer Application of IGNOU as one the programme recognised from 2018-19 to 2022-23. You may download all the recognition related information from the following web links.

- <http://www.ignou.ac.in/ignou/aboutignou/division/srd/new> and
- <http://ignou.ac.in/ignou/aboutignou/division/srd/Recognition>

1.8 Student Support Services

To provide individualised support to its learners, the University has created several Learner Support Centres (LSC) / Study Centres (SC) throughout the country for this programme. A list of the currently activated LSCs is given at page 43. These are administratively coordinated by the Regional Centres (RCs). The LSCs are the contact points for the students on all major aspects of the programme. These include theory and practical counselling sessions, reference library facilities, disseminating information and advice, facilities for audio-visual training aids and teleconferencing. The University may not always be able to communicate to all the learners individually. All the important communications are sent to the Regional Directors who in turn will intimate them to the LSC coordinators. The coordinators display such Circulars / Notifications on their notice boards for the benefit of the learners. You are, therefore, advised to be in touch with your LSC coordinator on a more regular basis to get the latest information about assignments, submission schedules (assignments and examination forms), declaration of results, etc.

2. PROGRAMME STRUCTURE AND DETAILED SYLLABI

This is a two-year master's degree programme in Chemistry, which is offered in both January and July cycles of admission. The programme has been divided into two semesters per year and comprises 14 core and compulsory theory courses worth total 50 credits, 9 compulsory lab courses worth 18 credits, and three elective courses worth 12 credits. To successfully complete this programme, you will have to earn 80 credits over a period of 2 to 4 years depending on your convenience. The detailed structure of the MSCCHEM programme is as follows:

Programme Structure

Course Code	Title of the Course	Type of Course	Course Credits
Semester I			
MCH-011	Inorganic Chemistry -I	Theory	04
MCH-012	Organic Chemistry-I	Theory	04
MCH-013	General Physical Chemistry	Theory	04
MCH-014*	Mathematics for Chemists	Theory	02
MCH-015*	Biology for Chemists	Theory	02
MCHL-011	Chemistry Lab-I	Lab	02
MCHL-012	Chemistry Lab-II	Lab	02
MCHL-013	Chemistry Lab-III	Lab	02
Semester II			
MCH-016	Inorganic Chemistry -II	Theory	04
MCH-017	Organic Chemistry-II	Theory	04
MCH-018	Quantum Chemistry and group theory	Theory	04
MCH-019	Green Chemistry	Theory	02
MCHL-014	Chemistry Lab-IV	Lab	02
MCHL-015	Chemistry Lab-V	Lab	02
MCHL-016	Chemistry Lab-VI	Lab	02
Semester III			
MCH-020	Atomic and Molecular spectroscopy	Theory	04
MCH-021	Chemistry of Materials	Theory	04
MCH-022	Separation and Spectroscopic Methods	Theory	04
MCHL-017	Separation and Spectroscopic Methods Lab	Lab	02
MCH-023	Environmental Chemistry	Theory	04
MCHL-018	Environmental Chemistry Lab.	Lab	02
Semester IV			
MCH-024	Introduction to research	Theory	02
MCH-025	Electroanalytical and Other analytical methods	Theory	04
MCHL-019	Electroanalytical and Other analytical methods Lab	Lab	02
MCHE-011	Elective- I: Applications of spectroscopy to Inorganic & Bioinorganic molecules	Elective	04
MCHE-012	Elective- II: Spectroscopic Identification of Organic Compounds	Elective	04
MCHE-013	Elective- III: Supramolecular Chemistry	Elective	04
MCHE-014	Elective – IV: Primary and Secondary Metabolites	Elective	04
MCHE-015	Elective – V: Advanced Kinetics and Electrochemistry	Elective	04

* The learners with biology background should choose MCH-014 (Mathematics for Chemists) course and the learners with mathematics background should choose MCH-015 (Biology for Chemists) course

2.1 Detailed syllabi of the Courses

Semester 1

MCH-011: INORGANIC CHEMISTRY-I**(04 Credits, 60 Lectures)**

General Characteristics of Main Group Elements and Transition Elements: Periodic Trends of Main Group Elements and Transition Elements; Electronic Configuration (Along with IUPAC Periodic Table), Periodic Trends in Properties, Atomic Radii, Atomic Volume and Density, Melting and Boiling Points, Ionisation Energy, Electronegativity, Electrode Potential, Oxidation States; Stability of various Oxidation States for Mn, Fe and Cu; Latimer Diagrams

The Structure of Molecules : VSEPR (Along with Point Groups); Walsh Diagram (Triatomic and Penta-atomic Molecules), $d\pi-p\pi$ Bond; Bent Rule and Energetics of Hybridization; Geometric and Optical Isomers

Phosphorus-nitrogen and Sulfur-nitrogen Compounds : Phosphorus-nitrogen Compounds; Synthesis, Structure, Bonding and Uses of Cyclo and Linear Phosphonitrilic Compounds; Sulphur-Nitrogen Compounds; Ring and Chain Compounds S_2N_2 , S_4N_4 . $(SN)_x$ etc.

Organometallic Compounds : Classification and Nomenclature of Organometallic Compounds; Organometallic Compounds of Alkali and Alkaline Earth Metals; Synthesis, Structure and Bonding, Properties and Uses; Organometallic Compounds of Transition Metals; Alkyls and Aryls Types, Routes of Synthesis, Stability and Decomposition Pathways, Organocopper Compounds and Its Applications

Metal Carbonyls: Metal Carbonyl; 18-electron Rule, Counting Electrons in Complexes, Structure and Bonding; Important Reactions of Metal Carbonyls; Vibrational Spectra of Metal Carbonyls; Bonding and Structural Elucidation of Carbonyls

Metal pi-Complexes: Transition Metal Nitrosyl Complexes; Transition Metal Dinitrogen and Dioxygen Complexes; Tertiary Phosphine as Ligand; Alkene, Alkyne, AllylDiene and Cyclopentadienyl Complexes; Arenes and Other Alicyclic Ligands

Metal Clusters : Higher Boranes, Wade's Rules; Carboranes, Metallaboranes and Metallocarboranes; Compounds with Metal-metal Multiple Bonds

Crystal Field Theory : Crystal Field Theory; Octahedral Complexes; Splitting of Orbitals in an Octahedral Field, Spectrochemical Series, Crystal Field Stabilization Energy, Weak and Strong Field Complexes, Pairing Energies, Low Spin and High Spin Complexes; Jahn Teller Effect ; Tetrahedral and Square Planar Complexes

Applications and Limitation of Crystal Field Theory : Applications of Crystal Field Theory; Lattice Energies, Ionic Radii, Thermodynamic and Related Aspects of Crystal Fields, Heats of Ligation, Site Preference Energies; Limitation of Crystal Field Theory; Molecular Orbital Theory, Nephelauxetic Effect; π -Bonding and Molecular Orbital Theory

Basics of Magnetochemistry : Definitions of Magnetic Properties; Types of Magnetic Bodies, Paramagnetism: Orbital & Spin Contribution; Magnetic properties; Lanthanoids, First Transition Metal Ions, Actinoids; Methods for Magnetic Susceptibility Measurements; Derivation of Van Vleck Equation

d-metal Complexes: Magnetism : Ferromagnetism and Antiferromagnetism; Mechanism of Anti-Ferromagnetic Interaction; Spin Cross Over and Anomalous Magnetic Moments; Applications of Magnetic Measurement for Structural Elucidation

Electronic Spectra of Transition Metal Complexes : Spectroscopic Terms; R-S Coupling of d^n System, Racah Parameters, Correlation of Spectroscopic Terms; Orgel and Tanabe-Sugano Diagrams for Transition Metal Complexes (d^1 - d^9 states)

$d-d$ transition and Charge Transfer Spectra : Selection Rules and $d-d$ transition in Metal Complexes; Charge Transfer Spectra; LMCT Transitions, MLCT Transitions, The Nephelauxetic Series; Spectroscopic Method of Assignment of Absolute Configuration in Optically Active Metal Chelates and their Stereochemical Information; Inter-Valence

Further Reading:

1. Advanced Inorganic Chemistry, F.A. Cotton and G. Wilkinson, John Wiley and Sons.
2. Inorganic Chemistry (4th ed.), J.E Huheey, Keiter, Keiter and Medhi, Pearson Education, 2006.
3. Chemistry of the Elements. N.N. Greenwood and A. Earnshaw, Pergamon.
4. Inorganic Electronic Spectroscopy, A.B.P. Lever, Elsevier.
5. Elements of Magnetochemistry (2nd Edition), R. L. Dutta & Syamal, EWP, New Delhi.
6. Comprehensive Coordination Chemistry eds., G. Wilkinson, R.D. Gillard, and J.A. McCleverty, Pergamon.

MCH-012: STEREOCHEMISTRY AND REACTIVE INTERMEDIATES (4 credits, 60 Lectures)

Section A: Stereochemistry of Organic Compounds (30 Lectures)

Molecular Symmetry and Chirality : Classification of Stereoisomers; Optical Isomers; Symmetry Operations and Symmetry Elements, Point Group Classification; Symmetry and Molecular Properties; Rotation of Polarised Light, Symmetry Number; Molecules with One Chiral Centre; Chirality and Symmetry

Stereoisomerism of Molecules with More than One Chiral Centers : Molecules with Two Chiral Centres; Racemic Modifications, Formation (by mixing, synthesis, racemisation etc.), Properties, Different Methods of Resolution, Criteria of Optical Purity; Molecules with Three or More Chiral Centres; Axial and Planar Chirality and Helicity (P and M); Cyclosteroisomerism

Conformations of Six-membered Rings : Basic Aspects of Conformations; Stereochemistry of Cycloalkanes; Conformations and Stability of Cyclohexanes; Monosubstituted Cyclohexanes, Disubstituted Cyclohexanes, Trisubstituted Cyclohexanes; Conformations and Stability of Cyclohexenes; Conformations and Stability of Cyclohexanones and Halocyclohexanones; Cyclohexanones, Halocyclohexanones; Conformations and Stability of Decalins, Decalols and Decalones; Decalins, Decalols, Decalones

Stereochemistry of Complex Systems: Stereochemistry of Allenes and Spiranes; Stereochemistry of Alkyldienes, Stereochemistry of Ethanal, Propanal and Ethyl Methyl Ketone; Stereochemistry of Adamantanes; Stereochemistry of Catenanes; Stereochemistry of Biphenyls, Atropisomerism; Stereochemistry of Bridged Biphenyls; Stereochemistry of Ansa Compounds and Cyclophanes

Configuration and its Correlation : Representation of Configuration: *D*, *L*, *R*, *S* and *E*, *Z*-nomenclature; Determination of Configuration-Different Methods; Chemical Correlation, Quasiracemates

Topicity and Prostereoisomerism : Topicity of Ligands and Faces and their Nomenclature; Stereogenicity; Chirogenicity; Pseudoasymmetry; Stereogenic and Prochiral Centres

Asymmetric Induction : Cram's, Prelog's, and Felkin-Ahn Model; Dynamic Stereochemistry (Acyclic and Cyclic); Qualitative Correlation between Conformation and Reactivity; Curtin-Hammett Principle

Molecular Dissymmetry and Chiroptical Properties : Linear and Circularly Polarised Lights; Circular Birefringence and Circular Dichroism; ORD and CD Curves; Cotton Effect; The Axial Haloketone Rule; Octant Diagrams; Helicity; Lowe's Rule; Application of ORD and CD to Structural and Stereochemical Problems

Section B: Reactive Intermediates in Organic Chemistry **(30 Lectures)**

Organic Reaction Mechanisms : Basic Aspects of Organic Reaction Mechanisms, HSAB principle and its Applications; Methods of Determination of Organic Reaction Mechanisms; Linear Free Energy Relationships and their Applications (Hammett Equation and Modifications)

Carbocations-I: Structural Aspects : Structure and Stability of Carbocations; Classical and Non-Classical Carbocations; Neighbouring Group Participation; Ion-pairs

Carbocations-II: Rearrangement Reactions : Recapitulation of General Reactions; Molecular Rearrangements in; Acyclic Systems, Monocyclic Systems, Bicyclic Systems; Stability and Reactivity of Bridge-Head Carbocations

Carbanions : Generation of Carbanions; Structure and Stability of Carbanions; Ambident ions and their General Reactions; Rearrangements of Carbanions

Free Radicals : Generation of Free Radicals; Structure of Free Radicals; Stability and Reactions; Cage Effects; Radical-cations and Radical-anions; S_RN1 Mechanisms

Carbenes : Formation and Structure of Carbenes; Reactions Involving Carbenes and Carbenoids, Electrophilic and Nucleophilic Reactions; Carbenoids

Nitrenes : Generation of Nitrenes; Structure and Reactions of Nitrenes

Arynes : Generation and Reactivity; Nucleophilic Aromatic Substitution Reactions; S_NAr Mechanism, Regioselectivity; Ipsso Effect

Further Readings

1. Carey, F.A. & Sundberg, R. J. Advanced Organic Chemistry, Parts A & B, Plenum: U.S. (2007)
2. Eliel, E. L. Stereochemistry of Carbon Compounds Textbook Publishers (2003).
3. Finar, I. L. Organic Chemistry Vol. 1, Longman (1998).
4. Lowry, T. H. & Richardson, K. S. Mechanism and Theory in Organic Chemistry Addison-Wesley Educational Publishers, Inc. (1981).
5. March, J. Advanced Organic Chemistry John Wiley & Sons (2004).
6. Kalsi, P. S. Stereochemistry: Conformation and Mechanism, 7th Edition New Age International, Delhi (2008).
7. Jonathan Clayden, Nick Greeves, Stuart Warren Organic Chemistry 2nd Edition

MCH-013: GENERAL PHYSICAL CHEMISTRY

(4 Credits, 60 Lectures)

Gibbs and Helmholtz's Functions : Laws of Thermodynamics; Gibb's Function and Equilibrium Criterion; Temperature and Pressure Dependence of Gibb's Energy; Helmholtz Function and Equilibrium Criterion

Systems of Variable Composition: Partial Molar Quantities and Their Significance, Experimental Determination Partial Molar Volume; Chemical Potential, Significance of Chemical Potential; Mixture of Gases, Fugacity and Its Significance; Gibbs-Duhem Equation

Introduction to Statistical Thermodynamics : Basic Probability Theory; Permutations and Configurations, Stirling Approximation; Probability Distribution Functions; Characteristics of Probability Distribution Functions; Boltzmann's Distribution; Microstates and Configurations, Physical Significance; Canonical Ensemble; Molecular Partition Functions; Translational Partition Functions, Rotation Partition Functions, Vibration Partition Functions, Electronic Partition Functions; Third Law of Thermodynamics

Fundamentals of Solid State : Solid State and Its Characteristics; Crystal Lattice, Designation of Lattice Planes; X-Ray Diffraction, Indexing Crystal Planes; Electronic Structure of Solids; Magnetic Properties of Solids, Curie and Curie-Weiss Laws, Calculation of Magnetic Moments

Crystal Symmetry : Molecular Symmetry, Symmetry Elements versus Symmetry Operations; Crystal Symmetry; Screw Axis, Glide Plane; Stereographic Projections

Collision and Transition State Theories : Collision theory and Its Limitations, Limitations of Collision Theory; Transition State Theory; Thermodynamic Approach, Statistical Approach,

Theories of Unimolecular Reactions : Unimolecular Reactions and Their Characteristics; Lindemann's Mechanism; Experimental Verification, Limitations of Lindemann's Mechanism; Hinshelwood's Theory, Limitations of Hinshelwood's Theory; RRKM Treatment

Kinetics of Reactions in Solution : Role of Solvents in Reactions in Solution; Theory of Reaction Rate in Solution; Salt Effects; Primary Salt Effects, Secondary Salt Effects

Kinetics of Fast Reactions : Fast Reactions and Their Importance; Flow Techniques; Continuous Flow Technique, Accelerated Flow Method, Stopped Flow Method, Limitations of Flow Techniques; Relaxation Methods; Shock Tubes, Flash Photolysis, Laser Photolysis; Spectroscopic Techniques

Kinetics of Enzyme Reactions : Enzymatic Reactions And Their Characteristics; The Michaelis–Menten Mechanism, Turnover Number and Michaelis Constant, Lineweaver–Burk Plot; Mechanisms of Enzyme Inhibition; Competitive Inhibition, Non-Competitive Inhibition

Catalysis : Adsorption Phenomenon, Langmuir Adsorption Isotherm; Gibbs Adsorption Isotherm; Multilayer Adsorption, Bet Equation and Its Application Heterogenous Catalysis

Debye Huckel Theory-I : Ionic Cloud, Poisson's Equation; Non-Ideality of Electrolytic Solutions; Activity and Mean Activity Coefficient, Measurement of Activity Coefficients; Debye Huckel Theory; Postulates of Debye Huckel Theory, Mathematical Treatment;

Debye Huckel Theory-II : Ionic Cloud and Electrostatic Potential; Charge Distribution around Central Ion, Chemical Potential Changes Due To Ion-Ion Interactions; Success And Limitations of Debye Huckel Theory, Modification in Huckel Law; Mean Ionic Activity Coefficients, Determination of Mean Ionic Activity Coefficients

Diffusion and Viscosity : Transport Phenomenon; Kinetic Theory of Gases; Distribution of Molecular Velocities, Mean Free Path; Diffusion Across Concentration Gradient; Fick's First Law of Diffusion, Relationship between Diffusion Coefficient and Mean Free Path; Viscosity and Coefficient of Viscosity; Osmosis; Diffusion versus Osmosis, Reverse Osmosis, Forward Osmosis

Thermal and Electrical Conduction : Thermal Conduction, Coefficient of Thermal Conductivity and Mean Free Path; Electrical Conduction; Drift Velocity, Relationship between Ionic Mobility and Conductance

Further Readings

1. Klotz Irving M. and Rosenberg Robert M. Chemical Thermodynamics: Basic Concepts and Methods; Wiley-Interscience; 7th edition (2008)
2. J. M. Bockris and A. K. N. Reddy, Modern Electrochemistry 1 (Ionics), Springer (2006).
3. Laidler, K. J. Chemical Kinetics 3rd Ed., Benjamin Cummings (1997).
4. Silbey, R. J., Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed. Wiley (2004)
5. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press (2006).
6. West, A.R. Basic Solid State Chemistry, 2nd Edition, John Wiley & Sons (2000).
7. Brett, C. M. A. & Brett, A. M. O. Electrochemistry Oxford University Press (1993).
8. Nash, L. K. Elements of Statistical Thermodynamics 2nd Ed., Addison Wesley (1974).
9. S. Glasstone, Thermodynamics for Chemists, New Delhi: Maurice Press, 2008.

MCHL-011: CHEMISTRY LAB-I

(2 Credits, 60 Lectures)

Semimicro Qualitative and Quantitative Analysis

1. Detection of less common metal ions: Ce, Ti, Mo, W, Zr, Th, V, U, (two metal ions in cationic/anionic forms: minimum two mixtures).
2. Separation and determination of two metal ions (Ca, Mg, Cu, Ni, Zn, Cu, Pb) involving volumetric titrations (redox & complexometric) and gravimetry (minimum four experiments).

Further Readings:

1. Vogel's Textbook of Quantitative Analysis, revised J. Bassett, R. C. Denney, G.H. Jeffery and J. Mendham, ELBS.
2. Introduction to Semimicro Qualitative Analysis by J.J. Lagowski and C.H. Sorum, Prentice Hall, Englewood Cliffs, N.J.
3. Vogel's Textbook of Qualitative Analysis, revised by G. Svehla, Orient Longman.

