

# PROGRAMME GUIDE

for

## M.Sc. (Analytical Chemistry)

### (MSCANCHEM)

#### **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.

**So 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 MSCANCHEM courses or solving the assignments.** Such guides will neither help you in understanding the subject matter nor in passing the examinations.

## **OUR TERMINOLOGY**

In IGNOU, we use different terms from the ones used in conventional Colleges or Universities. So do please learn them. **We use the following terms:**

**Programme for Course,  
Course for Paper, and  
Discipline for Subject.**

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\* Please refer to the IGNOU website [www.ignou.ac.in](http://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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## MESSAGE FROM THE PROGRAMME TEAM

**Dear Learner,**

**Welcome** to the family of distance learners and **M.Sc. in Analytical Chemistry (MSCANCHEM) programme** offered by the Chemistry discipline of the School of Sciences, Indira Gandhi National Open University, New Delhi. This programme intends to cater needs of the working professional in Industries, Research & Development Organisations and Academic Institutions. It may also be helpful for the graduates with chemistry who are aspiring to develop skills and get employment in the field of analytical chemistry in any of the industries, organisations, academic institutions, etc.

It is a two year programme during which you will study a wide range of topics related to Analytical chemistry. You will receive support from IGNOU through your Regional Centre (RC), Learner's Support Centre (LSC) (known earlier as Study Centre) and IGNOU's website. We expect you to be directly in contact with your RC and LSC. This Programme Guide contains the information related to the MSCANCHEM programme like instructional system, syllabi of the courses, details of evaluation scheme and links to assignments, other useful information and important forms.

The self-learning material (SLM) for MSCANCHEM programme will reach you after you get registered in this programme. The self-instructional course material will also be uploaded on **eGyankosh Website** and **IGNOU eContent App**.

You can download the assignments of the theory courses in which you have enrolled from IGNOU website. Each theory course contains one assignment that will be assessed by a counselor at your LSC. You should be very careful about finishing and submitting your assignments at your LSC within the stipulated last date of submission as these are the continuous assessment tools carrying 30% weightage. You will not be allowed to appear in the Term-end Exam unless the assignments have been submitted.

Your **registration** for this programme will be valid for **four years from the date of initial registration**.

In order to facilitate your learning, there is a provision of **face-to-face** counselling for all theory courses. You need to attend practical 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 Learner Support Centre/Study Centre. Therefore, you are advised to be in constant touch with your study centre.**

*It is to be noted that the payments that are mentioned in various proformas/formats/forms 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 / IGNOU Website before you make the payment. 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 during your study.

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

You can communicate through post to:

**The MSCANCHEM Programme Coordinator(s),**

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>

We wish you success in pursuing the MSCANCHEM Programme.

**MSCANCHEM Programme Team**

## THE UNIVERSITY

The Indira Gandhi National Open University 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 located 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**.

## 1. M.SC. (ANALYTICAL CHEMISTRY) PROGRAMME

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The School of Sciences has developed the M.Sc. (Analytical Chemistry) programme with the help of several eminent experts across India. The programme deals with the basic and core concepts of chemistry and analytical chemistry. In addition, practical work containing experiments of chemistry and analytical chemistry have been included to give a complete package of learning.

The demand for analytical chemists is increasing day by day due to its application in several fields. To meet this increasing demand, the M.Sc. (Analytical chemistry) programme has been developed which caters the needs of working professionals and graduates aspiring for employment in industries (agriculture, pharmaceutical industries etc), National Laboratories, R & D Organisations and Academic Institutions/ Universities/Colleges, etc.

This programme emphasises on important and fundamental concepts of inorganic, organic and physical chemistry. In the second year of the programme, basic aspects of analytical chemistry, separation methods including chromatographic methods, electroanalytical methods and spectral methods of analysis of compounds have been dealt in detail in different courses. This programme is especially useful for the working professionals who are interested in updating their knowledge in Analytical Chemistry. It would also help fresh graduates, who wish to continue their education and are interested in getting into the field of Analytical Chemistry.

### **MSCANCHEM Programme Objectives**

M.Sc. (Analytical Chemistry) is intended to provide higher education in Analytical Chemistry through open and distance learning mode. This programme has been designed in view of NEP 2020 with a semester approach in mind. This programme is aimed at providing theoretical knowledge and practical skills in core chemistry and analytical chemistry.

The objectives of this programme are to:

- ❖ provide higher education opportunities to the learners in the area of Chemistry / Analytical Chemistry
- ❖ provide an opportunity to the learners to find suitable jobs in analytical / industrial laboratories
- ❖ provide an opportunity to the learners to upgrade their qualifications
- ❖ provide the opportunities to the learner in building their careers in research and teaching in Chemistry / Analytical Chemistry.

### **Target Group:**

- ❖ The advantage of space, time and pace inherent in the proposed programme addresses the desire and demand of a large number of students of

BSC(G)/B.Sc. Hons./ Major in Chemistry

- ❖ The learners who have completed the PGDAC programme from IGNOU
- ❖ Science graduates looking for jobs in analytical/industrial and chemical R&D labs.
- ❖ The programme would also help a large number of in-service people to upgrade their qualifications for mobility in their career. This includes a large number of TGTs in the Schools spread across the country, who can improve their qualifications by earning a credible master's degree in Chemistry / Analytical Chemistry and become eligible for the post of a PGT.

### **Duration of Programme:**

To fulfil the requirements for acquiring the MSCANCHEM, 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.

### **Medium of Instruction**

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

### **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.

### **Programme Fee**

The total programme fee is ₹ 44,600/-\* which is divided into four semesters. In other words, the fees is ₹ 23,300/- per year.

\* Registration fee of ₹ 300/- (Non-refundable) is to be paid at the time of admission in addition to the programme fee.

### **Exit Option**

After successfully completing first two semesters, learner will be awarded **Post Graduate Diploma in Chemistry (PGDC)**.

### **Credit System**

The IGNOU follows the '**Credit System**' for its programmes. Each credit is of 30 hours



of study comprising all learning activities. Thus, a four-credit course involves 120 study hours. This helps learners to understand the academic effort he/she has to put into successfully completing a course. **Successful Completion of the programme requires successful completion of both assignments and the Term -End Examination of each course in the programme.**

## 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 of the programmes 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>

<http://ignou.ac.in/ignou/aboutignou/division/srd/Recognition>

## Student Support Services

To provide individualised support to its learners, the University has created a number of Learner Support Centres (LSC)/ Study Centres (SC) throughout the country for this programme. 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 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 so as to get the latest information about assignments, submission schedules (assignments and examination forms), declaration of results, etc.

## 2. PROGRAMME STRUCTURE AND DETAILS

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This is a two-year Master's degree programme in Analytical Chemistry, which is offered in both January and July cycles of admission. The programme has been divided into two semesters per year (July to December and January to June). This programme comprises 16 compulsory theory courses and 9 lab courses worth 2 credits each.

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 theory courses are designed to provide the basic knowledge of chemistry and techniques of Analytical Chemistry, which are necessary for applications in various areas. These theory courses will help you in studying the lab courses well. The lab courses have been designed in this programme independently and each semester has at least one lab course which has been developed based on the theory courses of that semester. **After successfully completing the first two semesters, you will be awarded the Post Graduate Diploma in Chemistry (PGDC).**

The detailed structure of the MSCANCHEM programme is as follows:

Programme Structure MSc (Analytical Chemistry)							
Semester-I		Semester-II		Semester-III		Semester-IV	
Course	Cr.	Course	Cr.	Course	Cr.	Course	Cr.
Course-I: Inorganic Chemistry -I	4	Course-IX: Inorganic Chemistry -II	4	Course-XVI: Basic Analytical Chemistry	6	Course-XXI Environmental Chemistry Lab	2
Course-II: Organic Chemistry-I	4	Course-X: Organic Chemistry-II	4	Course-XVII: Basic Analytical Chemistry Lab	2	Course-XXII Introduction to Research	2
Course-III: General Physical Chemistry	4	Course-XI: Quantum Chemistry and group theory	4	Course-XVIII: Separation Methods	6	Course-XXIII Spectroscopic Methods of Analysis	6
Course-IV: Chemistry Lab-I	2	Course-XII: Chemistry Lab-IV	2	Course-XIX: Separation Methods Lab	2	Course-XXIV Spectroscopic Methods of Analysis Lab	2
Course-V: Chemistry Lab-II	2	Course-XIII: Chemistry Lab-V	2	Course-XX Environmental Chemistry	4	Course-XXV: Electroanalytical and Other methods	6
Course-VI: Chemistry Lab-III	2	Course-XIV: Chemistry Lab-VI	2			Course-XVI: Electroanalytical and Other methods Lab	2
Course-VII: Mathematics* / Course-VIII: Biology* for Chemists	2	Course-XV: Green Chemistry	2				
<b>Total</b>	<b>20</b>		<b>20</b>		<b>20</b>		<b>20</b>

**\* for PCB / PCM Learner**

**\* Learner may opt either two theory courses "Operations Research" (4 credits) and "Stochastic Processes" (4 credits) together or a Project/Dissertation (8 credits).**

## Details of the Semester-wise Courses

In this section, a brief introduction of each course is given to provide an overview.

# Semester 1

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

The course Inorganic Chemistry I (MCH-011) is the first course on inorganic chemistry being offered in the first semester of the M.Sc. Chemistry Programme. It is worth 4 credits i.e. you have to spend a total of 10 hours for this course. The course has been divided into four blocks.

The first block has three units which deal with main group elements, transition elements and structure of molecules. In this block, the first unit deals with the periodic trends of main group elements & transition elements along with their electronic configuration and also includes Latimer diagrams. Thereafter, in the other units phosphorus-nitrogen and sulfur-nitrogen compounds as well as the structure of molecules has been discussed in the other units. The second block gives the complete picture of organometallic chemistry. Here there are six units. The topics that are included in this block are organometallic compounds, metal carbonyls, metal pi-complexes and metal clusters. The third block is on crystal field theory and the applications as well as the limitations of crystal field theory and they are covered in two units. Block four is on basics of magnetochemistry, *d*-metal complexes magnetism, electronic spectra and *d-d* transition and charge transfer spectra. In this block, there are four units

**General Characteristics of Main Group Elements and Transition Elements (4 lectures):** 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(4 lectures):**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 (4 lectures):** 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(5 lectures):** 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(4 lectures):** 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(4 lectures):** 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(4 lectures):** Higher Boranes, Wade's Rules; Carboranes, Metalloboranes and Metallocarboranes; Compounds with Metal-metal Multiple Bonds

**Crystal Field Theory (5 lectures):** Crystal Field Theory; Octahedral Complexes; Splitting of Orbitals by 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(4 lectures):** 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; Pi-Bonding and Molecular Orbital Theory

**Basics of Magnetochemistry (5 lectures):** 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(5 lectures):** 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(5 lectures):** 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(5 lectures):** 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.

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 (2<sup>nd</sup> Edition), R. L .Dutta & Syamal, EWP, New Delhi.
6. Comprehensive Coordination Chemistry eds., G. Wilkinson, R.D. Gillard and J.A. McCleverty, Pergamon.

<p style="text-align: center;"><b>MCH-012: STEREOCHEMISTRY AND REACTIVE INTERMEDIATES</b> <b>(4 credits, 60 Lectures)</b></p>
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The '**Stereochemistry and Reactive Intermediates**' is an Organic Chemistry course of Semester I of M.Sc. Chemistry programme which deals with the stereochemistry and reactive intermediates. It is a **four credits** course comprising of **four Blocks** with a total of **16 units**. In this course we take you to the advanced levels of stereochemistry and the reactive intermediates. This course aims to provide the learners a recall of the already learnt concepts, introduce some new concepts and connect the two through a smooth transition.

The first two blocks of the course are dedicated to the stereochemical aspects like the molecular symmetry, stereoisomerism of molecules with and without chiral centres and conformations of six membered rings. The concepts of configuration, topicity and prostereoisomerism, asymmetric induction, molecular dissymmetry and chiroptical properties are covered in detail. The other two blocks deal with the basics of the reaction mechanism and cover the reactive intermediates like, carbocations, free radicals, carbenes, nitrenes and benzyne. All the units in these blocks cover a good account of mechanistic details and the stereochemical aspects wherever required for the clear understanding of the reactive intermediates.

### **Section A: Stereochemistry of Organic Compounds (30 Lectures)**

**Molecular Symmetry and Chirality (3lectures):** 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 Centres (4lectures):** 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

**Conformation of Six-membered Rings(4 lectures):** 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 Alkylidines, 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(3 lectures):** Representation of Configuration: *D*, *L*, *R*, *S* and *E*, Z nomenclature; Determination of Configuration-Different Methods; Chemical Correlation, Quasiracemates

**Topicity and Prostereoisomerism(4 lectures):** Topicity of Ligands and Faces and their Nomenclature; Stereogenicity; Chirogenicity; Pseudoasymmetry; Stereogenic and Prochiral Centres

**Asymmetric Induction (4 lectures):** 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(4 lectures):** 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(3 lectures):** 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)

**CarbocationsI: Structural Aspects (3 lectures):** Structure and Stability of Carbocations; Classical and Non-Classical Carbocations; Neighbouring Group Participation; Ion-pairs

**CarbocationsII: Rearrangement Reactions(4 lectures):** Recapitulation of General Reactions; Molecular Rearrangements in; Acyclic Systems, Monocyclic Systems, Bicyclic Systems; Stability and Reactivity of Bridge-Head Carbocations

**Carbanions (4 lectures):** Generation of Carbanions; Structure and Stability of Carbanions; Ambidentlons and their General Reactions; Rearrangements of Carbanions

**Free Radicals(4 lectures):** Generation of Free Radicals; Structure of Free Radicals; Stability and Reactions; Cage Effects; Radical-cations and Radical-anions;  $S_RN1$  Mechanisms

**Carbenes(4 lectures):** Formation and Structure of Carbenes; Reactions Involving Carbenes and Carbenoids, Electrophilic and Nucleophilic Reactions; Carbenoids

**Nitrenes(3 lectures):**Generation of Nitrenes; Structure and Reactions of Nitrenes

**Arynes(4 lectures):** Generation and Reactivity; Nucleophilic Aromatic Substitution Reactions;  $S_NAr$  Mechanism, Regioselectivity; Ipso Effect

### Further Readings

1. Carey, F.A. & Sundberg, R. J. Advanced Organic Chemistry, Parts A & B, Plenum: U.S. (2007) /LATEST EDITION.
2. Eliel, E. L. Stereochemistry of Carbon Compounds Textbook Publishers (2003)/LATEST EDITION.
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)/LATEST EDITION .
5. Nasipuri, D. N. Stereochemistry of Organic Compounds: Principles & Applications South Asia Books (1994).
6. March, J. Advanced Organic Chemistry John Wiley & Sons (2004).
7. Kalsi, P. S. Stereochemistry: Conformation and Mechanism, 7th Edition New Age International, Delhi (2008).
8. Jonathan Clayden , Nick Greeves , Stuart Warren Organic Chemistry 2nd Edition

<p style="text-align: center;"><b>MCH-013: GENERAL PHYSICAL CHEMISTRY</b> <b>(4 Credits, 60 Lectures)</b></p>
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This course on General Physical Chemistry deals with general aspects of Physical Chemistry. It is designed to provide you with a solid foundation in the fundamental principles and advanced concepts of physical chemistry. The contents of the course assume a basic knowledge of physical chemistry at undergraduate level and builds on that. Throughout this course, you will explore a wide range of topics that are crucial for understanding the behaviour of chemical systems, from the microscopic to the macroscopic level. By the end of this course, you'll have acquired a deep understanding of the fundamental principles of physical chemistry and

developed the skills necessary to analyse and solve complex problems in a wide range of chemical systems.

**Introduction to Statistical Thermodynamics(5 lectures):** 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

**Gibbs and Helmholtz's Functions (3lectures):** 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(3lectures):** 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

**Fundamentals of Solid State(4 lectures):** 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(3 lectures):** Molecular Symmetry, Symmetry Elements versus Symmetry Operations; Crystal Symmetry; Screw Axis, Glide Plane; Stereographic Projections

**Collision and Transition State Theories(3 lectures):** Collision theory and Its Limitations, Limitations of Collision Theory; Transition State Theory; Thermodynamic Approach, Statistical Approach,

**Theories of Unimolecular Reactions(4lectures):** 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(3lectures):** 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(4 lectures):** 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(4 lectures):** 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(5 lectures):** Adsorption Phenomenon, Langmuir Adsorption Isotherm; Gibbs Adsorption Isotherm; Multilayer Adsorption, Bet Equation and Its Application Heterogenous Catalysis

**Debye Huckel Theory-I(5 lectures):** 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(5 lectures):** 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(5 lectures):** 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 (4 lectures):** 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. Solid State Chemistry & its Applications, John Wiley & Sons (1987).
7. West, A.R. Basic Solid State Chemistry, 2nd Edition, John Wiley & Sons (2000).
8. Smart, L.E. & Moore, E.A. Solid State Chemistry - An Introduction, 3rd Edition, CRC Press (2005).
9. Brett, C. M. A. & Brett, A. M. O. Electrochemistry Oxford University Press (1993).
10. Mc Quarrie, D. A. Statistical Mechanics Viva Books Pvt. Ltd.: New Delhi (2003).
11. Nash, L. K. Elements of Statistical Thermodynamics 2nd Ed., Addison Wesley (1974).
12. Mc Quarrie, A. Donald and John D Simon. Molecular thermodynamics. California: University Science Books 1999.
13. S. Glasstone, Thermodynamics for Chemists, New Delhi: Maurice Press, 2008.

