Central University of South Bihar

Integrated UG-PG Programme (5 yrs.) *in* Chemistry

(with multiple entry & multiple exit, in accordance with NEP 2020)

Course Structure & Syllabi

(with effect from academic session 2024-2025)

Department of Chemistry
School of Physical and Chemical Sciences,
Central University of South Bihar, NH-120,
Gaya-Panchanpur Road, Gaya-824236

1. Introduction to Department of Chemistry

The Department of Chemistry under the School of Physical and Chemical Sciences forms a key component of the university. The department is composed of dynamic faculty members, students and research scholars who are actively engaged in knowledge creation and dissemination at the frontiers of the Chemical Sciences. The discipline has an encompassing effect on the biological and physical sciences and therefore considered a central science. The department believes in interdisciplinary approach of learning and fosters a culture of excellence. Undergraduate and Post-graduate students of chemistry are nurtured and mentored well to compete at the national and international level (e.g. selection for the summer research fellowships of National Academies of Sciences, award at National Science Film Festival, JAM, UGC-CSIR NET, GATE and more…). The masters (M.Sc.) and doctoral (Ph.D.) programmes were started in 2018 and 2019, respectively. With the launch of integrated UG-PG programme in the year 2024, our young department envisages scaling new heights by incorporating all the key components of the National Education Policy (NEP) 2020. Many of the alumni are now well-placed in different research and academic institutions of repute. Knowledge and skills in chemistry play a crucial role in finding the solutions to most of the challenges (eg. energy, disease, and environment) faced by the mankind today. We envisage producing globally competent chemists who can solve the pressing problems of the nation.

2. Integrated UG-PG Programme in Chemistry

The programme is of 5 years' duration and has been designed in accordance to National Education Policy (NEP 2020), which visualizes our education system to be inquiry-driven, discovery-oriented, learner-centered, discussion-based. It follows the choice based credit system (CBCS) and has the provision of multiple-entry and multiple exits with BSc/BSc(Hons.)/BSc (Hons. with Research)/MSc degree. The programme has been developed for the young minds who have an interest in chemistry and a desire to explore the frontiers of science. This is a unique programme that combines core chemistry (Organic, Inorganic and Physical) with Nano Chemistry, Medicinal Chemistry, Agro-Chemistry and Green Chemistry. Along with thorough grounding in chemistry, it equips the students with the knowledge and skills in the emerging interdisciplinary area of green science and technologies which has now become a crucial requirement for the sustainable development globally. Computational Chemistry and Medicinal Chemistry have also been incorporated to equip the students better. In addition, courses based on rich scientific heritage of ancient and medieval India have also been incorporated into the curriculum, which will inspire the young minds and enable them to judiciously blend the ancient wisdom with the modern thoughts to solve a wide range of issues.

3. Programme Objectives and Outcomes:

The programme envisages creating good bench strength of future scientists and contribute to the scientific advancement of the nation. The objectives of the programme are as follows:

- Providing a learning platform for young minds incorporating all the key components of National Education Policy(NEP) 2020
- Laying a strong foundation in chemistry by imparting sound knowledge and thorough understanding of theoretical as well as experimental aspects of Chemistry.

- Developing critical thinking and problem-solving abilities through core courses;
- Widening the horizons with broader knowledge base through minor, multidisciplinary, value added courses.
- Imparting necessary laboratory skills along with hands-on training on sophisticated equipment.
- Training the students to become good researchers through Honours' and Masters' dissertation work

The major outcomes of the programme would be as following:

- Achieving the avowed objectives of National Education policy 2020 and provide multiple entry and exit option to students.
- Well-nurtured young minds with good understanding of core concepts of chemistry.
- Transforming students into globally competent chemists who can provide scientific solutions to some of the pressing problems of the mankind.
- Creating a platform for all-round development of the students
- Making chemistry professionals for academia and industry.
- Creating a good bench strength of future scientists and academicians.

4. Future Prospects

There is ample opportunities and employability for chemists having sound knowledge, analytical skills and hands-on training on sophisticated instruments. The chemical industry is India's one of the largest manufacturing sectors and plays an integral role in the country's economic development. The Indian chemical sector currently accounts for 13-14% of total exports. In terms of volume of production, it is the twelfth-largest in the world and the third-largest in Asia. Currently, the per capita consumption of products of the Indian chemical industry is one-tenth of the world average, which reflects the huge potential for further growth. The "Make in India" and "Atmnirbhar Bharat" scheme has further given a fresh impetus to this sector. For sustainable, environment-friendly growth, the sector is looking for new technologies that incorporate green chemistry and nanotechnology, and there lies the exciting and excellent career opportunities for young chemists. Besides the chemical industry, the training imparted in the interdisciplinary area of renewable energy, molecular theranostics, green science and nanotechnology will also enable the students to diversify and join other sectors such as energy, photovoltaics, photonics, biosensing, and healthcare etc.

The curriculum has been designed to keep abreast with changing times. In the long run, the programme is likely to produce globally competent chemists with bright innovative ideas. By understanding the nuances of chemistry, these young scientists would be creating new tools, products and technologies to address some of the world's biggest challenges such as (just to name a few) clean affordable energy, biomedical devices and drugs for treating diseases, bio-sensing and environmental remediation etc.

5. Different levels of Multiple Entry and Exit System and its credit requirements

Admission through a multiple-level entry

Sl. No.	Entry Points	Basic Eligibility	Mode of Entrance
1	Semester 1	Std. XII Certificate (Chemistry)	Common University Entrance Test
2	Semester 3	40 Credits with a UG Certificate and 4 credits of skill enhancement Course	Counseling-cum- interaction comprising 100 marks
3	Semester 5	80 Credits with a UG Diploma and 4 credits of skill enhancement Course	Counseling-cum- interaction comprising 100 marks
4	Semester 7	120 Credits with a Degree of Bachelor in Science	Counseling-cum- interaction comprising 100 marks
5	Semester 9	160 Credits with a Degree of Bachelor (Honours/Research)	Counseling-cum- interaction comprising 100 marks

Award of Certificate/ Diploma/ Degree along with multiple Exit Options.

Sl. No.	Exit Points	Qualification Title	NHEQF Level
1	after completion of Semesters 1 & 2	UG Certificate in Chemistry	Level 4.5
2	after completion of Semesters 1,2,3 & 4	UG Diploma in Chemistry	Level 5
3	after completion of Semester 1,2,3,4,5 & 6	Bachelor of Science in Chemistry	Level 5.5
4	after completion of Semesters 1,2,3,4,5,6,7 & 8	Bachelor of Science (Honours) in Chemistry or, Bachelor of Science (Honours with Research) in Chemistry	Level 6
5	after completion of Semesters 1,2,3,4,5,6,7,8,9 & 10	Master of Science in Chemistry	Level 6.5

6. The Course Structure

Undergraduate Certificate in Chemistry				
Semester I				
Nature of course	**Course Code**	**Course title**	**Credit of course (L+T+P)**	**Class hours/ week**
Major* (*minor for other disciplines)	**CHE51MJ13004 (CHE51MN13004)**	Inorganic & Physical Chemistry-I	**4** (3+1+0)	**4**
Minor		From other Dept.	4	**4**
Multidisciplinary course	**CHE51MD50103**	Chemistry in Everyday Life	**3** (3+0+0)	**3**
Ability Enhancement Course		Language Proficiency courses (English, Hindi, others)	**2** (2+0+0)	**2**
Skill Enhancement course	**CHE51SE13003**	Inorganic & Physical Chemistry Lab-I	3 (0+0+3)	**6**
Value Added course	**CHE51VA10102**	Scientific Heritage of Ancient and Medieval India	2 (2+0+0)	**2**
Value added Course		From Other Dept.	2	2
		Total	**20**	**23**
Semester II				
Nature of course	**Course Code**	**Course title**	**Credit of course (L+T+P)**	**Class hours/ week**
Major* (*minor for other disciplines)	**CHE52MJ20004 *(CHE52MN20004)**	Organic Chemistry-I	**4** (3+1+0)	**4**
Minor		From other dept.	4	4
Multidisciplinary course	**CHE52MD50203**	Industrial Chemistry	**3** (3+0+0)	**3**
Ability Enhancement Course		Language Proficiency courses (English, Hindi, others)	**2**	2
Skill Enhancement course	**CHE52SE20003**	Organic Chemistry Lab-I	**3** (0+0+3)	**6**
Value Added course	**CHE52VA10202**	Chemistry of Ayurveda	**2** (2+1+0)	**2**
Value added Course		From Other Dept.	2	2
		Total	**20**	**23**

Undergraduate Diploma in Chemistry				
Semester III				
Nature of course	**Course Code**	**Course title**	**Credit of course (L+T+P)**	**Class hours/ week**
Major* (*minor for other disciplines)	**CHE61MJ10004 *(CHE61MN10004)**	Inorganic Chem.-II	**4** (3+1+0)	**4**
Major* (*minor for other disciplines)	**CHE61MJ30004 *(CHE61MN30004)**	Physical Chem.-II	4 (3+1+0)	**4**
Minor		From other dept.	4	4
Multidisciplinary course	**CHE61MD50303**	Green Energy Systems	**3** (3+0+0)	**3**
Ability Enhancement Course		Language Proficiency courses (English, Hindi, others)	2	2
Skill Enhancement course	**CHE61SE13103**	Inorganic & Physical Chemistry Lab-II	**3** (0+0+3)	**6**
		Total	**20**	**23**
Semester IV				
Nature of course	**Course Code**	**Course title**	**Credit of course (L+T+P)**	**Class hours/week**
Major* (*minor for other disciplines)	**CHE62MJ10104 *(CHE62MN10104)**	Inorganic Chemistry-III	**4** (3+1+0)	**4**
Major* (*minor for other disciplines	**CHE62MJ20104 *(CHE62MN20104)**	Organic Chemistry-II	**4** (3+1+0)	**4**
Major	**CHE62MJ20204**	Organic Chemistry Lab -II	**4** (0+0+4)	**8**
Major	**CHE62MJ30102**	Physical Chemistry-III	**2** (2+0+0)	**2**
Minor		From other Dept.	4	4
Ability Enhancement Course		Language Proficiency courses (English, Hindi, others)	2	2
		Total	**20**	**24**

Bachelor of Science in Chemistry				
Semester-V				
Nature of course	**Course Code**	**Course title**	**Credit of course (L+T+P)**	**Class hours/ week**
Major* (*minor for other disciplines)	**CHE71MJ30204 *(CHE71MN30204)**	Physical Chemistry-IV	**4** (3+1+0)	**4**
Major* (*minor for other disciplines	**CHE71MJ20304 *(CHE71MN20304)**	Organic Chemistry-III	**4** (3+1+0)	**4**
Major	**CHE71MJ30304**	Physical Chemistry Lab -II	**4** (0+0+4)	**8**
Major	**CHE71MJ10202**	Inorganic Chemistry-IV	**2** (2+0+0)	**2**
Minor		From other dept.	4	**4**
Internship	**CHE71IS60002**	Internship	**2**	**2**
		Total	**20**	**24**
Semester-VI				
Nature of course	**Course Code**	**Course title**	**Credit of course (L+T+P)**	**Class hours/week**
Major* (*minor for other disciplines)	**CHE72MJ10304 *(CHE72MN10304)**	Inorganic Chemistry-V	**4** (3+1+0)	**4**
Major* (*minor for other disciplines	**CHE72MJ30404**	Physical Chemistry-V	**4** (3+1+0)	**4**
Major	**CHE72MJ10404**	Inorganic Chemistry Lab -II	**4** (0+0+4)	**8**
Major	**CHE72MJ20404**	Organic Chemistry-IV	**4** (3+1+0)	**4**
Minor		From other dept.	4	4
Total			**20**	**24**

B.Sc. (Honours) in Chemistry
or
B.Sc. (Honours with Research) in Chemistry

Semester VII

Nature of course	Course Code	Course title	Credit of course (L+T+P)	Class hours/ week
Major* (*minor for other disciplines)	**CHE81MJ10504 *(CHE81MN10504)**	Advanced Inorganic Chemistry-I	**4** (3+1+0)	**4**
Major * (*minor for other disciplines	**CHE81MJ20504 *(CHE81MN20504)**	Advanced Organic Chemistry-I	**4** (3+1+0)	**4**
Major* (*minor for other disciplines)	**CHE81MJ30504 *(CHE81MN30504)**	Advanced Physical Chemistry -I	**4** (3+1+0)	**4**
Major	**CHE81MJ10604**	Advanced Inorganic Chemistry Lab	**4** (0+0+4)	**8**
Minor (OEIC)		From other Dept.	4	4
		Total	**20**	**24**

Semester VIII

Option I: B.Sc. (Honours) in Chemistry

Nature of course	Course Code	Course title	Credit of course (L+T+P)	Class hours/ week
Major* (*minor for other disciplines)	**CHE82MJ40104 *(CHE82MN40104)**	Advanced Instrumental Techniques	**4** (3+1+0)	**4**
Major	**CHE82MJ30604**	Advanced Physical Chemistry Lab	4 (0+0+4)	8
Major	**CHE82DE…..**	Core Elective 1[A]	4 (3+1+0)	4
Major	**CHE82DE…..**	Core Elective 2[A]	4 (3+1+0)	4
Minor (OEIC)		From other Dept.	4	4
Total			**20**	**24**

[A] to be selected from the elective basket 'A' of the Dept.

Option II[#]: B.Sc. (Honours with Research) in Chemistry				
Nature of course	**Course Code**	**Course title**	**Credit of course (L+T+P)**	**Class hours/week**
Major* (*minor for other disciplines)	**CHE82MJ40104 *(CHE82MN40104)**	Advanced Instrumental Techniques	**4** (3+1+0)	**4**
Major	**CHE82MJ30604**	Advanced Physical Chemistry Lab	**4** (0+0+4)	**8**
Major	**CHE82MJ12312**	Project	**12** (0+0+12)	**24**
Minor (OEIC)		From other Dept.	4	**4**
		Total	**24**	**40**
[#]Only for students securing CGPA of 7.5 or above in Sem. VI of the programme				
Master of Science in Chemistry				
Semester-IX				
Nature of course	**Course Code**	**Course title**	**Credit of course (L+T+P)**	**Class hours/ week**
Major	**CHE91MJ40204**	Molecular Spectroscopy	**4** (3+1+0)	**4**
Major	**CHE91MJ20604**	Advanced Organic Chemistry Lab	**4** (0+0+4)	**8**
Major	**CHE91DE…..**	Core Elective 3[B]	**4** (3+1+0)	**4**
Major	**CHE91DE…..**	Core Elective 4[B]	**4** (3+1+0)	**4**
Major	**CHE91MJ12404**	Dissertation*	**4** (0+0+4)	**8**
		Total	**20**	**28**
[B]Courses to be selected from the elective basket 'B' of specialization papers				
*Projects will be assigned and the evaluation in semester IX (4Cr) will be based on literature review report submitted and the presentation -cum-viva voce examination. The experimental work will continue and the final dissertation will be submitted in semester X.				