MCHL-012: CHEMISTRY LAB- II

(2 Credits, 60 Lectures)

- A) Identification of components in a two-component mixture and preparation of their derivatives. Determination of b.p. / m.p. for components and m.p. for the derivatives. (3+3 mixtures) 3 days (6 Session)
- B) Any **Six preparations** from the following: 3 days (6 Sessions)
1. Preparation of o-benzoyl benzoic acid (Fridel Crafts Reaction)
 2. p-Nitrobenzoic acid from p-nitrotoluene (Oxidation)
 3. Anthroquinone from anthracene (Oxidation)
 4. Glucose pentaacetate from Glucose (Acetylation)
 5. m-Nitroaniline from m-dinitrobenzene (Reduction)
 6. Benzophenoneoxime from benzophenone (Addition reaction)
 7. p-Chlorotoluene from p-toluidine (Sandmeyers' Reaction)

- 2,3 - Dimethylindole from phenyl hydrazine and 2 - butanone (Fisher Indole Synthesis)
- 1,2,3,4 - Tetrahydrocarbazole from cyclohexanone (Fisher Indole Synthesis)
- Methyl orange from sulphanilic acid (Diazo Reaction)

Further Readings:

- Addison Ault Techniques and Experiments for Organic Chemistry 6th Ed. University Science Books (1998).
- Mann, F. G. & Saunders, B. C. Practical Organic Chemistry 4th Ed. Orient Longmans (1990).
- Vogel, A. I. Vogel's Textbook of Practical Organic Chemistry 5th Ed. (revised by A.R. Tatchell et al.) Wiley (1989) ISBN 0582-46236-3

MCHL-013: CHEMISTRY LAB-III**(2 Credits, 60 Lectures)****Note: Perform any ten of the following experiments**

Expt. No.	Title of the Experiment
1	To determine the partial molar volumes of sodium chloride solutions by measuring function of concentration, using a pycnometer.
2	Determine the mean activity coefficient (γ) of 0.01 M hydrochloric acid solution.
3	Determination of the specific rate constant for the acid catalysed hydrolysis of methyl acetate using hydrochloric acid at two temperatures by Initial Rate Method and calculate the thermodynamic parameters
4	To determine the molecular weight of a given macromolecule (PVP) by the viscosity method.
5	To verify Gibb's adsorption isotherm and determine the surface area of charcoal.
6	Set up saturated calomel electrode and measure its potential using the quinhydrone electrode as reference electrode.
7	To set up the Zn/ZnSO ₄ (0.1 M) electrode, measure its potential and obtain the value for its standard electrode potential
8	To determine the concentration of sodium carbonate in a commercial sample of soda ash by conductometric titration with hydrochloric acid.
9	To determine the strength of a moderately strong acid (salicylic/ mandelic acid) by conductometric titration using (a) salt-line method or (b) double alkali method.
10	To study the effect of dielectric constant (ϵ) on the nature of the conductometric titration between maleic acid and sodium methoxide using different combinations of methanol and hexane as solvents.
11	To study the stepwise neutralisation of oxalic acid or citric acid by conductometric titration and explain the variation in the plots.
12	To determine the dissociation constant of acetic acid potentiometrically.
13	To determine molar conductivity of a strong electrolyte at different concentrations and verify Debye-Hückel-Onsager equation.

Further Readings:

1. Experiments in Physical Chemistry, Carl W. Garland, Joseph W. Nibler, David P. Shoemaker, McGraw-hill
2. Experimental Physical Chemistry, Mathews, G. Peter, Oxford Clarendon Press (1985).
3. Levitt, Findlay's practical physical chemistry. Longman's London:1966.
4. A.M. James and D.E. Pritchard. Practical physical chemistry, Longman Group Ltd: 1968.
5. V.D. Athawale and Parul mathur. Experimental physical Chemistry. New Age International: New Delhi, 2001.

MCH-014: MATHEMATICS FOR CHEMISTS**(2 Credits, 30 Lectures)**

Differential Calculus : Limits and Continuity; Differentiation; Rules of Differentiation, Chain Rule, Differentiation by Substitution; Application of Differentiation; Maxima and Minima, Bohr's Radius, Most Probable Velocity; Exact and Inexact Differentials, Applications; Functions of Two or More Variables; Partial Differentiation, Transformation of Coordinates

Integral Calculus : Methods of Integration; Standard Integrals, Method of Substitution, Transformation of Trigonometric Integrands, Integration by Parts, Integration of Algebraic Fractions; Definite Integrals; Properties of Definite Integrals, Applications of Definite Integrals

Elementary Differential Equations : Ordinary Differential Equations; Classification of Differential Equations, Solution of Ordinary Differential Equations; First Order First Degree Equations; First Order Second Degree Equations, Applications; Second Order Differential Equations Applications; Partial Differential Equations, Applications

Experimental Errors, Probability, and Statistics : Probability and Probability Theorems; Systematic and Random Errors, Distribution of Errors; The Method of Least Squares and Curve Fitting; Principle of Least Squares, Fitting of Data to a Linear Function, Fitting of Data to Other Functions; Significance Tests; Significance Levels, The u-test, Student's t-test, χ^2 test, Applications of Significance Tests

Introduction to Vectors : Vectors and Scalars, Electronic Configuration (Along with IUPAC Periodic Table); Dot and Cross Product of Vectors, Latimer Diagrams; Gradient, Divergence and Curl

Matrix Algebra-I : Addition and multiplication of Matrices; Inverse, Adjoint and Transpose of Matrices; Special matrices and Their Properties; Symmetric and Skew-symmetric Matrices, Hermitian and Skew-Hermitian Matrices, Unit Diagonal and Unitary Matrices; Determinant of a Matrix

Matrix Algebra-II : Solution of simultaneous equations; Homogeneous Linear Equations; Non-homogeneous Linear Equations; Linear Dependence and Independence; Matrix Eigenvalues and Eigenvectors

Further Readings:

1. Mortimer, R. G. Mathematics for Physical Chemistry 2nd Ed. Elsevier (2005).
2. The Chemistry Mathematics Book, E. Steiner, Oxford University Press.
3. Mathematics for Chemistry, Doggett and Sutcliffe, Longman.
4. Mathematical Preparation for Physical Chemistry, F. Daniels, McGraw Hill.
5. Chemical Mathematics, D.M. Hirst, Longman.
6. Basic Mathematics for Chemists, TebbJtt, Wiley.

MCH-015: BIOLOGY FOR CHEMISTS**(2 Credits, 30 Lectures)**

Cell and Cell Organelles : Cell Structure, Structure of Prokaryotic and Eukaryotic Cells; Cell Organelles, Intracellular Organelles and Their Functions; Plant versus Animal Cells, Biological functions of micelles, bilayers, liposomes; Origin of Life; Unique Properties of Carbon, Chemical Evolution; Biological Membranes; Fluid Mosaic Model, Transport Across Membranes

Molecules of Life-I : Introduction to Molecules of Life, Role of Water in Living Systems; Important Derivatives of Monosaccharides; Glycosides and Amino Sugars, Disaccharides and Polysaccharides, Glycosaminoglycans, Glycoproteins and Glycolipids; Glycoproteins and Glycolipids

Molecules of Life-II : Structure and Function of Lipids; Triacylglycerols, Glycerophospholipids, Sphingolipids, Bile Acids, Prostaglandins; Lipoproteins; Composition and Function, Role in Atherosclerosis; Lipid Aggregates, Micelles, bilayers, liposomes; Proteins; Biological Functions and Their Structural Basis, Enzymes: Biological Function and Diagnostic Role

Metabolism-I : Overview of Metabolic Process; Catabolism and Anabolism, Intermediary Nature; Introduction to Bioenergetics; ATP- The Biological Energy Currency, Biochemical Standard State, Coupling Reactions, Universal Electron Carriers; Metabolism of Carbohydrates

Metabolism-II : Metabolism of Proteins; Metabolism of Fats; Metabolism of Nucleic Acids

Homeostasis : Need for Homeostasis; Regulation of Blood Glucose; Maintaining Water Balance; Acid-Base Balance; Thermoregulation.

Immune System : Introduction to Immunity; Origin and Concept, Levels of Immunity, Levels of Defence, Types of Immunity; Cellular and Humoral Immune Response; Characteristics of Immune System; Immunoglobulins, Types and Structures; Theories of Immune Response; HLA Typing

Genetics and Molecular Biology : Introduction to Genetics, The Chemical Basis for Heredity; Central Dogma; Expression and Processing Of Biological Information; Replication, Transcription, Translation, Regulation; Molecular Biology; Recombinant DNA Techniques, Genetically Modified Organisms, Stem Cell Research

Further Readings:

1. Principles of Biochemistry, A. L. Lehninger, Worth Publishers.
2. Biochemistry, I. Stryer, W.H. Freeman.
3. Biochemistry, J. David Rawn, Neil Patterson.
4. Biochemistry, Voet and Voet, John Wiley.
5. Outlines of Biochemistry, E. E. Conn and P. K. Stumpf, John Wiley.

Semester 2

MCH-016: INORGANIC CHEMISTRY-II**(04 Credits, 60 Lectures)**

Reaction Mechanisms in Substitution Reactions I : Mechanisms of Substitution Reactions of Square Planar Complexes; Potential Energy Diagrams, Transition States and Intermediates, Isotope Effects; Mechanisms of Substitution Reactions of Trigonal Bipyramidal Complexes; Potential Energy Diagrams, Transition States and Intermediates, Isotope Effects

Reaction Mechanisms in Substitution Reactions II : Mechanisms of Substitution Reactions of Square Pyramidal Complexes; Potential Energy Diagrams, Transition States and Intermediates, Isotope Effects;

Mechanisms of Substitution Reactions of Octahedral Complexes; Potential Energy Diagrams, Transition States and Intermediates, Isotope Effects

Ligand Substitution in Square Planar Complexes : Berry's Pseudo Rotation Mechanism; Factors Affecting the Reactivity of Square Planar Complexes, Swain-Scott Equation

Ligand Substitution in Octahedral and Tetrahedral Complexes : Trans Effect and its Application to Synthesis of Complexes; Stereochemical Changes in Substitution Reactions of Octahedral and Tetrahedral Complexes

Molecular Rearrangements-I : Molecular Rearrangement Processes; Electron Transfer Reactions (Outer and Inner Sphere); HOMO and LUMO of Oxidant and Reductant, Chemical Activation

Molecular Rearrangements-II : Precursor Complex Formation and Rearrangement; Nature of Bridged Ligands; Fission of Successor Complexes, Two-Electron Transfers

Methods of Synthesis of Coordination Compounds : Synthesis of Coordination Compounds Using Electron Transfer Reactions; Mixed Valence Complexes and Internal Electron Transfer

Energy Sources for Life(6 lectures): Ferritin, Transferrin and Siderophores; Hemoglobin and Myoglobin, Perutz Mechanism Models of Oxygen Carriers

Photosynthesis and Nitrogen Fixation : Photosynthesis PSI and PSII Systems; Nitrogen Fixation

Metalloenzymes: Zinc Enzymes-Carboxypeptidase and Carbonic Anhydrase; Iron Enzymes-Catalase; Peroxidase and Cytochrome P-450; Metalloenzyme-II; Copper Enzymes-Superoxide Dismutase; Molybdenum Exotransferase Enzymes-Xanthine Oxidase, Coenzyme Vitamin B12

Metal-Nucleic Acid Interactions : Metal-Nucleic Acid Interactions; Metal Complex – Nucleic Acid Interaction Modes of Binding to DNA, DNA Cleavage

Metals in Medicine : Metals in Medicine, Metal Deficiency and Disease; Toxic Effects of Metals; Metals Used for Diagnosis and Chemotherapy with Particular Reference the Anticancer Drugs

Further Reading:

1. Advanced Inorganic Chemistry, F.A. Cotton and G. Wilkinson, John Wiley.
2. Inorganic Chemistry, J.E. Huheey, Harper & Row.
3. Chemistry of the Elements. N.N. Greenwood and A. Earnshaw, Pergamon.
4. Physical Methods in Inorganic Chemistry, R. S. Drago.
5. Inorganic chemistry by D. F. Shriver, P. W. Atkins and C. H. Langford
6. Structural Methods in Inorganic Chemistry by Ebsworth.
7. An Introduction to Inorganic Chemistry by Purcell and Kotz
8. Mechanisms of Inorganic Reactions by R G Pearson, Fred Basolo

MCH-017: ORGANIC CHEMISTRY-II	(04 Credits, 60 Lectures)
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Section A: Heterocycles and Organic Synthesis **(30 Lectures)**

Introduction to Heterocyclic Compounds : Nomenclature; Spectral Characteristics; Reactivity and Aromaticity

Three Membered Heterocycles : Synthesis and Reactions of Aziridine, Oxiranes and Thiarines; Synthesis and Reactions of Azirines

Four Membered Heterocycles : Synthesis and Reactions of Azetidine; Synthesis and Reactions of Oxetanes; Synthesis and Reactions of Thietanes

Five Membered Heterocycles with Two Heteroatoms in Rings : Synthesis and Reactions of Pyrazole; Synthesis and Reactions of Imidazole; Synthesis and Reactions of Oxazole; Synthesis and Reactions of Thiazole; Synthesis and Reactions of Isothiazole and Benzofused analogs

Benzofused Five Membered Heterocycles with One Heteroatom : Synthesis and Reactions of Indole; Synthesis and Reactions of Benzofuran; Synthesis and Reactions of Benzothiophene

Bicyclic Heterocycles Containing One or More Heteroatoms : Synthesis and Reactions of Benzimidazole; Synthesis and Reactions of Benzotriazole; Synthesis and Reactions of Purine

Benzofused Six Membered Rings with More than One Heteroatoms : Synthesis and Reactions of Benzopyrans; Synthesis and Reactions of Quinolines and Isoquinolines; Synthesis and Reactions of Quinoxalines; Synthesis and Reactions of Phenoxazines and Phenothiazines

Seven and Large Membered Heterocycles : Synthesis and Reactions of Azepines; Synthesis and Reactions of Oxepines; Synthesis and Reactions of Thiepinines; Chemistry of Porphyrins

SECTION B: SYNTHESIS OF ORGANIC COMPOUNDS

(30 LECTURES)

Philosophy of Organic Synthesis : Disconnection Approach; One Group and Two Group Disconnections; Reversal of Polarity; Chemoselectivity; One Group C-C Disconnections; Two Group C-C Disconnections; 1,3-difunctional and 1,5-difunctional Compounds; Tandem Reactions, Domino Reactions and Multi-component Reactions

Applications of Pd (0) and Pd (II) Complexes in Organic Synthesis : Coupling Reactions; Stille, Suzuki and Sonogashira Couplings; Heck Reaction and Negishi Couplings

Reductions : Catalytic Hydrogenation: Stereochemistry and Mechanism; Metal-liquid Ammonia Reductions: Stereo-selection and Mechanism; Homogeneous Hydrogenations; Mechanisms and Applications Using Rh, Ru and Other Metal Complexes

Reductions using Hydride Transfer Reagents : Sodium Borohydride; Sodium Cyanoborohydride; Lithium Aluminium Hydride and Alkoxy Substituted LAH Reducing Agents; DIBAL; Applications of Hydroboration (Reductions, Oxidations and Carbonylations); Diborane Coupling Reaction; Diisoamylborane, Thexylborane and 9-BBN; Isopinocampheyl and Diisopinocampheylboranes

Oxidations : Use of Oxidizing Reagents with Applications and Mechanism; DDQ, SeO₂, Ti(NO₃)₃, Ceric Ammonium Nitrate; Sharpless Asymmetric Epoxidation; Asymmetric Hydroxylation and Aminohydroxylation

Enolates : Thermodynamic Versus Kinetic Enolates; Enolate Equivalents and Enamines; Applications in Carbon-Carbon Bond Formation and Related Reactions; Applications in Chiral Synthesis

Umpolung Reactions : Sulphur Compounds; Nitro Compounds; Lithiated Ethers and Related Compounds

Principles and Applications of Phase Transfer Catalysis : Crown Ethers; Polymer-Supported Reagents in Organic Synthesis

Asymmetric Synthesis : Development of Methodologies for Asymmetric Synthesis; Regioselectivity; Stereoselectivity; Diastereoselectivity and Stereospecificity

Further Reading

1. "Heterocyclic Chemistry" by J A Joule and K Mills
2. "Name Reactions in Heterocyclic Chemistry" by Jie Jack Li.

3. "Advances in Heterocyclic Chemistry" by Alan R Katritzky
4. Advanced Organic Chemistry-Reactions, Mechanism and Structure, M. B. Smith and Jerry March, John Wiley 2001.
5. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Plenum Publishers
6. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
7. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.
8. Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentice-Hall.
9. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic & Professional.

MCH-018: QUANTUM CHEMISTRY AND GROUP THEORY (04 Credits, 60 Lectures)

Fundamentals of Quantum Chemistry : Inadequacy Of Classical Mechanics; Blackbody Radiation, Photoelectric Effect, Heat Capacities at Low Temperature, Line Spectra, Wave-Particle Duality and Uncertainty Principle; Postulates of Quantum Mechanics; Well Behaved Wave Functions, Quantum Mechanical Operators, Expectation Value

Operators and Their Significance : Operators and Their Representation; Linear and Hermitian Operators; Commutation of Operators and Their Significance; Time Dependent and Time Independent Schrodinger Equations; Eigenvalue Problem and Orthonormal Sets

Particle in A Box : Particle in One Dimensional Box; Formulating Schrödinger Wave Equation, Boundary Conditions and Solution of Schrödinger Equation, Energy Level Diagram, Wave Functions and Probability Densities; Particle In Three-Dimensional Box; Formulating Schrödinger Wave Equation, Boundary Conditions and Solution of Schrödinger Equation, Energy Level Diagram, Concept of Degeneracy, Wave Functions and Probability Densities; Application of Particle in One Dimensional Box

Simple Harmonic Oscillator : Linear Harmonic Oscillator: Classical Treatment; Linear harmonic Oscillator; Formulating Schrödinger Wave Equation and Boundary Conditions, Solution of Schrödinger Equation: Series Solution Method, Quantised Vibrational Energies, Wave Functions for Linear Harmonic Oscillator, Average Values Of Kinetic And Potential Energies; Virial Theorem

Rigid Rotor : Rotational Motion: Classical Treatment; Rigid Rotor; Formulating Schrodinger Wave Equation, Separation of Variables; Solving \square Equation; Solving \square Equation

Hydrogen Atom-I :Hydrogen Atom, Formulating Schrodinger Wave Equation; Solving Schrodinger Wave Equation; Separation of Variables, Results of Solutions of $\square\square\square$, and R Equations; Quantum Numbers and Their Significance

Hydrogen Atom-II : Hydrogen Like Wave Functions; Radial Wave Functions, Angular Wave Functions (Spherical Harmonics), Radial Distribution Functions; Electron Spin and Spin Quantum Number

Angular Momentum : Classical Angular Momentum; Conservation of Angular Momentum, Representation of Angular Momentum; Angular Momentum In Quantum Mechanics; Orbital Angular Momentum, Spin Angular Momentum, Total Angular Momentum; Russel Saunders's Coupling

Approximation Methods : Variation Method and Its Applications; One Dimensional Box, Harmonic Oscillator, Hydrogen Atom; Perturbation Theorem

Multi Electron Atoms : Helium Atom, Formulation of Schrodinger Wave Equation; Approximating Energy; Ground State Energy of Helium Atom; First Order Perturbation, Variation Method;

Indistinguishability of Electron Spins, Pauli's Exclusion Principle; Multi Electron Atoms, Distribution of Electrons

Molecular Symmetry and Groups : Symmetry Operations and Elements, Molecular Symmetry Elements; Point Groups; Schoenflies System, Classification of Molecules Into Point Groups; Groups and Their Characteristics, Group Multiplication Tables

Representations of Groups : Matrix Representation And Its Characteristics; Basis for Representation, Similarity Transformations, Character of Representations; Irreducible Representation, Wavefunction as Basis for Representation; Great Orthogonality Theorem, Construction of Character Tables; Reduced Representation, Reduction of Representation; Symmetry Adapted Basis; Vanishing Integrals

Valence Bond Theory : Born-Oppenheimer's Approximation; Hydrogen Molecule, Coulomb's Integral, Exchange Integral, Overlap Integral; Polyatomic Molecules, Configuration Interaction

Molecular Orbital Theory-I : Born-Oppenheimer's Approximation; Hydrogen Molecule Ion; LCAO-MO Approach, Resonance and Overlap Integrals, Bonding and Antibonding Orbitals; Hydrogen Molecule

Molecular Orbital Theory-II : Homonuclear Diatomic Molecules, MO Configuration; Heteronuclear Diatomic Molecules; HF, LiF, CO; Polyatomic Molecules, Hybridisation

Hückel Molecular Orbital Theory : Hückel Molecular Orbital (HMO) Theory; Hückel Approximation, Applications of HMO; Extended Hückel Theory (EHT), Applications of EHT; Limitations of HMO and EHT

Further Reading

1. Lowe, J. P. & Peterson, K. Quantum Chemistry Academic Press (2005).
2. McQuarrie, D. A. Quantum Chemistry Viva Books Pvt Ltd.: New Delhi (2003).
3. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press (2006).
4. Levine, I. L. Quantum Chemistry 5th Ed., Prentice-Hall Inc.: New Jersey (2000).
5. Engel, T. & Reid, P. Physical Chemistry Benjamin-Cummings (2005).
6. McQuarrie, D. A. & Simon, J. D. Physical Chemistry: A Molecular Approach 3rd Ed., Univ. Science Books (2001).
7. Silbey, R. J., Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed. Wiley (2004)
8. F. A. Cotton, Chemical Applications of Group Theory, Wiley Eastern, 1990.
9. L. Robert Carter, Molecular Symmetry & Group Theory, John Wiley & Sons Inc Sea Pte Ltd, 2012.