## **MCHL-011: CHEMISTRY LAB-I**

### **(2 Credits, 60 Lectures)**

The course Inorganic Chemistry Lab-I (MCHL-011) is the first laboratory course on Inorganic chemistry being offered in the first semester of the M.Sc. Chemistry Programme. It is worth 2 credits i.e. you have to spend a total of 60 hours for this course. In the first Unit qualitative inorganic analysis of the semimicro level will be dealt with. Here you will be doing the preliminary investigation of the sample and then detecting the cations and after that confirmatory tests for the cations have to be carried out. Also, special test for the mixtures of cations have to be studied. You will be given inorganic mixtures containing at least 4 known cations along with rare elements and after that you will be identifying 4 cations along with rare elements (in cationic/anionic forms) in unknown inorganic mixtures. In the Experiment 2 you will be doing complexometric titrations and it has three experiments in it where different mixtures of metals have been discussed. In the Experiment 3 you will be using gravimetric method for estimation of copper and nickel together in a mixture.

#### **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 & complexometry) 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)**

The course Organic Chemistry Lab-II (MCHL-012) is the first course on organic chemistry being offered in the first semester of the M.Sc. Chemistry Programme. It is worth 2 credits i.e. you have to spend a total of 60 hours for this course. The course has been divided into two parts- Part A and Part B.

**Part A:** discusses the separation of two components of a mixture of two organic compounds which can be acidic, basic or neutral in nature. It has also been explained that how the separated organic compounds can then be identified individually by performing various tests which are characteristics of different functional groups. For this purpose, the basic aspects of

separation of binary mixtures and characteristics tests for compound containing individual functional group have discuss in Unit 1. The separated compounds are finally confirmed by preparing their derivatives and comparing the melting points of the compound and the derivative with those reported in the literature. The data tables and the preparation of some useful reagents have also been included as appendices for reference. *You will be given three binary mixtures containing known organic compounds and after that you will be identifying three binary mixtures containing unknown organic compounds.*

**Part B:** describes the preparation of various interesting organic compounds out of the ten given preparations, you are expected to prepare six compounds.

You will be preparing the compounds based on Friedel-Crafts reaction, oxidation reaction, acetylation, reduction, addition reaction Sandmeyer reaction, Fischer indole synthesis and dizotisation. You have come across all these reaction in your theory courses and it would be interesting to prepare compounds using these reactions in the laboratory.

- 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)
  8. 2,3 - Dimethylindole from phenyl hydrazine and 2 - butanone (Fisher Indole Synthesis)
  9. 1,2,3,4 - Tetrahydrocarbazole from cyclohexanone (Fisher Indole Synthesis)
  10. Methyl orange from sulphanilic acid (Diazo Reaction)

#### Further Readings:

1. Addison Ault Techniques and Experiments for Organic Chemistry 6th Ed. University Science Books (1998).
2. Mann, F. G. & Saunders, B. C. Practical Organic Chemistry 4th Ed. Orient Longmans (1990).
3. 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)**

This laboratory course is based primarily on the contents covered in the course on general physical chemistry. It provides hands-on experience in performing a variety of experiments that are fundamental to understanding and application of concepts of physical chemistry. We will provide the necessary theoretical background, and experimental details for each of the experiments included in this course. By engaging in these experiments, you'll develop critical laboratory skills, enhance your understanding of chemical principles, and gain practical experience that will be invaluable in your future scientific endeavors.

**Note: Perform any ten of the following experiments**

<b>Expt. No.</b>	<b>Title of the Experiment</b>
1	To determine the partial molar volumes of sodium chloride solutions by measuring their densities, as a function of concentration, using a pycnometer.
2	Determine the mean activity coefficient ( $\gamma$ ) 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 <sub>4</sub> (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 ( $\epsilon$ ) 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.
- 14 To determine the concentrations of KCl, KBr, and KI in a mixture by potentiometric titration.

**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)**

Mathematics is an essential and integral component of all of the scientific disciplines, and its applications within chemistry are numerous and widespread. Mathematics allows a chemist to understand a range of important concepts, model physical scenarios, and solve problems. In your earlier classes it is likely you have already encountered the use of mathematics within chemistry. In the masters degree programme you need to have a better understanding of a higher level of mathematics so that you can understand various derivations commonly used in physical chemistry. You will see mathematics increasingly used to explain chemistry concepts in more sophisticated ways, for example the use of vectors in understanding the structures of crystals, or numerical approximations of ordinary differential equations (ODEs) in kinetics to predict the rates and mechanisms of chemical reactions. The ability to understand and apply mathematics will be important regardless of the branch of chemistry you are studying, be it the more traditional areas of inorganic, organic and physical chemistry or some of the newer areas of the subject such as biochemistry, analytical and environmental chemistry.

**Differential Calculus(5 lectures):** 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(4 lectures):** 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(4 lectures):** 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(4 lectures):** 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,  $\chi^2$  test, Applications of Significance Tests

**Introduction to Vectors (4 lectures):** 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 (5 lectures):** 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 (4 lectures):** Solution of simultaneous equations; Homogeneous Linear Equations; Non-homogeneous Linear Equations; Linear Dependence and Independence; Matrix Eigenvalues and Eigenvectors

<p><b>MCH-015: BIOLOGY FOR CHEMISTS</b> <b>(2 Credits, 30 Lectures) 5</b></p>
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The 'Biology for Chemists' is a Semester I course of M.Sc. Analytical Chemistry programme that has been designed for the chemists who do not have a biology background or have not studied the subject of Biology at the Intermediate level of schooling. You might know that the postgraduate level of chemistry has no demarcations that separate the chemistry topics from the ones involving biological systems. In view of this the mentioned course starts from the very basic idea of cell and the functions of cell organelles. It apprises the learners with the important biomolecules present in living organisms and are significant for the physiological and other functions. The course introduces the bioenergetics and the metabolism of all the biomolecules discussed. Some other important topics include the immune system and the information pathways which are relevant to the chemists and would help in their studies at the Doctoral level. The purpose is not to add the content load so, it is a two credits course, comprising of two Blocks with a total of 8 units.

**Cell and Cell Organelles (5 lectures):** 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(3 lectures):** 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(4 lectures):** 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 (4 lectures):** 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 (3 lectures):** Metabolism of Proteins; Metabolism of Fats; Metabolism of Nucleic Acids

**Homeostasis (3 lectures):** Need for Homeostasis; Regulation of Blood Glucose; Maintaining Water Balance; Acid-Base Balance; Thermoregulation

**Immune System (3 lectures):** 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 (5 lectures):** 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

## Semester 2

<p><b>MCH-016: INORGANIC CHEMISTRY-II</b> <b>(04 Credits, 60 Lectures)</b></p>
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The course Inorganic Chemistry I (MCH-016) is the second course on inorganic chemistry being offered in the second semester of the M.Sc. Chemistry Programme. It is worth 4 credits i.e. you have to spend a total of 10 hours for this course. The course has been divided into three blocks. The first block is on reaction mechanisms in coordination compound where the first two units are on reaction mechanisms in substitution reactions. The third unit is square planar complexes and then ligand substitution in octahedral and tetrahedral complexes are dealt with in the fourth

unit. Thereafter the block 2 is on molecular rearrangements and reactions of coordinated ligands. The last block is on bioinorganic chemistry where the details of energy sources for life, photosynthesis and nitrogen fixation, metalloenzyme, metal-nucleic acid interactions and metals in medicine have been discussed.

**Reaction Mechanisms in Substitution Reactions I(5 lectures):** 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(5 lectures):** 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 (5 lectures):** Berry's Pseudo Rotation Mechanism; Factors Affecting the Reactivity of Square Planar Complexes, Swain-Scott Equation

**Ligand Substitution in Octahedral and Tetrahedral Complexes (5 lectures):** Trans Effect and its Application to Synthesis of Complexes; Stereochemical Changes in Substitution Reactions of Octahedral and Tetrahedral Complexes

**Molecular Rearrangements-I (5 lectures):** Molecular Rearrangement Processes; Electron Transfer Reactions (Outer and Inner Sphere); HOMO and LUMO of Oxidant and Reductant, Chemical Activation

**Molecular Rearrangements-II (5 lectures):** Precursor Complex Formation and Rearrangement; Nature of Bridged Ligands; Fission of Successor Complexes, Two-Electron Transfers

**Methods of Synthesis of Coordination Compounds (4 lectures):** 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 (5 lectures):** Photosynthesis PSI and PSII Systems; Nitrogen Fixation

**Metalloenzymes(5 lectures):** 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 (4 lectures):** Metal-Nucleic Acid Interactions; Metal Complex – Nucleic Acid Interaction Modes of Binding to DNA, DNA Cleavage



**Metals in Medicine (6 Lectures):** 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. Inorganic Electronic Spectroscopy, A.B.P. Lever, Elsevier.
5. Comprehensive Coordination Chemistry eds., G. Wilkinson, R.D. Gillars and J.A. McCleverty, Pergamon.
6. Inorganic Chemistry, G. Wilysberg, University Science Books.
7. Physical Methods in Inorganic Chemistry, R. S. Drago.
8. Inorganic chemistry by D. F. Shriver, P. W. Atkins and C. H. Langford
9. Structural Methods in Inorganic Chemistry by Ebsworth.
10. An Introduction to Inorganic Chemistry by Purcell and Kotz
11. Mechanisms of Inorganic Reactions by R G Pearson, Fred Basolo

**MCH-017: ORGANIC CHEMISTRY-II**  
**(04 Credits, 60 Lectures)**

This course on Organic Chemistry comprises of two sections: Heterocyclic Compounds and Organic Synthesis. The knowledge for both these areas is important for the learners of organic chemistry. Heterocyclic compounds constitute a large variety of structures from 3-membered rings to higher membered ones, having a heteroatoms such as O,N,S,P etc. and benzofused and other types of complex rings. Such structural variety leads to an interesting spectrum of their biological activities. These compounds have applications in the area of medicinal chemistry, biochemistry, polymers and diverse industries. You will study the about synthesis, reactions and applications of such compounds in this course.

In this second section on organic synthesis, important aspects of synthesis of organic compounds have been dealt. You will study about various ways to synthesise the organic compounds by using different reagents and techniques such as reduction, oxidation, umpolung reactions, phase transfer catalysis etc. A knowledge of these aspects would to design and plan synthesis of a equip you wide variety of organic compounds.

**Section A: Heterocycles and Organic Synthesis (30 Lectures)**

**Introduction to Heterocyclic Compounds (3 lectures):** Nomenclature; Spectral Characteristics; Reactivity and Aromaticity

**Three Membered Heterocycles (4 lectures):** Synthesis and Reactions of Aziridine, Oxiranes and Thiarines; Synthesis and Reactions of Azirines

**Four Membered Heterocycles(4 lectures):** Synthesis and Reactions of Azetidine; Synthesis and Reactions of Oxetanes; Synthesis and Reactions of Thietanes

**Five Membered Heterocycles with Two Heteroatoms in Rings (4 lectures):** 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 Benzofusedanalogs

**Benzofused Five Membered Heterocycles with One Heteroatom (4 lectures):** Synthesis and Reactions of Indole; Synthesis and Reactions of Benzofuran; Synthesis and Reactions of Benzothiophene

**Bicyclic Heterocycles Containing One or More Heteroatoms (3lectures):** Synthesis and Reactions o Benzimidazole; Synthesis and Reactions of Benzotriazole; Synthesis and Reactions ofPurine

**Benzofused Six Membered Rings with More than One Heteroatoms (4 lectures):** 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 (4 lectures):** Synthesis and Reactions of Azepines; Synthesis and Reactions of Oxepines; Synthesis and Reactions of Thiopines; Chemistry of Porphyrins

## **SECTION B: SYNTHESIS OF ORGANIC COMPOUNDS (30 LECTURES)**

**Philosophy of Organic Synthesis(3 lectures):** 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 (2 lectures):** Coupling Reactions; Stille, Suzuki and Sonogashira Couplings; Heck Reaction and Negishi Couplings

**Reductions (3 lectures):** Catalytic Hydrogenation: Stereochemistry and Mechanism; Metal-liquid Ammonia Reductions: Stereoselection and Mechanism; Homogeneous Hydrogenations; Mechanisms and Applications Using Rh, Ru and Other Metal Complexes

**Reductions using Hydride Transfer Reagents (4 lectures):** Sodium Borohydride; Sodium Cyanoborohydride; Lithium Aluminium Hydride and Alkoxy Substituted LAH Reducing Agents; DIBAL; Applications of Hydroboration (Reductions, Oxidations and Cabonylations); Diborane Coupling Reaction; Diisoamylborane, Thexylborane and 9-BBN; Isopinocampheyl and Diisopinocampheylboranes

**Oxidations (3 lectures):** Use of Oxidizing Reagents with Applications and Mechanism; DDQ,

SeO<sub>2</sub>, Ti(NO<sub>3</sub>)<sub>3</sub>, Ceric Ammonium Nitrate; Sharpless Asymmetric Epoxidation; Asymmetric Hydroxylation and Aminohydroxylation

**Enolates (4 lectures):** Thermodynamic Versus Kinetic Enolates; Enolate Equivalents and Enamines; Applications in Carbon-Carbon Bond Formation and Related Reactions; Applications in Chiral Synthesis

**Umpolung Reactions (3 lectures):** Sulphur Compounds; Nitro Compounds; Lithiated Ethers and Related Compounds

**Principles and Applications of Phase Transfer Catalysis (4 lectures):** Crown Ethers; Polymer-Supported Reagents in Organic Synthesis

**Asymmetric Synthesis (4 lectures):** 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.

<p style="text-align: center;"><b>MCH-018: QUANTUM CHEMISTRY AND GROUP THEORY</b> <b>(04 Credits, 60 Lectures)</b></p>
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This course on Quantum Chemistry and Group Theory delves into the fundamental principles of quantum mechanics and their applications in understanding the behavior of atoms and molecules. To begin with, you will learn about the need and the formalism of wave mechanics followed by application of wave mechanics to model systems. This will be followed by a detailed account of the quantum mechanical description of hydrogen atom, multielectron atoms and molecules. Additionally, this course covers the principles of group theory and their significance in understanding molecular symmetry.

**Fundamentals of Quantum Chemistry(4 lectures):** 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 (3 lectures):** 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(5 lectures):** 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 (3 lectures):** Linear Harmonic Oscillator: Classical Treatment; Linearharmonic 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(3 lectures):** Rotational Motion: Classical Treatment; Rigid Rotor; Formulating Schrodinger Wave Equation, Separation of Variables; Solving  $\phi$  Equation; Solving  $\theta$  Equation

**Hydrogen Atom-I(4 lectures):**Hydrogen Atom, Formulating Schrodinger Wave Equation; Solving Schrodinger Wave Equation; Separation of Variables, Results of Solutions of  $\Phi$ ,  $\Theta$  and R Equations; Quantum Numbers and Their Significance

**Hydrogen Atom-II (3 lectures):** Hydrogen Like Wave Functions; Radial Wave Functions, Angular Wave Functions (Spherical Harmonics), Radial Distribution Functions; Electron Spin and Spin Quantum Number

**Angular Momentum (3 lectures):** 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 (4 lectures):** Variation Method and Its Applications; One Dimensional Box

Harmonic Oscillator, Hydrogen Atom; Perturbation Theorem

**Multi Electron Atoms (4 lectures):** 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(4 lectures):** 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(5 lectures):** Matrix Representation And Its Characteristics; Basis for Representation, Similarity Transformations, Character of Representations; Irreducible Representation, Wave function as Basis for Representation; Great Orthogonality Theorem, Construction of Character Tables; Reduced Representation, Reduction of Representation; Symmetry Adapted Basis; Vanishing Integrals

**Valence Bond Theory(3 lectures):** Born-Oppenheimer's Approximation; Hydrogen Molecule, Coulomb's Integral, Exchange Integral, Overlap Integral; Polyatomic Molecules, Configuration Interaction

**Molecular Orbital Theory-I(4 lectures):** Born-Oppenheimer's Approximation; Hydrogen Molecule Ion; LCAO-MO Approach, Resonance and Overlap Integrals, Bonding and Antibonding Orbitals; Hydrogen Molecule

**Molecular Orbital Theory-II(4 lectures):** Homonuclear Diatomic Molecules, MO Configuration; Heteronuclear Diatomic Molecules; HF, LIF, CO; Polyatomic Molecules, Hybridisation

**Hückel Molecular Orbital Theory(4 lectures):** 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. Mc Quarrie, D. A. Quantum Chemistry Viva Books Pvt Ltd.: New Delhi (2003).
3. Pilar F. L. Elementary Quantum Chemistry 2nd Ed., Dover Publication Inc.: N.Y. (2001).
4. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press (2006).
5. Levine, I. L. Quantum Chemistry 5th Ed., Prentice-Hall Inc.: New Jersey (2000).
6. Engel, T. & Reid, P. Physical Chemistry Benjamin-Cummings (2005).
7. Mc Quarrie, D. A. & Simon, J. D. Physical Chemistry: A Molecular Approach 3rd Ed., Univ. Science Books (2001).
8. Silbey, R. J., Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed. Wiley (2004)
9. F. A. Cotton, Chemical Applications of Group Theory, Wiley Eastern,1990.
10. L. Robert Carter, Molecular Symmetry & Group Theory, John Wiley& Sons Inc Sea Pte Ltd, 2012.
11. K. Veera Reddy, Symmetry and Molecular Spectroscopy, New Age International Publishers, 2012.

## **MCH-019: GREEN CHEMISTRY**

### **(02 Credits, 30 Lectures)**

The use of chemicals in various aspects of life is difficult to avoid. Thus, their synthesis and use is unavoidable. But, there are safer alternatives in Chemistry under the umbrella of Green chemistry. It deals with the design and development of such products which have lesser harmful effects on human health and the environment.