Semester-X				
Option I: M.Sc. in Chemistry				
Nature of course	**Course Code**	**Course title**	**Credit of course (L+T+P)**	**Class hours/week**
Major	**CHE92MJ30704**	Phase Equilibria and Statistical Thermodynamics	**4** (3+1+0)	**4**
Major	**CHE92MJ12508**	Dissertation	**8** (0+0+8)	**16**
Major	**CHE92DE…..**	Core Elective 3[C]	**4** (3+1+0)	**4**
Major	**CHE92DE…..**	Core Elective 4[C]	**4** (3+1+0)	**4**
		Total	**20**	**28**
[C]Courses to be selected from the elective basket 'Ç' of specialization papers				
Semester-X				
Option II[#]: M.Sc. in Chemistry				
Nature of course	**Course Code**	**Course title**	**Credit of course (L+T+P)**	**Class hours/week**
Major	**CHE92MJ30704**	Phase Equilibria and Statistical Thermodynamics	**4** (3+1+0)	**4**
Major	**CHE92MJ12508**	Dissertation	**16** (0+0+16)	**32**
		Total	**20**	**36**
[#]Only for students securing CGPA of 7.5 or above in Sem. VI of the programme				

Elective Basket 'A' **[For students opting for B.Sc. (Hons.) in Semester VIII]**				
Nature of Course	**Course Code No.**	**Course Title**	**Credit of course (L+T+P)**	**Class hours/ week**
Core Elective	**10704**	Basics of Supramolecules and Its Advancement	4 (3+1+0)	**4**
Core Elective	**20704**	Green Chemistry I: Solvents & Synthesis	4 (3+1+0)	**4**
Core Elective	**30804**	Solid State and Structural Chemistry	4 (3+1+0)	**4**
Core Elective	**20804**	Green Chemistry II: Catalysis	4 (3+1+0)	**4**
Core Elective	**20904**	Nucleoside, Advances in Nucleic Acid and Proteins	4 (3+1+0)	**4**
Core Elective	**21004**	Chemistry of Natural Products	4 (3+1+0)	**4**
Core Elective	**21104**	Agrochemicals	4 (3+1+0)	**4**
Core Elective	**30904**	Nano Chemistry	4 (3+1+0)	**4**
Note: A few of these courses would be floated at the beginning of semester-VIII, out of which two courses will have to be opted by the students of B.Sc. Hons. Or PG Diploma in Chemistry				

Elective Basket 'B' **[to be opted in Semester IX according to the specialization]**				
Nature of Course	**Course Code No.**	**Course Title**	**Credit of course (L+T+P)**	**Class hours/ week**
Core Electives (for specialization in Inorganic Chemistry)	**10804**	Inorganic Materials and Their Applications	4 (3+1+0)	4
	10904	Inorganic Reaction Mechanism, Organometallics and Advanced Bioinorganic Chemistry	4 (3+1+0)	4
Core Electives (for specialization in Organic Chemistry)	**21204**	Modern Organic Synthesis	4 (3+1+0)	4
	21304	Chemistry of Biomolecules	4 (3+1+0)	4

Core Electives (for specialization in Physical Chemistry)	**31004**	Applied Electrochemistry	4 (3+1+0)	4
	31104	Advanced Photochemistry	4 (3+1+0)	4

Elective Basket 'C' [to be opted in Semester X according to the specialization]				
Nature of Course	**Course Code No.**	**Course Title**	**Credit of course (L+T+P)**	**Class hours/ week**
Core Electives (for specialization in Inorganic Chemistry)	**11004**	Chemistry of Materials	4 (3+1+0)	4
	11104	Applications of Spectroscopy Techniques to Inorganic Systems	4 (3+1+0)	4
Core Electives (for specialization in Organic Chemistry)	**21404**	Advanced Medicinal Chemistry	4 (3+1+0)	4
	21504	Spectroscopy and Chiroptical Properties	4 (3+1+0)	4
Core Electives (for specialization in Physical Chemistry)	**31304**	Advanced Quantum Mechanics and Surface Chemistry	4 (3+1+0)	4
	40304	Lasers in Chemistry	4 (3+1+0)	4

Important Points to note:

1. The numbers of students opting for B.Sc. (Hons with Research) will be capped to a maximum of 50% of the total strength.
2. While augmenting the seats in lateral entry scheme, the department's capacity will also be considered and a capping may be defined by the departmental committee
3. The multidisciplinary courses available in the university or on the SWAYAM portal will be reviewed and students can choose any course approved by the departmental committee.
4. The suitability of other courses on SWAYAM portal for minor, major, AEC, SEC, VACs will be checked and students can opt for the courses approved by the departmental committee.
5. Allotment of different branches of specialization will be done at the end of eighth (8) semester. An order of preference must be submitted by each student for the three different specializations, Organic, Inorganic or Physical Chemistry. Based on the two parameters, the choice and performance upto 8th semester, the specialization will be allotted subject to maximum of 40% of total strength of students in one specialization.

FIRST SEMESTER (ODD SEMESTER)

Course Details			
Course Title: Inorganic & Physical Chemistry-I			
Course Code	**CHE51MJ13004 *(CHE51MN13004)**	**Credits (L + T + P)**	4 (3 + 1 + 0)
Nature of Course	Major (*minor for others disciplines)	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	● 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ● 70% - End Term External Examination (University Examination)		

Course Objectives

- To develop an understanding of wave nature of electrons and its associated functions and plots
- To make the students learn the periodicity of atomic properties
- To impart in-depth knowledge about the kinetic theory of gases
- To equip the students with necessary skills to determine the heat capacity, enthalpy and other thermodynamic properties of a system.

Learning Outcomes: After completion of the course the learners will be able to:

- Predict and analyze the plots of radial and angular wave functions for electrons
- Explain the periodic variation in atomic properties of elements
- Solve problems based on behavior of ideal and real gases
- Determine the heat capacity, enthalpy etc. for a given system.

UNIT-I

Atomic Structure: (16L)

Bohr's model and atomic spectrum of hydrogen, Limitations of Bohr's model and Sommerfeld's modifications, de Broglie's concept, Heisenberg's uncertainty principle and its significance, Time independent Schrödinger's wave equation (without application and solution detail), Significance of ψ and ψ^2, Radial and angular wave functions for hydrogen atom (qualitative idea), radial probability distribution curves, shapes of s, p, d and f orbitals (qualitative idea), Quantum numbers and their significance, Pauli's exclusion principle, aufbau principle and limitations, Hund's rules, exchange energy, Electronic configurations of atoms. Elementary idea of microstates.

UNIT-II

Periodic properties: (14L)

Modern IUPAC periodic table and classification of elements in the table; Effective nuclear charge and its calculation using Slater's rules; Atomic radii, Ionic radii and Pauling's method for determining univalent ionic radii; Electronegativity (Pauling's, Mulliken's and Allred-Rochow's scale) and its applications, Ionization energy, Electron affinity and factors influencing these properties; Group trends and periodic trends of these properties with reference to s, p and d- block elements, Inert pair effect.

UNIT-III

Kinetic Theory and Gaseous state (18L)

Kinetic Theory of gases: Concept of pressure and temperature; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules).

Maxwell's distribution of speed and energy: Nature of distribution of velocities, Maxwell's distribution of speeds in one, two and three dimensions; Kinetic energy distribution in one, two and three dimensions, calculations of average, root mean square and most probable values in each case; Calculation of number of molecules having energy $\geq \varepsilon$, Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases.

Real gas and virial equation: Deviation of gases from ideal behavior; compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; its derivation and application in explaining real gas behavior, other equations of state (Berthelot, Dieterici); Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states; virial equation of state; van der Waals equation expressed in virial form and significance of second virial coefficient

UNIT-IV

Chemical Thermodynamics – I **(12L)**

Zeroth and 1st law of Thermodynamics: Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics; Concept of heat, work, internal energy and statement of first law; enthalpy, H; relation between heat capacities, calculations of q, w, U and H for reversible and irreversible expansion of gases under isothermal and adiabatic conditions; Joule's experiment and its consequences.

Thermochemistry: Standard states; Heats of reaction; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; Laws of thermochemistry; bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchhoff's equations and effect of pressure on enthalpy of reactions.

Suggested Textbooks:

1. Shriver & Atkins' Inorganic Chemistry, D. F. Shriver, P.W. Atkins, 5th Ed. Oxford University Press (2010).
2. Concise Inorganic Chemistry, 5th edition; J. D. Lee (1996).
3. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford Univ. Press (2022), 12th ed.
4. KL Kapoor, A Textbook of Physical Chemistry, States of Matter and Ions In Solution (SI Units) - Vol. 1-3, Sixth edition, McGraw Hill Education

Reference Books:

1. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970.
2. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
3. Cotton, F.A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry 3rd Ed.; Wiley India.
4. Sharpe, A.G., Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005.
5. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006.
6. Winter, M. J., The Orbitron, http:// winter.group.shef.ac.uk/orbitron/ (2002). An illustrated gallery of atomic and molecular orbitals.
7. Burgess, J., Ions in solution: basic principles of chemical interactions. Ellis Horwood (1999).
8. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford Univ. Press (2022), 12th ed.

9. Laidler, K. J. Chemical Kinetics, Pearson.
10. Glasstone, S. & Lewis, G.N. Elements of Physical Chemistry.
11. Rakshit, P.C., Physical Chemistry Sarat Book House.

Course Details			
Course Title: Chemistry in Daily Life			
Course Code	**CHE51MD50103**	**Credits (L + T + P)**	3 (3+ 0 + 0)
Nature of Course	Multidisciplinary	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45(L) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	● 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ● 70% - End Term External Examination (University Examination)		

Course Objectives

- To make the students learn about food chemistry and additive chemicals used
- To impart knowledge of Chemicals in cleansing agent.
- To impart in-depth knowledge about different drug
- To make the students learn about the polymer
- To make the students learn the pesticides.

Learning Outcomes:

After completion of the course the learners will be able to:

- Analyze the flavor of food and different types of vitamins.
- Will know chemicals in cleansing agent and their working.
- Understand about the various types of drugs and their action.
- Will know the various types of polymers, their classification, structure and usage.
- Will understand about the pesticides and analyze its toxicity.

UNIT-I

Food and additives **(9L)**

Chemicals in food: (i) Flavors and sweeteners (ii) Vitamins (iii) Antioxidants (iv) Preservatives

Soaps and detergents **(4L)**

Introduction – Chemicals in cleansing agent. Working principle. Classification of cleansing agent with few examples.

UNIT-II

Drugs **(9L)**

Introduction – Drug, Drug target Interaction-Enzymes as Drug Targets, Receptors as Drug Targets. Classification of Drug, Therapeutic Action of Different Classes of Drugs (brief) –Few Examples of (i) Antacid (ii) Antihistamine (iii) Tranquilizers (iv) Analgesics (v) Antibiotics (vi) Antiseptics and disinfectants.

UNIT-III

Polymers **(14L)**

General introduction, some important terminologies (monomer, polymerization, macromolecule, copolymerization, molecular mass of polymer), Classification of polymers

with some suitable examples-(i) based on source of their origin, (ii) based on type of polymerization reaction.

Rubber-Types of rubber, General characteristics, classifications with few examples (Natural rubber, Neoprene, Buna – N, Buna-S).

Biodegradable polymers: Introduction, Characteristics, Few examples and their usage (Poly β-hydroxybutyrate – co-β-hydroxy valerate, Nylon 2–nylon 6).

Few other commercially important polymers-structures and applications (Polypropylene, Polystryrene, Polyvinyl chloride, Bakelite, Urea-formaldehyde resin, Melamine — formaldehyde polymer, Polyester, Nylon 6,6, Teflon)

UNIT-IV

Pesticides **(9L)**

Pesticides: Definition, Classification of pesticides (with examples) based on (i) use (target) (ii) mode of action (iii) toxicity and (iv) chemical structure

SUGGESTED TEXTBOOKS:

1. Thapar, Food Chemistry, Pacific Book International.
2. David, G.L. Krupadanam, D., Prasad, V., Rao, K.V., Reddy, K.L.N., Sudhakar, C., Drugs, Universities Press (India) Limited 2007
3. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub
4. N. N. Melnikov, Chemistry of pesticides; Springer-Verlag- Technology & Engineering (2012).

Reference Books

1. Gayatri Baidya, Textbook of Food Chemistry, Book Rivers.
2. Chandrasekhar, Prasanna Ashwin-Ushas Conducting Polymers, Fundamentals and Applications A Practical Approach Authors: Corp., Inc. Kluwer Academic Publishers. Boston.
3. N. N. Melnikov, Chemistry of pesticides; Springer-Verlag- Technology & Engineering (2012).
4. Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.

Course Details			
Course Title: Inorganic & Physical Chemistry Lab-I			
Course Code	**CHE51SE13003**	**Credits**	3 (0+0+3)
Nature of Course	Skill-enhancement	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	90 Hours
Methods of Content Interaction	Lecture, Reagents Preparation and Practical Classes		
Assessment and Evaluation	● 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ● 70% - End Term External Examination (University Examination)		

Course Objectives

- To develop understanding of Quantitative analysis in chemistry
- To impart skills in various types of titrimetric methods
- To make students learn the concept of pH by experiments
- To equip the students with necessary skills to determine the enthalpy of a reaction

Learning Outcomes: After completion of the course the learners will be able to:

- Estimate the concentration of an acid or base in a given test-sample
- Distinguish between the weak/strong acids and bases and choose indicator for titration

- Determine the enthalpy of neutralization or dissolution
- Determine the pH by colorimetric or potentiometric methods

. **Learning software for drawing 2D- and 3D molecular Structures**

. **Preparation of standard solutions of some selected salts/reagents of different concentrations**

(i) 1 M, 0.1 M, 1mM
(ii) 1 N, 0.1 N, 1 mN
(iii) 1ppm, 1ppb

. **Titrations based on acid-base neutralization reactions**

(i) Determination of concentration of hydrochloric acid by titrating against NaOH
(ii) Determination of concentration of acetic acid by titrating against NaOH
(iii) Determination of concentration of bicarbonates by titrating against hydrochloric acid
(iv) Estimation of carbonate and hydroxide present together in a mixture
(v) Estimation of carbonate and bicarbonate present together in a mixture
(vi) Determination of total alkalinity of a given water sample
(vii) Determination of the molarity and percent by mass of acetic acid in vinegar
(viii) Estimation of alkali content of an antacid tablet.

4. Complexometric Titrations

(i) Determination of Ca^{2+} ions in a given water sample by titrating against EDTA solution
(ii) Determination of calcium content in a chalk sample
(iii) Determination of calcium content in a milk sample
(iv) Determination of hardness of water

5. Enthalpy of reactions

(i) Determination of heat of neutralization of a strong acid by a strong base.
(ii) Determination of heat of solution of oxalic acid from solubility measurement
(iii) Determination of enthalpy of dissolution of (a) $CaCl_2$ and (b) NH_4Cl in water

6. pH Measurements

(i) Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.
(ii) Determination of pH of unknown solution (buffer), by colour matching method.

7. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.

Any other experiment carried out in the class

*****A few experiments will be set from each section depending on the availability of chemicals and equipment.

REFERENCE BOOKS

1. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009).
2. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson. 2009
3. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007).
4. Palit, S.R., De, S. K. Practical Physical Chemistry Science Book Agency.
5. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta.
6. Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
7. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd.

Course Details			
Course Title: Scientific Heritage of Ancient and Medieval India			
Course Code	**CHE51VA10102**	**Credits (L + T + P)**	2 (2+ 0 + 0)
Nature of Course	Value-added Course	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	30 (L) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To develop an understanding of science and technology in ancient India
- To explore the scriptures of Vedic origin and writings of ancient scientists
- To acquaint with the rich scientific heritage of India
- To impart knowledge and skills for scientific analysis of ancient archeological findings

Learning Outcomes: After completion of the course the learners will be able to:

- Explain the vedic origin of some of the modern scientific findings
- Innovate and devise new tools/techniques using ancient wisdom
- Investigate and solve several such mysteries relating to ancient scientific wonders

UNIT-I

Science and Technology in Ancient India (15 L)

Astronomy, Mathematics, Biology and other sciences in Ancient India: Vedic Period, Vedānga, Classical Age; Vedic Concept of light, the scientific concept in vedas for the treatment of water (Apah), Derivation of Modern Scientific discoveries from Vedic Sastras, Metallurgy, Mathematics and astronomy during Indus civilization. Contribution of ancient scientists: Mahatma Kapila, Acharya Kanad, Sushrut, Charak, Bhaskracharya, Nagarjuna, Bhardwaj, Agastya, Brahmgupta, Aryabhatta; Madhava and Nilakantha

UNIT-II

Chemistry in Ancient and Medieval India (15 L)

Metallurgy & Chemistry : Copper, Iron and Glass technology in India from earliest time to medieval India; Smelting of metals, distillation of perfumes and fragrant ointments, making of dyes and pigments, developments of fixers, extraction of sugar, medicinal plants, ayurvedic medicines, understanding poisons, biofertilizers; science behind the metallurgical wonder, the Iron Pillar of Delhi; The extraordinary strength and sharpness of Damascus swords and its Indian origin, Carbon nanotubes in 600 BC potteries in India.

References:

1. Hegde, K.T.M., An Introduction to Ancient Indian Metallurgy, Banglore, 1991.
2. Hodges, H., Technology in the Ancient world, London, Pelican, 1970.
3. Kutumbia, P., Ancient Indian Medicine, New Delhi, 1962.

4. Randhawa, M.S., A History of Agriculture in India, New Delhi, 1980.
5. Rose, D.M. et al., Concise History of Science of India, New Delhi, 1971.
6. Singh, A.N. and Dutta, B.B., History of Hindu Mathematics (English and Hindi). Vols. I and II Lahore, 1935 and 1938.
7. Tripathi, Vibha. The Age of Iron in South Asia: Legacy and Tradition. Delhi. 2001
8. Ray, A.P.C., History of Hindu Chemistry, Vol 1-3, Bengal Chemicals and Pharmaceuticals Works Ltd., Kolkata, 1903.
9. Science-Vedas, the India's Science Base https://vedicheritage.gov.in/science/
10. Charak Sanhita, https://niimh.nic.in/ebooks/ecaraka
11. Paufler, Peter, *Carbon nanotubes in an ancient Damascus sabre*, Nature, *2006*, *444*, *286*
12. Hudson, JC, The Delhi Pillar, Nature, 1953, 172, 499–500
13. Lepkova, C, et. al, Uncovering the superior corrosion resistance of iron made via ancient Indian iron-making practice, Scientific Reports (Nature Publishing Group), 2021, 11, 4221
14. Chandrasekaran, V, Discovery of carbon nanotubes in sixth century BC potteries from Keeladi, India, Scientific *Reports* (Nature Publishing Group), 2020, 11, 4221
15. Indians predated Newton 'discovery' by 250 years https://www.manchester.ac.uk/discover/news/indians-predated-newton-discovery-by-250-years/

SECOND SEMESTER (EVEN SEMESTER)

Course Details			
Course Title: Organic Chemistry-I			
Course Code	**CHE52MJ20004 *(CHE52MN20004)**	**Credits (L + T + P)**	4 (3 + 1 + 0)
Nature of Course	Major (*minor for other disciplines)	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives:

- To learn the basics of molecular orbital theory, stereochemistry of organic compounds.
- To develop an understanding of the chemistry of hydrocarbons and their halogen derivatives.