MCH-019: GREEN CHEMISTRY

(02 Credits, 30 Lectures)

Green Chemistry: The Need and Origin of Green Chemistry; Principles of Green Chemistry; Concept of atom Economy

Tools of Green Chemistry: Use of Alternatives; Feed Stocks/Starting Materials; Reagents; Solvents; Product/Target Molecules; Catalysis and Process Analytical Chemistry

Evaluation of Chemical Products or Processes: Effects on Human Health and Environment; Evaluation of Reaction Types; Methods to Design Safer Chemicals

Harmful Effects of Chemistry: Toxicity to Humans, Toxicity to Wildlife, Effects on Local Environment, Global Environmental Effects

Planning a Green Synthesis: Green synthesis of Ibuprofen; Design and Application of Surfactants for Carbon Dioxide for Precision Cleaning in Manufacturing and Service Industries

Towards Safer Environment: Microbes as Environmentally Benign Synthetic Catalysts; Safe Marine Antifoulants; Use of Molting Agents (To Replace More Toxic and Environmentally Harmful Insecticides)

Using Safer Reagents: Carbon Dioxide as Blowing Agent; Oxidant Activators to Replace Chlorine Based Delignification Process in Paper and Pulp Industry

Greener Technologies: Polyester Regeneration Technology; Biodegradable Polyaspartate Polymers (For Inhibitors and Dispersing Agents); Recent Applications in Green Chemistry

Further Reading

1. Howard, W.L., Introduction to Industrial Chemistry, Wiley-Interscience (1986).
2. Weissermel, K., and Arpe, H.J., Industrial Organic Chemistry, VCH (1997) 3rd ed.
3. Sheldon, R.A., Arends, I., and Hannefed, U., Green Chemistry and Catalysis, Wiley-VCH Verlag GmbH and Co. (2007).
4. Anastas, P., and Williamson, T. C., Green Chemistry Frontiers in Benign Chemical Synthesis and Processes, Oxford University Press (1999).
5. Ahluwalia, V. K., and Kidwai, M., New Trends in Green Chemistry, Anamaya Publishers (2004)

MCHL-014: CHEMISTRY LAB-IV

(02 Credits, 60 Lectures)

Preparation and Characterization

Preparations: Synthesis and Characterization using any of UV/VIS/IR /EPR Spectral Methods and Magnetic Measurement of the following: (**Minimum Five Experiments should be Performed**)

1. VO (acac)₂
2. TiO (C₉H₈NO)₂H₂O
3. cis-K[Cr(C₂O₄)₂(H₂O)₂]
4. Na[Cr(NH₃)₂(SCN)₄]
5. Mn(acac)₃ (Green Method)
6. K₃[Fe(C₂O₄)₃]
7. [Co(NH₃)₆] [Co(NO₂)₆]
8. cis-[Co(trien) (NO₂)₂] Cl.H₂O
9. Hg[Co(SCN)₄]
10. [Ni(NH₃)₆]Cl₂
11. Ni(dmg)₂
12. [Cu(NH₃)₄]SO₄.H₂O
13. cis- and trans- bisglycinatocopper(II)
14. Prussian Blue, Turnbull's Blue

Further Readings:

1. Experimental Inorganic Chemistry by W.G. Palmer, Cambridge University Press, 1970
2. Synthesis and Characterisation of Inorganic Compounds, W. L. Jolly, Prentice Hall

3. Marr G. and B.W. Rockett. Practical Inorganic Chemistry, London: VanNostrand Reinhold Co., 1972.

MCHL-015: CHEMISTRY LAB-V
(02 Credits, 60 Lectures)

S. No.	Title of the Experiment
1	Preparation of 1,3,5-Tribromobenzene from Aniline
2	Preparation of 4-Nitroaniline from Aniline
3	Preparation of Benzanilide from Benzophenone
4	Preparation of Preparation of Anthranilic Acid from Phthalic Acid
5	Preparation of Preparation of <i>p</i> -Aminobenzoic Acid from Toluene
6	Preparation of Preparation of Benzilic Acid from Benzaldehyde
7	Preparation of Chalcone Epoxide from Benzaldehyde and Acetophenone
8	Estimation of Amino Groups
9	Estimation of Sugars
10	Estimation of Phenol
11	Estimation of Formaldehyde
12	Estimation of Amino Acids
13	Determination of Saponification Value of An Oil or Fat
14	Determination of Iodine Value of Oil or Fat

Further Readings:

- Experiments and Techniques in Organic Chemistry, D.P. Pasto, C. Johnson and M. Miller, Prentice Hall.
- Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Heath.
- Handbook of Organic Analysis-qualitative and Quantitative. H. Clark, Edward Arnold.
- Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
- Comprehensive Practical Organic Chemistry: Preparations and Quantitative Analysis by Ahluwalia & Aggarwal, University Press.
- Techniques and Experiments for Organic Chemistry by A. Ault, University Science Books.
- Organic Analytical Chemistry, Theory and Practice, Jagmohan, Narosa Publishing House (2003)

MCHL-016: CHEMISTRY LAB-VI
(02 Credits, 60 Lectures)

Expt. No.	Title of the Experiment
1	To determine the concentrations of KCl, KBr, and KI in a mixture by potentiometric titration.
2	To prepare silica (or silver) nanoparticles and study their spectrophotometric behaviour

3	a) To synthesise metallic nanoparticles by reducing the corresponding salts with tea extract and characterise them using UV-Visible spectrometry. b) To estimate the size of the nanoparticles using the energy expression for the particle in a 3D cubic box.
4	To determine the pKa value of methyl orange spectrophotometrically and study the effect of surfactant on it.
5	To determine manganese/chromium in steel sample spectrophotometrically.
6	To study the kinetics of the reaction of phenolphthalein with sodium hydroxide spectrophotometrically.
7	To record the UV spectra of toluene and pyrimidine (any one) in methanol. Compare and discuss various transitions involved in terms of MO theory Chalcone/ Coumarin
8	To study the spectra of mesityl oxide/ benzophenone in different solvents and classify the observed transitions in terms of $n \rightarrow \pi^*$ and $\pi \rightarrow \pi^*$ transitions. Discuss the shift in transitions relative to those in acetone by means of a qualitative MO diagram
9	To determine the stoichiometry of the complex formed between thiocyanate ions and iron(III) by Job's method of continuous variation and to determine the concentration equilibrium constant and molar absorptivity for the complex using the Benesi-Hildebrand equation.
10	To determine the critical micelle concentration of a surfactant (sodium lauryl sulphate) by conductivity method.

Further Reading

1. Experiments in Physical Chemistry, Carl W. Garland, Joseph W. Nibler, David P. Shoemaker, McGraw-Hill
2. Experimental Physical Chemistry, Mathews, G. Peter, Oxford Clarendon Press (1985).
3. A.M. James and D.E. Pritchard. Practical physical chemistry, Longman Group Ltd: 1968.
4. V.D. Athawale and Parul Mathur. Experimental physical Chemistry. New Age International: New Delhi, 2001.

Semester 3

MCH-020: ATOMIC AND MOLECULAR SPECTROSCOPY (04 Credits, 60 Lectures)

Fundamentals of Spectroscopy : Recapitulating EM Radiation and its Characteristics; Role of Quantum Mechanics in Spectroscopy; Interaction of Radiation and Matter, Characteristics of Spectrum; Intensity of Signal; Boltzmann Population Distribution, Einstein Coefficients, Transition Dipole Moments, and Selection Rules; Spectral Width, Natural line Width; Beer-Lambert's Law; Fourier Transform Spectroscopy, S/N Ratio

Atomic Spectroscopy : Hydrogen Atom Spectrum; Energy Levels and Selection Rules, Orbital and Spin Angular Momentum, Fine structure of Hydrogen Atom Spectrum, Hydrogen like Species; Multi Electron Atoms; Good Quantum Numbers, Singlet and Triplet States, Angular Momentum of Multi Electron Atoms, Spin–Orbit Coupling, Term Symbols; Zeeman and Stark Effects

Photoelectron Spectroscopy : Principle of Photoelectron Spectroscopy, Koopman's Theorem; X-ray Photoelectron Spectroscopy (XPS); Spin Orbit Splitting, Chemical Shift; Ultraviolet Photoelectron Spectroscopy; Applications of XPS and UPS

Rotational Spectroscopy : Rotation of Diatomic Molecules; Rigid Rotor Approximation

Determination of Bond Lengths and Atomic Masses, Isotopic Substitution, Non-Rigid Rotator; Classification of Polyatomic Molecules; Symmetric Top Molecules, Asymmetric Top Molecules; Applications of Rotational Spectroscopy

Vibration Spectroscopy : Vibration spectroscopy of Diatomic Molecules; Harmonic Oscillator Approximation, Force Constants and Amplitudes, Anharmonic Oscillator; Vibration-Rotation Spectra; P, Q and R Branches, Vibration Rotation Spectrum of CO; Breakdown of the Born-Oppenheimer Approximation, Interaction of Rotation and Vibration; Dissociation Energies from Vibrational Data.

Vibrational Spectroscopy of Polyatomic Molecules : Vibration Spectroscopy of Polyatomic Molecules; Normal Modes of Vibration, IR activity and Selection Rule; Overtones and Combination Bands; Effect of Rotation on Vibration Spectra; Linear Molecules, Symmetric Top

Raman Spectroscopy : Theory of Raman Spectroscopy; Quantum or Particle Theory, Classical or Wave Theory, Raman Activity of Vibrations, Rule of Mutual Exclusion, Depolarisation Ratio; Enhancement of Raman Spectral Intensities; Resonance Raman Spectroscopy, Coherent Anti-Stokes Raman Spectroscopy, Surface Enhanced Raman Scattering; Applications of Raman Spectroscopy

Electronic Spectroscopy of Diatomic Molecules : Electronic Energy Levels and Selection Rules; Molecular Term Symbols, Selection Rules; Electronic Spectrum of Diatomic Molecules; Born Oppenheimer Approximation, Vibrational Coarse Structure; Intensity of Spectral Lines, Frank Condon Principle; Rotational Fine Structure, Fortrat Diagram; Dissociation Energies of Diatomic Molecules, Birge-Sponer Extrapolation; Predissociation

Electronic Spectroscopy of Polyatomic Molecules : Electronic Transitions in Polyatomic Molecules; d-d Transitions, Charge Transfer Transitions, $\pi \rightarrow \pi^*$ and $n \rightarrow \pi^*$ Transitions; Factors Affecting electronic Transitions; Chromophores and Auxochromes, Effect of Solvent, Effect of Dielectric Constant, Effect of Viscosity; Photoelectron Spectroscopy; Diatomic Molecules, Simple Polyatomic Molecule, Adiabatic and Vertical Ionization Energies; Applications of Photoelectron Spectroscopy

Proton NMR Spectroscopy : Basic Phenomenon of NMR; Larmour Precession and Resonance, Chemical shift, and Factors affecting it, Chemical Exchange, Spin-Spin Coupling, Spin-Spin and Spin-Lattice Relaxations; Nomenclature of Spin Systems; Chemical and Magnetic Equivalence, Selection Rules; Analysis of NMR Spectra; AX System, AMX System, AB System

¹³C and 2D NMR Spectroscopy : CW and FT-NMR; Sensitivity Issue, Pulse NMR Experiment, Fourier Transformation; ¹³C NMR; Simplification of NMR Spectra; Homonuclear Decoupling, Heteronuclear Decoupling, Off Resonance; 2D NMR; Multi Pulse Experiment, COSY Spectrum, NOE Effect, NOESY Spectrum

ESR Spectroscopy : ESR Phenomenon; Electron Spin and its Characteristics, Intensity and Representation of ESR Spectrum; Hydrogen atom, Hyperfine Interaction; Isotropic Systems with More Than Two Nuclei, Contributors to Hyperfine Coupling Constants; Anisotropy in g Values; Anisotropy in Hyperfine Coupling

Mossbauer Spectroscopy : Mossbauer Effect, and Mossbauer Spectroscopy, Recoilless Emission and Absorption; Isomer Shift; Quadrupole Splitting; Magnetic Hyperfine Interaction

Further Readings

1. Hollas. J. M., Modern Spectroscopy 4th Ed., John Wiley & Sons (2004).
2. Kakkar, R., Atomic & Molecular Spectroscopy, Cambridge University Press (2015).
3. Chang, R. Basic Principles of Spectroscopy McGraw-Hill, New York, N.Y. (1970).
4. Drago, Russell S. Physical Methods for Chemists 2ed. East West Press Pvt. Ltd. (2016).
5. C. N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, TMH Edition, 2012.
6. G. M. Barrow, Introduction to Molecular Spectroscopy. McGraw Hill, Int. Students Edition. 1988.
7. J. D. Graybeal, Molecular Spectroscopy, McGraw Hill Int. Student Edition, 1990.

MCH-021: CHEMISTRY OF MATERIALS

(04 Credits, 60 Lectures)

Introduction to Polymers : Polymers and their Classification, Classification of Polymers; Tacticity of Polymers; Properties of Polymers; Crystallinity of Polymers, Glass Transition Temperature, Viscosity of Polymers; Polymer Molecular Mass; Dispersity, Determination of Molecular Mass

Kinetics and Mechanism of Polymerisation : Mechanism of Polymerisation; Chain Growth Polymerisation, Step growth Polymerisation, Co-polymerization; Kinetics of Addition Polymerisation; In the Absence of Catalyst, In Presence of Catalyst; Kinetics of Chain Growth Polymerisation; Free Radical Polymerization, Cationic Polymerization, Anionic Polymerization; Kinetics of Copolymerisation

Conducting Polymers : Conducting Polymers; Discovery of Conducting Polymers, Structural Features of Conducting Polymers, Origin of Conductivity in Conducting Polymers, Doping; Synthesis of Conducting Polymers; Electrochemical Polymerization, Chemical Polymerization, Emulsion Polymerization; Mechanism of Conduction; Band Theory, Charge Carriers (Polaron, Bipolaron, Soliton), SSH Soliton Theory, Inter-soliton Hopping Mechanism, Free-electron Molecular Orbital Model, Molecular-Electron Transfer Theory; Applications of Conducting Polymers; Biosensors, Tissue Engineering, Drug Delivery, Artificial Muscle

Stimuli Sensitive Polymers : Stimuli Responsive Polymers, Classification of Stimuli Responsive Polymers; pH Responsive Smart Polymers; Classification, Synthetic Strategies, Mechanism of Action; Application of pH Sensitive Smart Polymers; Delivery of Therapeutic Agents, Biomaterials, Glucose Sensors; Temperature-Responsive Smart Polymers; Factors Affecting Temperature-Responsive Behaviour, Mechanism of Action; Stereographic Projections

Degradable Polymers : Polymer Degradation; Need for Polymer Degradation, Factors Causing Degradation, Changes due to Degradation, Modes of Polymer Degradation; Biodegradable Polymer; Need of Biodegradable Polymer, Mechanism of Biodegradation, Factors Affecting, Biodegradation; Chemical Degradation; Methods of Chemical Degradation, Products of Chemical Degradation; Applications of Degradable Polymers

Hydrogels : Introduction to Hydrogels; Classification of Hydrogels, Polymers Used in Hydrogels, Swelling Characteristics of Hydrogels; Synthesis of Hydrogels; Characterisation of Hydrogels; Biomedical Applications of Hydrogels; Stimuli Responsive Hydrogels, Glucose Sensitive Hydrogels, Hydrogels in Drug Delivery

Functional Polymers : Biomedical Polymers; Contact Lens, Dental Polymers; Artificial Organs; Artificial Kidney, Skin, Blood Cells; Fire-Retarding Polymers

Biomimetic and Shape Memory Polymers : Biomimetics; Historical Perspective, Scope of Biomimetics; Biomimetic applications; Shape Memory Polymers; Shape Memory Effect, Mechanism of Shape Memory Effect; Applications of Shape Memory polymers

Introduction to Liquid Crystals : Liquid Crystalline State; Characteristics of Liquid Crystals, Structural Requirements of Liquid Crystals; Classification of Liquid Crystals; Molecular arrangement in Liquid Crystals; Positional Order, Orientational Order, Bond Orientational Order; Polymorphism in Liquid Crystals, Phase Transitions

Polymeric Liquid Crystals : Polymeric Liquid Crystals; Main Chain Polymer Liquid Crystals, Side Chain Polymer Liquid Crystals; Ordering and Texture; Optical Properties of Liquid Crystals; Applications of Polymeric Liquid Crystals

Surface Active Agents : Surfactants and Their Classification; Classification of Surfactants, Hydrophilic-lipophilic Balance; Micelles; Process of Micellisation, CMC and Factors Affecting It; Thermodynamics of Micellisation; Solubilisation by Surfactants, Factors Affecting Solubilisation; Emulsions, Stabilisation of Macroemulsions; Surfactants at the Solid-Liquid Interface, Electrokinetic Phenomenon

Glasses, Ceramics and Composites : Glasses; Glassy State, Glass Formers and Glass Modifiers, Applications; Ceramics, Structure and Properties; Classification of Ceramics; Clay Products, Refractories; Composites; Classification of Composites, Formation of Composites; Applications of Glasses, Ceramics and Composites

Nano Materials : Introduction to Nanomaterials, Characteristics of Nano Materials; Preparation of Nanomaterials; Physical Methods, Chemical Methods; Characterisation of Nanomaterials; Electron Microscopy, Dynamic Light Scattering, Atomic Force Microscopy; Properties of Nanomaterials; Optical Properties, Electrical Properties, Mechanical Properties, Magnetic Properties; Selected Applications of Nanomaterials

Thin and Langmuir-Blodgett Films : Thin Films and Their Formation; Physical Methods of Film Deposition; Physical Vapour Deposition (PVD), Sputtering; Chemical Methods of Film Deposition; MOCVD, Sol-Gel; Langmuir-Blodgett (LB) Film, Properties of LB Films; Applications of Thin and LB Films

Further Readings:

1. W.D. Callister, Material Science and Engineering. John Wiley & Sons; 8th Edition, 2010.
2. Materials Chemistry, Bradley D. Fahlman, Springer, 2011.
3. T. J. J. Müller and V. R. Gowariker, N. V. Viswanathan & T. Sreedhar, Polymer Science; New Age international, 2015
4. H.R. Allcock and F.W. Lampe Contemporary Polymer Chemistry, Prentice Hall, 2003
5. U. H. F. Bunz, Functional Organic Materials, Wiley-VCH, 2007.
6. Textbook of Polymer Science: F.W. Billmeyer (Wiley), 3rd Edn., 2007
7. Materials Chemistry, Bradley D. Fahlman, Springer, 2011
8. T. J. J. Müller and U. H. F. Bunz, Functional Organic Materials, Wiley-VCH, 2007.
9. György Inzelt, Conducting Polymers A New Era in Electrochemistry, Springer, 2008.