This course on Green chemistry highlights the need and origin of Green chemistry. The twelve principles of the green chemistry will be described along with various tools of Green chemistry. An account of various chemicals and process will be presented along with their harmful effects. The planning of green synthesis will be illustrated and several others strategies leading towards safer environment will be explained. All the aspects would form part of this course along with the use of safer reagents and greener technologies.

**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)**

The course Chemistry Lab-I (MCHL-014) is the second laboratory course on Inorganic chemistry being offered in the second semester of the M.Sc. Chemistry Programme. It is worth 2 credits i.e. you have to spend a total of 60 hours for this course. It consists of preparation and characterization (using any of UV/VIS/IR /EPR Spectral Methods and Magnetic Measurement) of various inorganic compounds.

#### **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)<sub>2</sub>
2. TiO (C<sub>9</sub>H<sub>8</sub>NO)<sub>2</sub>H<sub>2</sub>O
3. cis-K[Cr(C<sub>2</sub>O<sub>4</sub>)<sub>2</sub>(H<sub>2</sub>O)<sub>2</sub>]
4. Na[Cr(NH<sub>3</sub>)<sub>2</sub>(SCN)<sub>4</sub>]
5. Mn(acac)<sub>3</sub> (Green Method)
6. K<sub>3</sub>[Fe(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub>]
7. [Co(NH<sub>3</sub>)<sub>6</sub>] [Co(NO<sub>2</sub>)<sub>6</sub>]
8. cis-[Co(trien) (NO<sub>2</sub>)<sub>2</sub>] Cl.H<sub>2</sub>O
9. Hg[Co(SCN)<sub>4</sub>]
10. [Ni(NH<sub>3</sub>)<sub>6</sub>]Cl<sub>2</sub>
11. Ni(dmg)<sub>2</sub>
12. [Cu(NH<sub>3</sub>)<sub>4</sub>]SO<sub>4</sub>.H<sub>2</sub>O
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)**

This laboratory course has been designed basically to make you familiar with various experimental techniques used in the synthesis and quantitative analysis of organic compounds. The basic concepts and the chemical reactions on which the experimental procedures are based have been discussed as required. This course contains 12 experiments. Experiments 1 to 6 deal with preparative organic chemistry. It starts with describing, in Unit 1, various laboratory methods used in organic laboratory. It describes broadly the kind of apparatus that is used and makes you familiar with elementary safety rules which have to be observed.

In these set of experiments, we tell you how to plan a synthesis. We give you an idea about the various points which must be kept in mind while choosing a particular procedure out of the alternative available for preparing a compound. We also tell you the way you should maintain your laboratory record for the experiments of the 'Organic Preparations'. Then, the experiments, which have been set for you to do, are described. These experiments have been chosen to make you familiar with processes like electrophilic, nucleophilic, aromatic substitutions, acylation, nitration, oxidation, etc. Experiments 7 to 12 deal with quantitative organic analysis. Here we have described the step wise procedures that may be used for quantitative functional group analysis of organic compounds using classical titrimetric methods.

**A: Any Four Preparations from the Following Involving more than two Stages (4 days/8 Sessions)**

1. Nitrobenzene from aniline (acetylation, nitration and hydrolysis)
2. Benzanilide from benzophenone (addition and Beckmann rearrangement)
3. m-Nitro benzoic acid from methyl benzoate (nitration and hydrolysis)
4. 2, 4.-Dinitrobenzoic acid from p-nitrotoluene (oxidation and nitration)
5. m-Nitro benzoic acid from benzaldehyde (oxidation and nitration)
6. Benzil from benzaldehyde (rearrangement)
7. Anthraquinone from phthalic anhydride (Friedel Crafts reaction)
8. Acetyl salicylic acid from methyl salicylate (hydrolysis and acetylation)
9. 2- Phenyl indole from phenyl hydrazine (Fischer indole reaction)
10. m-nitroaniline from nitrobenzene (nitration and reduction)

**B. ANY four ESTIMATIONS of the following**

**2 days (4 sessions)**

1. Estimation of aniline



2. Estimation of phenol
3. Estimation of glucose
4. Estimation of ethyl methyl ketone
5. Estimation of amino group
6. Estimation of amide group
7. Saponification of fat or an oil
8. Iodine value of an oil
9. Estimation of sulphur in an organic compound

**Further Readings:**

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

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

This laboratory course includes experiments based the application of different analytical techniques. It provides hands-on experience in conducting a variety of experiments that are fundamental to understanding and applying principles of analytical and physical chemistry. We will provide the necessary theoretical background, and experimental details for each of the experiments included in this

course. Through a combination of practical work and theoretical knowledge, you will gain valuable skills in experimental techniques, data analysis, and scientific reasoning

<b>Expt. No.</b>	<b>Title of the Experiment</b>
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. 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.

## Semester 3

### MCH-001: BASIC ANALYTICAL CHEMISTRY (CREDITS:6)

This course deals with the basics of Analytical techniques in the first few units. The first unit gives a general perspective of the analytical chemistry on the whole. The second and third units are devoted to concepts like accuracy, precision types of measurements and evaluation of analytical data. Unit 4 deals with Sampling- the most important initial step crucial for any analytical measurement. As a chemical laboratory is prone to a number of hazards, a practicing chemist needs to and must adhere to the laboratory safety norms. The Unit 5 addresses the safety aspect of the laboratory in requisite details so that the learners are equipped with the information required for the safety of their own as well as the fellow workers in the laboratory. Sixth Unit deals with an introduction to the instruments used for analytical measurements as the modern means of analysis are instrument based.

The rest of the course from seventh unit onwards deals with a number of conventional analytical techniques. These include kinetic methods, neutralisation titrations, redox titrations, complexometric titrations, precipitation titrations and the gravimetric analysis

**Analytical Chemistry-General Perspective:** Analytical Chemistry-An Introduction - Classification of Chemical Methods of Analysis; Classification of Different Analytical Techniques - Classification of Chemical Methods of Analysis, Classification of Electrical Methods of Analysis, Classification of Optical Methods of Analysis, Classification of Nuclear Methods, Classification of Thermal Methods of Analysis, Classification of Separation Methods; Criteria for Evaluating the Utility of Analytical Techniques - Sampling, Dissolution of the Sample, Separation of Interfering Substances, Measurement, Interpretation of the Measurement; Emerging Needs and Recent Trends.

**Evaluation of Analytical Data I:** Error and Types of Errors - Error, Types of Errors; Detection and Minimization of Errors- Calibration of Equipment and Purification of Reagents etc, Use of Blanks, Addition of a standard, Independent Analysis, Improvement in Methods; Accuracy and Precision - Accuracy, Precision; Reporting of Results - Chemical Expression of Results, Numerical Expression of Results; Significant Figures.

**Evaluation of Analytical Data II:** Some Important Terms - Mean, Median, Mode, Deviation, Average Deviation, Probable Deviation, Range; Standard Deviation - Standard Deviation of the Mean, Relative Standard Deviation and Coefficient of Variation; Precision of Computed Results - Addition and Subtraction, Multiplication and Division; Gaussian Distribution of Data; Confidence Interval - Confidence Interval When  $\sigma$  is known or  $s$  is a Good Estimate of  $\sigma$ , Confidence Interval when  $\sigma$  is not known; Criteria for Rejection of Data - 4d Rule, The 'Q' test; Tests of Significance - The t-test or Student's t-Test, F-Test, The  $\chi^2$  (Chi-square) Test; Control Charts.

**Sampling:** Sampling -An Introduction; Factors Relevant To Sampling; Water Sampling - Type of Samples, Sampling Facilities, Sampling Frequency, Sample Containers, Sampling Equipment, Sampling Procedures, Preservation of Samples, Specific Preservation for Individual Parameters, Sampling for Bacteriological Analysis; Air Sampling - Selection of Sampling Locations, Specific Criteria for Selection of Location, Suspended Particulate Matters, Procedure for Operating Suspended Particulate Sampler, Gaseous Pollutants; Sampling of Solid Wastes - General Requirement of Sampling, Sampling of Food Materials.

**Safety in A Chemical Laboratory:** Maintenance of Safety in a Chemical Laboratory - Safety Aspects in the Design of a Chemical Laboratory, Safety Aspects of a Functional Chemical laboratory, Code of Practice in a Laboratory, Personal Protective Devices; Chemical Hazards in the Laboratory - Modes of Exposure to Chemicals, Effect of Chemicals on Body, Acute and Chronic Effects, The Fume Cupboard; Classification of Hazardous Materials-Carcinogens; Storage and Handling of Chemicals - Incompatibility of Chemicals, Handling of Chemicals; Safe Handling of Glassware; Equipment and Electrical Safety; Emergency Procedures.

**Kinetic Methods of Analysis:** Types of Kinetic Methods; Measurement of Reaction Rates - Differential Methods, Integration Methods, Induction Period Measurements, Differential Reaction Rate Methods, Logarithmic Extrapolation Method, Linear Extrapolation Method, Proportional Equation Method, Activation And Inhibition, Measurements of Partial Rate Order, Non-Catalytic Reactions, Stopped Flow Technique, Factors Influencing the Reaction Rate; Mathematical Basis of Kinetic Methods - Rate Law for First Order Reactions, Rate Laws for Second Order; Catalytic Reactions - Enzyme Catalysed Reactions; Comparison of Graphical Logarithmic Extrapolation Methods and of Proportional Equations; Instrumentation; Applications.

**Acid-Base Equilibria:** Acid-base concept; Autoprotolysis and leveling effect; Monoprotic acids and monoacidic bases; Polyprotic acids; Solution containing a polyacidic base; Buffer solutions; Buffer capacity.

**Neutralization Titration-I:** Basic Concepts of Titrimetry, Primary and Secondary Standards; Titration Curves- Titration of A Strong Acid Versus Strong Base, Titration of Weak Acid Versus Strong Base, Titration of a Weak Base Versus Strong Acid, Titration of Weak Acid Versus Weak Base, Titration of Sodium Carbonate Versus Strong Acid, Titration of Polyprotic Acid Versus Strong Base; Theory of Indicators - Ostwald's Theory, Modern Quinoid Theory; Colour Change Range of an Indicator; Selection of Indicator and Indicator Error.

**Neutralization Titrations-II:** Non-aqueous Titrations; Role of Solvents in Acid-Base Reactions; Solvent Systems; Importance of Dielectric Constant; Hammett's Acidity Functions; Titrants and End Point Detection; Some Applications.

**Redox Titrations:** Redox Reactions and Redox Potential-Redox Reaction as Two Half Reactions, Redox Potential, Electrochemical Cells, Nernst Equation, Cell Potential, Redox Equilibrium Constant; Redox Titration Curves; Redox Indicators; Redox Titrations in Nonaqueous Solvents - Criteria for Solvent Selection, Characteristics of Common Nonaqueous Solvents; Applications of Redox Titrations - Oxidimetric Reagents, Reductimetric Reagents.

**Complexometric Titrations:** Review of Coordination Compounds - Metal-Ligand Complexes, Metal-Ligand Equilibrium, Factors Affecting Stability of Metal-Ligand Complexes; Principles of Complexometric Titrations - EDTA - An Important Chelating Agent, Equilibria Involved in EDTA Titrations, EDTA Titrations and pH, Effect of Other Complexing Agents, Metal-EDTA Titration Curves; Determination of Equivalence Point - Metallochromic Indicators, Instrumental Methods of End Point Detection; Applications of Complexometric Titrations - Selectivity in Complexometric Titrations.

**Precipitation Titrations:** Precipitation Titration—An Introduction; Feasibility of Precipitation Titrations; Titration Curves - Major Regions of a Precipitation Titration Curve, Plot of a Precipitation Titration Curve, Titration of  $\text{Br}^-$  with  $\text{Ag}^+$ , Titration of  $\text{Cl}^-$  with  $\text{Ag}^+$ , Titration of Iodide—Chloride Mixture with Silver Ion, Factors Affecting the Sharpness of End Point, Completeness of the Reaction, Experimental Measures of Titration Curves with  $\text{Ag}^+$  Titrant; Indicators for Precipitation Titration; Vohlard's Titration - Volhard Titration Equilibrium; Fajan's Titration - How Adsorption Indicators Work, Ons for Functioning of Adsorption Indicators; Mohr's Titration - Calculation of End Point Equilibria in the Mohr Titration, Indicator Blank in the Mohr Chloride Titration; Applications.

**Gravimetric Analysis:** Gravimetric Analysis –A General Introduction; Supersaturation and Nucleation - Nucleation, Supersaturation; Rate of Precipitation - Some Suggested Procedures for Precipitation, Digestion of the Precipitate with the Mother Liquor; Coprecipitation - Adsorption at the surface of particles, Occlusion by incorporation of foreign ions (and solvent), Method of Minimizing Coprecipitation, Role of Coprecipitation for the Separation of Tracer Quantities; Postprecipitation; Differences in Coprecipitation and Post Precipitation; Precipitation Form Homogeneous Solution - Generating the Anions by Slowly Hydrolysing the Esters or Some Compounds, Raising the pH of the Solution by Slowly Boiling with Urea, Synthesizing the Reagents within the Solution by Reaction of the Different Components, Releasing the Cation Slowly Available by Change in its Oxidation State or Destroying its Complex; Washing of Precipitates; Drying and Ignition of Precipitates - Determination of Optimum Drying or Ignition Temperature; Organic Precipitants, their Advantages and Disadvantages - Classification, Reagents with Some Important Functional Groups, Advantages and disadvantages.

**Introduction to Analytical Instruments:** Analytical instruments an introduction; Analytical balance; Colorimeter, photometer, spectrophotometer - Colorimeter, Photometer, Spectrophotometer, Infrared spectrophotometer, Flame photometry; Spectrography; Inductively coupled plasma; Atomic absorption; Electro analytical methods; Role of computers in analytical Instrumentation.

## **MCHL-001: BASIC ANALYTICAL CHEMISTRY LAB (CREDITS:2)**

This laboratory course has been designed to put the concepts learnt in the MCH-001 course into practice. There are a total of ten experiments in this course. Of these, the first one is of a general nature which deals with the calibration of apparatus and statistical treatment of data. Rest of the experiments, are concerned with the quantitative determination of the analyte. The emphasis is on providing the necessary skills to use and exploit different quantitative analytical methods in order to determine the analyte in different types of samples. Two of these experiments deal with the gravimetric determination of ions in samples of brasa and steel having industrial applications.

The remaining seven experiments give an exposure to different types of titrimetric determinations. These cover acid-base, redox, complexometric and precipitation titrations. In this process, you would be learning about the variety of ways in which titrimetric determinations are designed and the principles behind such determinations.

### **EXPERIMENTS**

1. Calibration of volumetric apparatus and weights, and statistical treatment of data
2. Determination of percentage of tin in brass sample gravimetrically
3. Determination of nickel(II) in nickel steel gravimetrically using dimethylglyoxime
4. Determination of  $pK_a$  value of phosphoric acid titrimetrically
5. Determination of total alkalinity of  $OH^-$ ,  $HCO_3^-$ ,  $CO_3^{2-}$  for a water sample
6. Determination of ascorbic acid in a vitamin C tablet iodometrically
7. Determination of hard water
8. Determination of available chlorine in a bleaching powder sample iodometrically
9. Determination of zinc by  $K_4Fe(CN)_6$  by precipitation titration
10. Determination of silver by Mohr's/Volhard's/Fajan's method

## **MCHL-002: SEPARATION METHODS (CREDITS:6)**

As the list of details of the units indicates, the first Block on 'Classical Methods' of separation comprises of three units. The course begins with the discussion on basic aspects such as importance of separation methods, their classification and choice of separation methods in the first unit. Units 2 and 3 deal with the techniques of 'Solvent Extraction' and cover the general principles, classification of extraction systems, extraction equilibria, factors influencing extraction & metal ion separations as well as choice of organic phase for extractions.

Block 2 and 3 deal with the 'Chromatographic Methods' of separation. Block 2 comprises of three units. The first unit i.e. Unit 4 of this block explains the 'General Principles of Chromatography'. Unit 5 on 'Liquid Column Chromatography' recapitulates the basic aspects, explains experimental details and the choice of stationary and mobile phases, development techniques in addition to giving basic idea of HPLC. Unit 6 on 'Planar

Chromatography' explains basic principles of paper chromatography and its applications. A discussion of thin layer chromatography also forms the part of this unit. Block 3 continues the discussion on chromatographic methods and covers 'Gas Chromatography' in Unit 7 wherein the theoretical aspects, instrumental details and applications are discussed. Unit 8 on 'High Performance Liquid Chromatography' highlights the basic aspects as well as the applications of HPLC.

Block 4 comprises of two units, i.e. Unit 9 and Unit 10. Unit 9 on 'Ion Exchange Chromatography' describes the mechanism of ion exchange, classification of ion exchangers, synthesis of ion exchange resins and properties of resins. Besides this, details of operation, inorganic ion exchangers and applications of ion exchange chromatography have also been explained. Unit 10 on 'Size Exclusion Chromatography' discusses the basic principles of separation involving gels, gels and their properties and applications of this technique.

Block 5 covers other separation methods with two units i.e. Unit 11 and 12. Unit 11 on 'Membrane Separation' begins with classification of membrane processes, the mechanism of separation through membranes is also highlighted. This unit also discusses the phenomenon osmosis, reverse osmosis as well as dialysis and electro-dialysis. Finally, the applications of the membrane separation have also been explained in this unit. Unit 12 on 'Electrophoresis' discusses the theory of electrophoresis, classification and its applications.