Learning Outcomes: After completion of the course the learners will be able to:

- Understand the concepts of VBT, and can draw the molecular orbital diagrams of molecules and molecular ions.

- Can understand the electronic displacements, analyze the symmetry elements and can assign the R/S and or/E/Z nomenclature to the molecules.
- Students will be able to get knowledge of chemical reactions and mechanisms of aliphatic and aromatic organic molecules.

UNIT-I

Fundamentals of Organic Chemistry (15L)

Valence Bond Theory:

Concept of hybridization, shapes of molecules, resonance (including hyperconjugation); calculation of formal charges and double bond equivalent (DBE); orbital pictures of bonding (sp^3, sp^2, sp: C-C, C-N & C-O systems and s-cis and s-trans geometry for suitable cases).

MO theory:

Qualitative idea about molecular orbitals, bonding and antibonding interactions, idea about σ, σ*, π, π*, n – MOs; basic idea about Frontier MOs (FMO); concept of HOMO, LUMO and SOMO; interpretation of chemical reactivity in terms of FMO interactions; sketch and energy levels of π MOs of acyclic p orbital system (C=C, conjugated diene, triene, allyl and pentadienyl systems.

Electronic Displacements and Basic of Reaction Mechanism:

Inductive, electromeric, resonance, mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

UNIT-II

Stereochemistry-I (17L)

Concept of chirality and symmetry:

Symmetry elements and point groups (C_{nh}, C_{nv}, C_n, D_{nh}, D_{nd}, D_n, S_n (C_s, C_i); molecular chirality and centre of chirality; asymmetric and dissymmetric molecules; enantiomers and diastereomers; concept of epimers; concept of stereogenicity, chirotopicity and pseudoasymmetry; chiral centres and number of stereoisomerism: systems involving 1/2/3-chiral centre(s).

Relative and absolute configuration:

D/L and R/S descriptors; erythro/threo and meso nomenclature of compounds; syn/anti nomenclatures for aldols; E/Z descriptors for C=C, conjugated diene, triene, C=N and N=N systems; combination of R/S- and E/Z- isomerism.

Optical activity of chiral compounds:

Optical rotation, specific rotation and molar rotation; racemic compounds, racemisation (through cationic, anionic, radical intermediates and through reversible formation of stable achiral intermediates); resolution of acids, bases and alcohols via diastereomeric salt formation; optical purity and enantiomeric excess; invertomerism of chiral trialkylamines.

Conformation analysis of alkanes:

Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

UNIT-III

Chemistry of Aliphatic Hydrocarbons (18L)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structures.

Alkanes: Preparation: catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: mechanism for free radical substitution: halogenation.

Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Alkenes:

Preparation: elimination reactions: dehydration of alcohols and dehydrohalogenation of alkyl halides; *cis*- alkenes (partial catalytic hydrogenation) and *trans*- alkenes (Birch reduction). Reactions: cis-addition (alkaline $KMnO_4$) and trans-addition (bromine) with mechanism, addition of HX [Markownikoff's (with mechanism) and anti-Markownikoff's addition], hydration, ozonolysis, oxymercuration-demercuration and hydroboration-oxidation reaction.

Alkynes:

Preparation: acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline $KMnO_4$.

Cycloalkanes and Conformational Analysis:

Types of cycloalkanes and their relative stability, Baeyer strain theory, Methods of preparation and Reactions.

UNIT-IV

Aromatic Hydrocarbons: **Aromaticity**: **(10L)**

Aromaticity, Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

Reference Books

1. Paula Yurkanis Bruice, Organic Chemistry, 7th Edition, Pearson.
2. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education, latest).
3. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994,
4. Sengupta, Subrata. Basic Stereochemistry of Organic molecules.
5. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education, Latest).
6. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
7. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

Course Details			
Course Title: Fundamentals of Industrial Chemistry			
Course Code	**CHE52MD50203**	**Credits (L + T + P)**	3 (3 + 0 + 0)
Nature of Course	**Multidisciplinary course**	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) Hours

Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)

Course Objectives:

- This course is designed to provide an overview on fundamental scientific knowledge of energy materials such as fuels.
- Importance of fertilizers in agriculture, knowledge about the construction materials cement, and polymers, and applications of paints varnishes in our daily life.

UNIT-I

Fuels **(15L)**

Classification of fuel; heating values; origin of coal, carbonization of coal, coal gas, producer gas, water gas, coal-based chemicals; origin and composition of petroleum, petroleum refining, cracking, knocking, octane number, antiknock compounds, kerosene, liquefied petroleum gas (LPG), liquefied natural gas (LNG); petrochemicals (C1 to C3 compounds and their uses).

UNIT-II

Fertilizers, Dyes and pigments **(07L)**

Manufacture of ammonia and ammonium salts, urea, superphosphate, bio-fertilizers.

Basic idea on dyes and pigments, Natural and synthetic dyes, Ideas on some dyes such as methyl orange, congo red, malachite green, crystal violet.

UNIT-III

Cement, Paints and varnishes: **(08L)**

Portland cement: composition and setting of cement, white cement.

Primary constituents; formulation of paints; binders and solvents for paints; oil-based paints, latex paints, alkyd resin paint. Constituents of varnishes; formulation of varnishes.

UNIT-IV

Polymers, **(15L)**

Basic concept, structure and types of plastics, polythene, polystyrene, phenol-formaldehydes, PVC; manufacture, physical properties and uses of natural rubber, synthetic rubber, silicone rubber; synthetic fibers, nylon-66, polyester, terylene, rayon; foaming agents, plasticizers, and stabilizers.

Reference Books

1. Banerjee, S. P. A Text Book of Analytical Chemistry, The New Book Stall.
2. Gangopadhyay, P. K. Application Oriented Chemistry, Book Syndicate.
3. Mondal, A. K & Mondal, S. Degree Applied Chemistry, Sreedhar Publications.
4. Banerjee, S. P. A Text Book of Analytical Chemistry, The New Book Stall.
5. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont

Course Details			
Course Title: Organic Chemistry Lab-I			
Course Code	**CHE52SE20003**	**Credits (L + T + P)**	3 (0 + 0 + 3)
Nature of Course	**Skill Enhancement course**	**Course Duration**	One Semester

Semester	Even	**Contact Hours**	90 hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

*****Few experiments will be set from each section depending on the availability of chemicals and equipments.

Course Objectives:

- To make students proficient in separation of mixtures of binary compounds using acid base treatment.
- To get the knowledge about how to identify the functional groups present in the molecules.
- To impart effective training in synthesis of organic compounds and identification of reactions using TLC technique.

Learning Outcomes:

- After completion of the course the learners will be able to place the organic reactions for synthesis, and can understand the monitoring of the reaction.
- Students are able to separate the mixture of compounds.

Separation Techniques

Based upon solubility, by using common laboratory reagents like water (cold, hot), dil. HCl, dil. NaOH, dil. $NaHCO_3$, etc., of components of a binary solid mixture; purification of any one of the separated components by crystallization and determination of its melting point. The composition of the mixture may be of the following types: Benzoic acid/p-Toluidine; p-Nitrobenzoic acid/p- Aminobenzoic acid; p-Nitrotolune/p-Anisidine; etc.

Functional Group Identifications-I

Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.

Organic preparations

i. Acetylation of any one from the available compounds: amines (aniline, o-, m-, ptoluidines and o-, m-, p-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: a. Using conventional method. b. Using green approach

ii. Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and one of the following phenols (β-naphthol, resorcinol, pcresol) by Schotten-Baumann reaction.

iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).

iv. Bromination of any one of the following: a. Acetanilide by conventional methods b. Acetanilide using green approach (Bromate-bromide method)

v. Nitration of any one of the following: a. Acetanilide/nitrobenzene by conventional method b. Salicylic acid by green approach (using ceric ammonium nitrate).

vi. Selective reduction of meta dinitrobenzene to m-nitroaniline.

vii. Reduction of p-nitrobenzaldehyde by sodium borohydride.

viii. Hydrolysis of amides and esters.

ix. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.

x. S-Benzylisothiouronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).

xi. Aldol condensation using either conventional or green method.

xii. Benzil-Benzilic acid rearrangement. The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC

Any other experiment carried out in the class

Reference Books:

1. Bhattacharyya, R. C, A Manual of Practical Chemistry.
2. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, CBS Publishers and Distributors.
3. Mann, F. G. & Saunders, B. C. Practical Organic Chemistry, Pearson Education (2009).
4. Furniss, B. S., Hannaford, A.J., Smith, P. W. G., Tatchell, A. R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
5. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000). Page 18 of 70

Course Details			
Course Title: Chemistry of Ayurveda			
Course Code	**CHE52VA10202**	**Credits (L + T + P)**	2 (1 + 1 + 0)
Nature of Course	Value-added	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	30 (L)
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	● 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ● 70% - End Term External Examination (University Examination)		

Course Objectives

- To understand the origin of drugs from plants and the methods of formulations
- To equip the students with the skills of physical and chemical testing of ayurvedic formulations
- To acquaint with the various extraction, distillation and other modern methods
- To learn in detail, the different instrumental methods used for separation

Learning Outcomes: After completion of the course the learners will be able to:

- Explain the preparation of diverse type of Aurvedic formulations
- Determine the quality of Aurvedic formulations through physical and chemical testing.
- Predict the extraction procedure to separate phytochemicals in a formulation
- Determine the heat capacity, enthalpy etc for a given system.

UNIT-I

Ayurvedic formulations and its tests (15 L)

Preparation methods of Asava and Arishta, Arka, Panchavidha Kashaya Kalpana, Guggulu, Ghrita, Tailam, Lehyam, Kshara, Churna, Vati and Gutika. Animal origin drugs, Mineral origin drugs, plant origin drugs, Shodhana (Process of detoxification).

***Physical tests*:** Determination of optical rotation and specific optical rotation, Viscosity, Saponification value, Iodine value, Acid value, Peroxide value, Unsaponifiable matter, Mineral oil, Rancidity, Reichert and Polenske value,

Chemical tests: Estimation of Phenolics, Alkaloids, Tannins, Sugars, Total sugars, non-reducing sugars, Sucrose, Fructose- Glucose ratio, Sulphur Dioxide, Pesticide residue, Volatile oil, fatty oil, Proteins.

UNIT-II

Methods of Extraction and Separation (15L)

Extraction Methods: Maceration, percolation, Decoction reflux extraction, Soxhlet extraction, Pressurised liquid extraction, Supercritical fluid extraction, Ultrasound assisted extraction, Microwave assisted extraction, Pulse electric field extraction, Enzyme assisted extraction, Hydro distillation and steam distillation.

Separation methods: Adsorption column chromatography, Partition chromatography/Liquid-Liquid extraction, Membrane filtration, Gel-filtration chromatography, Ion exchange chromatography, Molecular distillation, Preparative gas chromatography (Prep-GC), Supercritical fluid chromatography (SFC), Molecular imprinted technology, Simulated moving bed chromatography, Multi-dimensional chromatographic separation

Textbooks/References

1. The Ayurvedic Formulary of India (AFI) Volume 1& 2
2. A Textbook of Bhaisajya Kalpana Vijana (Pharmaceutical Science) by Ravindra Angadi ISBN: 9390804639 (ISBN13: 9789390804634).
3. Ayurveda pharmacopeia of India (API) volume 6
4. Zhang et al. Chin Med (2018) 13:20, doi.org/10.1186/s13020-018-0177-x.
5. Separation Methods in Organic Chemistry and Biochemistry, Frank J. Wolf, eBook ISBN: 9781483220680.
6. Green Extraction in Separation Technology, Ali Haghighi Asl, Maryam Khajenoori, ISBN 9781032050409

THIRD SEMESTER (ODD SEMESTER)

Course Details			
Course Title: Inorganic Chemistry-II			
Course Code	**CHE61MJ10004 *(CHE61MN10004)**	**Credits (L + T + P)**	4 (3 + 1 + 0)
Nature of Course	Major (*****minor for other disciplines)	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To develop an understanding of covalent and ionic bonding
- To make the students learn about weak interactions and metallic bonding
- To impart in-depth knowledge redox reactions and precipitation reactions
- To equip the students with the concept of acid and bases and use of solvents

Learning Outcomes: After completion of the course the learners will be able to:

- Predict and analyze the bonding patterns in chemical compounds
- Explain the acidic and basic nature of a compound
- Solve problems related with oxidation states, complex formation tendency
- Determine the pH of a solution and solubility product of a sparingly soluble salt.

UNIT-I

Chemical Bonding-I **(15L)**

Covalent bond: Lewis structures, formal charge, Shapes of some inorganic molecules and ions on the basis of VSEPR, ***Valence Bond Theory***, and hybridization (sp, sp^2, sp^3, sp^3d, sp^3d^2 and dsp^2) with suitable examples from s and p block elements of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Directional character of covalent bonds, equivalent and non-equivalent hybrid orbitals, Bent's rules, dipole moments,
Resonance and Resonance energy: Study of some inorganic and organic compounds (O_3, NO_3^-, CO_3^{2-}, SO_4^{2-}, $RCOO^-$, C_6H_6).

Molecular Orbital (MO) Theory: The approximations of the theory, Linear combination of atomic orbitals (LCAO) (elementary pictorial approach): sigma and pi bonds and delta interaction, multiple bonding. Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, Orbital designations: gerade, ungerade, HOMO, LUMO, Orbital mixing. MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s- p mixing). Heteronuclear
molecular orbitals: CO, NO, NO^+, CN^-, HF, BeH_2, CO_2 and H_2O. Bond properties: bond orders, bond lengths.

UNIT-II

Chemical Bonding-II **(15L)**

Ionic Bonding: General characteristics of ionic bonding, types of ions, size effects, radius ratio rule and its application and limitations. Packing of ions in crystals. lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Born-Lande equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Defects in solids (elementary idea). Polarizing power and polarizabilty, Fajan's rules,

Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

UNIT-III

Redox Reactions and precipitation reactions **(15L)**

Qualitative idea about complimentary, noncomplimentary, disproportionation and comproportionation reactions, standard redox potentials with sign conventions, Electrochemical series and its application to explore the feasibility of reactions and equilibrium constants, Nernst equation; effect of pH, complexation and precipitation on redox potentials, formal potential; Basis of redox titration and redox indicators, Redox potential diagrams (Latimer and Frost) of common elements and their applications.

Solubility product principle, common ion effect and their applications to the precipitation and separation of common metallic ions as hydroxides, sulphides, carbonates, sulphates and halides.

UNIT-IV

Acid-Base Concepts and Solvents **(15L)**

Recapitulation of Arrhenius concept, Bronsted-Lowry concept, Solvent system concept (in H_2O, liq. NH_3, liq. SO_2 and liq. HF), Lux-Flood concept, Lewis concept, Solvent levelling and differentiating effects, Relative strength of different acids and bases, Pauling's rules, Hammett acidity function and super acids, HSAB principle and its applications, Acid-base equilibria in aqueous solution, pH, Buffer, Acid-base neutralization curves and choice of indicators

Reference Books:

1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970.
3. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
4. Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).
5. Cotton, F.A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry 3rd Ed.; Wiley India.
6. Sharpe, A.G., Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005.
7. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006.
8. Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
9. Mingos, D.M.P., Essential trends in inorganic chemistry. Oxford University Press (1998).
10. Winter, M. J., The Orbitron, http:// winter.group.shef.ac.uk/orbitron/ (2002). An illustrated gallery of atomic and molecular orbitals.
11. Burgess, J., Ions in solution: basic principles of chemical interactions. Ellis Horwood (1999).
12. Das, A. K., Fundamental Concepts of Inorganic Chemistry, Vol-1-6, Third Edition, CBS Publishers and Distributors

Course Details			
Course Title: Physical Chemistry-II			
Course Code	**CHE61MJ30004 *(CHE61MN30004)**	**Credits (L + T + P)**	4 (3 + 1 + 0)
Nature of Course	Major (*****minor for other disciplines)	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To develop an understanding of second and third law of thermodynamics
- To make the students learn about Chemical Equilibrium
- To impart in-depth knowledge about colligative properties
- To equip the students with the concept of chemical kinetics

Learning Outcomes: After completion of the course the learners will be able to:

- Predict and analyze the energy and entropy changes in a system
- Explain the various reactions under equilibrium

- Solve problems related to colligative properties
- Determine the rate constant and activation energy of a reaction.