MCH-022: SEPARATION AND SPECTROSCOPIC METHODS (04 Credits, 60 Lectures)

Section A: Separation Methods

Solvent Extraction : General Principles and Terminology; Classification of Extraction Systems; Distribution of Simple Molecules, Extraction by Compound Formation, Extraction by Solvation, Extraction by Ion Pair Formation, Extraction by Crown Ethers; Diluents and Modifiers; Factors Influencing Extraction; Different Approaches for Metal Ion Separation; Criteria for the Choice of Organic Phase

General Aspects of Chromatographic Methods : Classification and Basic Principles; Liquid Column Chromatography; Choice of Stationary and Mobile Phases, Development Techniques; Planar Chromatography; Paper Chromatography, Thin Layer Chromatography (TLC)

Gas Chromatography : Basic Aspects; Instrumentation; Sampling; Introduction of Sample into GC Unit; Applications;

High Performance Liquid Chromatography : Principle; Instrumentations; Advantages; Applications

Ion Exchange Chromatography : Ion Exchange Mechanism; Classification of Ion Exchangers; Synthesis of Ion Exchange Resins; Trade Names and Nomenclature; Resins Properties; Synthetic Inorganic Ion Exchangers; Applications

Size Exclusion Chromatography : Basic Principle; Gels and Their Important Properties; Classification, Synthesis and Properties of Different Gels; Applications

Membrane Separation : General Aspects; Important Membrane Processes; Mechanism of Separation Through Membrane; Osmotic Phenomena and RO Process; Dialysis and Electrodialysis; Applications

Electrophoresis : Electroosmotic Flow; Basic Principle and Operation; Different Forms of Electrophoresis; Slab Electrophoresis; DNA Gel Electrophoresis, SDS-PAGE Gel Electrophoresis; Capillary Electrophoresis; Capillary Electrochromatography

SECTION B: SPECTROSCOPIC METHODS

UV-VISIBLE Spectrometry : Origin and Characteristics of UV-VIS Spectrum; Characteristics of UV-VIS Spectrum, Absorbing Species; Principle of UV-VIS Spectrometry; Beer-Lambert's Law, Deviations from Beer-Lambert's Law; Types of UV-Visible Spectrometers; Single Beam Spectrometers Double Beam Spectrometers; Analytical Applications of UV-Visible Spectrometry; Qualitative Applications, Quantitative Applications, Quantitative Determination Methodology, Simultaneous Determination

IR and Raman Spectrometry : Theory of Infra-Red Spectrometry, Characteristics of IR Spectrum; Instruments for IR Spectrometry; Dispersive Infra-Red Spectrometers, Fourier Transform Infra Red Spectrometers; Applications of Infra-Red Spectrometry, Qualitative Applications, Quantitative Applications; Theory of Raman Spectroscopy; Rule of Mutual Exclusion, Depolarisation Ratio; Instrumentation for Raman Spectroscopy; Enhancement of Raman Spectral Intensities; Resonance Raman Spectroscopy, Coherent Anti-Stokes Raman Spectroscopy, Surface Enhanced Raman Scattering; Applications of Raman Spectroscopy

Fluorimetry and Phosphorimetry : Origin of Fluorescence and Phosphorescence Spectra; Jablonski Diagram, Fluorescent and Phosphorescent Species, Factors Affecting Fluorescence and Phosphorescence; Fluorescence Quenching, Quantum Yield; Instrumentation for Fluorescence Measurement; Instrumentation for Phosphorescence Measurement; Sampling, Recording Procedure; Applications of Fluorescence and Phosphorescence

Atomic Absorption and Emission Spectrometry : Origin and Classification of Atomic Spectra; Flame Atomic Absorption Spectrometry; Flame and its Structure, Principle of Flame Atomic Absorption Spectrometry; Graphite Furnace Atomic Absorption Spectrometry, Electrothermal Atomisers,

Advantages and Disadvantages of GFAAS; Flame Atomic Emission Spectrometry; Principle of Flame Atomic Emission Spectrometry, Instrumentation for Flame Atomic Emission Spectrometry; ICP- Atomic Emission Spectrometry; Plasma and its Characteristics, Inductively Coupled Plasma, Instrumentation for ICP-AES; Interferences in Atomic Absorption and Emission Spectrometry; Interferences in AAS and GFAAS, Interferences in AES, Interferences in ICP-AES; Analytical Applications of Atomic Absorption and Emission Spectrometry

¹H NMR Spectroscopy : Theory of NMR Spectroscopy; Larmor Precession, Mechanism of Resonance, Relaxation Mechanisms; Fourier Transform NMR; Chemical Shift, Factors Affecting Chemical Shift; Spin-Spin Coupling, Magnitude of Coupling Constants; Instrumentation for NMR Spectroscopy; Applications of NMR Spectroscopy; Quantitative Applications, Qualitative Applications

Two-Dimensional NMR Spectroscopy : Multi Pulse Technique; Two-dimensional NMR, Principle of 2D-NMR; Types of 2D-NMR Spectra, Multi Pulse Experiments; Instrumentation for 2D-NMR Spectroscopy; Analytical applications of 2D-NMR

¹³C NMR Spectroscopy : ¹³C NMR; Proton decoupling, Off-Resonance Decoupling, Pulse Decoupling, Nuclear Overhauser Effect; Analytical applications of ¹³C NMR; Structure Spectrum Correlation, Other Applications

High Resolution Mass Spectrometry : Theory of Mass Spectrometry; Characteristics of Mass Spectrum, Isotopic Peaks; Instrumentation for Mass Spectrometry; Ion Sources; Types of Mass Spectroscopic methods, APCI-MS, ESI-MS, MALDI-MS; Analytical applications of Mass Spectrometry; Qualitative Applications of Mass Spectrometry, Quantitative Applications of Mass Spectrometry

Hyphenated Techniques : Hyphenated Techniques; Spectrometer Interface, Various Types of Separators; Interfacing GC and LC with Mass Spectrometry; GC-MS, LC-MS; Interfacing GC and IR Spectrometry (GC-IR); Interfacing HPLC and Mass Spectrometry (HPLC-MS); Interfacing of Inductively Coupled Plasma and Mass Spectrometers (ICP-MS), Multielemental Character and Detection Limits; Analytical Importance of Hyphenated Techniques

Scattering and Diffraction : X-Rays: Generation and Properties; X-ray scattering from an Electron and an atom; Small Angle X-Ray scattering; X-ray Diffraction from a Crystal Lattice, Bragg's law; Experimental methods of X-Ray Diffraction; Applications of Scattering and Diffraction.

Further Readings:

1. Christian, G. D., Analytical Chemistry, 6th Ed., John Wiley & Sons, Inc. (2004).
2. Skoog, D. A., West, D. M., Holler, R. J & Nieman, T. A. Principles of Instrumental Analysis Saunders Golden Sunburst Series (1997).
3. Willard, H. H., Merritt, L. L., Dean, J. A. & Settle, F. A. (Eds.) Instrumental Methods of Analysis - 7th Ed., Wadsworth Publishing (1988) ISBN 0534081428
4. Instrumental Analysis, Editors, H.H. Bauer, G.D. Christian and J.E.O' Reilly, 2ndEdn, Allyn and Bacon, Inc., Boston (1991)
5. Principles and Practice of Analytical Chemistry by F.W. Fifield and D. Kealey, 5thEdn, Blackwell Science Ltd, New Delhi (2004).
6. Instrumental Methods of Chemical Analysis by G.W. Ewing, 5thEdn, Mc-Graw Hill Singapore (1985).
7. Instrumental Methods of Analysis by H. H. Willard, I. L. Merritt, J. A. Dean & F. A. Seattle CBS Publishers & Distributors, New Delhi (1986).

MCHL-017: SEPARATION AND SPECTROSCOPIC METHODS LAB (02 Credits, 60 Lectures)

Expt. No.	Title of the experiment
1	Liquid- liquid extraction behavior of Fe (III) and Ni (II) in tri- n-butyl phosphate (TBP) from hydrochloric acid medium .
2	Separations of Fe (III) and Ni (II) using TBP-HCl liquid- liquid extraction system.
3	Determination of ion exchange capacity of a cation and an anion exchanger.
4	Determination of total milliequivalents of metal ions in tap/sea water sample using a strong cation exchanger from HCl medium. or Separation of Fe (III) and Ni (II) using a strongly basic anion exchanger.
5	Separation of cations by paper chromatography or Separation of iron and aluminium by column chromatography . or Separation of amino acids by chromatography or Separation of chlorophyll pigments by column chromatography
6	Determination of Zinc in Pharmaceutical Preparations by Ion Exchange Separation and Complexometric Titration.
7	To determine sodium and potassium OR calcium and magnesium in tap water by flame photometry.
8	To determine the concentrations of Na ⁺ and K ⁺ ions flame photometrically, using internal standard method.
9	To determine the concentrations of chromium and manganese in a mixture spectrophotometrically.
10	The Determination of Aspirin and caffeine in a Proprietary Analgesic by Ultraviolet (UV) Spectrometry
11	To determine the pka of an indicator spectrophotometrically.
12	To study the Effect of pH on the visible spectrum of potassium dichromate solution.
13	To determine the equilibrium constant of keto-enol tautomerisation reaction.

Further Readings:

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall
2. Practical Physical Chemistry, A. M. James and F. E. Prichard, Longman
3. Findley's Practical Physical Chemistry, B. P. Levitt, Longman
4. Experimental Physical Chemistry, R.C. Das and B. Behera, Tata McGraw Hill.
5. "Principles of Instrumental Analysis" by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch, Cengage Learning
6. "Separation Process Principles" by J. D. Seader, Ernest J. Henley, and D. Keith Roper, Wiley

7. "Instrumental Methods of Analysis" by Hobart H. Willard, Lynne L. Merritt, Jr., and John A. Dean, Wadsworth Publishing
8. "Introduction to Modern Liquid Chromatography" by Lloyd R. Snyder, Joseph J. Kirkland, and John W. Dolan, Wiley
9. "High-Performance Liquid Chromatography" by L. R. Snyder and J. J. Kirkland, Wiley
10. "Fundamentals of Analytical Chemistry" by Douglas A. Skoog, Donald M. West, F. James Holler, and Stanley R. Crouch, Cengage Learning

MCH-023:: ENVIRONMENTAL CHEMISTRY**(04 Credits, 60 Lectures)**

Nature and Formation of Soil: Soil and its Importance; Soil Morphology: Characteristics of Soil Profile, Soil Horizons; Soil Genesis: Origin and Formation of Soil: Minerals and Rocks, Weathering and Soil Formation, Factors affecting Soil Formation; Soil Classification: Soil Types of India.

Soil Quality Parameters: Mechanical Parameters: Soil Texture and Methods of Analysis, Soil Textural Classes, Soil Aggregation and Soil Structure, Soil Aeration, Soil Water; Biological Parameters: Soil Flora, Soil Fauna, Beneficial Role of Soil Organisms; Physico-Chemical Parameters: Crystal Structure of Clays, Ion Exchange Property of Soils, Soil pH – Acidity and Alkalinity.

Soil Fertility and Productivity: Plant Nutrients: Macronutrients, Micronutrients, Availability of Nutrients in Soils, Chemical Methods of Estimating Available Nutrients, Soil pH and Nutrient Availability, Soil Fertility Evaluation, Concepts in Soil Fertility, Maximum Crop Yields; Management of Soil Productivity: Fertilizers and Fertilizer Management, Factors Affecting Fertilizer Requirements, Manures, Cultural Practices.

Water Resources: Units for Land Area and Rainfall: Global Distribution of Water: Water Resources of India: Annual Rainfall, River Systems in Our Country, River Basins, Groundwater Availability; Hydrological Cycle: Stages in Hydrological Cycle, Abnormal Properties of Water Helping the Operations of Hydrological Cycle, Importance of Hydrological Cycle; Hydrodynamics of Fresh Water Ecosystems: Crucial Issues Associated with Conservation and Management of Water Resources: Features Related to Water Availability and Usage, Need for Conservation and Management of Water Resources; Methods of Water Conservation and Management.

Water Characteristics: Physical Properties of Water Systems; Chemical Properties of Water Systems; Biological Properties of Water Systems; Factors Affecting Water Quality: Natural Factors, Human Activities, Biological Transformations; Solubility of Gases in Water; Carbonate Equilibrium.

Water Quality Criteria and Uses: Concerns for Water Quality: Water Quality Criteria for Various Purposes: Objectives, Criteria and Standards – Definition, Water Quality Criteria as Basis for Classification of Water Bodies; Factors that Influence Prescription of Criteria for Water Quality; Uses of Water Quality Criteria; Monitoring and Assessment – A Discussion: Water Quality Monitoring for Water Resources Management; Water Quality Monitoring System for Risk Assessment; A Comprehensive Scheme for Controlling River Water Quality; Uses of Monitoring Programmes; Analytical Techniques for Monitoring Water Quality: Physical and Chemical Methods of Monitoring; Biomonitoring; Need for Integrated Monitoring Mechanism.

Atmosphere: Nature and Importance: Origin of Atmosphere; Regions of Atmosphere:

Regions Based on Chemical Composition, Regions Based on Temperature, Regions Based on Physical and Chemical Properties; Composition of Atmosphere: Variation of Gaseous Composition with Height, Variation of Gaseous Composition with Latitude and Season; Atmospheric Effects and Reactions:

Reactions in Atmosphere; Water in Atmosphere: Water Vapour, Precipitation, Process of Precipitation ; Greenhouse Gases and Global Warming, Water Vapour, Carbon Dioxide, Methane, Nitrous Oxide, Nitrous Oxide, Chlorofluorocarbons, Ozone, Other Greenhouse Gases, Global Warming Potential of Greenhouse Gases, Energy and Greenhouse Gas Emissions; Ozone Layer and its Depletion: Effects of Ozone Layer Depletion , Ozone Layer Depletion and Global Warming, Impact of Ozone Layer Depletion on Air Pollution

Meteorological Aspects of Air pollution: Air Pollution Ecosystem; Primary Meteorological Parameters: Wind Speed and Wind Direction, Temperature, Atmospheric Stability, Mixing Height; Secondary Meteorological Parameters: Humidity and Precipitation, Visibility, Pressures, Solar Radiations; Influence of Stability on Stack Emissions; Meteorological Factors in Industrial Location; Urban Meteorology

Air Pollutants: Air Pollution Phenomenon: Air Pollutants: Common Forms; Classification of Air Pollutants: Natural and Anthropogenic Pollutants, Particulate and Gaseous Pollutants, Primary and Secondary Pollutants, Stationary and Mobile Source Pollutants, Ambient Air and Indoor Air Pollutants; Effect of Air Pollutants on Human Health: Carbon Monoxide, Nitrogen Oxides, Hydrocarbons, Sulphur Oxides, Suspended Particulate Matter; Effect of Air Pollutants on Animals: Arsenic, Fluorides, Lead, Insecticides and Pesticides;

Effect: Sulphur Dioxide, Ozone, Nitrogen Dioxide, Peroxy Acetyl Nitrate, Fluorides, Ethylene; Effect of Air Pollutants on Materials: Ferrous Metals, Aluminium and Aluminium Alloys, Copper and Silver, Building Materials, Leather, Paper, Textiles; Effect of Air Pollution on Visibility

Air Quality monitoring and Control: Air Quality: Indoor and Outdoor Air Quality, Air quality Management System and Standards, Measures of Air Quality; Air Quality Monitoring: National Ambient Air Management Programme, Ambient Air Sampling, Methods of Ambient Air Analysis, Analysis of Common Air Pollutants; Air Pollution Control

Industrial Effluents: – Pollution Parameters and Treatment Methods: Pollution Parameters; Treatment Methods; Effluents from Food and Food Processing Industries – Dairy Waste: Sources of Waste; Methods for Reducing Wastewater Quantity; Treatment of Dairy Waste; Effluents from Petrochemicals: The Petrochemicals Industry; Waste Characteristics; Waste Disposal Treatment; Effluents from Textiles: The Textile Industry; Textile Waste Characteristics; Textile Wastewater Problems; Textile Waste Treatment; Effluents from Pulp and Paper Industry: The Pulp and Paper Industry; Effluent from Pulp and Paper Industry; Characteristics of Effluent; Suspended Solids Reduction; Sludge Dewatering and Disposal; Methods for the Reduction of Organics; Land Disposal by Irrigation and Seepage; Effluents from Tanneries: The Leather Industry; Tannery Waste Characteristics; Tannery Waste Treatment; Hazardous Wastes: Hazardous Waste Generation; Hazardous Waste Management.

Environmental Pollution due to Agrochemicals: Pesticides: Pesticides in the Environment, Effects of Pesticides in Ecosystem, Ways of Minimising Environmental Effects of Pesticides, Minimisation of Pesticides Residues, Alternative Methods of Pest Control; Environmental Pollution Due to Fertilisers: Nitrogen as Pollutant, Nitrate in Water and Food and Human Health, Nitrates and Plant Growth, Gaseous Emission, Phosphorous as Pollutant, Potassium as Pollutant, Heavy Metals as Pollutants; Strategies to Reduce Environmental Pollution due to Fertilisers: Manures as Pollutants.

Municipal and Domestic Wastes: Sewage and Other Water Borne Wastes: Generation and their General Characteristics, Sewage Generation, General Characteristics of Sewage, Sewage Analysis, Sewage Sampling; Solid Matters in Sewage: Determination of Solid Matters in Sewage; Organic Matters in Sewage: Carbon, Nitrogen and Sulphur Cycles in Nature, Determination of Organic Matters, Nutrients, Detergents and Surfactants, Mineral Matters in Sewage and their Determination; Gaseous and Volatile Matters in Sewage: Determination of Gases in Sewage; Hydrogen Ion Concentration and Temperature: Hydrogen Ion Concentration of Sewage, Temperature of Sewage; Living Matters in Sewage:

Significance, Determination of Planktons; Microbial Contamination in Sewage: Micro-organisms in Sewage, Removal of Microorganisms, Bacteria; Decomposition of Sewage: Anaerobic Treatment of Sewage, Aerobic Treatment of Sewage, Oxygen Requirement for Decomposition of Sewage; Sewage Treatment and Disposal: Sewage Characteristics, Sewage Treatment Process, Sewage Disposal; Diseases Through Sewage.