**General Aspects of Separation Methods:** Separation Methods – A Unified Science; Scope of Separation Methods; Evolution of Chromatography; Classification of Separation Methods; Classification Based on Property Resulting in Separation - Volatility, Solubility, Partition, Ion Exchange, Surface Activity, Molecular Geometry, Electromigration; Classification Based on Equilibrium and Rate Processes - Classification Based on Equilibrium Processes, Classification Based on Rate Processes; Criteria for Selection of Separation Methods - Selectivity, Detectability, Reproducibility, Yield, Speed and Convenience, Capability for Hyphenation, Ease in Scaling up and Economics.

**Solvent Extraction – I:** General Principles and Terminology - Phase Rule Consideration, Distribution Law and its Limitations, Distribution Ratio, Percentage Extraction, Separation Factor, Multiple Extractions, Multiple Extractions with Successive Portions; 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 - Diluents, Modifiers.

**Solvent Extraction – II:** Studies on Extraction Equilibria - Extraction of Metal Chelates, Extraction by solvation, Extraction by ion pair formation, Synergism; Factors Influencing

Extraction -  $pH$ , Molarity of the Acid, Metal Ion Concentration, Presence of Salting out Agents, Presence of Masking (Sequestering) Agent, Concentration of the Extractant, Nature of Diluents; Different Approaches for Metal Ion Separation - Stripping,  $pH$  of the Aqueous Phase, Acid Molarity of the Aqueous Phase, Presence of Masking Agents in the Aqueous Phase, Selective Stripping from the Organic Phase; Criteria for the Choice of Organic Phase.

**General Principles of Chromatography:** Definition and Classification - Definition, Classification, Liquid Chromatography, Gas Chromatography, Supercritical Fluid Chromatography, Conclusions; Elution on Columns; Migration Rates - Distribution Constant, Retention Time, Retention Factor, Selectivity Factor (Separation Factor), Shapes of Peaks; Concept of Theoretical Plates; Rate Theory - Eddy Diffusion Term, Longitudinal Diffusion Term, Non-equilibrium in Mass Transfer Term, van Deemter Plot and Zone Broadening, Resolution.

**Liquid Column Chromatography:** Recapitulation of Basics - Liquid-Solid Chromatography, Liquid-Liquid Chromatography; Experimental Set up - Equipment; Choice of Stationary and Mobile Phases - Stationary Phases Used in Liquid-Solid Column Chromatography, Stationary Phases Used in Liquid-Liquid Column Chromatography, Mobile Phases in Liquid Column Chromatography; Development Techniques - Frontal Analysis, Displacement Development, Elution Analysis; Basic Aspects of HPLC; Applications.

**Planar Chromatography:** Paper Chromatography - Principle, Stationary Support, Solvent Systems, Development of Chromatogram, Detection Methods, Applications; Thin Layer Chromatography - Stationary Phases, Mobile Phases, Apparatus and Requirements, Detection Methods, Plate Concept Applied to TLC, High-Performance Thin Layer Chromatography (HPTLC), Applications; Quantitative Aspects of PC and TLC; Comparison of PC and TLC.

**Gas Chromatography:** Recapitulation of Basic Aspects - Column Efficiency, Solvent Efficiency; Instrumentation - Mobile Phase (Carrier Gas), Columns, Stationary Phase Support and Liquid Phases, Detectors; Sampling and Introduction of Sample into GC Unit - Hazards in Sampling, Introduction of the Sample into GC Unit, Applications - Identification of Compounds (Qualitative Analysis), Quantitative Analysis, Some Examples of Applications.

**High Performance Liquid Chromatography (HPLC):** Principle; Instrumentation - Sample Injection System, Column, Packing Material or Stationary Phase, Solvent Supply System, Pumps, Detectors; Optimization of Separation; Advantages; Comparison with Gas Chromatography; Applications - Polyaromatic Hydrocarbons, Isomeric Compounds, Sugars in Popular Drinks, Drug Abuse, Separation of Nucleic Acids, Analysis of Amino Acids, Partition Chromatography, Ion Chromatography, Chiral Separation of Enantiomers, Ion-Exclusion Chromatography, Speciation Studies; Interfacing HPLC with Mass Spectrometry - Thermospray Method, Particle Beam Interface, Atmospheric Pressure Chemical Ionization, Electrospray Interface, Moving Belt Interface.

**Ion Exchange Chromatography:** Basic Features of Ion Exchange Mechanism; Classification of Ion Exchangers - Natural Ion Exchangers, Synthetic Ion Exchangers, Liquid Ion Exchangers; Synthesis of Ion Exchange Resins - Cation Exchangers, Anion Exchangers, Amphoteric



Exchangers; Trade Names and Nomenclature; Resin Properties - Moisture Content, Particle Size, Cross Linkages, Capacity, Distribution Ratio, Equivalency of Exchange, Resin Selectivity; Operating Methods - Batch Operation, Column Operation, Moving Bed Operation; Ion Exchange in Mixed Aqueous - Organic Media; Specific Cation Exchangers; Synthetic Inorganic Ion Exchangers - Different Types and Their Characteristics, Special Properties and Applications; Applications - Separation of Metal Ions and Anions, Separation of Organics, Separation of Ionized from Nonionized, Separation of Actinide Elements, Miscellaneous Applications.

**Size Exclusion Chromatography:** Basic Principle; Gels and Their Important Properties - Important Properties of Gels for Chromatography; Classification, Synthesis and Properties; Variables Defining the Utility of Gel; Unique Features of the Technique; Some Applications - Analytical Applications, Preparative Applications, Miscellaneous Applications.

**Membrane Separation:** General Aspects of Membrane Process; Some Important Membrane Processes - Reverse Osmosis (RO), Nanofiltration (NF), Ultrafiltration (UF), Microfiltration (MF), Dialysis, Electrodialysis (ED), Gas Separation, Pre-vaporization, Liquid Membrane Processes; Mechanisms of Separations through Membranes - Sieving, Solution-Diffusion, Preferential Sorption-Capillary Flow, Donnan Effect, Knudsen Flow, Surface Flow, Facilitated Diffusional Transport, Active transport; Osmotic Phenomena; Reverse Osmosis Process - Basic Equations, Concentration Polarization; Dialysis; Electrodialysis; Applications - Desalination and Water Treatment, Protein Recovery, Production of Table Salt, Hemodialysis, Ion Selective Membrane Electrode, Specific Gas Probes, Detection and Analysis of Particulate Contamination, Microbiological Analysis.

**Electrophoresis** - Electroosmotic Flow; Basic Principle and Operation; Different Forms of Electrophoresis; Slab Electrophoresis - DNA Gel Electrophoresis, SDS-PAGE Gel Electrophoresis, Two-Dimensional SDS-PAGE Gel Electrophoresis; Capillary Electrophoresis - Capillary Zone Electrophoresis, Capillary Gel Electrophoresis, Capillary Isotachopheresis, Capillary Isoelectric Focusing; Capillary Electrochromatography.

<b>MCHL-002: SEPARATION METHODS LAB (CREDITS:2)</b>
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There are ten experiments covering a wide range of separation methods. The first two experiments are based on the liquid-liquid extraction, which is also known as solvent extraction. Experiment 3 involves the determination of ion exchange capacities while Experiment 4 highlights the use of the technique of ion-exchange in determining the total metal ions present in water. Experiment 5 explains the use of ion exchange in the separation of Fe(III) and Ni(II) which was done in Expts 1 and 2 by using liquid-liquid chromatography. Thus, the comparative utility of the two techniques can be appreciated by performing these experiments.

Rest of the experiments, *i.e.*, Experiments 6 to 10 are based on various chromatographic techniques. Experiments 6 and 7 discuss, respectively the separation of cations and amino

acids using the technique of paper chromatography – an example of planar chromatography. Experiment 8 describes the separation of carbohydrates by thin layer chromatography which is another technique classified under planar chromatography. Experiments 9 and 10, respectively, illustrate the application of column chromatography in the separation of chlorophyll pigments and metal ions such as iron and aluminum.

## EXPERIMENTS

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
5. Separation of Fe (III) and Ni (II) using a strongly basic anion exchanger
6. Separation of cations by paper chromatography
7. Separation of amino acids by chromatography
8. Separation of carbohydrates by thin layer chromatography
9. Separation of chlorophyll pigments by column chromatography
10. Separation of iron and aluminium by column chromatography

<p><b>MCHL-023: ENVIRONMENTAL CHEMISTRY</b> <b>(CREDITS: 4)</b></p>
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Environmental Chemistry is a multidisciplinary science involving chemistry, physics, life sciences, agriculture, medical sciences, public health, sanitary engineering, etc. and forms a part of broader objective of studying environment.

This course deals with the study of sources, reactions, effect and fate of chemical species in the three broad components of environment viz. air, water and soil and the effect of human activity upon these i.e. the pollution aspects. Besides this, the course gives theoretical as well as practical aspects of the analysis of these components of environment using instrumental and non-instrumental methods.

**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.

## Semester 4

<b>MCHL-018: ENVIRONMENTAL CHEMISTRY LAB (CREDITS: 2)</b>
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The experiments included in this course belong to three main categories viz. experiments related to soil analysis, water analysis and analysis for some atmospheric components. All the experiments make use of simple qualitative and quantitative analytical techniques. The quantitative techniques include volumetric as well as some instrumental methods.

The first experiment (1:(i)) is of a general type which describes the sampling of water and soil. Acidity of water and soil may vary from place to place and needs to be ascertained for various purposes. Experiment (1:(ii)) is related to the pH and conductivity measurement of water and soil samples using a pH meter and a conductometer. Agriculture carries a lot of weightage for our country. It is important to be aware of the nutrient elements present in soil so that it could be suitably fertilized to maximize crop yields. In view of this Experiments 2 and 3 are dedicated to the analysis of both major and minor nutrient elements in soil samples.

It has become inevitable to analyse and assess the quality of the water used by every living being in the world. Keeping this in mind Experiments 4 to 6 and 7 to 9 deal with analysis of water for detection of its alkalinity, soluble chlorides, nitrates, dissolved oxygen, hardness and chemical oxygen demand etc.

Experiments 10 to 13 are related to the analysis of emissions or pollutants which are released into atmosphere and determination of some meteorological aspects of atmosphere like rainfall, dust and humidity. The last experiment of the block viz. Experiment 14 deals with analysis of pesticides which enter into soil when sprayed in fields to kill the and are harmful to all those who consume plants grown in such a soil.

## Experiments

***Any ten experiments from the following:***

- 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 a Dustfall, Rainfall and Humidity
- Experiment 11: Detection of CO and NO<sub>2</sub> in Air/ Gaseous Emissions
- Experiment 12: Determination of Suspended Particulate Matter in Air and NO<sub>2</sub> in Ambient Air/Gaseous Emissions
- Experiment 13: Determination of Sulphur Dioxide in Ambient Air/Gaseous Emission
- Experiment 14: Identification of Pesticides in Pesticide Residues

<p style="text-align: center;"><b>MCH-020: INTRODUCTION TO RESEARCH</b> <b>(02 Credits, 30 Lectures)</b></p>
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The learners of a Post Graduate programme generally have a desire to go for a research degree programme after completing the PG degree in view of better placements in Academic and Research and Development institutions. The '**Introduction to Research**' course offered in the 4<sup>th</sup> Semester of the M.Sc. (Analytical Chemistry) programme aims to introduce various aspects and stages of research to the aspirants willing to go further in this direction. The course is worth **2 credits** only which gives the preliminary information on basic terms and their significance in initiating research in Chemistry. Thus it begins with explaining the concept of research methodology and research methods and the various ways of taking up research work in the current context. The learners would learn an effective way to pick up a research problem keeping in mind the criteria of feasibility and significance of the proposed work. The methods of sampling and data analysis are explained well for the interpretation of results. The units cover

the procedure of writing a paper and the ethical aspects related to publishing a paper. The self learning material gives the best way of presenting the work done using a power point presentation tool. Thus the course intends to motivate the learners to take up challenging problems in a systematic manner right from the beginning.

**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 toolsetc); 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] P. Oliver, Writing Your Thesis, New Delhi: Vistaar Publications, 2004.

- [4] J. W. Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 3rd. ed. Sage Publications, 2008.
- [5] Kumar, Research Methodology: A Step by Step Guide for Beginners, 2nd. ed. Indian: PE, 2005.
- [6] B. C. Nakra and K. K. Chaudhry, Instrumentation, Measurement and Analysis, 2nd. ed. New Delhi: TMH publishing Co. Ltd., 2005.
- [7] Gregory, Ethics in Research, Continuum, 2005.

<b>MCHL-003: SPECTROSCOPIC METHODS</b> <b>(CREDITS: 6)</b>
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Spectroscopic methods of analysis are based on the consequences of the interaction of radiation with matter. Spectroscopic methods course deals with the concepts based on the nature of matter and the type of interaction involved. It is divided into five blocks. Blocks 1 and 2 deal with molecular systems and are titled as '**Molecular Spectroscopic Methods-I**' and '**Molecular Spectroscopic Methods-II**', respectively. The first of these deals with absorption and scattering of radiation while the second covers methods based on emission of radiation. Blocks 3 and 4 deal with atomic systems and are accordingly titled as '**Atomic Spectroscopic Methods-I**' and '**Atomic Spectroscopic Methods-II**' respectively. Block 5, i.e. the last block, is titled '**Miscellaneous Methods**' and covers the nuclear magnetic resonance and mass spectrometric methods. We would like to mention here that though mass spectrometry is not a type of spectroscopy, yet it is included in the course as it is one of the important techniques of structural elucidation. Needless to say that it is an integral part of analytical methods. All the units covered in these blocks deal with details of principles, instrumentation and the applications of the techniques described.

**Electromagnetic Radiation: What is Electromagnetic Radiation?** - Wave Mechanical Model of Electromagnetic Radiation, Quantum Model of Electromagnetic Radiation; Consequences of Wave Nature of Electromagnetic Radiation - Interference, Diffraction, Transmission, Refraction, Reflection, Scattering, Polarisation; Interaction of EM Radiation with Matter - Absorption, Emission, Raman Scattering.

**UV-Visible Spectrometry:** Origin and Characteristics of UV-VIS Spectrum - Origin of UV-VIS spectrum, Characteristics of UV-VIS Spectrum, Absorbing Species; Principle of UV-VIS Spectrometry - Lambert's Law, Beer's Law, Deviations from Beer-Lambert's Law; Instrumentation for UV-VIS Spectrometry - Radiation Sources, Wavelength Selectors, Monochromators, Sample Handling, Detectors, Signal Processing and Output Devices; Types of UV-Visible Spectrometers - Single Beam Spectrometers, Double Beam Spectrometers, Photodiode Array Spectrometer; Analytical Applications of UV-Visible Spectrometry - Qualitative Applications, Quantitative Applications, Quantitative Determination Methodology, Simultaneous Determination.



**Infra Red Spectrometry:** Theory of Infra Red Spectrometry - Vibrations of Diatomic Molecules, Vibrations of Polyatomic Molecules, Complexity of the IR Spectra of Polyatomic Molecules, Characteristics of IR Spectrum; Basic Components of IR Instruments - Sources of IR Radiation, Sampling Devices, Monochromators and Frequency Modulators, Transducers or Detectors, Signal Processing and Output Devices; Instruments for IR Spectrometry - Dispersive Infra Red Spectrometers, Fourier Transform Infra Red Spectrometers; Applications of Infra Red Spectrometry - Qualitative Applications, Quantitative Applications, Clinical and Biomedical Applications.

**Raman Spectroscopy:** Theory of Raman Spectroscopy - Quantum or Particle Theory, Classical or Wave Theory, Raman Activity of Vibrations, Rule of Mutual Exclusion, Depolarisation Ratio; Instrumentation for Raman Spectroscopy - Radiation Sources for Raman Spectroscopy, Sample Handling Devices, Transducers or Detectors; 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, Activation, Deactivation; Fluorescence Spectrum; Fluorescent and Phosphorescent Species - Photoluminescence and Structure; Factors Affecting Fluorescence and Phosphorescence; Fluorescence Quenching - Quantum Yield; Instrumentation for Fluorescence Measurement - Sources, Wavelength Selectors, Sampling, Detectors, Read out Devices; Instrumentation for Phosphorescence Measurement - Sampling, Recording Procedure; Applications of Fluorescence and Phosphorescence.

**Applications of Fluorimetry and Phosphorimetry:** Fluorescence Analysis Methods - Direct Analysis Methods, Indirect Analysis Methods; Fluorescence Spectroscopy in Quantitative Analysis - Concentration Dependence of Fluorescence, Factors Affecting Quantitative Applications of Fluorimetry; Fluorimetry and Environmental Monitoring - Analysis of Gaseous Pollutants, Analysis of Water Pollutants; Fluorescence Spectroscopy in Medicine and Biology - Analysis of Amino Acids and Proteins, Fluorimetric Determination of Blood Glucose, Analysis of Blood Serum, Analysis of Creatinine Phosphokinase, Analysis of Calcium Ion, Bioluminescence; Fluorimetric Analysis of Inorganic Substances - Chemical Reactions Producing Fluorescence, Inorganic Substances Showing Luminescence, Fluorescence with Inorganic Reagents, Fluorescence with Organic Reagents; Fluorescence and Mineral Analysis; Phosphorimetric Methods in Chemical Analysis - Room Temperature Phosphorescence, Applications of Phosphorescence Measurements.