UNIT-I

Thermodynamics-II **(25L)**

Second Law: Need for a Second law; statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle and its efficiency; Carnot's theorem; Carnot engine and refrigerator; Physical concept of Entropy; Values of §dQ/T and Clausius inequality; Entropy as a state function, entropy as a function of V & T, entropy as a function of P & T, Entropy change involved in various physical transformations; Entropy change for ideal gases under different conditions, entropy change while mixing of ideal gases; Gibbs and Helmholtz Functions, (G and A) as thermodynamic quantities, Variation of G and A with T, P and V. Criteria for spontaneity and equilibrium.

Thermodynamic relations: Maxwell's relations; Gibbs-Helmholtz equation, Clapeyron equation and Clausius Clapeyron Equation and applications.

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

UNIT-II

Chemical equilibrium **(6L)**

Thermodynamic conditions for equilibrium; Law of Mass action, Van't Hoff's reaction isotherm (deduction from chemical potential)); Equilibrium constant and standard Gibbs free energy change; Definitions of K_P, K_C, K_X and their relations; Shifting of equilibrium due to change in external parameters e.g. temperature and pressure; variation of equilibrium constant on addition of inert gas; Le Chatelier's principle

UNIT-III

Solutions and Colligative Properties **(8L)**

Dilute solutions; lowering of vapour pressure. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution

UNIT-IV

Chemical Kinetics **(21L)**

Order and molecularity of a reaction, rate of a reaction, factors influencing the rate of a reaction: concentration, temperature, pressure, solvent, light, catalyst, catalyst. Differential and integrated form of rate expressions for-zero order, first order, second order reactions. Pseudo order reactions; Half-life and mean life. Determination of the order of reaction-differential method, method of integration, method of half-life period and isolation method. Kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms); chain reactions. Temperature dependence of reaction rates; Arrhenius equation; concept of activation energy; Collision theory; qualitative idea on transition state theory.

SUGGESTED TEXTBOOKS:

1. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford Univ. Press (2022), 12th ed.
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004)
3. Rakshit, P.C., Physical Chemistry Sarat Book House.
4. Laidler, K. J. Chemical Kinetics, Pearson.Puri, B. R., Sharma, L. R., Pathania, M.S. Principles of Physical Chemistry, Vishal Publishing Co.
5. Kapoor, K.L. A textbook of Physical Chemistry, Vol 2., Mc. Graw Hill education.

Reference Books

1. Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas.
2. Clauze & Rosenberg, Chemical Thermodynamics
3. Mortimer, R. G. Physical Chemistry, Elsevier.
4. Bahl, B.S., Bahl, A., Tuli, G.D., Essentials of Physical Chemistry, S. Chand & Co. ltd. https://ncert.nic.in/textbook/pdf/kech107.pdf
5. M. Soustelle, An Introduction to Chemical Kinetics, Wiley.

Course Details			
Course Title: Green Energy Systems			
Course Code	**CHE61MD50303**	**Credits (L+T+P)**	3 (3+0+0)
Nature of Course	Multidisciplinary	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L)
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To make students aware of the emerging energy scenario with respect to fast depletion of fossil fuels and climate change
- To impress upon the students, the need to innovate and design cleaner and greener techniques to generate energy
- To make students learn the principles, design and working of electrochemical power sources
- To impart the knowledge about fuel cells and emphasize the importance of hydrogen as a fuel
- To develop a comprehensive understanding of solar cells

Learning Outcomes: After completion of the course the learners will be able to:

- Understand the energy crisis in relation to climate change
- Compare and contrast the green and non-green energy sources
- Distinguish between primary and secondary electrochemical power sources
- Discuss the relevance of hydrogen as green fuel
- Explain the working of various types of solar cells

UNIT-I

Overview of energy scenario **(6L)**

Available energy options, their advantages and disadvantages. Environmental effects, comparative evaluation of energy options and energy needs. Fossil fuels: petroleum, natural gas and coal Origin, processing and production of value-added products available current conversion technologies.

UNIT-II

Photovoltaic cells **(13 L)**

Introduction, Photovoltaics (PV) in the context of global energy demand and climate change, The solar resource: Spectra, insolation, diffuse vs. direct, atmospheric absorption,

light absorption andcharge generation, recombination in semiconductors, depletion Approximation, derivation of ideal diode law, solarcell performance output parameters, Ideal efficiency limits, Practical sources of loss, characterizing solar cell performance, Improving efficiency by reducing optical losses: texturing, anti-reflection coatings, light trapping, photon recycling, concentrating PV. Commercial Technologies based on c-Si, CdTe, organic semiconduc

UNIT-III

Electrochemical Cells (13 L)

Electrochemical power sources theoretical background on the basis of thermodynamic and kinetic considerations.

Primary cells- various types, especially magnesium and aluminum based cells, magnesium reserve batteries. Secondary cells: classification based on electrolyte type, temperature of operation on the basis of electrodes, chemistry of the main secondary batteries for electric vehicles- present status.

UNIT-IV

Hydrogen as fuel (13 L)

Fuel cells: classification chemistry of fuel cells detailed description of hydrogen/oxygen fuel cells methanol molten carbonate solid polymer electrolyte and biochemical fuel cells. Hydrogen as fuel production (thermal, electrolysis, photolysis and photo electrochemical) storage and applications of hydrogen storage.

Solar energy conversion devices, photovoltaic cells, photo electrochemical cells, dye sensitized solar cells, semiconductor/electrolyte junctions, photocatalytic modes for fuel conversion process, photo biochemical options. Other methods of energy conversion: processes especially in the form of storage as chemical energy.

SUGGESTED TEXT BOOKS

1. C. A. Vincent Modern Batteries, Edward Arnold, 1984.
2. R. Narayanan and B. Viswanathan, Chemical and Electrochemical energy systems, Orient Longmans, 1997.
3. K. Sriram, Basic Nuclear Engineering, Wiley Eastern, 1990.
4. A. S. J. Appleby and F. K. Foulkes, Fuel cell Hand Book, Von Nostrand Reinhold, 1989.
5. D. Linden, Hand book of batteries and Fuel cells, McGraw Hill Book Company, 1984.
6. T. Ohta, Solar Hydrogen energy systems, Peragamon Press, 1979.
7. M. Gratzel, Energy Resources through photochemistry and catalysis, Academic Press, 1983.
8. T. Ohta, Energy Technology, Sources, Systems and Frontiers conversions, Pergamon, 1994.
9. J. G. Speight, The chemistry and technology of petroleum, Marcel Dekker Inc. (1980).
10. J. Nelson, Physics of Solar Cells, Imperial College Press, 2003. ISBN-13: 978-1860943492.
11. Gavin J. Conibeer and Arthur Willoughby, eds., Solar Cell Materials: Developing Technologies, John Wiley & Sons, Inc., 2014, ISBN: 978-0-470-06551-8.
12. J. Poortmans and V. Arkhipov, eds., Thin Film Solar Cells: Fabrication, Characterization, and Applications, John Wiley & Sons, Ltd., 2006.

Course Details			
Course Title: Inorganic & Physical Chemistry Lab-II			
Course Code	**CHE61SE13103**	**Credits**	3 (0 + 0 + 3)
Nature of Course	Skill-enhancement	**Course Duration**	One Semester

Semester	Odd	**Contact Hours**	90 Hours
Methods of Content Interaction	Lecture, Reagents Preparation and Practical Classes		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives:

- To make students proficient in quantitative analysis using iodometry and redox titrations
- To impart skills in setting a kinetics experiment and its analysis.
- To provide training on measurements of properties of liquids
- To impart skills in qualitative analysis of cations and an anion

Learning Outcomes: After completion of the course the learners will be able to

- Determine the concentration of iron in a samples and free chlorine in freshwater system.
- Set up kinetics experiment and determine the rate constant and activation energy
- Determine viscosity, surface tension, reflective index of a liquid
- Detect the presence of cations and anions in a given sample

1. **Redox titrations**
   - **(i)** Estimation of Fe (II) ions by titrating it with $KMnO_4$
   - **(ii)** Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ solution
   - **(iii)** Estimation of Fe(III) using $KMnO_4$ solution
   - **(iv)** Determination of dissolved oxygen in a sample of freshwater system
2. **Iodometric Titrations**
   - **(i)** Standardization of thiosulfate solution and estimation of Cu^{2+} by performing iodometric titration
   - **(ii)** Determination of 'free chlorine' in a given water sample
3. **Chemical Kinetics**
   - **(i)** Study of kinetics of acid-catalyzed hydrolysis of ester.
   - **(ii)** Study of kinetics of decomposition of H_2O_2.
   - **(iii)** Study of kinetics of base-catalyzed hydrolysis of ester
   - **(iv)** Study of kinetics of iodination of acetone
4. **Properties of liquids**
   - **(i)** Determination of density of liquids using specific gravity bottle.
   - **(ii)** Determination of viscosity of the given liquid using Ostwald's viscometer.
   - **(iii)** Measurement of the surface tension of the given liquid using stalagmometer.
   - **(iv)** Vapor pressure measurement of pure liquid and a solution involving it.
   - **(v)** Determination of the enthalpy of vaporization of water
   - **(vi)** Determination of the refractive index of a pure liquid
5. **Qualitative semi-micro analysis of mixtures containing three radicals. Emphasis should be given to the understanding of the chemistry of different reactions.**

   Acid Radicals: Cl^-, Br^-, I^-, NO_2^-, NO_3^-, S^{2-}, SO_4^{2-}, BO_3^{3-}, H_3BO_3

   Basic Radicals: K^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Cr^{3+}, Mn^{2+}, Fe^{3+}, Ni^{2+}, Cu^{2+}, NH_4^+.

Any other experiment carried out in the class.

*****Few experiments will be set from each section depending on the availability of chemicals and equipments.

REFERENCES BOOKS:

1. A Text Book of Qualitative Inorganic Analysis: A I Vogel
2. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012
3. Practical Physical Chemistry: A Findlay University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta, 2003.
4. Palit, S.R., Practical Physical Chemistry Science Book Agency.
5. Mukherjee, N.G., Selected Experiments in Physical Chemistry J. N. Ghose & Sons.
6. Dutta, S.K., Physical Chemistry Experiments Bharati Book Stall.
7. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009).
8. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
9. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007).
10. Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
11. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry

FOURTH SEMESTER (EVEN SEMSTER)

Course Details			
Course Title: Inorganic Chemistry-III			
Course Code	**CHE62MJ10104 *(CHE62MN10104)**	**Credits (L + T + P)**	4 (3 + 1 + 0)
Nature of Course	Major (*minor for other disciplines)	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To make the students learn about the properties of s and p block elements
- To make the students learn about Nobel gases and inorganic polymers
- To get idea about coordination compounds
- To impart in-depth knowledge on valence bond theory and crystal field theory

Learning Outcomes: After completion of the course the learners will be able to:

- Predict and analyze the hydrogen bonding, host-guest interactions in chemical compounds
- Explain the crystal field splitting pattern in a complex
- Solve problems on coordination number and geometric shape of complexes
- Determine the bond order and bond length of chemical compounds
- Relate synthetic strategies of inorganic polymers for specific purposes

UNIT-I

Chemistry of s and p Block Elements **(15L)**

(a) Allotropy and catenation. Complex formation tendency of s and p block elements. Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate.

(b) Study of the compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides; Structure and bonding in boranes, carboranes, metallocarboranes, Wade's rules, Wades-Mingos and Lauher rules; borohydrides (diborane) carboranes and graphitic compounds, silanes. Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

(c) Silicates- Classification, structures, isomorphous replacement, pyroxenes, layered and vitreous silicates, zeolites and molecular sieves

UNIT-II

Nobel gases and Inorganic polymers (15L)

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

(b) Inorganic Polymers: Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates, P, N and S compounds

UNIT-III

Introduction to Coordination Chemistry (10L)

Werner's coordination theory, Types of ligands, monodentate, bidentate ambidentate and polydentate ligands (including Acceptor and macrocyclic ligands.). IUPAC Nomenclature of Co-ordination compounds. Various types of isomerism of 4-and 6- coordinate compounds; Stereoisomerism: chirality, optical activity in inorganic complexes

UNIT-IV

Valence bond theory and Crystal field theory (20L)

(a) Valence Bond Theory (VBT), Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature.

(b) Crystal Field Theory (CFT): Postulates of CFT, splitting of d-orbitals in octahedral, tetrahedral and square planar fields, Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields: pairing energy, Factors affecting the magnitude of Δ. Spectrochemical series. Comparison of CFSE for O_h and T_d complexes. Jahn- Teller distortion. Octahedral site stabilization energy (OSSE). Metal-ligand bonding (MO concept, elementary idea), sigma- and pi-bonding in octahedral complexes (qualitative pictorial approach) and their effects on the oxidation states of transitional metals (examples).

Reference Books:

1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.

2. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970.

3. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
4. Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).
5. Cotton, F.A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry 3rd Ed.; Wiley India.
6. Sharpe, A.G., Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005.
7. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006.
8. Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
9. Mingos, D.M.P., Essential trends in inorganic chemistry. Oxford University Press (1998).
10. Winter, M. J., The Orbitron, http:// winter.group.shef.ac.uk/orbitron/ (2002). An illustrated gallery of atomic and molecular orbitals.
11. Burgess, J., Ions in solution: basic principles of chemical interactions. Ellis Horwood (1999).
12. Das, A. K., Fundamental Concepts of Inorganic Chemistry, Vol-1-6, Third Edition, CBS Publishers and Distributors.

Course Details			
Course Title: Organic Chemistry-II			
Course Code	**CHE62MJ20104 *(CHE62MN20104)**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Major (*minor for other Disciplines)	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	● 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ● 70% - End Term External Examination (University Examination)		

Course Objectives:

- To develop an understanding of the chemistry of halides, alcohols, carbonyl compounds and carboxylic acid derivatives.

Learning outcome: After completion of the course the learners will be able to:

- Understand the synthesis of above functional group containing compounds and learn their chemistry.
- Use these functional groups for their manipulation in the organic synthesis.
- Learn the mechanism of all related reactions.

UNIT-I

AKYL AND ARYL HALIDES **(15L)**

Alkyl halides: A study of alkyl halides highlighting its synthetic applications, nomenclature and classes of alkyl halides, methods of formation, chemical reactions. *Nucleophilic **substitution reactions**:* Substitution at sp^3 centre: mechanisms (with evidence), relative rates

& stereochemical features: S_N1, S_N2, S_N2', S_N1' (allylic rearrangement) and S_Ni; effects of solvent, substrate structure, leaving group and nucleophiles (including ambident nucleophiles, cyanide & nitrite); substitutions involving neighboring group participation (NGP); role of crown ethers and phase transfer catalysts; Polyhalogen compounds: chloroform, carbon tetrachloride.

Aryl halides: Methods of formation of aryl halides, nuclear and side chain reactions. The addition-elimination and elimination-addition mechanisms of nucleophilic aromatic substitution reactions. Relative reactivities of alkyl halides vs. allyl, vinyl and aryl halides. Synthesis and uses of DDT and BHC, difficulty in biodegradation and idea of their toxicity

UNIT-II

Alcohols, Phenols, Ethers and Epoxides (15L)

Alcohols: preparation, physical and chemical properties, and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$.

UNIT-III

Carbonyls and Carboxylic Acid Derivatives (15L)

Carbonyl Compounds

Structure of the carbonyl group, nomenclature of aldehydes and ketones, important methods of synthesis with special reference to the synthesis of aldehydes from acid chlorides, synthesis of aldehydes and ketones using 1,3-dithianes, synthesis of ketones from nitriles and from carboxylic acids. Physical properties. Mechanism of nucleophilic addition to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensations. Use of acetals as protecting group. Baeyer-Villiger oxidation of ketones, Cannizzaro reaction, MPV, Clemmensen, Wolff-Kishner, $LiAlH_4$ and $NaBH_4$ reductions. Halogenation of enolizable ketones. An introduction to α,β-unsaturated aldehydes and ketones.

Organic Synthesis Via Carbanions

Synthesis of ethylacetoacetate by Claisen condensation and diethyl malonate. Acidity of α-hydrogens, alkylation of diethyl malonate and ethyl acetoacetate. Synthetic applications of malonic ester: dicarboxylic acids-succinic acid and adipic acid; α,β-unsaturated acids: crotonic acid and cinnamic acid; antipyrine, uracil and actyl acetone. Keto-enol tautomerism of ethyl acetoacetate., alkylation and acylation of enamines.