Effects of Soil and Water Pollution: Industrial Pollution Cycle and Adverse Effects; Water Related Diseases; Biological Hazards, Chemical and Radioactive Hazards; Water Related Disease and Seasonal Variation: Adverse Effects of Soil Pollution: Soil Pollution of Biological Disease Agents, Soil Pollution and Solid Waste Disposal, Soil Pollution by Toxic Chemicals.

Further Readings:

1. Environmental Chemistry, S. E. Manahan, Lewis Publishers.
2. Environmental Chemistry, Sharma & Kaur, Krishna Publishers.
3. Environmental Chemistry, A. K. De, Wiley Eastern. Environmental
4. Environmental Chemistry, C. Baird, W. H. Freeman.
5. Reaction mechanisms in environmental organic chemistry, Richard A. Larson and Eric J. Weber

MCHL-018: ENVIRONMENTAL CHEMISTRY LAB

(04 Credits, 60 Lectures)

- Experiment 1: i) Sampling of Soil and Water Samples
ii) Determination of pH and Conductance of Water and Soil Samples
- Experiment 2: Determination of Total Available Nitrogen in a Soil Sample
- Experiment 3: Determination of Available Phosphorus in a Soil Sample
- Experiment 4: Estimation of Alkalinity of a Water Sample
- Experiment 5: Estimation of Soluble Chlorides in a Water Sample
- Experiment 6: Estimation of Soluble Sulphates in a Water Sample
- Experiment 7: Estimation of Dissolved Oxygen in a Water Sample
- Experiment 8: Determination of Hardness in a Water Sample
- Experiment 9: Determination of Chemical Oxygen Demand of a Polluted Water Sample
- Experiment 10: Determination of Dust fall, Rainfall and Humidity
- Experiment 11: Detection of CO and NO₂ in Air/ Gaseous Emissions
- Experiment 12: Determination of Suspended Particulate Matter in Air and NO₂ in Ambient Air/Gaseous Emissions
- Experiment 13: Determination of Sulphur Dioxide in Ambient Air/Gaseous Emission
- Experiment 14: Identification of Pesticides in Pesticide Residues

Further Readings:

1. Vowels P.D. and D.W. Connel, Experiments in Environmental chemistry Pergamon 1980.
2. Pollution Analysis, S.M. Khopkar, Wiley Eastern
3. Standard Method of Chemical Analysis, F.J. Welcher Vol. III, Van Nostrand Reinhold Co. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
4. Elemental Analysis of Airborne Particles, Ed. S. Landsberger and M. Creatchman, Gordon and Breach Science Publication.

Semester 4

MCH-024: INTRODUCTION TO RESEARCH

(02 Credits, 30 Lectures)

Foundations of Research: Basics of Research; Meaning and Significance, Objectives of Research, Research Methods, and Research Methodology; Types of Research; Qualitative and Quantitative Research, Fundamental or Basic Research, Experimental and Non-experimental Research; Stages of Research

Research Problem: What is a Research Problem; Need of a Research Problem, Characteristics of a Good Research Problem, Criteria of Selecting a Research Problem; Identification of a Research Problem; Library Resources, Web Resources, Search Engine, Literature Review, Guidelines for Literature Review; Formulation of Research Problems; Framing Aim and Objectives, Research Title

Research Design: Definition of Research Design, Need and Importance; Features of a Good Research Design; Types of Research Design; Exploratory, Descriptive, Experimental; Research Hypotheses; Importance of Hypotheses, Characteristics of a Good Hypothesis; Types of Hypothesis; The Hypotheses Variables, Alternate versus Null Hypotheses

Sampling and Data Analysis: Sampling in Research; Characteristics of a Good Sample, Statistical Population; Types of samples; Data Analysis; Errors and Accuracy, Data collection Tools, Methods of Statistical Analysis

Writing a Research Paper: Layout of a Research Paper, Title page, Abstract, Introduction, Methodology, Results, Discussion, References; Style of writing the Scientific Report, APA/ACS format –

Ethics in Research: Defining Ethics in Science; Role of Ethics in Science; Terms Used in Ethics; Core Principles of Ethics; Misconduct in Academic Work; Plagiarism and Misuse of Sources, Breach of Principles; Deviations in Publishing

Presentation of Research Work: PowerPoint Presentation; Characteristics of a Good ppt; Use of Software (like Chemdraw, Excel, drawing tools etc); Points to Remember; Preparation of a Sample PPT with a topic of Choice

Further Reading

1. C. R. Kothari, Research Methodology Methods and Techniques, 2nd.ed. New Delhi: New Age International Publishers, 2009.
2. R. Panneerselvam, Research Methodology, New Delhi: PHI, 2005.
3. J. W. Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 3rd. ed. Sage Publications, 2008.
4. Kumar, Research Methodology: A Step by Step Guide for Beginners, 2nd. ed. Indian: PE, 2005.
5. B. C. Nakra and K. K. Chaudhry, Instrumentation, Measurement and Analysis, 2nd. ed. New Delhi: TMH publishing Co. Ltd., 2005.

MCH-025: ELECTROANALYTICAL TECHNIQUES AND OTHER METHODS OF ANALYSIS

(04 Credits, 60 Lectures)

Introduction to Electro Analytical Methods: Basic Concepts; Classification and an Overview of Electroanalytical Methods; Potentiometry, Voltammetry, Polarography, Amperometry, Electrogravimetry and Coulometry, Conductometry

Electrogravimetry: Electrogravimetric Analysis; Polarisation; Types of Electrogravimetric Methods; Constant Current Electrolysis, Constant Cathode Potential Electrolysis, Application of Electrogravimetry

Coulometry: Types of Coulometric Methods; Controlled Potential Coulometry, Constant Current Coulometry; Applications of Coulometric Methods

Voltammetry: Electrodes and Electrode Processes; Common Voltammetric Methods; Pulse Methods, Stripping Methods; Alternating Current Methods, Determination of the nature of the ion ($E_{1/2}$); Applications of Voltammetry; Voltammetry – Instrument, Practical methods: Steps Involved in Voltammetry

Polarography: Dropping Mercury Electrode; Currents in Polarography; Polarographic Equation; $E_{1/2}$ and Effect of Complexing Agents; Qualitative and Quantitative Polarographic Analysis

Amperometric Titrations: Basics Amperometric Titrations; Examples of Amperometric Titration; Titrations with the Rotating Platinum Electrode; Biamperometry or Dead-Stop End Point Method; Applications of Amperometric Titrations

Thermogravimetric Analysis: Principle; Instrumentation: Working Function of Each Component; Sources of Error in TGA; Factors Affecting TG Curve; Interpretation of TG Curve Thermogravimetric analysis (TGA); Application of Thermogravimetric Analysis; Analysis of Inorganic Mixtures, Determination of nature of Gravimetric Precipitation, Reaction Kinetics

Differential Thermal Analysis: Differential Thermal Method of Analysis; Principle, Instrumentation, DTA Curves, Factors Affecting DTA Curves, Sources of Errors; Applications of DTA

Differential Scanning Calorimetry: Differential Scanning Calorimetry; Experimental Setup, Sources of Errors, Factors Affecting DSC Curves, Interpretation of DSC Curve, Applications of DSC, Advantages of DSC; Thermometric Titrations; Principle of Thermometric Titration, Instrumentation, Application of Thermometric Titrations; Combined thermal instruments: Introduction to TGA/MS and TGA/FTIR, High Resolution TGA, Microthermal Analysis

Fundamentals of Radioactivity: Radioactivity and Decay Law; Natural Radioactivity; Decay Series, Classification of Nuclides, Isotopic and Relative Atomic Masses; Artificial Radioactivity; Nuclear Reactions, Commonly used Radioisotopes, Preparation of Radioisotopes and Labelled Compounds; Detection and Measurement of Radioactivity; Statistical Aspects of Radioactivity Measurements; Background in Radioactivity Measurements

Radioanalytical Methods: Radiotracer Techniques; Choice of Radiotracers, Factors Affecting Choice of Radiotracers; Isotope Dilution Analysis (IDA); Activation Analysis (AA); Comparison of NAA and IDA with Other Methods; Radiometric titrations (RT); Radio Chromatography (RC); Radioimmunoassay (RIA)

Surface Analysis Methods I: Types of Surface Measurements; Photon Probe Techniques: X-Ray Photoelectron spectroscopy; Principle, Instrumentation, Applications; Electron Probe Techniques; Scanning Electron Microscopy (SEM): Principle, Instrumentation, Applications; Transmission Electron Microscopy (TEM); Principle, Instrumentation, Applications

Surface Analysis Methods II: Energy Dispersive X-ray Spectroscopy (EDX); Principle, Instrumentation, Applications; Electron Probe X-ray analysis (EPXMA); Principle, Instrumentation, Applications; Auger Electron Spectroscopy (AES); Principle, Instrumentation, Applications; Ion Probe Techniques: Rutherford Backscattering Spectrometry (RBS); Principle, Instrumentation, Applications; Secondary Ion Mass Spectrometry (SIMS) – Fundamental Aspects of Sputtering; Principle, Instrumentation (Static and Dynamic), Applications; Scanning Probe Microscopy Techniques: Scanning Tunneling Microscopy; Principle, Instrumentation, Applications; Atomic Force Microscopy; Principle, Instrumentation, Applications

Further Readings:

1. "Electrochemical Methods: Fundamentals and Applications" by Allen J. Bard and Larry R. Faulkner, Wiley
2. "Instrumental Methods of Analysis" by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch, Cengage Learning
3. "Electroanalytical Chemistry: A Series of Advances" by Allen J. Bard, CRC Press
4. "Principles of Instrumental Analysis" by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch, Cengage Learning
5. "Modern Electrochemistry 1: Ionics" by Bockris and Reddy, Springer
6. "Modern Electrochemistry 2A: Fundamentals of Electrode Processes" by John O'M. Bockris and Amulya K.N. Reddy, Springer
7. "Electroanalytical Chemistry: Basic Principles and Applications" by Milan Paunović, Springer
8. "Electrochemical Methods of Chemical Analysis" by Fritz Scholz, Wiley

**MCHL-019: ELECTROANALYTICAL TECHNIQUES AND OTHER METHODS OF ANALYSIS LAB
(02 Credits, 60 Lectures)****List of Experiments**

1. pH titration of a strong acid (battery acid)
2. pH titration of a weak acid – Determination of pK_a , of acetic acid
3. Potentiometric titration of a strong acid with a strong base using quinhydrone electrode
4. Potentiometric titration of Fe^{2+} with $Cr_2O_7^{2-}$
5. Potentiometric determination of Cl^- content of common salt using $AgNO_3$
6. Conductometric titration of a strong acid with a strong base
7. Conductometric determination of acetic acid content of vinegar
8. Conductometric titration of a mixture of a strong acid and weak acid with a base
9. Identification and determination of $Cd^{2+}/Pb^{2+}/Zn^{2+}$ by polarography
10. Amperometric titration of Pb^{2+} with $Cr_2O_7^{2-}$
11. Demonstration- Determination of the solubility of a sparingly soluble salt by radiotracer method (Demo)

Further Readings:

1. "Principles of Instrumental Analysis" by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch, Cengage Learning
2. "Experimental Electrochemistry: A Laboratory Textbook" by Oliver J. Murphy, Royal Society of Chemistry
3. "Instrumental Methods of Analysis" by Hobart H. Willard, Lynne L. Merritt, Jr., and John A. Dean, Wadsworth Publishing
4. "Electroanalytical Chemistry: Basic Principles and Applications" by Milan Paunović, Springer
5. "Electrochemical Methods of Chemical Analysis" by Fritz Scholz, Wiley
6. "Laboratory Techniques in Electroanalytical Chemistry" by Peter T. Kissinger and William R. Heineman, CRC Press

ELECTIVE COURSES (TO CHOOSE ANY THREE)

MCHE-011: APPLICATIONS OF SPECTROSCOPY TO INORGANIC & BIOINORGANIC MOLECULES (04 Credits, 60 Lectures)

Vibrational Spectroscopy : Vibrational Spectroscopy, Symmetry and Shapes of AB₂, AB₃, AB₅, AB₆; Mode of Bonding of Ambidentate Ligands; Ethylenediamine and Diketonato Complexes

Application of Raman Spectroscopy : Application of Raman Spectroscopy; Application of Resonance Raman Spectroscopy, Particularly for the Study of Active Sites of Metalloproteins

Electron Spin Resonance Spectroscopy : Basic Principles of ESR Inclusive of Treatment of Hydrogen Atom; ESR Spectra; Hyperfine Coupling, Organic Radicals, Transition Metal Ions; Isotropic HFS; Spin Polarization in Organic Free Radicals, Core Polarization in Transition Metal Ions; Spin-Orbit Coupling and Significance of G-Tensors and A-Tensors; Applications to Transition Metal Complexes (Having One Unpaired Electron); Biological Systems, Inorganic Free Radicals eg., PH₄, F₂⁻ and [BH₃]⁻

Applications of ESR Spectra : Determining Charge-Delocalization in Complex Molecules, Unpaired Electron on Metal vs Unpaired Electron on Ligand; Zero-Field Splitting and Its Influence on the ESR Spectral Properties; Anisotropic (Axial And Rhombic) ESR Spectra

NMR of Inorganic Molecules & Organometallic Compounds : Chemical shift for Inorganic Molecules; NMR in Organometallic Compounds, Spectral Changes of Organic Ligands upon Binding to Metal Ions

Applications of NMR Spectra in Inorganic Compounds : Applications of NMR Spectra in Inorganic Compounds; Multinuclear NMR, ¹H, ¹¹B, ¹³C -Detection and Structural Studies of Different Compounds; More Applications of NMR Spectra in Inorganic Compounds, ¹⁵N, ¹⁹F and ³¹P - Detection and Structural Studies of Different Compounds

NMR Spectral Studies in Inorganic Molecules : NMR Spectral Studies; Tin Compounds, Vanadium Compounds, Platinum Coordinated Hydrides; Nuclear Magnetic Resonance of Paramagnetic Compounds in Solution; Variable Temperature NMR Studies; Fluxional Molecules, Exchange of Ligands; Detection of cis-trans and fac-mer Isomers

Applications of NMR of Metal Nuclides : The Contact and Pseudo Contact Shifts; Factors Affecting Nuclear Relaxation; Applications in Biochemical Systems; An Overview of NMR of Metal Nuclides

Mossbauer Spectroscopy : Mossbauer Spectral Parameters and Spectral Display; Mossbauer Effect; Basic Principles of Mossbauer Spectroscopy, Doppler Shift and Recoil Energy; Isomer Shift and its Interpretation; Nuclear Quadrupole Coupling/Splitting; Effect of Internal and External Magnetic Field on Mossbauer Spectra, Hyperfine Splitting

Applications of Mossbauer Spectroscopy-I : Applications to Metal Complexes; Metal Carbonyls, Fe-S Cluster and Tin Compounds; Partial Quadrupole Splitting and Geometry of the Complexes

Applications of Mossbauer Spectroscopy-II : Applications of Mossbauer Spectroscopy; Bonding and Structures of Iron Compounds, Spin Crossover; Sn²⁺ and Sn⁴⁺ Compounds; Nature of M-L Bond, Coordination Number; Structure and Detection of Oxidation State and Inequivalent Mossbauer Atoms

Electron Spectroscopy for Chemical Analysis (ESCA) : Historical Background (Einstein's Photoelectric Effect, Pierre Auger, Siegbahn and coworkers, Turner and co-workers); Photoionisation and Auger Processes; Ionization Potential, Binding Energies; ESCA through UVPEs and XPS, PESIS, PESOS; Meaning of Photoelectron Spectrum, Explanations in Terms of Atomic and Molecular Energy Levels

X-Ray Fluorescence and AUGER Process : Photoelectron Spectral Description in Terms of BE Vs Intensity, Comparison of Photoionization; X-Ray Fluorescence and AUGER Process; Related Techniques, Electron-Impact Spectroscopy, Photoemission, Penning Ionisation Spectroscopy (PIS), Ion Neutralising Spectroscopy

AES and AAS : Emission and Absorption Process; Atomic Spectroscopy; Spectral States for p^2 and d^2 Electronic Configurations (Example), Concentration Determination for Impurities in Solid State and Metal Ions in Biological Materials; Characteristic Emission or Absorption for Individual Elements; Modern Day Instrumentation

Further Readings:

1. "Spectroscopic Methods in Inorganic Chemistry" by Ralf W. Adams, CRC Press
2. "Inorganic Spectroscopic Methods" by Alan K. Brisdon, Oxford University Press
3. "Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life" by Ivano Bertini, Harry B. Gray, Edward I. Stiefel, and Joan S. Valentine, University Science Books
4. "Spectroscopic Properties of Inorganic and Organometallic Compounds: Techniques, Materials, and Applications" by Joseph R. Lakowicz, Wiley
5. "Inorganic Spectroscopy" by A. B. P. Lever, Elsevier
6. "Inorganic Electronic Structure and Spectroscopy: Methodology" by Edward I. Solomon, David R. Larson, and James A. Ibers, Wiley
7. "Bioinorganic Chemistry" by Stephen J. Lippard and Jeremy M. Berg, University Science Books
8. "Bioinorganic Chemistry: Structure and Bonding" by Wolfgang Kaim and Brigitte Schwederski, Springer
9. "Biological Inorganic Chemistry: A New Introduction to Molecular Structure and Function" by Robert R. Crichton, Academic Press
10. "Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life" by Wolfgang Kaim and Brigitte Schwederski, Wiley

MCHE-012: SPECTROSCOPIC IDENTIFICATION OF ORGANIC COMPOUNDS
(04 Credits, 60 Lectures)

UV-Visible Spectroscopy: Some Basic Concepts : Various Electronic Transitions; Beer-Lambert Law; Effect of Solvent on Electronic Transitions; Ultraviolet Spectra of Carbonyl Compounds; Unsaturated Carbonyl Compounds

UV-Visible Spectra of Some Illustrative Compounds : Ultraviolet Spectra of Dienes; Conjugated Polyenes; Fieser-Woodward Rules for Conjugated Dienes and Carbonyl Compounds; Ultraviolet Spectra of Polyenes; Ultraviolet Spectra of Aromatic Compounds; Steric Effect in Biphenyls

Infrared Spectroscopy-Basic Aspects and Applications : Instrumentation and Sample Handling; Characteristic Vibrational Frequencies of Alkanes, Alkenes, Alkynes and Aromatic Compounds; IR Spectra of Alcohols, Phenols and Ethers; IR Spectra of Amines

IR Spectra of Some More Classes of Organic Compounds : IR Spectral Study of Vibrational Frequencies of Carbonyl Compounds: Aldehydes and Ketones; Carboxylic Acids, Derivatives of Carboxylic Acids, Esters, Amides, Anhydrides; IR Spectra of Lactones, and Lactams; IR Spectra

of Conjugated Carbonyl Compounds; Effect of Hydrogen Bonding and Solvent Effect on Vibrational Frequencies; Overtones, Combination Bands and Fermi Resonance

Basic Concepts of NMR Spectroscopy : Natural Abundance of ^{13}C , ^{19}F and ^{31}P Nuclei; The Spinning Nucleus; Effect of External Magnetic Field; Processional Motion and Frequency; Energy Transitions

^1H NMR Spectroscopy : Chemical Shift and Its Measurement; Factors Influencing Chemical Shift; Anisotropic Effect, Electronegativity/Inductive Effect, Hybridisation, Hydrogen Bonding; Chemical and Magnetic Equivalence; Spin-Spin Coupling; Magnitude of Coupling Constants; Simple, Virtual and Complex Spin-Spin Coupling; Factors Affecting the Coupling – First and Non-First Order Spectra; Proton Exchange

Complex NMR Spectra : Simplification of Complex Spectra; Solvent Effect, Field Effect; Double Resonance and Lanthanide Shift Reagents; NOE Experiments, (NOESY, HOESY, ROESY, etc.)