**Flame Photometry:** Origin and Classification of Atomic Spectroscopic Methods - Origin of Atomic Spectrum, Classification of Atomic Spectroscopic Methods; Characteristics of Atomic Spectrum - Position of the Signal, Intensity of the Signal, Spectral Line Width; Principle of Flame Photometry - Fate of the Sample in the Flame; Flame and its Characteristics - Structure of Flames, Reactions in Flames; Instrumentation for Flame Photometry - Flame Atomiser, Atomiser Burners, Monochromator, Detector, Amplifier and Readout Device; Applications of Flame Photometry - Qualitative Applications, Quantitative Applications, Methodology of

Quantitative Analysis, Other Applications; Interferences in Quantitative Determinations - Spectral Interferences, Ionisation Interferences, Chemical Interferences, Other Factors; Merits and Limitations of Flame Photometry.

**Atomic Fluorescence Spectrometry:** Origin of Atomic Fluorescence - Atomic Fluorescence Spectrum, Types of Atomic Fluorescence Transitions; Principle of Atomic Fluorescence Spectrometry - Fluorescence Intensity and Analyte Concentration; Instrumentation for Atomic Fluorescence Spectrometry - Radiation Sources, Atom Reservoirs, Monochromators, Detectors, Readout Devices; Applications of Atomic Fluorescence Spectrometry - Interferences, Merits and Limitations.

**Atomic Absorption Spectrophotometry:** Principle of Atomic Absorption Spectrophotometry - Concentration Dependence of Absorption, Quantitative Methodology; Instrumentation for Atomic Absorption Spectrophotometry - Radiation Sources, Atomisers, Monochromators, Detectors, Readout Devices; Graphite Furnace Atomic Absorption Spectrophotometry - Electrothermal Atomisers, Handling Background Absorption in GFAAS, Advantages and Disadvantages of GFAAS; Atomic Absorption Spectrophotometers - Single Beam Atomic Absorption Spectrophotometer, Double Beam Atomic Absorption Spectrophotometer; Interferences in Atomic Absorption Spectrophotometry - Spectral Interferences, Chemical Interferences, Physical Interferences; Sample Handling in Atomic Absorption Spectrophotometry - Preparation of the Sample, Use of Organic Solvents, Microwave Digestion, Sample Introduction Methods; Applications of Atomic Absorption Spectrophotometry.

**Atomic Emission Spectrometry:** Principle of Atomic Emission Spectrometry - Atomic Emission Spectrometry using Plasma Sources; Plasma and its Characteristics - Inductively Coupled Plasma, Direct Current Plasma, Microwave Induced Plasma, Choice of Argon as Plasma Gas; Instrumentation for ICP-AES - Sample Introduction, Monochromators, Detectors, Processing and Readout Device; Types of instruments for ICP-AES - Sequential Spectrometers, Simultaneous Spectrometers; Analytical Methodology in ICP-AES - Qualitative Analysis using ICP-AES, Quantitative Analysis using ICP-AES; Interferences in ICP-AES - Spectral Interferences, Physical Interferences, Chemical Interferences; Applications of ICP-AES.

**Applications of AAS and AES:** Salient features of AAS and AES - Salient features of AAS, Salient features of AES, Comparison between AAS and AES; Sample Preparation; Applications of AAS - Biological Samples, Environmental Samples, Industrial Samples; Applications of AES - Biological Samples, Geological Samples, Environmental Samples, Industrial Samples.

**NMR Spectroscopy:** Theory of NMR Spectroscopy - Types of Nuclei, Magnetic Moment, Quantisation, Population of Energy Levels, Larmor Precession, Mechanism of Resonance, Relaxation Mechanisms, Nuclei other than Protons; Fourier Transform NMR; Chemical Shift - Shielding Mechanism, Standard for Chemical Shift, Unit of Chemical Shift, Factors Affecting Chemical Shift; Spin-Spin Coupling - Magnitude of Coupling Constants; Instrumentation for NMR Spectroscopy - Magnet, The Sample Probe, Detector System, Sample Handling, Representation of NMR; Applications of NMR Spectroscopy - Quantitative Applications, Qualitative Applications.

**Mass Spectrometry:** Theory of Mass Spectrometry - Characteristics of Mass Spectrum, Isotopic Peaks; Instrumentation for Mass Spectrometry - Inlet Devices, Ionisation Chamber or Ion Sources, Analysers, Detectors or Ion Collectors, Processing and Output Devices; Applications of Mass Spectrometry - Qualitative Applications of Mass Spectrometry, Quantitative Applications of Mass Spectrometry.

**Structure Elucidation by Integrated Spectroscopic Methods:** Molecular Formula and Index of Hydrogen Deficiency; Structural Information Available from Different Types of Spectra - Mass Spectrum, UV-VIS Spectrum, IR Spectrum,  $^1\text{H-NMR}$  Spectrum; Structure Elucidation of Organic Molecules.

<b>MCHL-003: SPECTROSCOPIC METHODS LAB</b> <b>(CREDITS: 2)</b>
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You would recall that in the introduction to the course on spectroscopic methods we mentioned that in today's world of ever expanding scientific endeavour venturing into newer frontier, we are confronted with the challenges of analysing smallest possible amounts of the analyte in the shortest span of time and in such a scenario the spectroscopic methods of analysis are indispensable. The course then embarked on establishing the same by delineating the theoretical foundations of different spectroscopic methods; the principles of the instruments that make the measurements of different spectra possible and the myriad to applications in diverse areas like, pharmacy, medicine, industry, petrochemicals, astronomy, environment, forensic sciences, etc. Having learnt all that, we feel that, you have the necessary theoretical background to take up some of the actual analytical determinations based on spectroscopic measurements.

This laboratory course has been designed to put the concepts learnt in the MCH-003 course into practice. There are a total a ten experiments in this course. Of these, nine are based on molecular spectroscopic methods and one is based on different spectroscopic methods in different ways like, the quantitative determination of different species, alone as well as in the mixtures, determination of physical constants like  $\text{pK}_a$  of a weak organic acid, and on the structure determination of organic molecules. The first six and the last experiments pertain to the quantitative determinations whereas the experiments 7, 8 and 9 provide the necessary inputs to decipher the structure of an organic molecule based on its IR, NMR and mass spectra.

The list of experiments is given below:

### EXPERIMENTS

1. Spectrophotometric determination of Fe(II) ions using 1,10-orthophenanthroline
2. Spectrophotometric determination of Ni(II) ions using dimethylglyoxime.
3. Spectrophotometric determination of Cr and Mn ions in a mixture of the two

4. Spectrophotometric Determination of Methyl ethyl Ketone
5. Determination of  $pK_a$  value of indicators spectrophotometrically
6. Turbidometric determination of sulphate ions
7. Characterisation of functional group in organic compounds using IR spectroscopy
8. Structural Determination of Simple Organic Compounds Using  $^1H$ -NMR Spectrometry
9. Determination of the structure of an organic compound using UV, IR, NMR, and Mass spectra
10. Flame photometric determination of Na and K or Ca and Mg using internal standard method

<p style="text-align: center;"><b>MCHL-004: ELECTROANALYTICAL AND OTHER METHODS</b> <b>(CREDITS: 6)</b></p>
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This course is introduced to give you a reasonable understanding in the major techniques of electroanalytical methods, thermal methods and radioanalytical methods. In this course we will cover the basic theory, the practical aspects and scope of all individual techniques of these three categories. In electroanalytical techniques we use one or more electrical properties under controlled condition to obtain qualitative and quantitative information of a sample. These techniques can be divided into several classes depending on which aspects of the electrochemical cell are controlled and which are measured. You may be familiar with some of the electroanalytical techniques like **potentiometry**. In this course along with these techniques we will also introduce few new electroanalytical techniques like **coulometry** and **voltammetry**. All these electroanalytical techniques will be discussed in Blocks 1, 2 and 3.

Similar to electrical properties, in **thermal methods** we study changes in the physical and chemical properties of a sample while it is undergoing heating process. We are also focusing on three important thermal techniques, that is, **thermo gravimetric analysis** (TGA), **differential thermal analysis** (DTA) and **differential scanning calorimetry** (DSC). These techniques are discussed in Block 4. In last block of this course, i.e. Block 5, you will study **radioanalytical** methods which are unique with regard to theoretical principles involved, handling of radioisotopes, and instrumentation.

**Introduction to Electro-Analytical Methods:** Basic Concepts - Electrical Units, Basic Laws of Electrochemistry, Electrode Potential, Liquid-Junction Potentials, Electrochemical Cells, The Nernst Equation, Cell Potential; Classification and an Overview of Electroanalytical Methods - Potentiometry, Voltammetry, Polarography, Amperometry, Electrogravimetry and Coulometry, Conductometry; Classification and Relationships of Electroanalytical Methods.

**Potentiometry-I:** Potential - Measurement of Potential; Direct Potentiometry - Reference Electrodes, Indicator Electrodes; Determination of Equilibrium Constants; Potentiometric Titrations - Location of End Points, Types of Potentiometric Titrations.

**Potentiometry-II:** Concept of pH; Glass Membrane Electrodes; pH Meter; Measurement of pH; pH Titration; Modified Glass and Solid State Membrane Electrodes.

**Conductometry:** Electrolytic Conductance - Molar Conductivity, Variation of Conductance with Concentration, Limiting Molar Conductivity, Effect of other Factors on Conductance; Measurement of Electrolytic Conductance - The Wheatstone Bridge Principle, Measurement of Conductance of a Solution; Applications of Conductometry.

**Electrogravimetry and Coulometry:** Electrogravimetric Analysis; Polarisation; Types of Electrogravimetric Methods - Constant Current Electrolysis, Constant Potential Electrolysis; Coulometry; What is a Coulometer?; Types of Coulometric Methods - Controlled Potential Coulometry (Potential Coulometry), Constant Current Coulometry (Amperostatic Coulometry).

**Applications of Conductometry, Electrogravimetry and Coulometry:** Application of Conductometry - Degree of Dissociation of Weak Electrolyte and its Dissociation Constant, Ionic Product of Water, Solubility and Solubility Product of Sparingly Soluble Salt, Conductometric Titrations; Application of Electrogravimetry; Application of Coulometry - Applications of Coulometric Titrations.

**Voltammetry:** Electrodes and Processes; Common Voltammetric Methods; Direct Methods - Linear Sweep Voltammetry, Sampled DC Polarography, Hydrodynamic Voltammetry; Pulse Methods - Normal Pulse Voltammetry, Differential Pulse Voltammetry, Square Wave Voltammetry, Cyclic Voltammetry; Stripping Methods - Anodic Stripping Voltammetry, Cathodic Stripping Voltammetry, Adsorptive Stripping Voltammetry, Alternating Current Methods - Voltammetry-Instrument.

**Polarography and Amperometric Titrations:** Polarography; Dropping Mercury Electrode; Limiting and Migration Currents - The Limiting Current, The Migration Current; Diffusion and Residual Currents - The Diffusion Current, The Residual Current; Factors affecting the Diffusion Current - Concentration of Electroactive Substance, Capillary Characteristics, Temperature, Solvent and Supporting Electrolyte; Polarographic Equation;  $E_{1/2}$  and Effect of Complexing Agents - Half-Wave Potential, Effect of Complexing Agents; Estimation of  $n$ -values and Reversibility; Currents other than the Diffusion Current - Kinetic Currents, Catalytic Currents, Adsorption Waves; Polarographic Maxima and Maximum Suppressors; Qualitative and Quantitative Polarographic Analysis; Instrument; Amperometric Titrations - Advantages of Amperometry, Few Examples of Amperometric Titration, Titrations with the Rotating Platinum Electrode, Biamperometry or Dead-Stop End Point Method.

**Applications of Polarography, Amperometric Titrations and Voltammetry:** Applications of Polarography; Applications of Amperometric titrations; Polarography Experiments - Determination of ascorbic acid in citrus fruits, Determination of ascorbic acid (Vitamin C) in the citrus juice by the standard addition and calibration curve methods, Other industrial important determinations for traces or minor constituents, Determination of lead and copper in carbon steels, Determination of the amount of  $Cd^{2+}$  present in the unknown solution, Determination of the nature of the ion ( $E_{1/2}$ ); Applications of voltammetry - Voltammetry – Instrument, Practical methods: steps involved in voltammetry; Application of Cyclic Voltammetry.

**Thermogravimetric Analysis:** Instrumentation; Sources of Error in TGA; Interpretation of TG Curve; Factors Affecting TG Curve; Applications of Thermogravimetric Analysis.

**Differential Thermal Analysis, Scanning Calorimetry and Thermometric Titrations:** Differential Thermal Analysis (DTA) - Principle, Characteristics of DTA Curves, Instrumentation, Factors Affecting DTA Curves, Sources of Errors, Interpretation of DTA Curve, Applications; Differential Scanning Calorimetry - Principle, Instrumentation, Factors Affecting DSC Curves, Sources of Errors, Interpretation of DSC Curve, Applications, Advantages of DSC; Thermometric Titrations - Principle, Instrumentation, Applications.

**Fundamentals of Radioactivity:** Radioactivity and Decay Law - What is Radioactivity?, Why Radioactive?, Discovery of Radioactivity, Laws of Radioactivity, Units of Radioactivity; 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 - Gas Ionization Detectors, Scintillation Detector, Semiconductor Detector; 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) - Principle and Equation, Instrumentation, Applications, Advantages and Limitations, Substoichiometric Isotope Dilution Analysis (SIDA); Activation Analysis (AA) - Principle of NAA, Neutron Sources, Interferences, Sensitivity and Detection Limits, Classification, Instrumentation, Applications, Advantages and Limitations; Comparison of NAA and IDA with Other Methods; Radiometric Titrations (RT) - Procedure, Advantages and Limitations; Radiochromatography; Radioimmunoassay - Principle, Methodology, Procedure, Applications.

## **MCHL-004: ELECTROANALYTICAL AND OTHER METHODS LAB** **(CREDITS: 2)**

This course deals with experiments in Electroanalytical and other Methods. Along with the experimental detail, the basic concepts on which the experiment procedures are based have also been discussed as required. There are eleven experiments in this course. These experiments can be divided into four types. The first five experiments are based on the potentiometry and pH-metry while Experiments 6 to 8 based on conductometry. Experiments 9 and 10 are concerned with polarography and amperometry. Last experiment is based on radiotracer techniques. This experiment is a demonstration type for which video demonstration may be arranged.

The list of experiments of this course are as given below:

### **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  $\text{Fe}^{2+}$  with  $\text{Cr}_2\text{O}_7^{2-}$
5. Potentiometric determination of  $\text{Cl}^-$  ion content of common salt using  $\text{AgNO}_3$
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  $\text{Cd}^{2+}/\text{Pb}^{2+}/\text{Zn}^{2+}$  by polarography
10. Amperometric Titration of  $\text{Pb}^{2+}$  with  $\text{Cr}_2\text{O}_7^{2-}$
11. Determination of the solubility of a sparingly soluble salt by radiotracer method

## **Scheme of Study**

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In order to enable you to complete your M.Sc. (Analytical Chemistry) programme within the minimum period of two years, you will have to complete 80 credits worth of courses in four semesters. Registration to the programme is annual, so you register for the first and second semester in Year 1 and for the third and fourth semester in Year 2. In the second year irrespective of whether you pass or not in all the courses of the first year, you must re-register for the third and fourth semester by submitting the Re-registration Form with the requisite programme fee.

It is quite possible that you may not find sufficient time to prepare for the Term End Examinations of all the courses you have registered for. You can focus only on those courses in which you intend to take the examination. You can give the examination of the remaining courses later. You may appear for the term-end examinations for the first time after one year of admission to the programme, at that time, you are eligible to appear for the exams of the first and second semesters. Thereafter you can appear for your exams every six months till the completion of the validity of your admission. Examinations are held in the month of June/December of each year. In this way, you can plan your courses within two to four years. By a proper planning every year, you can complete this programme according to your convenience.

## **3. INSTRUCTIONAL SYSTEM**

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The methodology of instruction in Indira Gandhi National Open University is different from that of the conventional universities. The Open and Distance Learning (ODL) University system is more learner- oriented, and the learner has to be an active participant in the teaching-learning process. Most of the instruction is imparted through distance mode with only a small component of face-to-face communication. The University follows a multi-channel approach for instruction. It comprises a suitable mix of:

- ☞ Self-instructional material in pdf or printed form
- ☞ Face-to-face counselling at LSC by academic counsellors
- ☞ Compulsory practical sessions at the LSCs
- ☞ Reference library
- ☞ eGyankosh
- ☞ Assignments
- ☞ Interactive Radio Counselling through Gyan Vani

## **Self-instructional Material**

Self-instructional materials are the primary form of instructional materials. These are provided to the learners in the form of several booklets called volumes. A volume which comes in the form of a booklet, consists of blocks and a block, comprises several units. The first page of each volume/block indicates the numbers and titles of the blocks/units comprising the volume/block. In the first volume/block of each course, we start with course introduction. This is followed by a brief introduction to the volume/block.

**Please read the Course Introduction and the Block Introduction carefully as these will give you an overview of the Course and Block, respectively.**

Each unit begins with an introduction in which we tell the learners about the contents of the unit. We also outline a list of learning objectives which we expected from learners to achieve after working through the units. This is followed by the main body of the unit, which is divided into various sections and sub-sections. We finish each unit by summarizing its contents. In each unit, there are several examples, self-assessment

Questions and terminal questions. These are meant to help the learner to assess his/her understanding of the subject contents. For all courses of the programme, the learner will be receiving printed study materials in the form of booklets called volumes. The material prepared by us is properly planned, self-content, self-motivated, and self-instructional in nature. The lessons which called units, are structured to facilitate self-study. The printed materials for MSCAST programme along with the Programme Guide are sent to the learners by registered post at their residential address provided by them.