UNIT-IV

CARBOXYLIC ACIDS -I (15L)

Nomenclature, structure and bonding. Preparation of carboxylic acids-by oxidation, by using Grignard reagent and by hydrolysis of nitriles. Physical properties, acidity, effect of substituents on acid strength of carboxylic acids. Reactions of carboxylic acids: HVZ reaction, synthesis of acyl chlorides, esters and amides. Reduction of carboxylic acids. Mechanism of

decarboxylation. Hydroxy acids: malic, tartaric and citric acids, methods of formation and important chemical reactions.

Unsaturated monocarboxylic acids: Methods of formation and chemical reactions.

Dicarboxylic acids: methods of formation and effect of heat and dehydrating agents.

Carboxylic acid derivatives: Structure, nomenclature, preparation and chemical reactions of acyl chlorides, esters, amides and acid anhydrides. Mechanism of esterification and hydrolysis (acid, base conditions).

REFERENCE BOOKS:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
4. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
5. Organic Chemistry 4th ed - Francis A. Carey, The McGraw-Hill Companies, Inc

Course Details			
Course Title: Organic Chemistry Lab-II			
Course Code	**CHE62MJ20204**	**Credits (L + T + P)**	4(0 + 0 + 4)
Nature of Course	Major	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	120 hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	● 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) ● 70% - End Term External Examination (University Examination)		

*****Few experiments will be set from each section depending on the availability of chemicals and equipments.

Course Objectives:

- To equip the students with necessary laboratory skills for performing experiments such as synthesis, and identification of functional groups.
- To acquaint students with basics of laboratory purification techniques such as column chromatography and crystallization.

Learning Outcomes: After completion of the course the learners will be able to:

- Identify the functional groups, purify the compounds using column and crystallization techniques

Organic Preparations:

A. Functional groups tests-II,

B. Preparation of crystalline derivative and determination of their m.p.s and reference to literature to identify the compounds A minimum of **8** following compounds to be studied as unknown covering at least one from each of the solubility classes.

Glucose, benzoic acid, 2-chloro benzoic Acid, Anisic acid, p-Nitrobenzoic acid; p-Cresol, p-Chlorophenol, β-Naphthol; Aniline, o/m/p-Chloroanilines; N-Methyl aniline/N-Ethylaniline, *N*,*N*-Dimethylaniline, Benzamide, Benzaldehyde, Anisaldehyde,

Acetophenone, benzophenone, Ethylbenzoate, methylbenzoate, Nitrobenzene, chlorobenzene, bromobenzene, naphthalene, biphenyl anthracene.

C. Purification of the crude product is to be made by crystallization from water/alcohol, crystallization after charcoal treatment, or sublimation, whichever is applicable.

D. Purification of few selected compounds synthesized above using thin layer and column Chromatographic techniques.

**Any other experiment carried out in the class.*

Reference Books:

1. Text book of practical organic chemistry, Vogel 2.
2. Spectral identification of organic compounds Bassler, Silverstein 5th Edition
3. Vogel, A. I. Elementary Practical Organic Chemistry, Part 1: Small scale Preparations, CBS Publishers and Distributors.
4. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003.
5. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
6. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. Practical Organic Chemistry, 5th Ed. Pearson (2012).
7. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
8. Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.

Course Details			
Course Title: Physical Chemistry-III			
Course Code	**CHE62MJ30102**	**Credits (L + T + P)**	2 (2 + 0 + 0)
Nature of Course	Major	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	30 (L) Hours
Methods of Content Interaction	Lecture, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives:

- To develop an understanding of liquid and solid state.
- To impart knowledge about ionic equilibrium

Learning outcome: After completion of the course the learners will be able to:

- Predict crystal structure of solids and determine surface tension, viscosity of liquids
- Analyze salt hydrolysis and determine acid dissociation constants

UNIT-I

Liquid state **(5L)**

Definition of Surface tension, its dimension and principle of its determination using stalagmometer; Viscosity of a liquid and principle of determination of coefficient of viscosity using Ostwald viscometer; Effect of temperature on surface tension and coefficient of viscosity of liquid (qualitative treatment only).

UNIT-II

Solid state **(7L)**

Nature of the solid state, definition of space lattice, unit cells. Laws of crystallography: (i) Law of constancy of interfacial angles, (ii) Law of rationality of indices and (iii) Law of Symmetry. Miller indices of different planes and interplanar distance, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law; Predicting crystal structure. Defects in solids

UNIT-III

Ionic equilibrium **(18L)**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations

SUGGESTED TEXT BOOKS:

1. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford Univ. Press (2022), 12th edition
2. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
3. Puri, B. R., Sharma, L. R., Pathania, M.S., Kaur, N. Principles of Physical Chemistry (New edition as per NEP), Vishal Publishing Co.
4. Rakshit, P.C., Physical Chemistry, Sarat Book House.
5. Bahl, B.S., Bahl, A., Tuli, G.D., Essentials of Physical Chemistry S. Chand & Co. ltd.

Reference Books

1. Goodstein, D.L. (1985). States of Matter. Dover Phoenix. ISBN 978-0-486-49506-4.
2. Palit, S. R., Elementary Physical Chemistry Book, Syndicate Pvt. Ltd.
3. James N. Butler, Ionic Equilibrium: Solubility and pH Calculations, Wiley.
4. M.A. Wahab, Solid State Physics: Structure and Properties of Materials. Alpha Science. ISBN 978-1-84265-218-3 (2005).

FIFTH SEMESTER (ODD SEMESTER)

Course Details			
Course Title: Physical Chemistry-IV			
Course Code	**CHE71MJ30204 *(CHE71MN30204)**	**Credits (L + T + P)**	4 (3 + 1 + 0)
Nature of Course	Major (*minor for other disciplines)	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorial, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives:

- To develop an understanding of the conductivity of the electrolytic solutions.

- To learn the concept of emf and different types of electrochemical cells
- To make students learn Debye-Huckel law and its applications

Learning outcome: After completion of the course the learners will be able to:

- Apply the conductivity measurements for quantitative and qualitative analysis.
- Construct various types of electrochemical cells.
- Explain the ion-ion interaction based on Debye-Huckel law

UNIT-I

Conductance of electrolytic solutions (18L)

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equations (only elementary idea of the terms), Ostwald's dilution law.

Ionic mobilities, transference numbers, Principles of Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, and (iv) conductometric titrations

UNIT-II

Electrochemistry-I (24L)

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, redox potential, redox half reaction, standard hydrogen electrode-reference electrodes, standard electrode potential, sign conventions electrochemical series and its applications, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values using hydrogen, quinone-hydroquinone, glass electrodes.

Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and solubility product. Qualitative discussion of potentiometric titrations.

UNIT-III

Electrochemistry-II (18L)

Electrochemistry of solutions: Ionic atmosphere, Debye-Huckel theory for the problem of activity coefficient, Debye-Huckel limiting Law, its modification for finite size of ions and for appreciable concentration, Debye-Hückel-Onsagar conductance equation and its extension to short-range ion-ion interaction leading to ion pair formation (Fuss modification). Bjerrum's model for pair-wise ionic association, Ion association, triple-ion pairs, and conductance minima. Thermodynamics of electrified interface, derivation of electro-capillary Lipmann's equation, surface excess, thermodynamic aspects of surface excess. The method of determination and measurement of interfacial tension as a function of applied potential difference across the interface.

SUGGESTED TEXT BOOKS:

1. Atkins, P.W & Paula, J.D. Physical Chemistry, 10th Ed., Oxford University Press (2014).

2. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
3. Glasstone, S., Lewis, D., Elements of Physical Chemistry, Marusen Asian Edition
4. Marron S.H., Pruton, C.F. Principles of Physical Chemistry, CBZ Publishers
5. Puri, B. R., Sharma, L. R., Pathania, M.S. Principles of Physical Chemistry, Vishal Publising Co.

Reference Books

1. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
2. Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
3. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
4. Rogers, D. W. Concise Physical Chemistry Wiley (2010).
5. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005)

Course Details			
Course Title: Organic Chemistry III			
Course Code	**CHE71MJ20304 *(CHE71MN20304)**	**Credits (L + T + P)**	4(4 + 0 + 0)
Nature of Course	Major (*Minor for other disciplines)	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives:

- To develop the concepts in depth about reactions, and mechanisms related to organic compounds of nitrogen.
- To understand chemistry and the importance of carbohydrates, amino acids, and alkaloids for human kind.

Learning Outcomes:

- Here students will be able to know the depth understanding of the chemical reactions, preparations, and chemistry of nitrogen compounds such as amino acids, and alkaloids, carbohydrates.
- In addition to the chemistry of these compounds, students can also get the knowledge of the importance of these compounds in macromolecules present in the living organism.

UNIT-I

Organic Compounds of Nitrogen **(15L)**

Nitro compounds: Introduction, preparation of nitroalkanes and nitroarenes, chemical reactions of nitroalkanes. Mechanism of nucleophilic substitution in nitroarenes and their reductions in acidic, neutral and alkaline media. Picric acid

Aliphatic and aromatic amines: structure and nomenclature of amines, preparation of alkyl and aryl amines (reduction of nitro compounds, nitrites), reductive amination of aldehydic and ketonic compounds. Gabriel-phthalimide reaction, Hofmann bromamide reaction. Reactivity, physical properties, stereochemistry of amines, separation of primary, secondary, and tertiary amines (Hinsberg's method). Structural features affecting basicity of amines. Electrophilic aromatic substitution in aryl amines, reactions of amines with nitrous acid. Synthetic transformations of aryl diazonium salts and azo coupling.

UNIT-II

Carbohydrates **(15L)**

Occurrence, classification and their biological importance.

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation; Disaccharides – Structure elucidation of maltose, lactose and sucrose.

Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

UNIT-III

(15L)

Amino acids, peptides, proteins and nucleic acids

Classification, structure, and stereochemistry of amino acids. Acid-base behavior, isoelectric point, and electrophoresis. Preparation and reaction of □-amino acids. Classification of proteins. Peptide structure determination- end group analysis, selective hydrolysis of peptides. Solid-phase peptide synthesis. Primary and secondary structure of proteins. Protein denaturation.

Nucleic acid: Introduction, constituents of nucleic acids. Ribonucleosides and ribonucleotides. The double helical structure of DNA

UNIT-IV

Alkaloids and Terpenoids **(15L)**

Alkaloids: Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

Terpenoids:

Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and α-terpineol.

Reference Books:

1. Clayden, J., Greeves, N., Warren, S. Organic Chemistry, Second edition, Oxford University Press 2012.
2. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education, Latest edition).
4. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976).
6. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc. 6. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
7. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
8. March, J. Advanced Organic Chemistry, Fourth edition, Wiley

Course Details			
Course Title: Physical Chemistry Lab-II			
Course Code	**CHE71MJ30304**	**Credits(L + T + P)**	4(0 + 0 + 4)
Nature of Course	Major	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	120 Hours
Methods of Content Interaction	Lecture, Reagents Preparation and Practical Classes		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives:

- To equip the students with necessary laboratory skills for viscosity and surface tension measurements
- To acquaint students with basics of X-ray diffraction and teach them indexing of the lattice planes
- To make student proficient in performing pH-metirc/potentiometric titrations
- To impart skills in measurements of heat capacity and enthalpy

Learning Outcomes: After completion of the course the learners will be able to:

- Determine the viscosity and surface tension of any liquid
- Analyze the X-ray diffractogram and assign *hkl* indices
- Determine acid dissociation constant using pH-metry
- Determine enthalpy od dissolutions, hydration and various other reactions

1. Surface tension measurements.

(a) Determine the surface tension by (i) drop number (ii) drop weight method.

(b) Study the variation of surface tension of detergent solutions with concentration.

2. Viscosity measurement using Ostwald's viscometer.

(a) Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) Sugar at room temperature.

(b) Study the variation of viscosity of sucrose solution with the concentration of solute.

3. Indexing of a given powder diffraction pattern of a cubic crystalline system.

4. pH metry

(a) Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.

(b) Preparation of buffer solutions of different pH

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide

(c) pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.

(d) Determination of dissociation constant of a weak acid.

5. Thermochemistry

(i) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).

(ii) Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

(iii) Calculation of the enthalpy of ionization of ethanoic acid.

(iv) Determination of enthalpy (endothermic and exothermic) of dissolution of salts.
(v) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
(vi) Determination of enthalpy of hydration of copper sulphate.
(vii) Study of the solubility of benzoic acid in water and determination of ΔH

Any other experiment carried out in the class

*A few experiments will be set from each section depending on the availability of chemicals and equipments.

REFERENCE BOOKS

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
3. Halpern, A. M. &McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).
4. Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry* New Age International: New Delhi (2001).

Course Details			
Course Title: Inorganic Chemistry-IV			
Course Code	**CHE71MJ10202**	**Credits (L + T + P)**	2 (2+ 0+ 0)
Nature of Course	Major	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	30 Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To impart in-depth knowledge on properties of d- and f-block elements
- To develop a thorough understanding about the isolation/separation and purification of various d and f block elements from their ore.

Learning Outcomes: After completion of the course the learners will be able to:

- Solve problems related with oxidation states, complex formation tendency and separation of d and f block elements
- Analyze the industrial applications of compounds of d and f block elements

UNIT-I

Chemistry of d-block elements **(15L)**

(a) General group trends with special reference to electronic configuration, color, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of

various oxidation states and e.m.f. (Latimer & Ebsworth diagrams). Difference between the first, second and third transition series.

(b) Chemistry of Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Zr, Mo, Cd, Ag, W, Au, Pt, Hg in various oxidation states (excluding their metallurgy). Conductors, insulators, semiconductors and super conductors

UNIT-II

Chemistry of f-block elements **(15L)**

(a) Terrestrial abundance and distribution; relativistic effect, oxidation states; aqueous, redox and complex chemistry in different oxidation states as applicable.

(b) Preparations, isolation, purification, properties and reactivities of the lanthanide and actinide elements and variations within the lanthanide and actinide series; lanthanide and actinide contraction and consequences; separation of lanthanides and actinides. Lanthanide compounds as high temperature superconductor, NMR shift reagent and MRI reagent.

Suggested Textbooks

1. Basic Inorganic Chemistry-F. A. Cotton, G. Wilkinson and P. L. Gaus; John Wiley and sons. Inc. 6^{th} edition.
2. Inorganic Chemistry; J. E. Huheey, E.A. Keiter and R. L. Keiter, Addison; Wesley.
3. Inorganic Chemistry, D. F. Shriver, P.W. Atkins and C. H. Langford, ELBS; Oxford University Press.
4. Concise Inorganic Chemistry, J. D. Lee, ELBS (1996), 5^{th}edition;

Suggested Reference books

1. Basic Organometallic Chemistry: Concepts, Syntheses and Applications of Transition metals, 2010, CRC Press and Universities Press.
2. Advanced Inorganic Chemistry, 6^{th} edition; F. A. Cotton and G. Wilkinson.
3. Inorganic Chemistry, 3^{rd} Edition; Gary. L. Miessler and Donald. A. Tarr (2007).
4. Chemistry of Elements; N. Greenwood and A. E. Earnshaw, Butterworth Heinemann (1997).

SIXTH SEMESTER (EVEN SEMESTER)

Course Details			
Course Title: Inorganic Chemistry-V			
Course Code	**CHE72MJ10304 *(CHE72MN10304)**	**Credits (L + T + P)**	4 (3 + 1 + 0)
Nature of Course	Major (*minor for other disciplines)	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To impart in-depth knowledge about metal-ligand equilibrium reactions
- To equip the students with necessary skills to determine the equilibrium constants using various instrumental techniques

- To acquaint the students with the photochemical reactions of coordination compounds
- To introduce the core concepts of magnetochemistry for analysing properties of complexes
- To familiarize with the inorganic molecules/complexes present in biological systems and their respective functions

Learning Outcomes: After completion of the course the learners will be able to:

- Explain the thermodynamic and kinetic stability of complexes
- Make use of the photochemical behavior of complexes in designing solar cells
- Design and perform photochemical reactions of metal complexes
- Analyze the magnetic properties of complexes
- Make use of bioactive properties of complexes for disease diagnosis and therapy.

UNIT-I

Metal-Ligand equilibria in solution (15L)

Step-wise and over all formation constant and their relationship, trends in step-wise constant, kinetic and thermodynamic stability of metal complexes, factors affecting the stability of metal complexes with reference to the nature of the metal ion and ligand, chelate effect, macrocyclic effect and their thermodynamic origin. Determination of binary formation constant by pH-metry, spectrophotometry, polarography and ion exchange methods.