Applications of NMR Spectroscopy : Structure Elucidation of Simple Organic Compounds, Structure Elucidation of Some Complex Organic Compounds; Applications of NMR Spectroscopy in Medicine and Diagnosis; Applications of NMR Spectroscopy in Polymers; Solid-state NMR Spectroscopy; We may add some more applications

Introduction to 2D-NMR: Basics of COSY and its Application; Basics of HMQC and its Application; HETECOR Spectra and its Application;

^{13}C NMR Spectroscopy : Resolution and Multiplicity of ^{13}C NMR; ^1H -decoupling; Noise Decoupling, Broad Band Decoupling, Off-resonance Decoupling; Deuterium, Fluorine and Phosphorus Coupling; NOE Signal Enhancement; DEPT and INEPT

Applications of DEPT, INEPT and ^{13}C NMR Spectroscopy : Structural Applications of; DEPT, INEPT, CMR Studies

MASS Spectrometry : Theory and Instrumentation; Unit Mass and Molecular Ions; Important Terms- (Singly, Doubly/Multiple Charged Ions, Metastable Peak, Base Peak, Isotopic Mass Peaks, Relative Intensity, FTMS, etc.); Recognition of M^+ Ion Peak; Ionisation Methods (EI, CI, FAB, ESI, APCI and MALDI)

General Fragmentation Rules : Fragmentation of Oxygen Containing Organic Compounds; Fragmentation of Sulphur Containing Organic Compounds; Fragmentation of Nitrogen and Halogens Containing Organic Compounds; α -, β -, Allylic and Benzylic Cleavages; Mc Lafferty Rearrangement; Ortho Effect

Structure Elucidation of Organic Compounds using IR, NMR and Mass Spectra

: Examples of Structure Elucidation of Different Compounds

Further Reading

1. Introduction to Spectroscopy by Donald L. Pavia, Gary M. Lampman and George S. Kriz
2. "Spectrometric Identification of Organic Compounds" by Robert M. Silverstein and Francis X. Webster, Wiley
3. "Introduction to Spectroscopy" by Pavia, Lampman, and Kriz, Cengage Learning
4. "Structure Elucidation by NMR in Organic Chemistry: A Practical Guide" by Eberhard Breitmaier and Gunther Jung, Wiley-VCH
5. "Organic Spectroscopy" by William Kemp, Palgrave Macmillan

6. "Spectroscopic Methods in Organic Chemistry" by Dudley H. Williams and Ian Fleming, McGraw-Hill Education
7. "Mass Spectrometry for the Novice" by John Greaves and Andrew Bradbury, CRC Press
8. "Spectroscopy of Organic Compounds" by P.S. Kalsi, New Age International

MCHE-013: SUPRAMOLECULAR CHEMISTRY (04 Credits, 60 Lectures)

Concepts of Supramolecular Chemistry (4 hrs): Supramolecular Chemistry, Definition and Development; Nature of Supramolecular Interactions, Ion-ion, ion-dipole, dipole-dipole, H-bonding, van der Waals and Solvophobic Interactions

Different Effects and Binding Processes (4 hrs): Cooperativity, Anti-cooperativity and Allosteric Effects, Induced Fit; Kinetically Controlled and Thermodynamically Controlled Binding Processes, Complexation Selectivity

Molecular Receptors (4 hrs): Design of Molecular Receptors, Chelate Effect ; Preorganization, Enthalpy and Entropic Contributions

Molecular Recognition (5 hrs): Molecular Recognition; Types of Recognition, Classification of Host Guest Compounds, Cation Binding Hosts, Binding of Anions, Neutral Molecules, Organic Molecules

Cation-binding Hosts (4hrs): Concepts; Cation Receptors; Crown Ethers, Cryptands, Spherands, Calixarens; Selectivity of Cation Complexation, Macrocyclic and Template Effects

Binding of Anions (4 hrs): Concepts, Anion Host Design; Anion Receptors, Shape and Selectivity

Binding of Neutral Molecules (4 hrs): Neutral Receptors; Clathrates, Cavitands, Cyclodextrins, Cyclophanes

Supramolecular Chemistry in Biology I (5 hrs): Self-Replication as the Key to Life, Replicators and Replicator Evolution, Orthogonal Translation; Origin of Life, Compartmentalization, Catalysis and Replication

Supramolecular Chemistry in Biology II (4 hrs): Cells, Membranes; Photosynthesis and Artificial Leaves, Oxygen Transport; Biological Mimics; Enzymes, Metallobiosites, Heme Analogues

Supramolecular Catalysis and Transport (4 hrs): Supramolecular Reactivity and Catalysis; Transport Processes and Carrier Design

Self-assembly (5 hrs): Biological Self Assembly, The Tobacco Mosaic Virus and DNA; Self-Assembling Coordination Compounds; Molecular Squares, Boxes and Spheres, Self-Assembly of Metal Arrays; Supramolecular Entanglements, Rotaxanes, Catenanes and Knots

Solid-state Supramolecular Chemistry (4 hrs): Solid State Inclusion Compounds, Clathrate Formation; Tectons, Synthons, Co-crystals; Polymorphism

Supramolecular Devices (4 hrs): Supramolecular Photochemistry; Supramolecular Electronic Ionic and Switching Devices; Self-assembly in Supramolecular Chemistry, Examples

Applications of Supramolecular Chemistry (5 hrs): Rational Design; Molecular Paneling; Supramolecular Devices; Nanoscience Applications

Further Reading:

1. J. M. Lehn, Supramolecular Chemistry, Concepts and Perspectives, VCH, 1995.
2. H. Dodziuk, Introduction to Supramolecular Chemistry, Kluwer Academic, 2002.
3. F. Vogtle, Supramolecular Chemistry, An Introduction, John Wiley & Sons, 1991.

4. J. W. Steed, J. L. Atwood, *Supramolecular Chemistry, A Concise Introduction*, John Wiley, 2000.
5. A. Bianchi, K. B. James, E. G. Espana, *Supramolecular Chemistry of Anions*, Wiley-VCH, 1997.
6. M. Fujita, *Molecular Self-assembly, Organic Versus Inorganic Approaches*, Springer, 2000.
7. J. L. Atwood, J. E. D. Davies, D. D. MacNicol, F. Vogtle, J. M. Lehn, *Comprehensive Supramolecular Chemistry*, Pergamon, 1996.

MCHE-014: PRIMARY AND SECONDARY METABOLITES (04 Credits, 60 Lectures)

Basic Aspects of Terpenes: Occurrence; Isolation; Classification; Nomenclature; Structure Determination; General Methods of Structure Determination, Isoprene Rule

Synthesis of Monoterpenes: Biosynthesis and Synthesis of the Following Monoterpenoids; Citral, Geraniol, α -terpeneol, Menthol

Sesquiterpenoids: Chemistry and Synthesis of Farnesol (Acyclic); Chemistry and Synthesis of Zingiberene (Monocyclic); Chemistry and Synthesis of Santonin (Bicyclic)

Diterpenoids: Biosynthesis and Synthesis of Phytol; Biosynthesis and Synthesis of Abietic Acid

General Methods of Structure Determination of Carotenes: β -carotene; α -carotene; γ -carotene; Lycopene and Vitamin A

Xanthophylls: Spirilloxanthin; Capsorubin; Fucoxanthin; Carotenoid Acids (Apocarotenoids): Bixin and Crocetin; Bio Synthesis of Carotenoids

Basic Aspects of Alkaloids: Occurrence; Isolation; Nomenclature; Physiological Action

Structural Aspects of Alkaloids: General Methods of Structure Elucidation; Degradation; Classification Based on Nitrogen Heterocyclic Ring; Role of Alkaloids in Plants

Structure, Synthesis and Biosynthesis of Alkaloids: Ephedrine; Coniine; Nicotine; Atropine; Quinine; Morphine

Basic Aspects of Steroids: Occurrence; Nomenclature; Basic Skeleton; Diel's Hydrocarbon and Stereochemistry

Cholesterol: Isolation; Structure Determination; Synthesis of Cholesterol

Chemistry of Steroids: Androsterone; Testosterone; Estrone; Progesterone; Biosynthesis of Steroids

Some Basic Aspects: Occurrence; Nomenclature; General Methods of Structure Determination

Anthocyanins: Occurrence, Isolation and Synthesis of Cyanin; Occurrence, Isolation and Synthesis of Pelargonidin; Chemistry of Hirsutidin

Polyphenols-I: Occurrence and Synthesis of Flavones (Chrysin); Occurrence and Synthesis of Flavonols (Quercitin); Occurrence and Synthesis of Isoflavones (Daidzein)

Polyphenols-II: Occurrence and Synthesis of Coumarins; Occurrence and Synthesis of Quinones (Lapachol); Biosynthesis of Flavonoids: Acetate Pathway and Shikimic Acid Pathway

Further Readings:

1. *Natural Products- Chemistry and Biological Significance*, J. Mann, R.S. Davidson, J. B. Hobbs, D.V. Banthrope and J. B. Harborne, Longman, Essex.
2. *Organic Chemistry Vol. II*, I.L. Finar, ELBS.
3. *Rodd's Chemistry of Carbon Compounds*, Ed. S. Coffey, Elsevier.

4. Introduction to Flavonoids, B.A.Bohm, Harwood Academic Publishers.
5. New Trends in Natural Product Chemistry, Atta-ur-Rahman M. I. Choudhary, Harwood Academic Publishers.

MCHE-015: ADVANCED KINETICS AND ELECTROCHEMISTRY (04 Credits, 60 Lectures)

Kinetics of Complex Reactions Reversible Reactions, Opposing reactions of Second Order; Parallel Reactions; Consecutive Reactions; Autocatalysis, Steady-State Treatment

Kinetics of Photochemical Reactions : Photochemical Reactions, Kinetic Features of Photochemical Reactions; Kinetics of Chain Reactions; Hydrogen-Chlorine Reaction, Hydrogen- bromine Reaction, Pyrolysis of Acetaldehyde

Kinetics of Oscillatory Reactions : Oscillatory Reactions: Historical Account; Models of Chemical Oscillations, Lotka-Volterra Model; Belousov-Zhabotinskii Reaction, Mechanism of B-Z Reaction; Briggs-Rauscher Reaction

Kinetics of Solid State Reactions : Characteristics of Solid-State Reactions, Factors Affecting Solid State Reactions; Wagner's Mechanism ; Rate laws for Solid State Reactions

Electron Transfer Reactions : Inner Sphere Electron Transfer; Taube's Experiments, Characteristics of inner Sphere Electron Transfer Reactions, Mechanism of Inner Sphere Electron Transfer Reactions; Outer Sphere Electron Transfer, Marcus Theory

Complex Enzyme Reactions : Michaelis-Menten Mechanism; Reactions with Single Intermediate, Reactions with Double Intermediates; King-Altman Method, Complex Enzyme Reactions; Enzyme Inhibition, Reversibility and Products Inhibition.

Reaction Dynamics : Molecular Reaction Dynamics, Energy Disposal in an Exoergic Chemical Reaction; Molecular Beams, Principle of Crossed-Molecular Beams; Molecular Collisions; Impact Parameter, Collision Cross-ction, Reaction Cross-section; Reaction Cross-section and Reaction Rate

Electrode Kinetics : Essentials of Electrode Reactions; Butler-Volmer Equation; Derivation of Equation, Significance of Butler-Volmer Equation; Overpotential; Current-Overpotential Equation, Tafel Plot

Kinetics of Multistep Electrode Reactions : Multistep Electrode Reaction Pathway, Rate Determining Step; Two-Step Electrochemical Reactions; Complex Electrochemical Reactions; Charge Transfer at Electrode-Solution Interfaces; Quantization of Charge Transfer, Tunnelling

Electrochemical Methods : Coulometry; Controlled Potential Coulometry, Controlled Current Coulometry; Hydrodynamic Techniques; The Dropping Mercury Electrode, The Rotating Disc and Ring Disc Electrode; Scanning Probe Microscopy; Electrochemical Instrumentations

Corrosion : Introduction to Corrosion, Forms of Corrosion; Electrochemical Corrosion Theory, Corrosion Cells and Reactions; Corrosion Monitoring, Factors Affecting the Rate of Corrosion; Prevention of Corrosion; Metallic Coating, Electrical Protection, Corrosion Inhibitors, Impressed Current Cathodic Protection (ICCP)

Conversion And Storage of Electrochemical Energy : Fuel Cells; Charge Distribution around Central Ion, Chemical Potential Changes due to Ion-Ion Interactions; Supercapacitors; Classification of Supercapacitors, Supercapacitors versus Batteries, Electrochemical Double-Layer Capacitors, Hybrid Capacitors; Applications of Supercapacitors; Lithium-Ion Batteries, Advantages and Disadvantages of Lithium-Ion Batteries

Electrocatalysis : Electrocatalysis; Sabatier Principle, Factors Affecting Electrocatalysis; Applications of Electrocatalysis; The Hydrogen Evolution Reaction (HER), The Carbon Dioxide Reduction Reaction

Electrocrystallisation : Electro Growth of Metals on Electrode; Nucleation, Growth, Surface Diffusion; Underpotential Deposition; Mechanism of UPD, Characteristics of UPD; Shapes Formed in Electrodeposition

Further Readings:

1. "Physical Chemistry: A Molecular Approach" by Donald A. McQuarrie and John D. Simon; University Science Books
2. "Modern Electrochemistry 2A: Fundamentals of Electrodeics" by John O'M. Bockris and Amulya K.N. Reddy, Springer
3. "Modern Electrochemistry 2B: Electrodeics in Chemistry, Engineering, Biology, and Environmental Science" by John O'M. Bockris and Amulya K.N. Reddy, Springer
4. "Electrochemical Methods: Fundamentals and Applications" by Allen J. Bard and Larry R. Faulkner, Wiley
5. "Electrochemical Reaction Engineering" by Andrzej Lasia, Springer
6. "Principles of Chemical Kinetics" by James E. House, Academic Press
7. "Kinetics of Chemical Reactions: Decoding the Concepts and Clarifying the Language" by Alexandru T. Balaban, Springer
8. "Physical Chemistry" by Peter Atkins and Julio de Paula, Oxford University Press

3. Regional & Study Centre Details for MSCCHEM

The details of the study centres activated till date are given here. More study centres are being activated. For the updated list of the activated study centres [click here](#)

Regional Centre	Study Centre (Code)
Hyderabad	Nizam College (01152)
Shimla	Government Degree College (1104)
Port Blair	Jnr Mahavidyalala (201)
Bhubaneshwar	IGNOU Regional Centre Bhubaneshwar LSC Code (2100)
Ranchi	P.K. Roy Memorial College, Dhanbad (503)
Nagpur	Institute of Science R T Road Civil Line Nagpur Maharashtra (36009p)
Noida	D.N. (PG) College Meerut (2799)
Noida	Meerut College, Meerut (2728)
Guwahati	Handique Girls College (408)
Trivandrum	Mar Ivanios Institute of Advance Studies (1441)
Madurai	Central University of Tamil Nadu (43087)
Varanasi	Harish Chandra P.G. College Maidagin Varanasi (48048)

Varanasi	Udai Pratap Autonomous College, Varanasi (2708)
Patna	Anugrah Narayan College (0529)
Patna	Gaya College (0511)
Jodhpur	Govt. P.G. College (Boys) (2362)
Angul	Govt College Rourkela (2103)

4. Instructional System

The methodology of instruction in this University is different from that in the conventional universities. The Open University system is more learner-oriented, and the learner is an active participant in the teaching-learning process. Most of the instructions are imparted through distance rather than face-to-face communication. For MSCCHEM programme the instruction will be by following multiple media.

- Self-instructional printed material
- Audio and video programmes
- Academic counselling
- Teleconference/ web conference.
- Interactive radio counselling (IRC)
- Gyan darshan channel
- e-Content Mobile App

4.1 Self-Instructional Print Material

The printed self-instructional material is the mainstay of the instruction. Herein, the content presented as units put together in blocks / volumes are structured to facilitate self-study.

How to Study the Units

The course materials will be provided to you in the form of well-designed printed booklets. Each booklet is called a block and contains a few units. Generally, a 4 credits course has 4 blocks that contains 3-5 thematically related units. The first page of each block indicates the numbers and titles of the units comprising the block. In the first block of each course, we start with course introduction. This is followed by a brief introduction to the block. Each unit begins with an introduction in which we tell you about the contents of the unit. We also outline a list of objectives which we expect you to achieve after working through the unit. This is followed by the main body of the unit, which is divided into various sections and sub-sections. We end each unit by summarising its contents. We summarise what has been said in the whole unit to enable you to recall the main points. In addition, each unit, has several Self-Assessment Questions (SAQs) and Terminal Questions (TQs)/exercises /activities. These are meant to help you to assess your understanding of the subject contents. Answers of both SAQs and TQs are given in section 'Answers' in the units.

You are advised to read the units carefully and note down the important points. You can use the space in the margin of the printed page for making notes and writing your comments. Read the unit again and again until you have understood the point. However, if you still do not understand something, consult your counsellor during the face-to-face sessions at the study centre for clarification. Try to answer SAQs after completing the unit. These exercises will help you to reinforce the information you gain through your reading of the text. You can compare your answers with the answers given at the end of the unit.

4.2 Audio-Video Programmes

In addition to the print material, audio and/or video programmes will be available. These supplementary to print material. Hence, we advise you to make use of it, as it will help you to understand the subject better. These are transmitted by Doordarshan on National Network every day from 6.05 to 6.35 a.m. The schedule of transmission is communicated through the IGNOU website, through the IGNOU Newsletter and on Saptahiki aired on every Sunday on DD1 at the same time. Audio-video material will not be supplied individually to you but will be made available to Study Centres. You can watch these programmes during counselling sessions. Anyone desirous of buying the audio-video CDs can procure them from: The Director, Electronic Media Production Centre (EMPC), IGNOU, Maidan Garhi, New Delhi-110068.

4.3 Academic Counselling

In distance education, face-to-face contact sessions between learners and their tutors/counsellors is an important activity. The purpose of such contact sessions is to answer some of your questions and clarify your doubts which may not be possible through any other means of communication. It is also intended to provide you an opportunity to meet your fellow students. There are experienced academic counsellors at the study centres to provide counselling and guidance to you in the courses that you have chosen for study. The counselling sessions for each of the courses will be held at suitable intervals throughout the whole academic session. Attending counselling sessions for theory courses is not compulsory. However, they may be very useful in certain respects such as: to share your views on the subject with teachers and fellow participants, comprehend some of the complex ideas or difficult issues, and get clarification for many doubts which you would not otherwise try to raise and consult academic counsellors for selecting courses of study.

The MSCCHEM programme has two types of courses viz., theory, and practical courses. **The detailed schedule of the counselling sessions for both theory and lab courses will be informed to the learners by the coordinator of their Learner Support Centre.**

- **Theory Counselling**

Each of all theory courses of this programme will have 4-5 counselling sessions each of two hours for a 4-credit theory course and 2-3 counselling sessions each of two hours for a 2-credit theory course. The sessions for theory counselling are not compulsory to attend. But it is advisable to attend these sessions to clear your doubts and concepts.