## **eGyankosh and IGNOU eContent App**

The self-instructional material is also assessable in electronic form through IGNOU eGyankosh website and eContent App. The eGyankosh is a digital repository consists of the reference links Self instructional materials. The links for the eGyankosh related to School of Sciences are:

eGyankosh Homepage: <http://www.egyankosh.ac.in/>

Self-Learning Material: <http://www.egyankosh.ac.in/handle/123456789/25>



## IGNOU eContent App

The self-instructional course material of various programmes of IGNOU are made available through IGNOU eContent App. You can download this **IGNOU e-Content App** from Google play store. <https://play.google.com/store/apps/details?id=ac.in.ignou.Viewer&hl=en>

## Counselling Sessions

In distance education, fact-to-face contact between the learners and their tutors/counsellors is relatively less as compared to the conventional university and, therefore, is an important activity. The purpose of such contacts is to answer some of learners' questions and clarify their doubts which may not be possible through any other means of communication. There are academic counsellors at the Learner Support Centres to provide counselling and guidance to the learner in the courses that they have chosen for study. Normally, these sessions will be held at the Learner Support Centres during weekends (**Saturdays and Sundays**).

The candidates should note that the counselling sessions will be very different from the classroom teaching or lectures. Counsellors will not be delivering lectures as in conventional teaching. They will try to help the learners to overcome difficulties which they face while studying. In these sessions, the learner must try to resolve his/her subject-based difficulties and any other related problems.

**Before going to attend the counselling sessions, you are advised to please go through the course materials and make a plan of the points to be discussed during counselling sessions. Unless you have gone through the units, there may not be much to discuss during counselling sessions.**

The MSCAST programme has three types of courses: theory, practical and project/dissertation. **The detailed schedule of the counselling sessions for both theory and lab courses will be informed to the learners by the coordinator of their Study 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 should be as follows:

- (i) Lab counselling of 3 days (2 sessions per day each of 4 hours) should be compulsory for 2 credits lab course.

- (ii) Lab counselling of 6 days (2 sessions per day each of 4 hours) should be compulsory for 4 credits labcourse.
- (iii) Lab counselling of 9 days (2 sessions per day each of 4 hours) should be compulsory for 6 credits labcourse.

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 Study Centre to know the schedule of the LabSessions.**

**Note:** Project/dissertation is an optional course where the learner can take either project/dissertation or opt for alternative theory courses “MSTE-011: Operations Research” (4 credits) and “MSTE-012: Stochastic Processes” (4 credits) together.

## **Web Based Supports**

The learners can have access to IGNOU’s website at the following address (URL):  
[www.ignou.ac.in](http://www.ignou.ac.in)

**This website gives relevant information to the general public and learner support facilities to the learners. These include:**

- Results of the Term- End Examinations
- Downloadable prospectus/application forms of various programmes
- Catalogue of audio/video programmes
- Schedule of Gyan Darshan/ Gyan Vani/ EDUSAT programmes
- Admission announcements
- Addresses of Regional and Study Centres
- Update on the latest happenings at the University
- Checking of learner’s mailing address
- Online submission of Term-End Examination Form
- TEE date-sheet
- Examination Hall Ticket
- Course Completion Status

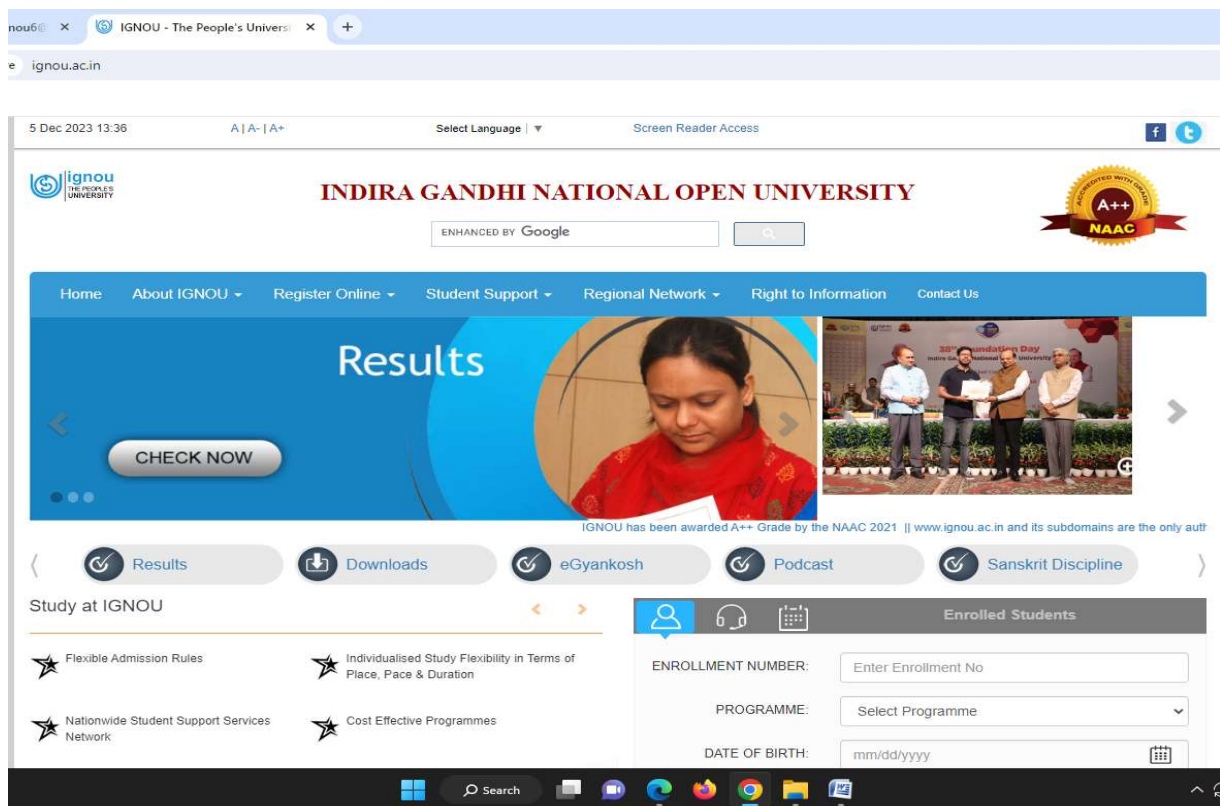
The learners access **e-Gyankosh** using this website to download their course material. Programme Guide and Assignments are also available at the IGNOU website.

## Browsing IGNOU's Website

The IGNOU's website is a dynamic source of latest information and is subject to continuous updates. Thus, various pages shown here may change in future. IGNOU itself is continuously changing to bring about improvement in quality of its services. You must visit IGNOU website for all latest information, filling up or downloading various form, downloading of assignments, results, etc.

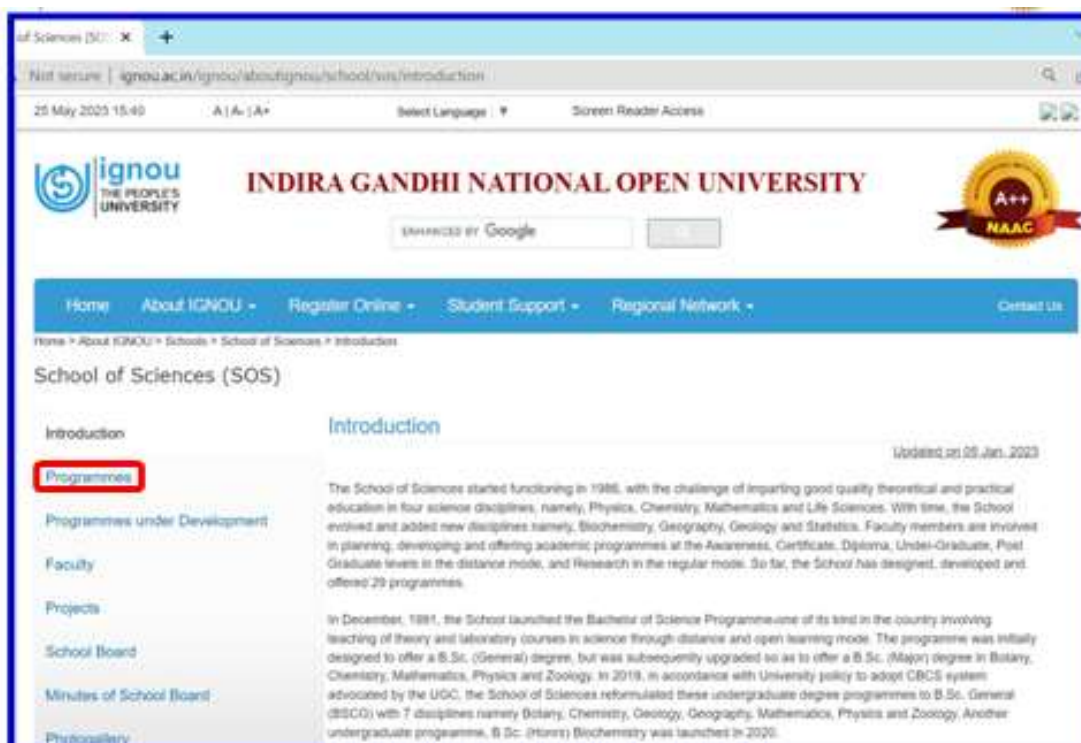
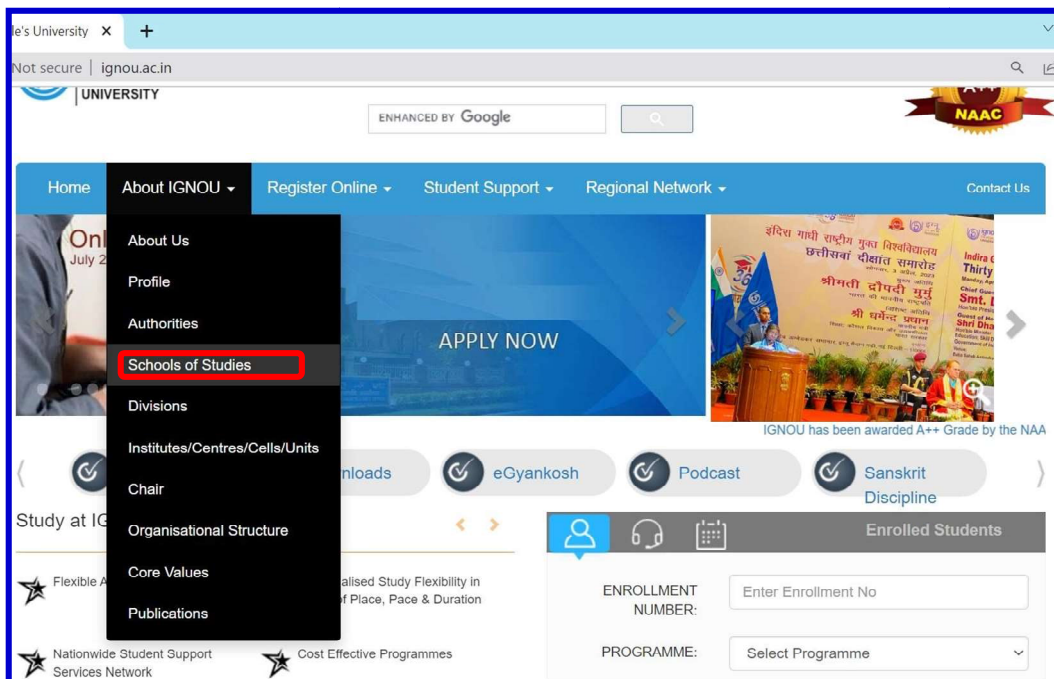
## Navigation from Home Page

The learners can have access to IGNOU's website at the following address (URL) ***http:// www.ignou.ac.in***. As learners get connected to this site, the Home Page of the IGNOU's website will appear (as shown in Fig. 1).



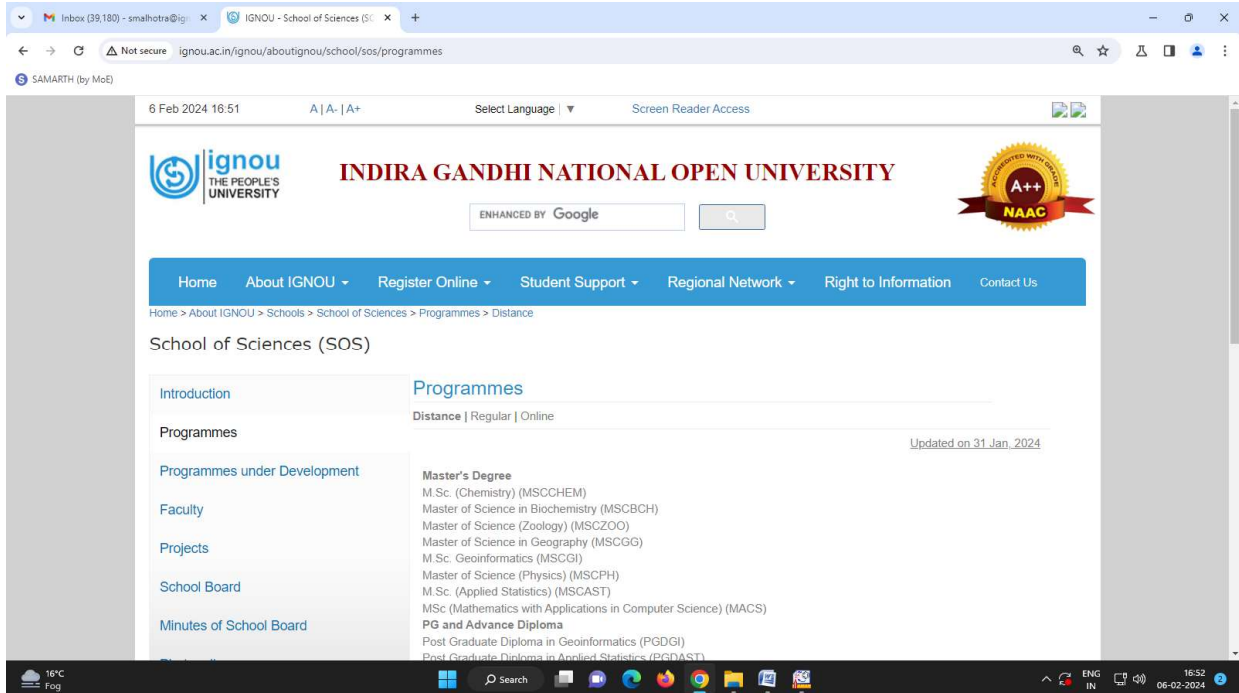
**Fig. 1: Home Page of the IGNOU's Website**

From this **Home page**, a learner can navigate to various pages by clicking on various options to get the related information. A learner can select **Schools of Studies** from **About IGNOU** option to display various **School of Studies** of IGNOU (Fig. 2a). You can select **School of Sciences (SOS)** to display page of School of Sciences (Fig. 2b).



**Fig. 2: School of Sciences Home Page**

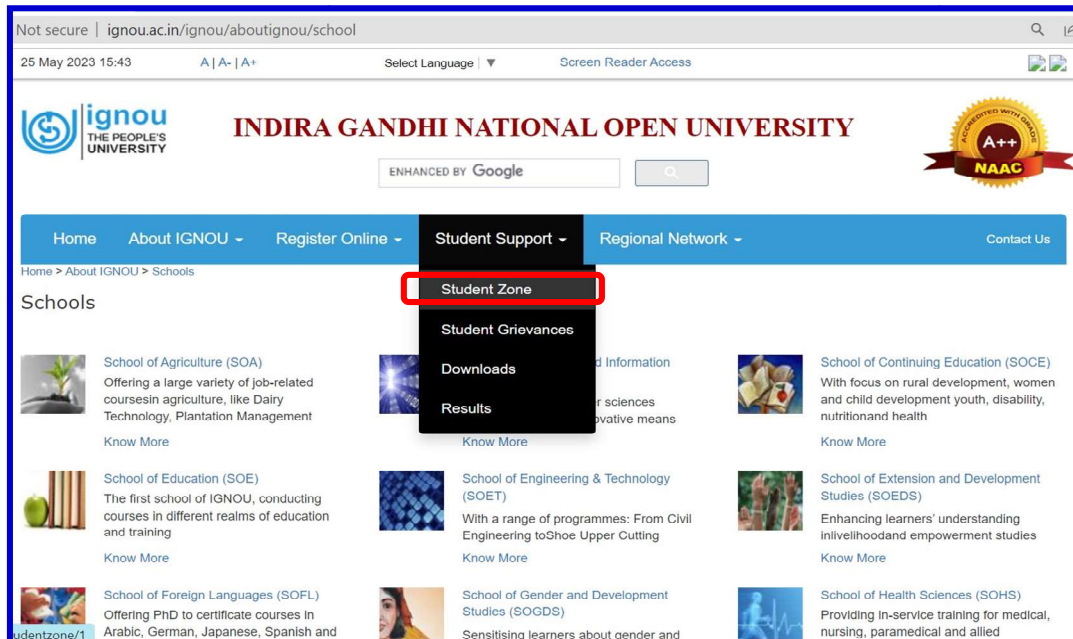
You can click on **Programmes** link on School of Sciences page to get the list of programmes on offer by School of Sciences as shown in Fig. 3.