Mechanism of ligand substitution in octahedral & sq. planar complexes- kinetics, factors affecting substitution in octahedral complexes: Leaving group, chelate and metal effects. Examples of Labile, inert, stable and unstable complexes

UNIT-II

Photochemical reactions of transition metal complexes (10L)

Basic photochemical processes, Kasha's rule, quantum yield, *Jabolnskii* diagrams, photo substitution reactions, photo-redox reactions, ligand photoreactions, photo reactions and solar energy conversion

UNIT-III

Magnetic properties of complexes (20L)

(a) Terminology in describing magnetic properties: pole strength, lines of force, magnetic moment, intensity of magnetization, magnetic induction, magnetic susceptibility, magnetic permeability.

(b) Magnetic behavior: Paramagnetism, diamagnetism, magnetic properties of octahedral complexes, Antiferromagnetism, Curie temperature, Neel point

(c) Orbital and spin magnetic moments, spin only moments of d^n ions and their correlation with effective magnetic moments, including orbital contribution; quenching of magnetic moment: super exchange and antiferromagnetic interactions (elementary idea with examples only).

(d) Magnetic susceptibility and its determination-Gouy, Faraday, VSM method. Diamagnetic correction, orbital contribution, spin-orbital coupling, ferro- and antiferromagnetic coupling, spin crossover. Magnetic properties of Lanthanide and Actinide metal complexes.

UNIT-IV

Bioinorganic Chemistry (15 L)

(i) Essentials and trace elements of life, ionophores and siderophores, membrane transport (active and passive transport process); sodium / potassium-pump. Excess and deficiency

of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, deficiency of Fe, Ca and iodine and consequences; use of chelating agents in medicine (chelation therapy), platinum complexes as anticancer drugs.

(ii) Active site structure and functions of haemoglobin, myoglobin and role of iron and globin chain in haemoglobin, active site structure of chlorophyll and role of magnesium and phytyl group in chlorophyll, role of Co in vitamin B12. Metalloenzymes-Carbonicanhydrase, Carboxypeptidase, hemocyanin-active site structures and functions.

Reference Books:

1. Basic Inorganic Chemistry- F. A. Cotton, G. Wilkinson and P. L. Gaus; John Wiley and sons. Inc, 2007.
2. Chemistry of Elements-N. N. Greenwood and A. E. Earnshaw, Butterworth Heinemann (1997).
3. Inorganic Chemistry IV edition; J. E. Huheey, E. A. Keiter and R. L. Keiter, Addison; Wesley, 2008.
4. Inorganic Chemistry, III edition, D. F. Shriver, P. W. Atkins and C. H. Langford, ELBS; Oxford University Press, 1999.
5. Inorganic Electronic spectroscopy, A. B. P. Lever, Elsevier. (1968).
6. Magnetochemistry, R.L. Carlin, Springer Verlag, 1986.
7. Electronic Absorption Spectroscopy and related Techniques, D. N. Sathyanarayana, University Press (2001).
8. Inorganic Chemistry a Unified Approach by W. W. Porterfield, Elsevier 2005 2nd edition.
9. Textbook of inorganic chemistry by G. S. Sodhi, Viva books Pvt. Ltd (2011).
10. Advanced Inorganic Chemistry, 6th edition; F. A. Cotton and G. Wilkinson.
11. Principles of Bioinorganic Chemistry; S. J. Lippard and J. M. Berg; Viva Book Publishers, 1997.
12. Bioinorganic Chemistry - Inorganic Elements in the Chemistry of Life, W Kaim, 2nd Edition,

Course Details			
Course Title: Physical Chemistry-V			
Course Code	**CHE72MJ30404 *(CHE72MN30404)**	**Credits (L + T + P)**	4 (3 + 1 + 0)
Nature of Course	Major (*minor for other disciplines	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorial, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course objective:

- To equip the students with the skills in quantum mechanics
- To lay the foundations of quantum mechanics by giving the mathematical background and concept of operators.
- To make the students understand the Quantum mechanical treatment of translational, rotational and vibrational motion though models such as particle in a box (1-D, 2D, 3D), rigid rotor, harmonic oscillator
- To develop a comprehensive understanding of a single electronic and multi-electronic systems including spectroscopic transitions.

Learning Outcomes: After completion of the course the learners will be able to:

- Formulate and solve quantum mechanical equations for a given system
- Analyze a given situation from quantum mechanical viewpoint and write appropriate Schrodinger equation

UNIT-I

Mathematical Concepts **(14L)**

Logarithmic relations, some fundamental trigonometric relations, curve sketching, linear graphs and calculation of slopes, differentiation of functions like f(x), e^x, x^n, sin x, log x; maxima and minima, partial differentiation and reciprocity relations. Integration of some useful/relevant functions, Factorials and Probability.

Concepts of Operators: Laplacian, Hamiltonian, Linear and Hermitian operators. Angular Momentum operators and their properties. Ladder operator method for angular momentum. Commutation of operators. Normalization, orthogonality and orthonormality of wave functions. Average (expectation) values

UNIT-II

Quantum Mechanics-I **(19L)**

Introduction to quantum mechanics. Postulates of quantum mechanics. Wave equations and their solutions, Schrödinger wave equation. Time-independent and time-dependent Schrödinger wave equations and the relation between their solutions. Eigen functions and Eigenvalues. Physical Interpretation of wave function.

Postulates of quantum mechanics. Solutions of Schrödinger wave equation for a free particle, particle on a ring, particle in a three-dimensional box. Quantum mechanical degeneracy. Application of Schrödinger equation to harmonic oscillator, Vibrational energy of diatomic molecules and zero-point energy, rigid rotator. Eigen functions and eigenvalues of angular momentum

UNIT-III

Quantum Mechanics-II **(11L)**

Schrödinger equation to hydrogen atom in spherical polar co-ordinates. Solution of Θ, Φ, equation and statements of solution of R equation. Total wave functions of hydrogen atom. Quantum numbers and their characteristics. List of wave functions for few initial states of hydrogen like atoms. Diagrams of radial and angular wave functions. Radial and angular probability functions and their significance. Electron spin (Stern-Gerlach experiment), spin-orbital, anti-symmetry and Pauli-exclusion principle, Slater determinants.

UNIT-IV

Methods of Approximation **(16L)**

Need for approximate methods. Perturbation method. Rayleigh Schrödinger perturbation theory for time-independent non-degenerate system. Application to electron in a box under the influence of an electric field. Application to He atom. Variation theory-statement and proof. Application of variation method to particle in a one-dimensional box and He atom.

Spectroscopic Transitions: Time dependent Schrodinger equation, origin of selection rules, Coupling of angular momenta. Russell-Saunders and JJ-coupling, Term symbols. Spin-orbital interaction and explanation of term multiplicities, Zeeman effect.

SUGGESTED TEXT BOOKS

1. Quantum Chemistry: Donald A. McQuarrie University Science Books, 2nd edition (2008).
2. Introduction to Quantum Chemistry, A. K. Chandra, Tata McGraw Hill, (1988).
3. Quantum Chemistry, Ira N. Levine, Prentice Hall, New Jersey, (1991).

SUGGESTED REFERENCE BOOKS

1. Molecular Quantum Mechanics, P. W. Atkins and R. Friedman, Oxford Univ. Press, 5th edition (2011).
2. Quantum Chemistry, J. P. Lowe, K.A. Peterson, Elsevier, 3rd Edition (2006).
3. Atoms, Molecules and Photons, W. Demtröder, 2nd edition, Springer (2010).
4. Quantum Chemistry, R. K. Prasad, New Age International, 2nd edition, (2000).
5. Quanta, Matter, and Change: A Molecular Approach to Physical Chemistry, Peter Atkins, Julio de Paula, Ronald Friedman, Oxford Univ. Press (2009)

Course Details			
Course Title: Inorganic Chemistry Lab -II			
Course Code	**CHE72MJ10404**	**Credits (L + T + P)**	4(0 + 0 + 4)
Nature of Course	Major	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	120 Hours
Methods of Content Interaction	Lecture, Reagents Preparation and Practical Classes		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To develop an understanding of the ion-exchange columns/resin and the associated techniques.
- To impart skills in sol-gel synthesis of nanoparticles and its characterization.
- To make students proficient in preparation of transition metal complexes and its spectroscopic analysis
- To impart training in determination of TDS and TSS of water

Learning Outcomes: After completion of the course, the learners will be able to:

- Prepare ion-exchange resin for water-softening and other purposes.
- Apply sol-gel technique for synthesis of various types of nanoparticles
- Synthesize transition metal complexes of various types and analyze their properties

- Determine TDS and TSS of water

1. Ion-Exchange -based experiments:
   (i) Determination of the Exchange Capacity of a Cation Ion-Exchange resin
   (ii) Determination of percentage of Fe and K present in unknown crystals by ion-exchange titrations
   (iii) Preparation of ion-exchange resin for softening of water
2. Sol-Gel based experiments:
   (i) Synthesis of silica nanoparticles
   (ii) Synthesis of magnetite nanoparticles
   (iii) Synthesis of ZnO nanoparticles
   (iv) Synthesis of CdS nanoparticles
3. Determination of total dissolved and suspended solids in water
4. Preparation of Transition metal complexes and its characterization
   (i) Cobalt and chromium complexes and their spectroscopic analysis.
   (ii) Linkage isomers of nitro- and nitrito-complexes of cobalt
   (iii) Nickel-Dimethylglyoxime complex
   (iv) Prussian blue
5. **Inorganic preparations**
   (i) Cuprous Chloride, Cu_2Cl_2
   (ii) Preparation of Manganese (III) phosphate, $MnPO_4.H_2O$.
   (iii) Preparation of Aluminum potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.
   (iv) borax/ boric acid.

Any other experiment carried out in the class.

***A** Few experiments will be set from each section depending on the availability of chemicals and equipment.

REFERENCE BOOK:

1. Fahlman, B.D. Materials Chemistry, Springer, 2004.
2. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009

Course Details			
Course Title: Organic Chemistry -IV			
Course Code	**CHE72MJ20404**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Major	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To develop an understanding of the basic principles of spectroscopy and to learn to apply these principles for structural elucidation of simple organic compounds.
- To build up a knowledge about the applications of dyes and polymers in daily life, and importance of heterocyclic compounds.

Learning Outcomes: After completion of the course the learners will be able to:

- Analyze spectroscopic data for identification of organic compounds.
- Can have the idea about the applications of dyes and polymers in industry and in our daily life.

UNIT-I

(18L)

Organic Spectroscopy: General principles Introduction to absorption and emission spectroscopy.

UV Spectroscopy: Types of electronic transitions, λ_{max}, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λ_{max} for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids, and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.

UNIT-II

(10L)

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds. Applications of IR, UV and NMR for identification of simple organic molecules.

UNIT-III

(20L)

Dyes: Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing; Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes – Phenolphthalein and Fluorescein; Natural dyes –structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

Polymers: Introduction and classification including di-block, tri-block and amphiphilic polymers; Number average molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity Index. Polymerisation reactions -Addition and condensation - Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene); Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives;

Introduction to liquid crystal polymers; Biodegradable and conducting polymers with examples.

UNIT-IV

Heterocyclic Compounds **(12L)**

Introduction and definition: Simple five and six membered ring compounds with one hetero atom like Furan. Thiophene and pyrrole, etc. Aromatic character – six- electron system (four-electrons from two double bonds and a pair of non-bonded electrons from the hetero atom). Resonance structures: Preparation of furan, Pyrrole thiophene and pyridine. Detailed discussion on the physical properties and chemical reactions.

REFERENCE BOOKS:

1. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
2. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.
4. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub
5. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
7. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
8. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
9. Kemp, W. Organic Spectroscopy, Palgrave.
10. Pavia, D. L. et al. Introduction to Spectroscopy 5th Ed. Cengage Learning India Ed. (2015).

SEVENTH SEMESTER (ODD SEMESTER)

Course Details			
Course Title: Advanced Inorganic Chemistry-I			
Course Code	**CHE81MJ10504 *(CHE81MN10504)**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Major (*minor for other disciplines)	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To develop understanding of group theory and apply the concepts of symmetry to molecular systems

- To enhance the understanding of metal-ligand bonding in view of point groups and molecular symmetry.
- To equip the students with necessary skills to anlayse electronic spectra of complexes
- To acquaint with the basics of nuclear chemistry and its applications in daily life

Learning Outcomes: After completion of the course the learners will be able to:

- Identify the symmetry elements present in a molecule,
- Assign the point groups to a molecule and perform symmetry operations
- Analyze the molecular structure and bonding in molecules and coordination complexes with the help of group theory
- Identify the nature of electronic transitions and determine the d-d splitting energy
- Explain the working of nuclear reactors and radioactive transformations

UNIT-I

Symmetry and Group Theory in Chemistry (15L)

Definition of groups, subgroups, cyclic groups, conjugates relationships, classes, simple theorems in group theory. Symmetry elements and symmetry operations, point groups, Schöenflies notations, representations of groups by matrices, reducible and irreducible representations, characters of representations, Great Orthogonality Theorem (without proof) and its applications, character tables and their uses (representations for the C_n, C_{nv}, C_{nh}, D_{nh} etc groups to be worked out explicitly), Mulliken symbols for irreducible representations Direct products.

UNIT-II

Metal-ligand bonding (15L)

Limitations of CFT, experimental evidence for metal-ligand covalent bonding in complexes, nephelauxetic effect, Ligand Field Theory, MO theory: tetrahedral and octahedral complexes (including π- bonding), angular overlap model. Stereochemical non-rigidity, self-assembly in supramolecular chemistry.

Boding in metal clusters: M-M bond and metal atom clusters, carbonyl and halide clusters, bonding in $[Re_2Cl_8]^{2-.}$ Metal carbonyl clusters- LNCC's and HNCC's. Electron counting in carbonyl clusters. Structure and bonding in isocyanide, CO, NO, N_2 tertiary phosphine and other similar ligands and their transition metal complexes

UNIT-III

Electronic spectra of complexes (15L)

(a) Spectroscopic terms, d-d transitions, L-S and RS coupling, Spectrochemical and nephelauxetic series, electronic spectra of simple T_d and O_h complexes,

(b) Selection rules for electronic spectral transitions; Orgel diagram (d^1 to d^9 system) and Tanaube-Sugano diagrams, Racah parameter. Charge transfer spectra (elementary idea).

(c) Calculation of Dq, B and β parameters, Spectra of metal complexes of d and f-block elements.

UNIT-IV

Radioactivity and Nuclear Chemistry (15L)

(a) Radioactive decay and equilibrium, theories of α, β-, β+ and γ-decay, ionizing radiations and their effects, Auger effect, Bremsstrahlung, counting techniques such as G.M. ionization and proportional counter. Elementary particles: quarks, neutrino, antineutrino;

classification of nuclides, nuclear stability, nuclear potential, binding energy. Nuclear Models: Liquid drop and Shell models.

(b) Nuclear Energy: Principles of Fission, critical mass, Fission reactors, Thermal reactors, Fast Breeder reactors, U-enrichment and processing of spent fuels. Nuclear reactor kinetics, controlled nuclear fusion, evaluation of magnetic and other confinement options for nuclear energy.

(c) Radioactive techniques: tracer technique, Neutron Activation Analysis (NAA), Radioimmunoassay, Boron-Neutron Capture Therapy (BNCT), Positron Emission Tomography (PET), Therapeutic uses of Gamma-rays.

Suggested Textbooks

1. Basic Inorganic Chemistry-F. A. Cotton, G. Wilkinson and P. L. Gaus; John Wiley and sons. Inc, 6th edition.
2. Inorganic Chemistry; J. E. Huheey, E.A. Keiter and R. L. Keiter, Addison; Wesley.
3. Inorganic Chemistry, D. F. Shriver, P. W. Atkins and C. H. Langford, ELBS; Oxford University Press.
4. Concise Inorganic Chemistry, 5thedition; J. D. Lee (1996).
5. Chemical Applications of Group Theory, F. A. Cotton, Wiley Eastern (1976).
6. Nuclear and Radioactive chemistry; Friedlander, Kennedy and Miller; Chapters 8 and 9, 1981.

Suggested Reference Books

1. Basic Organometallic Chemistry: Concepts, Syntheses and Applications of Transition metals, 2010, CRC Press and Universities Press.
2. Advanced Inorganic Chemistry, 6th edition; F. A. Cotton and G. Wilkinson.
3. Inorganic Chemistry, 3rd Edition; Gary. L. Miessler and Donald. A. Tarr (2007).
4. Molecular Symmetry, D.S. Schonland, Van Nostrand (1965).
5. Chemistry of Elements; N. N. Greenwood and A. E. Earnshaw, Butterworth Heinemann (1997).
6. Essentials of Nuclear Chemistry by H. J. Arnikar, New Age international Private Limited, New Delhi (1997)

Course Details			
Course Title: Advanced Organic Chemistry-I			
Course Code	**CHE81MJ20504 *(CHE81MN20504)**	**Credits (L + T + P)**	4(3 +1 + 0)
Nature of Course	Major (*minor for other disciplines)	**Course Duration**	One Semester
Semester	odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		

Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)

Course Objectives:

- To learn the basic and advanced concepts of chemical bonding, reaction mechanisms, and prediction of reaction mechanisms by the physical phenomenon. Develop knowledge in-depth about stereochemistry, and applications of organometallic compounds in organic synthesis.