- **Lab Counselling**

The number of lab counselling sessions at the learner support centre for each of the 2-credit lab course will be as:

The lab course will be conducted for seven days with two sessions of four hours each i.e., a total of 14 sessions distributed as follows:

Introduction		Guided Experiments		Unguided Experiment (Test)	Total
01	+	12	+	01	14

The first session will be for introduction wherein the counsellor will give an overview of the course and how the course will be conducted etc. In the next twelve sessions you will be conducting different experiments under the guidance of the counsellor. You will be required to prepare the laboratory record book and get it assessed by the counsellor every day. The marks scored in this account for 70% of the total marks for the course. You should bear in mind that **the attendance in the Laboratory course is compulsory**, and you must attend all the sessions all the sessions are evaluated. In the fourteenth session i.e., on the 7th day you would be required to perform an experiment (assigned to you by the counsellor) on your own (unguided) and would be evaluated and account for the remaining 30%. Hence, you must perform all the experiments to be able to secure maximum marks.

You are advised to pace your laboratory courses. As far as possible, you should complete the laboratory courses in the year in which you register for them. The learners are advised to complete the lab courses within the same semester, otherwise pro-rata fee of Rs. 400/- per course will be charged for re-registering for the missed/repeat lab sessions.

Please keep in touch with the Coordinator of your Learner Support Centre to know the schedule of the Lab Sessions.

The detailed schedule of the counselling sessions will be made known to you by the Coordinator of your Study Centre. You are advised to go through your course materials and note down the points to be discussed before you go to attend the counselling sessions.

4.4 Teleconference

Teleconference/web conference, using one-way video and two-way audio transmission via satellite, is another medium to impart instruction to and facilitate learning for a distance learner. The learners concerned would be informed about the teleconferencing schedule and the place where it is to be conducted.

4.5 Interactive Radio Counselling

Interactive phone-in radio counselling is available on every Sunday at all primary channels of AIR and Gyan Vani FM station. The radio counselling sessions are broadcast 'live' and are relayed by 184 radio stations across the country. Now, there is a synchronized weekly transmission "IGNOU HOUR" on Sundays from 4.00 p.m. to 5.00 p.m. with coverage of almost all over the country.

4.6 Gyan Darshan

Gyan Darshan, an 24 hours educational TV channel is a joint venture of IGNOU with Doordarshan. It is available through Cable TV network. **Please ask your cable operator to provide this channel.** The telecast schedule of Gyan Darshan is published in the IGNOU Newsletter and is also available at <http://ignou.ac.in/ignou/aboutignou/icc/empc/gyantime>.

4.7 e-Content Mobile App

IGNOU-e-Content Mobile App is an official mobile app of Indira Gandhi National Open University (IGNOU), New Delhi. This app is an ICT initiative of IGNOU to provide Digital Learning Environment to IGNOU learners and extending Technology Enhanced Learner Support Services to them. The aim of this initiative is to disseminate the digitised course materials to IGNOU Learners. IGNOU learners can use this app to access their course materials through their hand-held devices such as Mobile Phones and Tablets. The App can be downloaded from Google Play store.

5. EVALUATION SCHEME

The system of evaluation, both for theory courses and practical course is as follows:

5.1 Theory Evaluation: For theory courses, evaluation comprises three aspects:

- a) **Self-evaluation exercises** are given within each unit of study material in the form of Self-Assessment Questions (SAQs) and Terminal Questions (TQs). They have no credit. These are given for your practice.
- b) **Continuous evaluation** is in the form of compulsory tutor marked assignments. This carries a weightage of 30% for each course.
- c) **Term-end evaluation** has a weightage of 70% in each theory course.

5.2 Practical Evaluation: Evaluation of the practical course comprises two aspects given as follows:

- a) **Continuous evaluation** of lab exercises is done at the learner support centre by the counsellor. Evaluation of lab exercises which learners do throughout the semester under the guidance of their counsellor(s) at the learner support centre constitutes continuous evaluation and carries 70% weightage. The laboratory record book will be a part of continuous assessment; you must submit your laboratory record book daily to the counsellor for evaluation. Every lab exercise is evaluated and is included for final evaluation.
- b) **Term-end evaluation** of performance in the lab exam carries a weightage of 30% for each lab course. The evaluation of lab exercises assigned to the learner in Term-end practical exam on the scheduled date and time at the Programme/Study centre constitutes term-end evaluation.

5.3 Qualifying Marks: You will have to obtain at least 40% marks in each course (both in theory and lab) in both continuous and term-end evaluation separately for the successful completion of a course.

Overall Marking: The final marking for each course is computed by combining continuous evaluation score and term-end examination score. The University is following numerical marking system for continuous evaluation as well as term-end examination. The notional correlates of the letter grades and percentage of marks are as follows:

Letter Grade	Qualitative Value	Division	Equivalent percentage Range of numerical marks
A	Excellent	First division with Distinction	80% and above
B	Very good	First division	60% but less than 80%
C	Good	Second division	50% but less than 60%
D	Satisfactory	Third division	40% but less than 50%
E	Unsatisfactory	Fail	Less than 40%

To be able to appear for the term-end examination, it is pre-requisite that the learners submit all assignments according to the prescribed schedule. The learners are required to give an undertaking to this effect in the examination form and it should not be later found that they had, in fact, not submitted the assignments as prescribed, otherwise the results of the term-end examination will be treated as cancelled.

5.4 Assignments

An assignment is a **compulsory** component of each theory course. The assignments are uploaded on the IGNOU website. The main purpose of the assignments is to test learner's comprehension of the learning material which they receive from the University and to help them get through the course by providing feedback to them. These assignments will be checked by their counsellors, who will also explain the candidate, where and how he/she can improve his/her understanding. The information given in the printed course material is sufficient for answering the assignments. However, a learner can refer to other books assessable to him/her.

There will be one assignment for each theory course (weightage of 30%). The set of all assignments for each semester is uploaded on the IGNOU's website. These assignments are to be submitted to the learner support centre, according to the submission schedule provided in the assignment's booklet. Before submission, a learner should ensure that he/she has answered all questions in all assignments. Incomplete answers of the assignment's questions bring them poor grades.

The assignments are valid for one year. This means that the assignments uploaded on the website for the semester beginning of January are valid up to December of the same year. Similarly, the assignments of

the July semester are uploaded on the website in the month of July are valid up to the June of the next year. In any case, they have to submit assignments once before appearing in the examination for any course.

The learners have to complete the assignments on time. He/She will not be allowed to appear in the term-end examination for a course if he/she does not submit the assignments in time for that course. If he/she appears in term-end examination without submitting the assignments, then the result of term-end examination is liable to be cancelled.

For your own record, please keep a copy of all assignment responses which you submit to the programme coordinator of your learner support centre. If you do not get back your duly evaluated tutor marked assignments along with a copy of the assessment sheet containing comments on your assignments by the evaluator after submission, please try to get it from your learner support centre personally.

Unfair means in attempting the Assignments.

If the learners copy the assignments, which is an important component of the ODL system, such assignments will be awarded “zero” and such learners will be directed to re-attempt the fresh assignments pertaining to the next year which will indirectly delay the award of degree by a semester/year.

Specific Instructions for Tutor Marked Assignments

While answering Assignments, you will find it useful to keep the following points in mind:

1. **Planning:** Read the assignment carefully. Go through the units on which they are based. Make some points regarding each question, solve them and rearrange these in logical order.
2. **Organisation:** Be a little more selective and analytical before drawing up a rough outline of your answer. Make sure that your answer:
 - (i) is logical and coherent;
 - (ii) has clear connection between sentences and paragraphs;
 - (iii) is written correctly giving adequate consideration to your expression, style and presentation;
 - (iv) mention the formulae, hypothesis tested (if required), interpretation, etc. in the solution of your questions.
3. **Presentation:** Once you are satisfied with your answers, you can write down the final version for submission, writing each answer neatly and underlining the points you want to emphasize.
4. The following format is to be followed for submission of the assignment:
 - (i) Write Enrolment Number, Name, Full Address, Signature and Date on the top right and corner of the first page of the response sheet.
 - (ii) Write the Programme title, Course code, Course title, Assignment code and Name and Code of the learner support centre and Assignment code may be reproduced from the assignment. The first page of the response sheet for each assignment should be like this:

ENROLLMENT NO. :

NAME :

ADDRESS :

.....

PROGRAMME CODE:

COURSE CODE:

COURSE TITLE:

ASSIGNMENT CODE:

STUDY CENTRE CODE:

DATE:

- (iii) Read the assignments carefully and follow the specific instructions, if any, given in the assignment itself.
- (iv) The learners should use only A4 size paper for the responses and tie all pages carefully. Avoid using very thin paper. Allow a 4 cm margin on the left and at least 4 lines in between each answer. This may facilitate the evaluator to write useful comments on the margin at appropriate places.
- (v) Write the assignments response in your own handwriting. Do not print or type the answers. Learners should not reproduce their answers from the units sent to them by the University. If they reproduce from the units, they will get poor marks for the respective question.
- (vi) The learners should write each assignment separately. All assignments should not be written in continuity.
- (vii) **The learners should write the question number with each answer. Photocopy of the submitted assignment is to be retained by the learner for his or her own record and future reference, if any.**
- (viii) **The learners should not copy the assignments from other learners. If copying is noticed, the assignments of such learners will be rejected, and disciplinary action will be taken against the learners as per rules of the University.**
- (ix) The completed assignments should be sent to the Coordinator of the learner support centre allotted to learners. Under no circumstance the tutor marked assignments should be sent to the Learners Evaluation Division or the School at Headquarter for evaluation.
- (x) After submitting the assignment at the learner support centre in person, the learners should get the acknowledgement from the coordinator on the prescribed assignment-cum-acknowledgement card (**Form No. 1**); otherwise, the assignment response should be sent under certificate of posting through post. The learners should get back evaluated assignments from their learner support centre for the feedback and for their future guidance.
- (xi) In case the learner has requested for a change of learner support centre, s/he should submit her/his assignments only to the original learner support centre until the University effects the change of learner support centre.

Please remember that Continuous evaluation in the form of an Assignment carries 30% weightage in the result.

5.5 Guidelines Regarding the Submission of Assignments

1. It is compulsory for the learners to submit all prescribed assignments. They will not be allowed to appear for the term-end examination of a course if they do not submit the specified number of assignments in time for that course.
2. Learners should download the latest assignment from the IGNOU website.
3. The assignment responses should be complete in all respects. Before submission, the learners should ensure that they have answered all the questions in all assignments. Incomplete answer sheets bring poor grades.
4. The coordinator of the learner support centre has the right to reject the assignments received after the due date. Therefore, the learners are advised to submit their assignments before the due date.

5. Learners should enclose a self-addressed stamped assignment remittance-cum- acknowledgement card (**Form No. 2**) with each assignment response to ensure the delivery of assignments before the last dates prescribed for submission of assignments.
6. In case any learner fails to submit the assignments or fails to score minimum qualifying marks, s/he has to wait for fresh assignments meant for the current batch of learners.
7. For their own record, learners should retain a photocopy of all the assignment responses, which they submit to the coordinator of their learner support centre. If they do not get back their duly evaluated assignment after evaluation, they should try to get it from their learner support centre personally. This may help them to improve upon future assignments.
8. As per the University norms, once the learner's scores minimum qualifying marks in an assignment, they cannot re-submit it for improvement of marks.
9. Assignments are not subject to re-evaluation except for factual errors, if any. The discrepancy noticed by the learners in the evaluated assignments should be brought to the notice of the Coordinator of the LSC, so that he forwards the correct score to the SED at the Headquarters.
10. The learners should not enclose or express doubts for clarification, if any, along with the assignments. They should send their doubts in a separate cover to the Registrar, SED, Indira Gandhi National Open University, Maidan Garhi, New Delhi - 110068. While doing so they should give their complete Enrolment number, name, address, programme code. In case of not successfully completed or missed; the assignments should be demanded only if your registration for that course is valid.

Note: Please submit your Assignments on or before the due date at your LSC.

There is no provision for re-evaluation of Assignments, and practical examination.

5.6 Term-End Examination (TEE)

The University conducts Term-end examinations twice a year in the month of June and December every year. The candidate will be permitted to appear in Term-end examinations subject to the condition that registration for the courses in which he/she wishes to appear is valid, maximum time to pursue the programme is not over and he/she has also submitted the required number of assignments, if any, in those courses by the due date.

Examination Fee and Examination Form

Examination fee of Rs 200/- per course is required to be paid. The examination forms can be submitted online through IGNOU website: <https://exam.ignou.ac.in/>

Date of Submission of Examination Form

JUNE, TEE	DECEMBER, TEE	LATE FEE	WHERE TO SUBMIT THE FORM
1 st March to 31 st March	1 st Sept to 30 th Sept	NIL	At the concerned Regional Centre under which your Examination Centre falls.
1 st April to 30 th April	1 st Oct to 31 th Oct	` 500/-	
1 st May to 15 th May	1 st Nov to 15 th Nov	` 1000/-	

To avoid discrepancies in filling up examination form for the Term-end examination you are advised to:

1. remain in touch with the Coordinator of the Learner Support Centre/Regional Centre/SRD & SED for change in schedule of submission of examination form, if any.
2. fill up the examination form for next Term-end examination without waiting for the result of the previous Term-end examination and also filling up the courses, for which result is awaited.

3. fill up all particulars carefully and properly in the examination to avoid rejection and delay in processing of the form.
4. retain a proof of mailing/submission of examination form till you receive examination hall ticket.

5.7 General Guidelines Regarding the Term-End Examination

1. To be eligible to appear the Term-end Exam in any course, the learners are required to fulfil the following conditions:
 - a) Registration for the courses, in which they wish to appear is valid.
 - b) They should have opted and pursued the prescribed courses.
 - c) Minimum time to pursue these courses is elapsed.
 - d) They have also submitted the required number of assignment(s), if any.
 - e) They have submitted the online examination form of IGNOU and have paid the requisite examination fees.
2. The University conducts term-end examination twice a year, in June and December. The learner can take the examination only after the minimum period prescribed for the course of study has elapsed.
3. Examination schedule indicating the date and time of examination which is available at IGNOU website <http://www.ignou.ac.in> for each session i.e. June/December.
4. The online examination form is to be filled up from IGNOU website about 2-3 months prior to examination. (You MUST visit IGNOU website for actual cutoff dates. The details of late fee are also displayed on the website.). You are required to pay examination fee per course at the time of filling up of the form. For December 2023 term-end examination this fee was @200/- per course for theory courses and @200/- per course for practical courses. You can pay online using Credit Card / Debit Card /Net Banking while filling up the form. It may also be noted that in case, examination fee needs to be returned to learner due to technical reasons, the fee will be refunded to the same account (Credit card/ Debit card/ Net Banking) from which the payment was made.

The link to online Examination form, in general, is put on the HOME page of IGNOU website.

You must read and follow all the instructions very carefully. You can save these instructions for any future reference. These instructions relate to:

- Dates for the Submission of Online Term-end Examination form
- Prerequisite for the submission of the Term-end Examination Form
- Process to submit Term-end Examination Form
- Examination fee and Mode of Payment
- Un-successful submission of Exam Form
- Related to Refund excess Examination Fee
- Hall Ticket for Term-end Examination
- Contact details

Important Guidelines and instructions for submission of Term-end Examination form and other forms (Please note that guidelines and fee for forms may change, therefore, you are advised to read guidelines and fee details as per latest forms available online or on the IGNOU website)

1. Please ensure that you have already submitted the assignments as applicable for the courses you are filling in the Examination Form. You are required to pay examination fee for every course of theory as well as practical.

2. Learners are requested to check the result status before filling examination form.
3. Select and enter Programme code and Examination Centre Code from the options available. A learner can choose Exam Centre anywhere throughout India from the list of allotted Exam Centres of IGNOU. But Lab exam will be held at your concern Learner support centre. If the centre opted by the learner is not activated as examination centre or not allotted for any other reason, alternative examination centre will be allotted.
4. Select courses carefully. Courses for theory as well as practical need to be selected separately from the list appearing on the screen.
5. Learners will be allowed to appear in Term-end Examination for the course(s) for which registration is valid and not time-barred and assignment(s) is/are submitted. Examination fee once submitted will not be refunded.
6. Learners should carry their **Identity Card and Hall ticket** (download hall ticket from IGNOU website indicating Centre and Date of Examination) to the Examination Centre.
7. In case a learner fails to receive the intimation slip/Hall ticket may please contact at SED (SE-II) <http://www.ignou.ac.in/ignou/aboutignou/division/sed/contact> branch.
8. Learners must carry IGNOU Identity-Card in the Examination Hall for writing Examination. In case, learners do not have IGNOU Identity card due to various reasons, they can download from IGNOU website for attending Examination.
9. The learners will be entitled to appear for the examination only at the examination centre allotted to them and **NOT** at any other centre without specific permission from the University. The Examination Centre once opted for in a form shall not be changed.
10. Although all efforts will be made to declare the results in time, there will be no binding on the University to declare the results of the last examination before the commencement of next examination. The learners may, therefore, fill up the examination form without necessarily waiting for the result and get it cancelled at a later date, if so desired. In case the learner gets result after filling up the exam form, s/he should not re-appear in the course qualified by her/ him with a view to improve the qualified score.
11. Learners who fail to complete the minimum required number of course(s) prescribed for the Programme within the allotted period of study shall cease to be on the rolls of this University for that programme till they re-enroll themselves, if they wish to do so. Such learners are advised to get in touch with the Regional Director concerned.

Issue of Examination Hall Ticket

University issues Examination Hall Ticket to the learners at least two weeks before the commencement of Term-end examination and it could also be downloaded from the University's website www.ignou.ac.in. In case you fail to receive the Examination Hall Ticket within one week before the commencement of the examination. You can download the hall ticket from the website and approach the exam centre for appearing in the exam.

The enrolment number is the Roll number for examinations of the learner. Be careful in writing it. Any mistake in writing the Roll number will result in non-declaration of the result.

If a learner has missed any Term-end Examination of a course for any reason, or failed in the examination, he/she may appear in the subsequent Term-end Examination. This facility will be available until he/she secures the minimum pass grade but only up to a period of four years from the date of registration.

While communicating with the University regarding examinations please clearly write the enrolment number and complete address. In the absence of such details, we may not be able to attend the learner's problems.

Early Declaration of Result

If candidate has got offer of admission for higher study and or selected for employment, etc. and are required to produce statement of marks/grade cards by a specified given date, he/she may apply online through IGNOU website, for early processing of his/her answer script and declaration of result. The candidates are required to apply online with fee of `700/- per course. He/she can submit his/her request for early declaration before the commencement of the Term-end Examination, i.e., before 1st June and 1st December, respectively. The University, in such cases, will make arrangement for early processing of answer scripts and declare the result as a special case possibly within a month time from the date of conduct of examination.

Re-Evaluation of Answer Script(s)

If learners are not satisfied with marks/grade awarded to them in Term-end Examination, they may apply online through IGNOU website for re-evaluation within one month from the date of declaration of results, i.e., the date on which the results are made available on the University's website, on payment of ` 750/- per course. The better of the two scores of original marks/grade and marks/grades after re-evaluation will be considered and updated in the learner's record.

Note: Re-evaluation is permissible in Term-End Examination only and is not in Practical courses, Project Workshop, and an Assignment.

Photocopy of the Evaluated Answer Script

The learners may obtain the photocopy of the evaluated answer scripts for the Term-end Examination on request. They may apply online, from 1st September to 15th October for June Term-end Examination and from 1st March to 15th April for December Term-end Examination along with the requisite fee of Rs. 100/- per course.