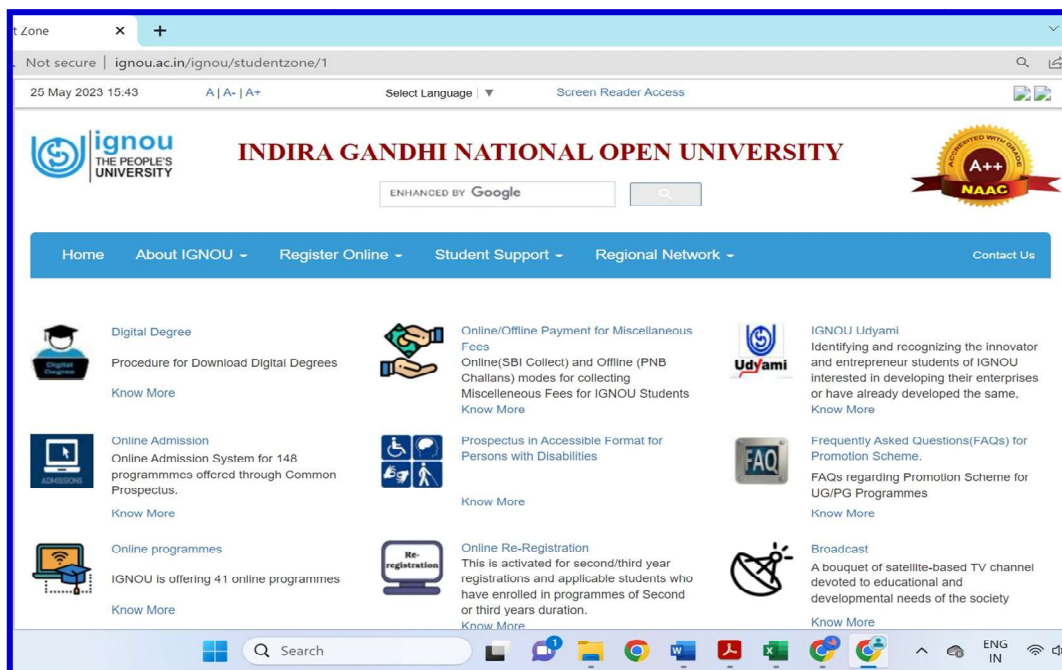
The screenshot shows the IGNOU website's 'Programmes' page for the School of Sciences (SOS). The page features a navigation menu with options like Home, About IGNOU, Register Online, Student Support, Regional Network, Right to Information, and Contact Us. The main content area is titled 'School of Sciences (SOS)' and lists various programmes under Development, Faculty, and Projects. A sidebar on the left provides links to Introduction, Programmes, and Minutes of School Board. The top right corner displays the NAAC A++ accreditation logo.

**Fig. 3: Programmes of the School of Sciences**

One of the most important links for learners is Student Zone which can be reached from Home page by selecting Student Zone option on the Student Support Option List (Link address: <http://www.ignou.ac.in/ignou/studentzone>). Fig. 4 displays the options of the Student Zone page.



The screenshot shows the IGNOU website's 'Student Support' menu. The 'Student Support' option is highlighted in a dark blue box, and a dropdown menu is visible with 'Student Zone' highlighted in a red box. Other options in the dropdown include Student Grievances, Downloads, and Results. The background shows the 'Schools' section of the website, listing various schools like School of Agriculture (SOA), School of Education (SOE), School of Foreign Languages (SOFL), School of Engineering & Technology (SOET), School of Gender and Development Studies (SOGDS), School of Health Sciences (SOHS), School of Continuing Education (SOCE), and School of Extension and Development Studies (SOEDS).



**Fig. 4: Student Zone page**

One of the most important links for learners is Student Zone which can be reached from Home page by selecting Student Zone option on the Student Support Option List (Link address: <http://www.ignou.ac.in/ignou/studentzone>). Fig. 4 displays the options of the Student Zone page.

## 4. EVALUATION SCHEME

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

**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.

**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 30% weightage. The learners have to submit a record book containing R/Python codes of the solutions of exercises given at the end of each lab session along with the output of the programs and necessary screenshots, hypotheses, interpretations, etc. This record book will be a part of their continuous assessment and will be required to submit before the term-end lab examination to the Programme Coordinator/Counsellor at Study Centre.

Every lab exercise is evaluated and is included for final evaluation, the weightage for the continuous assessment (record book) is 30%.

- b) Term-end evaluation** of performance in the lab exam carries a weightage of 70% 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 and carries 70% weightage out of which 50% is allotted for term-end exam and 20% for Viva-voce. The schedule of term-end lab examination will be notified to the learners by the Coordinator of their Programme/Study Centre and intimated to the eligible candidates by the Regional Centre.

**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. However, the overall average should also be at least 40% 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%

In order 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.

## Assignments

An assignment is a **compulsory** component of each theory course. 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 also 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:** .....

- 
- (i) Read the assignments carefully and follow the specific instructions, if any, given in the assignment itself.
  - (ii) 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.

- (iii) 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.
- (iv) The learners should write each assignment separately. All assignments should not be written in continuity.
- (v) **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.**
- (vi) **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.**
- (vii) 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.
- (viii) 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.
- (ix) 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 final result.**

### **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, practical examination and project evaluation.

## **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. **In this programme, a learner is eligible to appear for the Term End examinations one year after admission for all courses of the first and second semesters, and every six months thereafter.** You can also appear for these exams in later cycles as per the validity of your programme.

### 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 <sup>st</sup> March to 31 <sup>st</sup> March	1 <sup>st</sup> Sept to 30 <sup>th</sup> Sept	NIL	At the concerned Regional Centre under which your Examination Centre falls.
1 <sup>st</sup> April to 30 <sup>th</sup> April	1 <sup>st</sup> Oct to 31 <sup>th</sup> Oct	500/-	
1 <sup>st</sup> May to 15 <sup>th</sup> May	1 <sup>st</sup> Nov to 15 <sup>th</sup> 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.

### 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 (Creditcard/ 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](http://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 1<sup>st</sup> June and 1<sup>st</sup> 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 1<sup>st</sup> September to 15<sup>th</sup> October for June Term-end Examination and from 1<sup>st</sup> March to 15<sup>th</sup> April for December Term-end Examination along with the requisite fee of ` 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. The fee for official transcripts is as under:

#### **For Indian Learners:**

₹ 300/- for each transcript, if to be sent to the Learner/Institute **within India**

₹ 500/- for each transcript, if to be sent to the Learner/Institute **out of India For SAARCCountries Learners:**

₹ 1200/- for each transcript, if to be sent to the Learner/institute of **SAARC Countries. For Non-SAARC Countries Learners:**

\$ 120 for each transcript, if to be sent to the Learner/Institute of **Non-SAARC Countries.**

Format is available in the Programme Guide or IGNOU website: [www.ignou.ac.in](http://www.ignou.ac.in)

## 5. OTHER USEFUL INFORMATION

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### 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.

### 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. have 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 have to 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](http://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](mailto: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](mailto:campusplacement@ignou.ac.in). They are further advised to visit our home page [www.ignou.ac.in](http://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 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.

**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**

## 6. 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, <a href="mailto:assignment@ignou.ac.in">assignment@ignou.ac.in</a> . 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, <a href="mailto:ssc@ignou.ac.in">ssc@ignou.ac.in</a> , Ph. 011-29535714,29533869, 2953380, Fax: 011-29533129

## 7. 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 have 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*

## Useful links and Forms

- **Latest Assignment(s)**
- **Online Re-Registration for MSCAST programme**
- **Online Term end Examination form**
- **Form for early declaration of result**
- **Form for obtaining photocopy of the answer script**
- **Form for Re-evaluation of Answer script**
- **Application form for improvement in Division/Class**
- **Form for obtaining Duplicate Grade Card / Mark-sheet**
- **Form for issue of Official Transcript**
- **Form for issue of Migration Certificate**
- **Date sheet of all programmes**
- **Some other useful links**

### 1. Assignments related links

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

### 2. Re-registration

Link to Online Re-Registration for  
MSCAST 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](#)

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 Prpgramme

[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.

## Assignments Remittance-Cum-Acknowledgement Card

Enrol No. _____ Programme Title _____ Name: _____ Course Code: _____ Medium: _____ S.No.      Assignment      For Office Use Only	 <p><b>INDIRA GANDHI NATIONAL OPEN UNIVERSITY</b> <b>ASSIGNMENTS REMITTANCE-CUM ACKNOWLEDGEMENT CARD</b></p>																		
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 80%;"></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> </table>						S. No. _____			Date of Receipt: _____			Name of Evaluator: _____	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;">           Enrol No. _____            Name: _____            Course Code: _____            S.No.      Assignment         </td> <td style="width: 50%; padding: 5px;">           Programme Title: _____            Medium: _____            For Office Use Only         </td> </tr> <tr> <td style="padding: 5px;">           Signature of the receiver _____            Date: _____         </td> <td style="padding: 5px; text-align: center;">           Seal         </td> </tr> <tr> <td style="padding: 5px;">           Signature of the student            Name: _____            Address of the Student: _____            Date: _____         </td> <td style="padding: 5px;"></td> </tr> </table>	Enrol No. _____ Name: _____ Course Code: _____ S.No.      Assignment	Programme Title: _____ Medium: _____ For Office Use Only	Signature of the receiver _____ Date: _____	Seal	Signature of the student Name: _____ Address of the Student: _____ Date: _____	
		S. No. _____																	
		Date of Receipt: _____																	
		Name of Evaluator: _____																	
Enrol No. _____ Name: _____ Course Code: _____ S.No.      Assignment	Programme Title: _____ Medium: _____ For Office Use Only																		
Signature of the receiver _____ Date: _____	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: _____																			

**Affix  
Stamp  
Here**

From: \_\_\_\_\_ To \_\_\_\_\_

The Coordinator  
THE STUDENT) Study Centre concerned

(ADDRESS OF

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



Form No. 2

(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.***

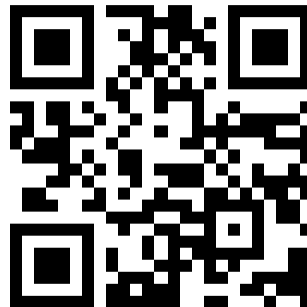
**QR Code of Some of the  
Useful Web Links**



**eGyankosh Online Re-Registration Online(for Online Course Materials)**



**iGRAM To Watch Live Telecast/(IGNOU Grievance control Room)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/Appof your smart mobile phone.**

### List of Study Centres for M.Sc. Analytical Chemistry Programme

S.No.	Name	LSC Codes	Regional Centres
1	Central University of Tamil Nadu	43087	MADURAI
2	Govt. P.G. College (Boys), Jodhpur	2362	JODHPUR
3	D.N. (P.G.) College, Meerut	2799	NOIDA
4	Meerut College, Meerut	2728	NOIDA
5	Udai Pratap Autonomous College, Varanasi	2708	VARANASI
6	Institute Of Science R T Road Civil Line, Nagpur, Maharashtra	36009P	NAGPUR
7	Harish Chandra P.G. College Maidagin, Varanasi	48048	VARANASI
8	Government Degree College, Shimla	1104	SHIMLA
9	Mar Ivanios Institute of Advance Studies, Trivandrum	1441	TRIVANDRUM
10	Handique Girls College, Guwahati	0408	GUWAHATI
11	Gaya College, Gaya	0511	PATNA
12	Anugrah Narayan College, Patna	0529	PATNA
13	JNR Mahavidyalala, Portblair	0201	PORT BLAIR
14	P.K. Roy Memorial College, Dhanbad	0503	RANCHI
15	Govt College, Rourkela	2103	ANGUL
16	Nizam College, Hyderabad	01152	HYDERABAD
17	JNR Mahavidyalala, Port Blair	0201	PORT BLAIR
18	Govt College Rourkela	2103	ROURKELA

You may refer to IGNOU website for latest details of the activated centres for this programme

### List of Regional Centres for M.Sc. Analytical Chemistry Programme

S. No.	Regional Centres	RC Code	Address of Regional Centre Tel. Fax & E-mail	Operational Area
1.	AGARTALA	26	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE M.B.B. COLLEGE COMPOUND P.O. AGARTALA COLLEGE <b>AGARTALA-799004 TRIPURA</b> 0381-2516715/25162660381- 2516714 rd_agartala@rediffmail.com <a href="mailto:rcagartala@ignou.ac.in">rcagartala@ignou.ac.in</a>	STATE OF TRIPURA
2.	AHMEDABAD	09	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE OPP.NIRMA INSTT OF TECHNOLOGY SARKHEJ-GANDHI NAGAR HIGHWAY CHHARODI <b>AHMEDABAD-382481, GUJARAT</b> 02717-24297502717-24157902717- 241580 rcignouahd@yahoo.comrcahmedbad @ignou.ac.in	STATE OF GUJARAT UNION TERRITORY OF DAMAN DIU, DADRA & NAGAR HAVELI
3.	AIZWAL	19	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE LAL BULAIA BUILDING M.G. ROADKHATLA (NEAR CENTRALY MAOFF.) <b>AIZWAL-796001 MIZORAM</b> 0389-2311693,0389-2311692,0389- 2311789 rd_aizwal@rediffmail.com, rcaizawl@ignou.ac.in	STATE OF MIZORAM
4.	ALIGARH	47	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE 3/310 MARRIS ROAD <b>ALIGARH-202001, UTTAR PRADESH</b> 0571-2700120,2701365 ignousrcaligarh@yahoo.comrcaligarh @ignou.ac.in	DISTRICT OF UTTAR PRADESH ETAH, KASGANJ, FIROZABAD, RAMPUR, ALIGARH, HATHRAS, BADAUN, AGRA, BULAND SAHAR, MORADABAD, MANPURI, ETAWAH, MATHURA & JPNAGAR
5.	BANGALORE	13	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE NSSS KALYANA KENDRA, 293,39 <sup>TH</sup> CROSS, 8 <sup>TH</sup> BLOCK JAYANAGAR <b>BANGALORE-560070 KARNATAKA</b> 080-26654747/26657376080- 26639711, 080-26644848 ignourcblr@gmail.com rcbangalore@ignou.ac.in	STATE OF KARNATAKA EXCEPT THE DISTRICT S DHARWAD, BELGAM & UTTARA KARNATAKA

6.	BHOPAL	15	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE SANCHI COMPLEX, 3 <sup>RD</sup> FLOOR OPP. BOARD OF SECONDARY EDN. SHIVAJI NAGAR, <b>BHOPAL- 462016, MADHYA PRADESH</b> 0755-2578455, 0755-25784540755- 2578452, 0755-2578454 ignoubhopal@rediffmail.com ignou_bhupal@yahoo.com rcbhupal@ignou.ac.in	STATE OF MADHYA PRADESH EXCEPT FOR DISTRICTS MENTIONED UNDER REGIONAL CENTRE JABALPUR
7.	BHUBANESHWAR	21	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE C- INSTITUTIONAL AREA <b>BHUBANESHWAR – 751013 ORISSA</b> 0674-2301348 /2301250 /2301352 0674-2300349 rcbhubaneswar@ignou.ac.in	STATE OF ORISSA (EXCEPT THE DISTRICTS MENTIONED UNDERRC KORAPUT & GAJAPATI)
8.	CHANDIGARH	06	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE SCO-208, Sector14, Panchkulan- 134109 Haryana. Ph. 0172-2590208 ignouch@gmail.com rrcchandigarh@ig nou.ac.in	CHANDIGARH U.T., DISTRICT RUPNAGAR. PATIALA. MOHALI AND FATEHGARH SAHIB OF PUNJAB AND DISTRICT UNA OF HIMACHAL PRADESH OPERATED BY RC KHANNA
9.	CENNAI	25	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE C.I.T. CAMPUS TARAMANI <b>CENNAI-600113 TAMILNADU</b> 044-22541919/22542727044- 22542121 044-22542828 rgnldirector@yahoo.in rrcchennai@igno u.ac.in	STATE OF TAMILNADU THE FOLLOWING DISTRICTS AND UNION TERRITORY OF PONDICHEERY, CHENNAI. KANCHIPURAM, VELLORE, CHENGAIPAT, CUDDALORE, VILLUPPURAM. SALEM. NAMAKKAL, PERAMBALU & TIRUVALLORE
10.	COCHIN	14	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE KALOOR <b>COCHIN-682017 KERALA</b> 0484-2340203, 2348189, 23, 0484-2533021 0484-2533021, 2330891, 2340204 igrc14@vsnl.net rccochin@ignou.ac.in	STATE OF KERALA EXCLUDING DISTRICTS MENTIONED UNDERRC TRIVANDRUM

11.	DARBHANGA	46	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE LALIT NARAYAN MITHLA UNIV.CMPKAMESHWARANAGAR. NEAR CENTRAL BANK <b>DARBHANGA-846004 BIHAR</b> 06272-25371906272-251833 srcdarbhanga@yahoo.com antripathi29@rediffmail.comrcdarbhanga@ignou.ac.in	STATE OF BIHAR COVERING DISTRICTS OF PASCHIM CHAMPARAN. GOPALGANJ, SIWAN. SARAN. PURBICHAMPARAN SHEOHAR, MUZAFFARPUR, VAISHALI, SITAMARHI. MADHUBANI, DARBHANGA, SAMASTIPUR,BEGU SARAI, SUPAUL, SAHARSA. KHAGARIA
12.	DEHRADUN	31	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE NANOORKHERA,TAPOVANRAIPUR ROAD <b>DEHRADUN-248001</b> <b>UTTARANCHAL</b> 0135-27891800135-27892050135- 2789190 dimrianiik2002@yahoo.co.inrcdehradun@ignou.ac.in	STATE OF UTTARANCHAL, DISTRICTS OF SARANPUR, MUZAFFARNAGAR, BIJNOR, DEHRADUN, HARIDUAR, UTTARKASHI, SRINAGAR, RUDRAPRAYAG, KOTDWAR, GOPESHWAR, BOAGESHWAR, PITHORGRAH, CHAMPAWAT, ALMORA, NANITAL, UDHAMSINGNAGAR & PURI
13.	DELHI 1	07	REGIONAL DIRECTOR(I/C)IGNOU REGIONAL CENTRE Plot No. J/21,Block-B1, Mohan Cooperative Industrial Estate, Mathura Road,,New Delhi-110044 011-26990082,26990083 Fax: 2690084 email:rcdelhi1@ignou.ac.inwebsite:w ww.ignourcdelhi1.ac.in	SOUTH DELHI, WEST DELHI, DISTRICT FARIDABAD OF HARYANA
14.	DELHI 2	29	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE-2 GANDHISMIRITI & DARSHANSAMITI <b>RAJGHAT, NEW DELHI-110002</b> 011-23392375/23392376/233923772 011-23392374, 011-23392373 ignourd2@ngmail.comrcdelhi2@ignou .ac.in	NORTH-EAST DELHI, EAST DELHI, NORTH DELHI & CENTRAL DELHI