Learning Outcomes:

- Students will be able to make the correlation of bonding, structure, reactivity, and stability of organic molecules. And by using the above concepts, students will be able to understand the spatial arrangements of substituents in organic molecules and their implication in stereoselective reactions.
- Depth knowledge of different kinds of reaction mechanisms and also know different tools available to predict the reaction mechanism.
- Students will be able to develop a basic knowledge of Organometallic compounds and their application in organic synthesis
- Understand and apply the applications of organometallic compounds for catalytic applications, in the construction of C-C, C-C multiple bonds, C=X, and C-X bonds which are relevant to pharmaceutical and industrial applications.

UNIT-I

(10L)

Physical Organic Chemistry: Thermodynamic and kinetic control reactions, Thermodynamic Properties, Reaction Kinetics, Interpretation of rate constant, Hammond postulate, Curtin-Hammett principle. Potential energy diagrams, transition states, and intermediates.

Methods of determining mechanisms: Based on the structure of products, determination of the presence of intermediates, isotopic labelling, isotope effects, chemical trapping, and crossover experiments. Use of IR and NMR in the investigation of reaction mechanisms

UNIT-II

(20L)

Stereochemistry-II: Chirality in compounds with a stereogenic centre, Stereogenic unit: Center of chirality, axis of chirality, plane of chirality and helicity. Stereochemistry of allenes, alkylidene, biphenyls, cyclophanes, and Ansa compounds, *trans*-cyclooctene, helicenes, and spiranes (with a stereogenic axis).

Conformational analysis: Conformational analysis of cycloalkanes: cyclobutane, cyclopentane, cychexanes (monosubstituted e.g., methyl, iso-propyl, tert-butyl and di-substituted cyclohexanes e.g., dialkyl, dihalo, diols) and cycloheptane.

Nomenclature and conformations of fused rings *e.g.* indane, decalines and perhydrophenanthrene, bridged ring systems like bicyclo[2.2.2], [2.2.1] systems.

Dynamic Stereochemistry: Fundamental of asymmetric synthesis: Introduction, Topocity in molecules Homotopic, stereoheterotopic (enantiotopic and diastereotopic), groups and face

asymmetry, Cram's and Prelog's rules substitution and addition criteria. Prochirality nomenclature: Pro-R, Pro-S, Re and Si. Selectivity in synthesis: stereo specific reaction, stereo selective reactions-examples of addition, elimination, substitution and rearrangement reactions. Enantioselectivity and diastereoselectivity.

UNIT-III

Addition Reactions: Addition to carbon-carbon multiple bonds (15L)

Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals. Regio, stereo- and chemoselectivities. Cis and trans additions. Orientation and reactivity. Addition to cyclopropane ring. Additions to C=C double bonds that are related to cycloadditions and form three-membered rings. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Addition of alkenes and/or alkynes to alkenes and/or alkynes. Ene synthesis. Michael reaction.

Methods for forming Carbon-carbon multiple bonds: **Elimination Reactions:** The E_2, E_1 and E_1cB mechanisms. Orientation of the double bond. Reactivity-effects of substrate structure, attacking the base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination reactions (including Chugave reaction), stabilized and unstabilized Wittig reagents, and olefination reactions

UNIT-IV

(15L)

Basic principles, preparation, properties, and applications of Organometallic in Organic Synthesis

Preparation and applications of Grignard, lithium organocuparates/ Organocopper reagents in organic synthesis.

Organosilicons: Introduction, preparation, and general applications in organic synthesis, reactions involving β-carbocations and α-carbanions, the utility of trimethyl silyl halides, cyanides, and triflates

Applications of Pd/Ni/Zn/Mo/W Complexes in organic synthesis: Baylis-Hillman reaction, Kulinkovich reaction, Sakurai reaction, Ugi reaction. Brook rearrangement; Tebbe olefination. Metal mediated C-C and C-X coupling reactions: Heck, Stille, Suzuki, Stille coupling, Kumada coupling, Negishi and Sonogashira, Nozaki-Hiyama, Buchwald-Hartwig, Ullmann coupling reactions, directed ortho metalation, Pauson Khand reaction, synthesis and use of Zinc dialkyls, olefin-cross metathesis/ring-closing metathesis reactions, Simmons Smith, and Reformansky reaction.

SUGGESTED TEXT BOOKS

1. Advanced Organic Chemistry – Reactions, Mechanism and Structure, Jerry March, John Wiley (2008).
2. Advanced Organic Chemistry, F. A. Carey and R. J. Part A, Sundberg Springer; 5th Corrected ed. 2007
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman, (2000).
4. Organic Chemistry, R. T. Morrison and R N Boyd, Prentice-Hall, (1998).
5. Principles of Organic Synthesis, R. O. C. Norman and J. M. Coxon, Blackie Academic and Professional, (1996).

6. Stereochemistry of Organic Compounds, D. Nasipuri, New-Age International, (1999).
7. Smith M. B. and March J. March's Advanced Organic Chemistry, Wiley.
8. Carey F. A. and Sundberg R. Advanced Organic Chemistry, Part B, Plenum Press.
9. Norman R. O. C. and Coxon J. M. Principles of Organic Synthesis, Nelson Thornes

SUGGESTED REFERENCE BOOK

1. Mechanism and Theory in Organic Chemistry, T. H. Lowry and K. S. Richardson, Addison-Wesley, 1998.
2. Structure and mechanism of Organic Chemistry, C. K. Ingold, Cornell University Press (1999).
3. Stereochemistry of Carbon Compounds, E. L. Eliel, S. H. Wilen and L. N. Mander, John Wiley, (1994).
4. Organic Chemistry, Volumes I and II, I L Finar, Longman, (1999).
5. Hegedus, L.S.; Transition metals in the synthesis of complex organic molecules, second edition, University Science, Book, CA, 1999.
6. Trost B. M. and Fleming I. Comprehensive Organic Synthesis, Pergamon Press.
7. László Kürti and Barbara Czakó:,Strategic Applications of Named Reactions in Organic Synthesis, Elsevier Academic, Burlington, 2005.
8. Schlosser, M., Organometalllics in Synthesis, A manual, John Wiley, New York, 1996.
9. Handbooks of reagents for organic synthesis by Reich and Rigby, Vol-I-IV.
10. Astruc, D.; Organometallic Chemistry and Catalysis, Springer Verlag, 2007.
11. Davies, S. G.; Organotransition metal chemistry: Applications to organic synthesis, Pergamon Press, New York, 1986.

Course Details			
Course Title: Advanced Physical Chemistry-I			
Course Code	**CHE81MJ30504 *(CHE81MN30504)**	**Credits (L + T + P)**	4 (3 + 1 + 0)
Nature of Course	Major (*minor for other disciplines)	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorial, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives:

- To impart knowledge of surface structure and skills in analyzing the adsorption phenomena through different types of isotherms, eg, Gibbs, BET, Langmuir etc.
- To make the students understand colloids and related phenomena and correlate it with examples in daily life
- To enhance the understanding of reaction kinetics and related phenomena.
- To make the students learn the concepts of catalysis

Learning Outcomes: After completion of the course, the learners will be able to:

- Determine the binding affinity of analyte on a surface using Langmuir or BET isotherms
- Design colloidal systems with enhanced stability and use it for solving problems in daily life
- Determine the rate constant and activation energy for a reaction
- Explain the reaction mechanism and rate enhancement due to catalysts

UNIT-I

Surface Phenomena (18L)

Adsorption, molar enthalpy of adsorption, Physisorption and Chemisorption, Factors affecting adsorption, Adsorption isotherms: Freundlich isotherm, Langmuir isotherm, Dubinin-Radushkevich isotherm, Temkin isotherm; Estimation of surface area using BET equation, Types of Adsorption isotherms, Gibbs adsorption isotherm and its significance; Surface tension and surface energy, surface phenomenon to explain various applications in daily life situations, Pressure difference across curved surface (Laplace equation), Vapour pressure of droplets (Kelvin equation), Surface film on liquids (electro-kinetic phenomena), Catalytic activity of surfaces and characteristics of catalyzed reactions, effect of particle size and efficiency of nanoparticles as catalysts.

UNIT-II

Colloids (10L)

Types of colloids, relationship with interface, contact angle & wetting, Brownian motion, sedimentation, adsorption from solution, micellization & self-assembly, Intermolecular forces & introduction to the electric double layer, zeta-potential, coagulation and flocculation, micellar catalysis. Host-guest chemistry.

UNIT-III

Reaction Dynamics-I (Kinetics) (20L)

Thermodynamical formulation of reaction rates; derivation of Eyring equation, Reaction between ions in solutions–Influence of ionic strength on reaction rates (primary and secondary salt effects). Concept of Steady state kinetics; Kinetic study of Chain reactions.

Photochemistry-definition; Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry: Grothus-Drapper law, Stark-Einstein law. Jablonski diagram showing various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non-radioactive processes (internal conversion, intersystem crossing). Photochemical processes, Quantum yield. Photosensitized reactions-energy transfer processes (simple examples). Quenching of fluorescence, Stern-Volmer equation. Chemiluminescence.

Mechanisms of few thermal and photochemical reactions (Photolysis of HI, formation of HBr from hydrogen and bromine, Pyrolysis of acetaldehyde).

UNIT-IV

Reaction Dynamics-II (Catalysis) (12L)

Types of catalyst, specificity and selectivity, Kinetics of homogeneous catalysis-kinetics of auto catalytic reactions, kinetics of acid-base catalysed reactions. Enzyme catalysis, Comparison of enzyme catalysed and chemical catalysed reactions, Mechanism (Lock and Key theory), Kinetics of enzyme catalyzed reactions Henri-Michaelis- Menten mechanism, Significance of Michaelis-Menten constant, Lineweaver-Burk plot. Effects of enzyme concentration, pH, Temperature, Activators and Inhibitors on enzyme activity. Theories of unimolecular reactions

SUGGESTED TEXT BOOKS:

1. A Textbook of physical Chemistry Vol- 4 and 5- K. L. Kapoor 5th edition Mcgraw Higher Ed (2015)

2. Puri, B. R., Sharma, L. R., Pathania, M.S. Principles of Physical Chemistry, Vishal Publising Co.
3. S. Pahari, Physical Chemistry: Volume I,
4. Chemical Kinetics-K. J. Laidler, McGraw Hill.Inc. New York (1988)
5. Physical Chemistry-P. Atkins and J. D. Paula, 9th Edn. Oxford University Press (2010).
6. S.H. Maranand C.F. Pruton, 4th Edn.Oxford & IBH publishing Co. Pvt. Ltd. New Delhi (1965).
7. An Introduction to Interfaces & Colloids, J.C. Berg, World Scientific (2010).
8. Colloids and Interfaces in Life Sciences and Bionanotechnology, W. Norde, Taylor & Francis (2011)

Reference book

1. Adsorption: Fundamental Processes and Applications, Mehrorang Ghaedi, Academic Press (2021).
2. Introduction to Adsorption, Chi Tien, Elsevier Science (2018)
3. Colloids and Colloid Assemblies, Frank Caruso, Wiley (2007)
4. Structure and Functional Properties of Colloidal Systems, Roque Hidalgo-Alvarez, Taylor and Francis (2017)
5. Physical Chemistry: A Molecular Approach, McQuarie and Simon, Viva, New Delhi, (2001).
6. Principles of Chemical Kinetics– House J. E. Wm C Brown Publisher, Boston, (1997).
7. Text book of physical chemistry Samuel Glastone, 2nd edition, Mac Millan India Ltd (1991).
8. Kinetics and Mechanism–A. A. Frost and R. G. Pearson, John-Wiley, New York, (1961).
9. Introduction to Biophysical Chemistry, R. Bruce Martin, McGraw-Hill, NY, 1964.

Course Details			
Course Title: Advanced Inorganic Chemistry Lab			
Course Code	**CHE81MJ10604**	**Credits**	4(0+0+4)
Nature of course	Major	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	120 Hours
Methods of Content Interaction	Lecture, Reagents Preparation and Practical Classes		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives:

- To equip the students with necessary laboratory skills in semimicro qualitative analysis
- To impart skills in the synthesis of inorganic complexes and spectroscopic analysis
- To train the students in quantitative analysis of metals in alloys, ores and solutions
- To give hands on training on chromatographic and solvent extraction techniques

Learning Outcomes: After completion of the course the learners will be able to:

- Detect the presence of anions and cations in a mixture
- Synthesize various types of inorganic complexes and analyze its properties
- Determine the amount of metal present in an ore, alloy or solutions
- Perform chromatography and solvent extraction techniques for separation of components

Lab-I: Qualitative Analysis

Semimicro qualitative analysis of mixtures containing one anion, one common cation and one less familiar element: W, Mo, Ce, Th, Zr, V, U and Li.

Lab-II: Synthesis and characterization of inorganic complexes

Preparation and quantitative analysis of inorganic complexes:

1. *Cis*-and *trans*-potassiumdioxalatodiaquachromium(III)complex [analysis of oxalate and chromium]
2. Hexamminecobalt(III)chloride [analysis of cobalt]

Lab-III: Quantitative analysis of metals in alloys, ores and solution Gravimetric analysis

1. Gravimetric determination of Fe in iron ore as Fe_2O_3.
2. Gravimetric determination of Ni in Cu and Ni solution.
3. Gravimetric determination of Fe in Fe and Cr solution.

Volumetric analysis

1. Volumetric estimation of Ca and Mg in Dolomite solution.
2. Volumetric estimation of Cu in Cu and Ni (German silver).
3. Volumetric estimation of Fe in Cu and Fe solution.

Chromatography:

(a) Separation of mixtures

(i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.

(ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.

(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their R_f values.

(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. Solvent Extractions:

(a) To separate a mixture of Ni^{2+}& Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry.

(b) Solvent extraction of zisconium with amberliti LA-1, separation from a mixture of irons and gallium.

(c) Analysis of soil:

(i) Determination of pH of soil.
(ii) Total soluble salt
(iii) Estimation of calcium, magnesium, phosphate, nitrate

(d) Ion exchange:

(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.
(ii) Separation of metal ions from their binary mixture.
(iii) Separation of amino acids from organic acids by ion exchange chromatography.

III Spectrophotometry

1. Determination of pKa values of indicator using spectrophotometry.
2. Structural characterization of compounds by infrared spectroscopy.
3. Determination of dissolved oxygen in water.
4. Determination of chemical oxygen demand (COD).
5. Determination of Biological oxygen demand (BOD).
6. Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Any other experiment carried out in the class.

*A Few experiment will be set from each section depending on the availability of chemicals and equipments.

References:

1. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009).
2. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson. 2009
3. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007).
4. Palit, S.R., De, S. K. Practical Physical Chemistry Science Book Agency.
5. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta.
6. Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
7. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd

EIGHTH SEMESTER (EVEN SEMSTER)

Course Details			
Course Title: Advanced Instrumental Techniques			
Course Code	**CHE82MJ40104**	**Credits**	4 (3+1+0)
Nature of Course	Major	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To equip the students with the knowledge and skills in advanced instrumental techniques
- To develop a comprehensive understanding of diffraction-based techniques such as X-ray Diffraction (XRD), Electron Diffraction (ED) and Neutron Diffraction (ND)
- To make students learn the core concepts of absorption spectroscopic techniques such as UV-Vis absorption, FT-IR and Raman spectroscopy and its applications
- To impart knowledge and skills about the Resonance based techniques such as Mossbauer, NMR and EPR spectroscopy

Learning Outcomes

After completion of the course the learners will be able to:

- Deduce the lattice structure by analyzing the XRD, ED and ND patterns
- Analyze the UV-Vis absorption, vibrational (FTIR, Raman) and rotational (microwave) spectra
- Apply Mossbauer spectroscopy technique to explain the hyperfine properties of iron and tin compounds
- Apply electroanalytical techniques such as voltammetry, polarography etc for physicochemical analysis
- Analyze thermal stability of materials and compounds using techniques such as TGA, DTA, DSC
- Determine the chemical composition of compounds/materials using CHN, XRF, ICP-AES techniques
- Perform the microstructural analysis using microscopy techniques such as SEM, TEM, AFM, STM etc.