Issue of Official Transcript

The University provides the facility of official transcripts on request made by the learners on plain paper addressed to Registrar, Student Evaluation Division (SED), Block 12, IGNOU, Maidan Garhi, and New Delhi – 110068.

6. OTHER USEFUL INFORMATION

Newsletter

IGNOU Newsletter is published twice in a year (April and October) in English and Hindi. Information regarding Examination schedule, new courses to be launched, admissions etc., is also provided through IGNOU newsletters. It covers various activities at IGNOU Headquarters, Regional Centres and Study Centres. It also carries important notifications from time to time.

Refund of Fee

Fee once paid will not be refunded under any circumstances except the provision of refund of admission fee as notified by the University. It is also not adjustable against any other programme of this University. However, in cases where University denies admission, the programme fee will be refunded after deduction of processing fee, if any, through online mode.

If a student applies for cancellation of application/admission and refund of fee, the refund request will be considered as per the University policy as under:

Before confirmation of admission: Full Programme fee paid shall be refunded.

After confirmation of admission:

Within 15 days of confirmation of admission: Programme Fee paid shall be refunded after deduction of Rs.500/- .

Within 16-90 days of confirmation of admission: Programme Fee paid shall be refunded after deduction of Rs.1000/- .

After 90 days of confirmation of admission: No refund shall be allowed.

Reservation

The University provides reservation of seats for Scheduled Castes, Scheduled Tribes, Non-Creamy Layer of OBC, Economically Weaker Sections, War Widows, Kashmiri Migrants and Physically Handicapped learners, as per the Government of India rules, for admission to its various programmes. However, submission of forged certificate under any category shall be liable for not only cancellation of admission but also to be legally implicated as per Government of India rules.

Scholarships and Reimbursement of Fee

Reserved Categories, viz., Scheduled Castes, Scheduled Tribes and Physically Handicapped learners etc. need to pay the fee at the time of admission to the University along with other learners. Physically Handicapped learners admitted to IGNOU are eligible for Government of India scholarships. They are advised to collect scholarship forms from the respective State Government Directorate of Social Welfare or Office of the Social Welfare Officer and submit the filled-in forms to them through the Regional Director of IGNOU concerned. Similarly, SC/ST learners must submit their scholarship forms to the respective State Directorate of Social Welfare or Office of the Social Welfare Officer, through the Regional Director of IGNOU concerned for suitable reimbursement.

The Application for reimbursement of Programme Fee to SC/ST learners can be downloaded from the link: <http://ignou.ac.in/userfiles/Application%20form%20for%20Reimbursement%20of%20fee.pdf>

Fee Exemption for SC/ST Learners under the SCSP and TSP Schemes:

Detail information regarding this scheme may be obtained from the link:

<http://www.ignou.ac.in/userfiles/Joint%20Notification%20of%20SCSP%20TSP.pdf>

SC/ST learners who are availing any kind of fellowship or fee exemption from other agencies are not eligible for fee exemption under SCSP/TSP scheme. The exemption of fee is confined to Programme Fee mentioned in this Admission Prospectus. The scheme will not exempt late fee, term-end-exam fee, convocation fee, etc. Eligible and interested learners may contact the Regional Centre concerned. Details of the scheme and notification are uploaded on www.ignou.ac.in

Waiver of IGNOU Programme fee to Inmates lodged in Prisons.

Inmates lodged in Prisons in the country are exempted from payment of programme fee, including cost of Prospectus. The under-trial/short term prisoners are also eligible for the same benefit of FREESHIP as is extended to other prisoners with the condition that when they go out of jail, they will be treated as normal learners and shall pay subsequent fees wherever applicable (examination fee, re-registration fee, registration fee for convocation etc.).

Correction of Address and Study Centre Change

Learners can initiate the request for change of address, Learner Support Centre, and Regional Centre online from their user account. The user account is to be created at <https://ignou.samarth.edu> in by clicking 'New Registration.

Correction/Change of Name/Surname of Learner

Spelling mistakes, if any, committed at the time of data entry stage will be rectified at the Regional Centre and corrected data transmitted to Student Registration Division for updating in the database. However, learners are expected to write their correct name (as indicated in the High School Certificate) in the

Admission Form. In case any change in the name (other than the one mentioned in his/her High School Certificate), then it is mandatory for the prospective learners to furnish legal evidence of having changed his/her name/ surname while submitting the admission form.

For 'Change of Name/Surname', after confirmation of admission, the learners are required to submit the following documents at the Regional Centre, for onward transmission to Registrar, SRD:

- a) Original copy of Notification in a daily newspaper notifying the change of name;
- b) Affidavit, in original, on non-judicial Stamp Paper of the appropriate value sworn in before 1st Class Magistrate specifying the change in the name;
- c) Marriage Card/ Marriage Certificate in case of women candidates for change in surname;
- d) Gazette Notification, in original, reflecting the change of name/surname; and
- e) Demand Draft of Rs. 500/- drawn in favour of IGNOU payable at New Delhi.

Request for correction and/or change of Name / Surname will be entertained only before completion of the programme.

Change of Region

When a learner wants transfer from one region to another, he/she has to write to that effect to the Regional Centre from where he/she is seeking a transfer marking copies to the Regional Centre where he/she would like to be transferred to. Further, he/she has to obtain a certificate from the coordinator of the learner support centre from where he/she is seeking transfer regarding the number of assignments submitted. The Regional Director from where the learner is seeking the transfer will transfer all records including details of fee payment to the new Regional Centre under intimation to the Registrar, Student Registration Division (SRD) and the learner as well. For change of 'Region' in practical oriented Programmes, '**No Objection Certificate**' is to be obtained from the concerned Regional Centre/Study Centre where the learner wishes his/her transfer.

In case any learner is keen for transfer from Army/Navy/ Air Force Regional Centre to any other Regional Centre of the University during the cycle/session, he/she would have to pay the fee-share money to the Regional Centre. In case the learner seeks transfer at the beginning of the session/cycle, the required programme course fee for the session/cycle shall be deposited at the Regional Centre. However, the transfer shall be subject to availability of seats wherever applicable.

The learner can seek transfer to any other overseas study centre only after six months of Registration or submission of first year/semester assignments for the programme of one year or longer duration.

Disputes on Admission & other University Matters

The place of jurisdiction of filing of suit, if necessary, will be New Delhi/Delhi ONLY.

Pre-admission Counselling of Persons with Disabilities

Persons with disabilities before opting for a programmes for admission may please go through the category of perspective jobs for persons with disabilities and the physical requirements of jobs by visiting the link (<http://www.disabilityaffair.gov.in/content/page/rules-and-regulations.php#ipd2013>) of Department of Empowerment of Persons with Disabilities, Ministry of Social Justice and Empowerment, Government of India. After having made this informed decision, the person with disability seeking admission must give an undertaking in the prescribed proforma available on IGNOU Website.

Prevention of Malpractice/Notice for General Public

Learners seeking admission to various academic programmes of Indira Gandhi National Open University are advised to directly contact IGNOU headquarters at New Delhi or Regional Centres of IGNOU only. Learners interacting with intermediaries shall do so at their own risk and cost. However, in

case of any specific complaint regarding fraudulent institutions, fleecing learners etc., please contact any of the following members of the Malpractices Prevention Committee:

1. Director, SSC (Tele: 29535714)
2. Director, RSD (Tele: 2953 2118, 29572412)
3. Registrar, SED (Tele: 2953 5828, 29572204)
4. Registrar, SRD (Tele: 2953 2741, 9571302)
5. Registrar, MPDD (Tele: 29534521, 29572002)
6. Deputy Registrar, F&A (Tele: 29534934)

Alternatively, complaints may be faxed on 29532312.

Email: ignouregistrar@ignou.ac.in

Website: <http://www.ignou.ac.in>

Note: Except the above-mentioned complaints, no other queries will be entertained at the above phone numbers.

As per directions of Hon'ble Supreme Court of India ragging is prohibited. If any incident of ragging comes to the notice of the authority the concerned learner shall be given liberty to explain and if his explanation is not found satisfactory, authority would expel him from the University. IGNOU admissions are made strictly on the basis of merit. Only those learners who satisfy the eligibility criteria fixed by the university will be admitted. Learners will not be admitted if they are not eligible as per the eligibility criteria. Therefore, the candidates should not be misled by the false promises of admission made by any private individuals or institution.

Placement Services

In order to further extend learner support services to its geographically distributed learner population who are pursuing various IT and Non-IT related Degree, Diploma and Masters Programme, the university has established the Campus Placement Cell (CPC). The mission and endeavour of CPC is to enhance and facilitate the process of prospective suitable employment opportunities that are commensurate with the personal profiles of our learners. All learners interested in seeking the assistance of CPC for procuring suitable job opportunities are requested to send their current resume/bio-data to campusplacement@ignou.ac.in. They are further advised to visit our home page www.ignou.ac.in for regular updates on placement related activities.

Incomplete and Late Application

Incomplete application forms/Re-registration forms, received after due date or having wrong options of courses or electives or fast information, will be summarily rejected without any

**ALWAYS KEEP A COPY OF YOUR COREESPONDENCE
WITH THE UNIVERSITY, ASSIGNMENT, ETC. WITH YOU.
PLEASE MENTION YOUR ENROLMENT NUMBER ON ALL
THE CORRESPONDENCE YOU MAKE WITH THE**

intimation to the learners. You are, therefore, advised to fill the relevant columns carefully and enclose the copies of all required certificates duly attested by a Gazetted Officer. **The form is to be submitted to the Regional Director concerned ONLY on or before the due date.** The applications form sent to other offices of the University will not be considered and the application will have no claim whatsoever on account of this.

7. SOME USEFUL ADDRESSES

1.	Identity Card, Fee Receipt, Bonafide Certificate, Migration Certificate, Scholarship forms, Change of Programme/ Medium / Courses / Elective / Opting of left over electives / Project query after submission of Projects	Concerned Regional Centre. The demand Draft should be drawn in favour of 'IGNOU' payable at city of the Regional Centre.
2.	Non-receipt of study material and assignments	Concerned Regional Centre
3.	Schedule/Information regarding Exam-form, Entrance Test, Date-sheet, Hall Ticket	Asst. Registrar (Exam.II), SED, Block-12, Room No. 02, IGNOU, Maidan Garhi, New Delhi-110068 Ph. 011-29536743, 29572202, 29572209
4.	Result, Re-evaluation, Grade Card. Provisional Certificate, Early Declaration of Result, Transcript	Deputy Registrar (Exam.III), SED, Block-12, Room No. 01, IGNOU, Maidan Garhi, New Delhi-110068 Ph. 011-29536103, 29572201, 29571316
5.	Non-reflection of Assignment Grades/marks	Assistant Registrar (Assignment), SED, Block-03, IGNOU, Maidan Garhi, New Delhi-110068, assignment@ignou.ac.in . Ph. 011-29571312, 29571319, 29571325
6.	Deletion of excess credits/Project query after submission	Asst. Registrar (Project), SED, Block-03, IGNOU, Maidan Garhi, New Delhi-110068, Ph. 29571312
7.	Original Degree/Diploma/verification degree/diploma	Deputy Registrar (Exam.I), SED, Block-9, IGNOU, Maidan Garhi, New Delhi-110068 Ph. 011-29535438, 29572224, 29572213
8.	Student Grievance (SED)	Asst. Registrar (Student Grievance), SED, Block-3, Room No. 13, IGNOU, Maidan Garhi, New Delhi-110068 Ph. 011-29532294, 29571313
9.	Purchase of Audio/Video Tapes	Marketing Unit, EMPC, IGNOU, Maidan Garhi, New Delhi-110068 Ph. 011-29532167
10	Academic Content	Director, School of Sciences, IGNOU, Maidan Garhi, New Delhi-110068 sos@ignou.ac.in Ph: 011-29532167; 011-29572832
11	Approval of Project Synopsis	Project Coordinator in the Concerned School
12	Submission of Project Reports	Deputy Registrar, SED, Block-12, Room No. 01, IGNOU, Maidan Garhi, New Delhi-110068, Ph. 29572216
13	Student Support Services and Student Grievances, pre-admission. Inquiry of various courses in IGNOU	Regional Director, Student Service Centre, IGNOU, Maidan Garhi, New Delhi-110068, ssc@ignou.ac.in , Ph. 011-29535714, 29533869, 2953380, Fax: 011-29533129

8. LINKS TO FORMS AND ENCLOSURES

In this section, we are enclosing the IGNOU website links to various forms, which are useful for you. Whenever you need to correspond with the university, please download the form from the Website and fill it carefully and send as per instructions therein. The detailed instructions for all these-forms are provided in form itself. Some of these links may change, in those cases please use search option to find the desired link.

Note: You may download the Forms from the Website using the links given below:

Useful links and Forms

1. Assignments related links

Link to Latest Assignment(s) <https://webservices.ignou.ac.in/assignments/Master-Degree/Master.htm>

2. Re-registration

Link to Online Re-Registration for MSCCHEM Programme

<https://onlinerr.ignou.ac.in/>

Last date of Re-Registration is announced on the IGNOU website. In general, the re-registration is to be done 2-3 months prior to the start of Session. For example, the last date of re-registration for session starting from July cycle is in the last of May. Similarly, the last date for session starting January cycle may be in the last of November. You must verify the cutoff dates and fee from the website prior to filling up this offline form.

3. Term-end Examination and Related Links

Link to online Term End Examination form

<https://exam.ignou.ac.in/>

Link to form for Early Declaration of Result

<http://www.ignou.ac.in/userfiles/APPLICATION%20FORM%20FOR%20EARLY%20DECLARATION%20OF%20RESULT%20OF%20TERMEND%20EXAMINATION.pdf>

Link to Application Form for Obtaining Photocopy of the Answer Script

[http://www.ignou.ac.in/userfiles/Application%20form%20for%20Reevaluation%20of%20Answer%20Scripts\(1\).pdf](http://www.ignou.ac.in/userfiles/Application%20form%20for%20Reevaluation%20of%20Answer%20Scripts(1).pdf)

Link to form for Re-evaluation of Answer script

[http://www.ignou.ac.in/userfiles/Application%20form%20for%20Reevaluation%20of%20Answer%20Scripts\(1\).pdf](http://www.ignou.ac.in/userfiles/Application%20form%20for%20Reevaluation%20of%20Answer%20Scripts(1).pdf)

Link to Application form for Improvement of Division/Class

<http://www.ignou.ac.in/userfiles/Improvement%20form.pdf>

Link to form for Duplicate Grade Card/Mark-sheet

<http://www.ignou.ac.in/userfiles/Duplicate%20mark%20sheet%20form.pdf>

Link to form for Issue of Official Transcript

<http://www.ignou.ac.in/userfiles/Official%20Transcript%20form.pdf>

Link to form for Issue of Migration Certificate

<http://ignou.ac.in/userfiles/Migration%20Certificate.pdf>

Link to form for Date sheet of all Programme

[http://ignou.ac.in/userfiles/DATE%20SHEET\(1\).pdf](http://ignou.ac.in/userfiles/DATE%20SHEET(1).pdf)

4. Other Important Links

Link for Old Question Papers

<https://webservices.ignou.ac.in/Pre-Question/>

Link for Checking Study Material Status

<http://www.ignou.ac.in/ignou/aboutignou/division/mpdd/material>

In case the learner does not receive the study material from the Regional Centre concerned, the learner may approach **Regional Director, IGNOU, Regional Centre where they stand enrolled/admitted** through e-mail/fax/letters along with proof of depositing of fee for the course of study. Link for eGyankosh for Online Course Materials <http://egyankosh.ac.in/>

Forms


We are enclosing some samples of following forms for your use.

1. Assignment Submission-cum-Acknowledgement form (Form No.1)
2. Change of Address/Correction of Name (Form No.2)

Whenever you have to correspond with the University for any of the above listed subjects, it is better to retain the original form for reuse and get a photocopy of the relevant form, fill it carefully and send as per instruction therein. The detailed instructions for all the above listed subjects are provided in the Programme Guide.

Form No. 1

Assignments Remittance-Cum-Acknowledgement Card

Enrol. No. _____ Programme Title _____ Name: _____ Course Code: _____ Medium: _____ <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">S.No.</th> <th style="width: 60%;">Assignment</th> <th style="width: 30%;">For Office Use Only</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td> </td> </tr> <tr> <td> </td> <td> </td> <td>S. No. _____</td> </tr> <tr> <td> </td> <td> </td> <td>Date of Receipt: _____</td> </tr> <tr> <td> </td> <td> </td> <td>Name of Evaluator: _____</td> </tr> </tbody> </table>	S.No.	Assignment	For Office Use Only						S. No. _____			Date of Receipt: _____			Name of Evaluator: _____	<div style="text-align: center;">  <p>INDIRA GANDHI NATIONAL OPEN UNIVERSITY ASSIGNMENTS REMITTANCE-CUM ACKNOWLEDGEMENT CARD</p> </div> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">Enrol No. _____</td> <td style="width: 50%;">Programme Title: _____</td> </tr> <tr> <td>Name: _____</td> <td>Medium: _____</td> </tr> <tr> <td>Course Code: _____</td> <td rowspan="2" style="text-align: center; vertical-align: middle;"><u>For Office Use Only</u></td> </tr> <tr> <td>S.No. Assignment</td> </tr> <tr> <td> </td> <td>S.No. _____</td> </tr> <tr> <td> </td> <td>Signature of the receiver _____</td> </tr> <tr> <td> </td> <td>Date: _____</td> </tr> <tr> <td> </td> <td style="text-align: right;">Seal</td> </tr> <tr> <td colspan="2">Signature of the student</td> </tr> <tr> <td colspan="2">Name: _____</td> </tr> <tr> <td colspan="2">Address of the Student: _____</td> </tr> <tr> <td colspan="2">Date: _____</td> </tr> </table>	Enrol No. _____	Programme Title: _____	Name: _____	Medium: _____	Course Code: _____	<u>For Office Use Only</u>	S.No. Assignment		S.No. _____		Signature of the receiver _____		Date: _____		Seal	Signature of the student		Name: _____		Address of the Student: _____		Date: _____	
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	Seal																																						
Signature of the student																																							
Name: _____																																							
Address of the Student: _____																																							
Date: _____																																							
Signature of the Student Date: _____ Date of dispatch to the Evaluator: _____ Date of receipt from the Evaluator: _____	Date of Receipt: _____ Name of Evaluator: _____																																						

**Affix
Stamp
Here**

From:

The Coordinator
Study Centre concerned

To

(ADDRESS OF THE STUDENT)

.....
.....
.....

(For Change of Address, send it duly filled-in to the concerned
Regional Director, who will forward it to the Registrar (SRD),
Maidan Garhi, New Delhi after verification)

Application for Change of Address

Date: _____

To

The Regional
Director IGNOU
Regional Center

THROUGH THE REGIONAL DIRECTOR CONCERNED

Enrolment No. _____

Programme _____ Name
(in caps) _____

1. DETAILS FOR CHANGE/CORRECTION OF MAILING ADDRESS

New Address**Old Address**

City _____ Pin _____
State _____City _____ Pin _____
State __________
Signature of the Student

***Please retain a photocopy of any document that you submit to
the University.***

QR Code for Some Useful Web Links



eGyankosh Online
(for Online Course Materials)



Re-Registration Online



iGRAM
(IGNOU Grievance control Room)



**To Watch Live Telecast/
To listen live Broadcast**



On-line Examination form



Assignments

Note: The above QR Codes can be scanned and open through and QR Code Scanner Application/App of your smart mobile phone.