15.	DELHI3	38	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE F-634-636, Palam Extn., Ramphal Chok, Near Sector-7, Dwarka, New Delhi-45 011- 25088939, 25088944, 25088983 rcdelhi3@ignou.ac.in	WEST DELHI AND DISTRICT OF GURGAON OF HARYANA, OPERAT ED FROM RC DELHI-1
16.	GANGTOK	24	REGIONAL DIRECTOR (I/C) IGNOU REGIONAL CENTRE 31A, NATIONAL HIGHWAY, 5 <sup>TH</sup> MILE, BELOW MANIPAL HOSPITAL, TADONG <b>GANGTOK-737102</b> <b>SIKKIM</b> 03592-2311102, 27092303592- 270364 03592-212501 rd_gangtok@rediffmail.comrcgangtok @ignou.ac.in	STATE OF SIKKIM
17.	GUWAHATI	04	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE HOUSE NO 71. GM CROAD CHRISTIAN BASTI, <b>GUWAHATI-781003, ASSAM</b> 0361-2662879 grcignou@sancharnet.inrcguwahati@i gnou.ac.in	STATE OF ASSAM
18.	HYDERABAD	01	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE PLOT NO 207 KAVURI HILLS PHASE II NEAR MADHAPUR POLICE STATION JUBILEE HILLS (PO) <b>HYDERABAD-500033</b> <b>ANDHRA PRADESH</b> 040-40266470, 40266471, 402266478 040-40266479 <a href="mailto:hyd2_ignourch@sancharnet.in">hyd 2_ignourch@sancharnet.in</a> rchyderabad@ignou.ac.in	STATE OF ANDHRA PRADESH EXCEPT DISTRICTS COVER ED UNDER RC VIJAYAWADA
19.	IMPHAL	17	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE, ASHA JINA COMPLEX NORTH, AOC <b>IMPHAL-795001 MANIPUR</b> 0385-2421190, 2421191 0385-2421192385-2421192 ignouimphal@rediffmail.comrcimphal @ignou.ac.in ignouimp@man.nic.in	STATE OF MANIPUR
20.	ITANAGAR	03	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE 'HORN HILL COMPLEX' CSECTOR (NEAR CENTRAL SCH.) NAHARLAGUN <b>ITA NAGAR-791110 ARUNACHAL</b> <b>PRADESH</b> 0360-2247536/22475380360-2247537 rd_itanagar@rediffmail.comignou_itanagar @yahoo.comrd_itanagar@rediffmail.com	STATE OF ARUNACHAL PRADESH

21.	JABALPUR	41	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE 2ND FLOOR, RAJSHEKHAR BHAVAN, RANI DURGAVATI VISHVA VIDYALAYA CAMPUS, PACHPEDHI, <b>JABALPUR-482001</b> <b>MADHYA PRADESH</b> 0761-2609269, 6533569 0761-2600411 0761-2609919 ignoujabalpur@hotmail.com rcjabalpur@ignou.ac.in website: www.ignoujabalpur.in	STATE OF MP COVERING DISTRICTS OF JABALPUR, NARSIMHAPUR, CHHINDWARA, SEONI, BALAGHAT, MANDLA. DINDORI, SHAH DOL, UMARIA, KATNI. SIDHI, SINGRAULI & ANUPPUR
22	JAIPUR	23	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE 70/79, SECTOR-7 PATEL MARG, MANSAROVAR, <b>JAIPUR-302020</b> <b>RAJASTHAN</b> 0141-27857500 141-2274292 0141-2784043 ignou-raj@nic.in rcjaipur@ignou.ac.in	STATE OF RAJASTHAN
23	JAMMU	12	REGIONAL DIRECTOR IGNOU REGIONAL CENTRES PM COLLEGE OF COMMERCE CANAL ROAD, <b>JAMMU-180001, JAMMU &amp; KASHMIR</b> 0191-25465290 191-25795720 191-2546995 jammurc12@rediffmail.com rcjammu@ignou.ac.in	STATE OF JAMMU & KASHMIR (JAMMU REGION)
24	JORHAT (Camp Office)	37	REGIONAL DIRECTOR House No.71, GMC Road, Christian Basti, Guwahati-781003, Assam 0361-2662879	OPERATED FROM RC GUWAHATI
25	KARNAL	10	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE OLD GOVT. COLLEGE CAMPUS RAILWAY STATION ROAD, <b>KARNAL-132001, HARYANA</b> 0184-2271514 0184-2260075 0184-2255738 ignourck10@bsnl.in rckamal@ignou.ac.in	STATE OF HARYANA (EXCEPT THE DISTRICTS OF PANCHKULA AND AMBALA)
26	KHANNA	22	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE I.T.I. BUILDING BULEPUR (DISTRICT LUDHIANA) <b>KHANNA-141401 PUNJAB</b> 01628-229994/229993/237361/ 238284, ignoukhanna@yahoo.co.in rckhanna@ignou.ac.in	STATE OF PUNJAB (EXCEPT DISTRICTS RUPNAGAR, PATIALA, MOHALI AND FATEHGARH SAHIB)



27	KOHIMA	20	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE Near Mount Hermon School, Don Bosco Hr. Sec. School Road, Kendouzou, <b>KOHIMA -797001</b> 0370-2260366,2260147,2260216 rd_kohima@rediffmail.comrckohima@ ignou.ac.in	STATE OF NAGALAND
28	KOLKATA	28	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE BIKASH BHAWAN, 4 <sup>TH</sup> FLOOR NORTH BLOCK, SALT LAKE, BIDHAN NAGARKOLKATA -700091 <b>WEST BENGAL</b> 033-23349850/23592719/23589323 (RCL) 033-23347576 ignourd28@yahoo.com,rd28cal@redi ffmail.comrckolkata@ignou.ac.in	STATE OF WEST BENGAL (EXCEPT THE DISTRICTS MENTIONED AGAINST RC SILIGURI)
29	KORAPUT	44	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE DISTRICT AGRICULTURE OFFICE RD BEHIND PANCHAYAT BHAVAN <b>KORAPUT-764020 ORISSA</b> 06852-25298206852-251535 ignou_korapat@rediffmail.com rckorapat@ignou.ac.in	KORAPUT, NABARANGPUR, RAYAGADA, MALKANAGIRI, BALANGIR, SONEPUR, KALAHANDI, NUAPADA, BOUDH, PHULBANI (PART OF ORISSA) GAJAPATI, SRIKAKULAM (PART OF AP), DANTEWADA, BASTAR (PART OF CG)
30	LUCKNOW	27	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE B-1/33, SECTOR - ALIGANJ <b>LUCKNOW-226024 UTTAR PRADESH</b> 0522-2745114,0941796654 0522-2762410(RCL/23644530522- 2364889) ignoulko@sancharnet.in rclucknow@ignou.ac.in	STATE OF UTTAR PRADESH (EXCEPT THE DISTRICTS UNDER RC VARANASI. RC ALIGARH AND RC NOIDA)
31	MADURAI	43	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE CSI INSTITUTIONAL CAMPUS TPK ROAD (NH-7) PAUMAALAI <b>MADURAI-625004 TAMILNADU</b> 0452-2380733,2380387,0452- 2370588, ignoumadurai@yahoo.co.in, rcmadurai@ignou.ac.in	FOLLOWING DISTRICTS OF TAMILNADU COIMBATORE, NILGRIS,ERODE, KARUR, THANJAVUR, MADURAI, DINDIGUL, TENI,VIRUDUNAGAR RAMANATHAPURAM,SIV AGANGA, PUDUKKUTTAI, THIRUPPURTIRUNELVE LI,TUTICORIN&TRICHI

32	MUMBAI	49	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE OMLEVA VIKAS NIKETAN, NANEPADA ROAD, MULUND(E) <b>MUMBAI-400081 MAHARASHTRA</b> 022-25633159 ignourcmumbai@gmail.com rcmumbai@ignou.ac.in	FOUR DISTRICTS OF MAHARASHTRA: MUMBAI, THANE, RAIGARH AND RATNAGIRI
33	NAGPUR		REGIONAL DIRECTOR IGNOU REGIONAL CENTRE GYANVATIKA, 14, HINDUSTAN COLONY, <b>Amravati Road,</b> <b>NAGAPUR 440033 MAHRASHTRA</b> 0172-2022000, 09657339936(MOB) rcnagpur@ignou.ac.in	STATE OF MAHRASHTRA COVERING DISTRICTS AMRAVATI, BULDHANA. AKOLA WASHIM, HINGOLI, PARBHANI, NANDED, YAVATMAL, WARDHA, CHANDRAPUR, NAGPUR, BHANDARA, GONDIA, GADCHIROU (14 DISTRICTS)
34	NOIDA	39	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE C-53, SECTOR 62, INSTITUTIONAL AREA, <b>NOIDA-201305, UTTAR PRADESH</b> 0120-2405012/2405014 0120-2405013(Fax) rcnoida@ignou.ac.in	NOIDA, GREATER NOIDA, GHAZIABAD, G.B. NAGAR, MEERUT & BAGPAT DISTRICT OF UTTAR PRADESH OPERATED FROM RC DELHI2
35	PANAJI	08	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE BEHIND CHODANKAR HOSPITAL, NEAR P&T STAFF QUARTERS OF MAPUSA PANAJI ROAD, <b>POVORIM-403521</b> <b>GOA</b> 0-9444024242(MOB)0832-2462315 msparthasarathy@yahoo.com	STATE OF GOA & THREE ADJOINING DISTRICTS OF KARNATAKA i.e DHARWARD, BELGAUM, UTTARA KANNAD & SINDHUDURG (DISTRICTS OF MAHARASHTRA)
36	PATNA	05	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE 2 <sup>ND</sup> FLOOR, BISCOMAUN TOWER WEST GANDHI MAIDAN, <b>PATNA-800001 BIHAR</b> 0612-2221538/22215410612- 2221539 rcpatna@gmail.com rc05patna@gmail.com ignourcpatna@gmail.com	STATE OF BIHAR EXCEPT FOR THE DISTRICTS UNDER JURISDICTION OF RC- DARBHANGA

37	PORTBLAIR	02	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE JNRM CAMPUS, <b>PORT BLAIR-744104</b> <b>ANDAMAN &amp; NICOBAR ISLANDS</b> 03192-242888,230111 rc_portblair@rediffmail.com rcportblair@ignou.ac.in	ANDAMAN & NICOBAR ISLANDS
38	PUNE	16	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE 1 <sup>ST</sup> FLOOR, MSFC BUILDING 270, SENAPATI BAPAT ROAD, <b>PUNE-411016 MAHARASHTRA</b> 020-256671867,020-25671864 ignourcpune42@vsnl.net rcpune@ignou.ac.in	STATE OF MAHARASHTRA NANDURBARIDHULE, JALGAON, AURANGABAD, NASIK, JALNA, AHMADNAGAR, BID,PUNE, OSMANABAD, SOLAPUR, SANGLI, SATARA & KOLHAPUR (14 DISTRICTS)
39	RAIPUR	35	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE REST HOUSE & E.M.OFFICE HALL SECTOR-1,SHANKARNAGAR <b>RAIPUR-492007 CHATTISGARH</b> 0771-2428285/5056508/2445839/ 2445839 rrcignou@cg.nic.in, rcraipur@ignou.ac.in	STATE OF CHHATTISGARH EXCEPT DISTRICTS OF DANTEWADA & BASTAR
40	RAJKOT	42	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE SAURASHTRA UNIVERSITY CAMPUS <b>RAJKOT-360005 GUJARAT</b> 0281-2572988 subrcrajkot@yahoo.co.in,rcrajkot@ig nou.ac.inwebsite:www.ignourajkot.org	STATE OF GUJRAT COVERING THE DISTRICTS OF RAJKOT, KACHCHH, JAMNAGAR, PORBANDER, JUNAGADH, AMRELI, BHAVNAGAR, SUREN DRANAGAR & DIN
41	RANCHI	32	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE 457/A. ASHOK NAGAR, <b>RANCHI-834022 JHARKHAND</b> 0651-2244688,2244699,2244677, 2244400 ignouranchi@yahoo.com, rdranchi@ignou.ac.in	STATE OF JHARKHAND
42	SHILLONG	18	REGIONAL DIRECTOR IGNOU REGIONAL CENTRES SUNNY LODGE NONGTHYMMAINON SHILUANG <b>SHILLONG-793003 MEGHALAYA</b> 0364-2521117/2521271/2521271 ignou18@sancharnet.in rd_shillong@rediffmail.com	STATE OF MEGHALAYA

43	SHIMLA	11	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE CHAUHAN NIWAS BUILDING.KHALINI <b>SHIMLA-171002</b> <b>HIMACHAL PRADESH</b> 0177- 2624613,2624611,2625843/2624612 0177-2624611 sml_gnoures@sancharnet.in dbnegi@gmail.com rcshimla@ignou.ac.in	STATE OF HIMACHAL PRADESH (EXCEPT DISTRICT UNA)
44	SILIGURI	45	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE NETAJI MORE SUBHASPALLY <b>SILIGURI-734001 WEST BENGAL</b> 0353-25268180353-2526819 ignourcsiliguri@yahoo.com rcsiliguri@ignou.ac.in	STATE OF WEST BENGAL COVERING DISTRICTS OF JALPAIGURI, DARJILING, KOCHBIHAR, UTTARDINAJPUR, DAKSHIN, DINAJPUR, MALDAH (PART OF WB)
45	SRINAGAR	30	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE IMANTOO HOUSE, RAJBAGH NEAR MASJIDAL-FAROOQ, <b>SRINAGAR-190008 JAMMU &amp; KASHMIR</b> 0194-23112510194-23112580194- 2311259 ignousgr@hotmail.com rcsrinagar@ignou.ac.in	STATE OF JAMMU & KASHMIR (SRINAGAR & LADAKH REGION)
46	TRIVANDRUM	40	REGIONAL DIRECTOR IGNOU REGIONALCENTRE MEPRAMMANSION,CHEKKALAMU KKUSREEKARIYAM, <b>TRIVANDRUM-695017 KERALA</b> 0944750581(MOB) ignourctrivandrum@gmail.comrctrivan drum@ignou.ac.in	KANYAKUMARI, DISTRICT OF TAMIL NADU & THIRUVANANTHAPUR AM, KOLLAM & PATHANAMTHITTA (DISTRICTS OF KERALA)
47	VARANASI	48	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE GANDHI BHAWAN, B.H.U. CAMPUS <b>VARANASI-21005, UTTAR PRADESH</b> 0542-2368022,23686220522- 2364893 0542-2317383 ignousrc.vns@gmail.com rcvaranasi@ignou.ac.in	DISTRICTS OF AMBEDKAR NAGAR, SANTKABIRNAGAR, MAHARAJGANJ, JAUNPUR, BALLIA, AZAMGARH, GORAKHPUR, DEORIA. KUSHINAGAR, SANT RAVIDAS NAGAR MIRZAPUR, VARANASI GHAZIPUR, MAUNATHBHANJAN, CHANDAUL, SONBHADRA

48	VIJAYAWADA	33	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE 1 <sup>ST</sup> FLOOR. SKPVV. HINDU HIGH SCHOOL, KOTHAPETHA, <b>VIJAYWADA 520001 ANDHRA PRADESH</b> 0866-2565950866-25652530866- 2565353 ignourcvijaywada@gmail.com rcvijaywada@ignou.ac.in	STATE OF ANDHRA PRADESH COVERING THE DISTRICTS OF VIZAINAGARAM. VISAKHAPTNAM, EAST GODAVARI,WEST GODAVARIKHAMMA, KRISHNA, GUNTUR, PRAKASHAM. NELLORE, SRIKAKULAMAND CHITTOOR
49	RAGHUNATHGANJ	50	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE. NO. 312, SECOND FLOOR NEW ADMINISTRATIVE BUILDINGS DOJANGIPUR OFFICE COMPOUND RAGHUNATHGANJ DISTT. MURSHIDABAD-742225 03483-271555/271666 rcraghunathganj@ignou.ac.in	STATE OF WEST BENGAL (DISTRICT MURSHIDABAD, BIRBHUM, MALDA)
50	BHAGALPUR	82	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE	STATE OF BIHAR (DISTRICT: KISHANGANJ, ARARIA, KATIHAR, PURNEA, BHAGALPUR, BANKA.MUNGER, KHAGARIA, MADHEPURA) <i>Note: Currently under Darbhanga and Patna RC</i>
51	VATKARA	83	REGIONAL DIRECTOR IGNOU REGIONAL CENTRE	STATE OF KERALA (DISTRICT: KOZHIKODE, KANNUR, KASARAGOD, WAYANAD) <i>Note: Currently under Cochin RC</i>