UNIT-I

Diffraction based techniques **(15L)**

X-ray diffraction: *Powder X-ray diffraction:* construction of the instrument, Identification of unknown materials, Determination of sample purity, Determination and refinement of lattice parameters, Determination of crystallite size/stress

Single-crystal X-ray diffraction: determination of crystal structure, position of H-atom in inorganic compounds, determination of bond lengths,

X-ray diffraction using synchrotron source: determination of complex molecules like proteins, enzymes. Neutron diffraction, electron diffraction

UNIT-II

Electroanalytical Techniques **(15L)**

Electrode Potential, Currents in Electrochemical cells, Potentiometric titrations. Electrogravimetry-faraday's laws of electrolysis, Coulometry, Coulometric titrations. Voltammetry- principle, DME-advantages, limitations, Hydrodynamic Voltammetry, Cyclic voltammetry-priciple, conditions for reversible, quasi reversible and irreversible reactions. Anodic stripping voltammetry-priciple and applications, Polarography, Pulse polarography, Amperometry-titrations, different titration curves, applications, numerical problems on all these techniques .

UNIT-III

Thermal Methods of Analysis **(10L)**

Principle, methodology and applications: thermogravimetric and differential thermal analysis, differential scanning calorimetry; Thermo-mechanical and dynamic mechanical

analysis; thermometric titrations. Thermal stability of polymers, applications, decomposition patterns, decomposition reactions-examples.

UNIT-IV

Microscopy & Imaging Techniques (20L)

Scanning Electron Microscope (SEM): SEM Basics of electron optics, resolution in SEM. Contrast Mechanisms. Detectors. STEM. Sample preparation for the SEM.

Atomic Force Microscopy (AFM): Basic Machinery, Deflection detection methods, control systems. Harmonic oscillator response. Contact mode AFM. Lateral Force Microscopy. Determination of spring constants,

Scanning Tunneling Microscopy (STM): Theoretical Description of tip-sample tunnelling. STM components. Feedback control. Speed. Stability and Drifts. Vacuum and Low temperature STM. Application examples, Scanning Tunneling Spectroscopy and Spectroscopic Imaging. Interpretation of STM data;

Transmission Electron Microscopy (TEM): Theoretical Description of TEM image formation. Anatomy of the TEM. Sample preparation.

SUGGESTED TEXT BOOKS

1. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, and J. A. Dean, 6th Edition (1986),
2. Quantitative Chemical Analysis, Daniel C. Harris
3. Fundamentals of Analytical Chemistry by A. Skoog and M. West
4. Vogel's Hand Book of Quantitative Analysis by Longman
5. Physical methods for chemists: R.S. Drago.

SUGGESTED REFERENCE BOOKS

1. R. Wiesendanger, Scanning Probe Microscopy and Spectroscopy, Cambridge University Press, 1994.
2. Frank A. Settle, Handbook of instrumental techniques for analytical chemistry, Prince Hall, New Jersey, 1997.
3. K. W. Kolasinski, Surface science: Foundations of catalysis and nanoscience, John Wiley and Sons, West Susses, 2002.
4. D. A. Skoog, D. M. West, F. J. Holler and S. R. Couch, Fundamentals of analytical chemistry. Brooks/ColeCengage learning, New Delhi, 2004.
5. P. Atkins and J. de Paula, Atkins' physical chemistry, 8th Ed., Oxford University Press, New Delhi, 2008.
6. T. Pradeep, Nano: The essentials, McGraw-Hill Education, New Delhi, 2010.
7. F. Scholz, Electroanalytical Methods, Springer, 2nd Ed., 2010.

Course Details			
Course Title: Advanced Physical Chemistry Lab			
Course Code	**CHE82MJ30604**	**Credits**	4(0+0+4)
Nature of Course	Major	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	120 Hours
Methods of Content Interaction	Lecture, Reagents Preparation and Practical Class		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

*****Few experiments will be set from each section depending on the availability of chemicals and equipment.

Course Objectives:

- To equip the students with necessary laboratory skills for performing experiments such based on thermodynamics and kinetics
- To make students proficient in performing pH-metric/potentiometric and conductometric titrations
- To impart training to the students in various instrumental techniques such as, UV-Vis spectrophotometry, FTIR spectroscopy and cyclic voltammetry.

Learning Outcomes: After completion of the course the learners will be able to:

- Determine the activation energy, rate constant and equilibrium constant of different reactions using various instrumental techniques
- Determine the concentration and dissociation constant of acids using pH metric titration

Lab-I

1. Comparison of acid strength (HCl and H_2SO_4) by studying acid-catalysed hydrolysis of ester at lab temperature.
2. Determination of rate constant and energy of activation for the base hydrolysis of ethylacetate Verification of Beer's Law for $Cu^{2+}$and Fe^{2+}ions
3. Estimation of Fe^{2+} ions concentration in the given solution by titration of FAS versus $KMnO_4$ through colorimetric method.
4. Estimation of Fe^{2+} ions concentration using EDTA through colorimetric method.
5. Phase diagram of two component systems and determination of Ec, E_T and the determination of the composition of given unknown.
6. Determination of partial molar volume of solute–H_2O system by apparent molar volume method.
7. Determination of the viscosity of a mixture by apparent molar volume method.
8. Verification of Freundlich and Langmuir isotherms for adsorption of oxalic / acetic acid on activated charcoal.

Lab-II

1. Study the hydrolysis of methyl acetate at two different concentrations of HCl and report the relative strength.
2. Determination of dissociation constant of a given indicator by colorimetric method.
3. Study of kinetics of autocatalytic reaction between $KMnO_4$ versus oxalic acid.
4. Determination of degree of hydrolysis of aniline hydrochloride at room temperature and calculation of dissociation constant of the base by pH-metry
5. Study of variation of viscosity of a liquid with temperature, determine the constant A and B.
6. Analysis of a binary mixture of two miscible liquids and to determine the composition of the given unknown mixture.
7. Evaluation of Arrhenius parameter for the reaction between $K_2S_2O_8$ versus KI (first order)

Lab -III

Conductometry

1. Conductometric titration of strong acid with string base

2. Conductometric titration of weak acid with string base
3. Conductometric titration of oxalic acid with string base
4. Conductometric titration of acid mixture with string base
5. Conductometric titration of $AgNO_3$ with KCl
6. Conductometric titration of $BaCl_2$ with Na_2SO_4
7. Determination of Molar and Equivalent conductivity of a given strong electrolyte (and weak electrolyte) as a function of concentration

Potentiometry

1. Determination of strength of HCl, CH_3COOH and oxalic acid versus NaOH by pH-metry
2. To determine the acidic and basic dissociation constant of an amino acid and determination of isoelectric point by pH-metry.
3. Determination of dissociation constant of H_3PO_4 using potentiometric / pH-metric method.
4. Determination of strength of Fe^{2+} solution by performing potentiometric titration with $K_2Cr_2O_7$ or $KMnO_4$
5. pH-metric titration of mixture of weak and strong acid against NaOH
6. Determination of stability constant of copper-ethylenediamine complex by Potentiometry
7. Determination of pKa of amino acids by potentiometric titration

Lab -IV

Additional experiments based on FTIR spectroscopy, cyclic voltamtery and electrogravimetry

1. Estimation of copper by electrogravimetric method
2. Polarographic analysis, identification and estimation of metal ions (Pb^{2+}, Cd^{2+}, Zn^{2+})
3. Cyclic voltammetry of a standard redox couple (ferricyanide-ferrocyanide couple)
4. Identification of various functional groups using FTIR spectroscopy and the analysis of shift in the vibrations frequencies on binding to metal ions.

Any other experiment carried out in the class

REFRENCE BOOKS

1. Practicals in Physical Chemistry, P S Sindhu, Macmillan, 2005
2. Practical Physical Chemistry, Alexander Findlay, CHIZINE PUBN, 2018
3. Experimental Physical Chemistry: A Laboratory Textbook, Arthur Halpern, George McBane, 1. W. H. Freeman, 2006
4. Experiments in Physical Chemistry: Second Revised and Enlarged Edition, J. M. Wilson, R. J. Newcombe, A. R. Denaro, Elsevier, 2016
5. Experimental Physical Chemistry - Scholar's Choice Edition, Daniels Farrington, Scholar's Choice, 2015
6. Quantitative Chemical Analysis, 9th edition, Daniel C. Harris, W. H. Freeman, 2015
7. Vogels Textbook of Quantitative Chemical Analysis, Mendham, Pearson Education India, 2006

NINTH SEMESTER (ODD SEMESTER)

Course Details			
Course Title: Molecular Spectroscopy			
Course Code	**CHE91MJ40204**	**Credits**	4 (3 + 1 + 0)
Nature of Course	Major	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To equip the students with necessary knowledge and skills in spectroscopy, namely, rotational, vibrational and electronic spectroscopy

Learning Outcomes: After completion of the course the learners will be able to:

- Analyze spectroscopic data for identification of compound and use it for understanding intermolecular interactions.

UNIT-I

Introduction to spectroscopy **(15L)**

Regions of electromagnetic spectrum, understanding photons as a boson, oscillating dipole in a molecule, the light-matter interaction, conservation of angular momentum, signal to noise ratio, resolving power, width and intensity of spectroscopic transitions, Beer-Lambert law

Rotational Spectroscopy: Rotations of molecules, rigid diatomic molecule-rotational energy expression, energy level diagram, rotational wave function and their symmetry, selection rules, expression for the energies of spectral lines, computation of intensities, effect of isotopic substitution, centrifugal distortion and the spectrum of a non-rigid rotor. Rotational spectra of polyatomic molecules-linear, symmetric top and asymmetric top molecules. Nuclear effects in rotational spectroscopy.

UNIT-II

Infrared Spectroscopy **(15L)**

Infrared Spectroscopy-I: Vibrations of molecules, harmonic and anharmonic oscillators-vibrational energy expression, energy level diagram, vibrational wavefunctions and their symmetry, selection rules, expression for the energies of spectral lines,computation of intensities, hot bands, effect of isotopic substitution. Diatomic vibrating rotor, Born-Oppenheimer approximation, vibrational-rotational spectra of diatomic molecules, P, Q and R branches, breakdown of the Born-Oppenheimer approximation.

Infrared Spectroscopy-II: Vibrations of polyatomic molecules: Normal coordinates translations, vibrations and rotations, vibrational energy levels and wave functions, fundamentals, overtones and combinations. Vibration- rotation spectra of polyatomic

molecules- parallel and perpendicular vibrations of linear and symmetric top molecules Techniques and instrumentation.

FTIR spectrometer: construction of the instrument, dispersive and non-dispersive spectrometers, change dipole moments during molecular vibrations, Interferogram and its Fourier Transformation, Far-IR, Mid-IR, Near IR spectral regions, optical windows: KBr, CsI pellet technique, Paraffin mulls, ZnSe, CaF_2 windows; Total internal reflectance based devices.

UNIT-III

Electronic Spectroscopy (15L)

Born-Oppenheimer approximation, vibrational coarse structure, intensities by Franck-Condon principle, Dissociation energy, rotational fine structure, Fortrat diagram, pre-dissociation, Electronic structure of diatomic molecules-basic results of MO theory, classification of states by electronic angular momentum- and molecular orbitals, selection rules, spectrum of singlet and triplet molecular hydrogen**,** Electronic spectra of polyatomic molecules-localized MOs, spectrum of HCHO, change of shape on excitation**,** Decay of excited states-radiative (fluorescence and phosphorescence) and non-radiative decay, internal conversion.

UV-Vis Absorption and Fluorescence Spectrophotometer: construction of the instrument, measuring a spectrum, Beer-Lambert law, deviations from Beer's law, Relating UV-Vis spectra and color, spectroscopic monitoring of titrations and kinetics. Fluorescence quantum yield measurement.

UNIT-IV

Raman Spectroscopy (15L)

Rayleigh and Raman Scattering, classical and quantum mechanical view point; Vibrational Raman spectroscopy, Stokes and Anti-Stokes lines, mechanistic aspects, polarizability, electric field and induced dipole, Raman active/inactive vibrations / rotations in molecules, polarizability ellipsoid, mutual exclusion principle, polarized Raman lines during vibration, Combined Raman and infrared spectra for structural determination; Rotational Raman spectroscopy, selection rules, spectra of symmetric top and spherical top molecules. Resonance Raman Spectroscopy

Raman Spectrometer: instrumentation, measuring a spectrum, lasers and their use in Raman spectroscopy.

SUGGESTED BOOKS

1. Introduction to Molecular Spectroscopy, C. N. Banwell, TMH Edition (1994).
2. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill (Int. Students Edition) (1988).
3. Molecular Spectroscopy, J. D. Graybeal, McGraw Hill (Int. Students Edition) (1990). Spectroscopy, Vols. 1-3, B. P. Straughanand W. Walker, Chapman Hall (1976).

Course Details			
Course Title: Advanced Organic Chemistry Lab			
Course Code	**CHE91MJ20604**	**Credits (L + T + P)**	4(0 + 0 + 4)
Nature of Course	Major	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	120 hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

*Few experiments from each section will be set to perform the experiments depending on the availability of chemicals.

Course Objectives

- To develop skills of synthesis, purifications and characterisation of organic compounds.

Learning Outcome: After completion of the course the learners will be able to:

- Can handle how to place the various reactions.
- Students will be able analyses and propose the chemical formula and chemical structure of compounds using IR, UV and NMR spectrums.

Organic Chemistry Practical-I: Instrumental techniques in Organic Chemistry

1. Determination of specific rotation of given compounds and of racemic mixture
2. Determination of pka of amino acids by potentiometric titration
3. Estimation of a common drug (paraacetamol) by UV spectroscopy
4. Estimation of Keto-enol tautomerism by IR
5. Separation of amino acids by thin layer chromatography
6. Separation of proteins by gel electrophoresis
7. Estimation of protein in food samples
8. Estimation of Vitamin A in food samples
9. Determination of concentration of chiral compounds

Organic Chemistry Practical-II:

Preparations of various organic compounds employing different reactions such as

1. Diels-Alder reaction between furan and maleic acid,
2. Thiamine hydrochloride catalyzed benzoin condensation,
3. Pechmann condensation for coumarin synthesis,
4. Electrophilic aromatic substitution reaction,
5. Radical Coupling reaction,
6. Three component coupling reaction etc.

Products should be characterization using UV, IR and NMR technique with a view to give the student sufficient training in synthetic organic chemistry

Structural elucidation based on spectral data from UV – Vis, IR, NMR and Mass Spectrometry

Any other experiment carried out in the class

SUGGESTED TEXT BOOKS

1.A Text Book of Quantitative Inorganic Analysis: A. I. Vogel, 1989.

2. Vogel A. I. Practical Organic Chemistry, Longman Group Ltd.
3. Bansal R. K. Laboratory Manual of Organic Chemistry, Wiley-Eastern.
4. Ahluwalia V. K. and Aggarwal R. Comprehensive practical organic chemistry, University press.
5. Nad A. K.; Mahapatra B. and Ghoshal A. An advanced course in practical chemistry, New Central Book Agency (P) Ltd.
6. Wilson, John H. Block, Ole Gisvold, John Marlowe Beale, 2004.

TENTH SEMESTER (EVEN SEMESTER)

Course Details			
Course Title: Phase Equilibria and Statistical Thermodynamics			
Course Code	**CHE92MJ30704**	**Credits (L + T + P)**	4 (3 + 1 + 0)
Nature of Course	Major	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorial, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objective:

- To develop an understanding of the partial molar quantities and activity coefficient
- To comprehend the concepts of phases and phase equilibria
- To equip the students with necessary knowledge and skills in Statistical Thermodynamics, and non-equilibrium thermodynamics
- To impart basic skills in computational chemistry

Learning Outcomes: After completion of the course the learners will be able to:

- Write partition functions for rotational, vibrational motion or electron dynamics in molecules

UNIT-I

Systems of Variable Composition **(15L)**

Concept of Partial molar quantities-partial molar free energy, chemical potential, partial molar volume and its significance, dependence of thermodynamic parameters on composition; Concept of fugacity, Determination of fugacity by graphical method and compressibility factor method. Activity and activity coefficient: Determination of activity coefficient by EMF and solubility method. Gibbs- Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases. Excess thermodynamic functions

UNIT-II

Phase Equilibria **(15L)**

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems. Phase diagram for one component systems, with

applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform-acetic acid system, triangular plots. Gibbs-Duhem-Margules equation, its derivation, azeotropes, steam distillation. Nernst distribution law: Applications (finding out K_{eq} using Nernst distribution law for $KI+I_2 = KI_3$ and dimerization of benzoic acid).

UNIT-III

Statistical Thermodynamics (15L)

Introduction: Concept of ensembles, partition functions and distributions, microcanonical, canonical and grand canonical ensembles, canonical and grand canonical partition functions, Boltzmann, Fermi-Dirac and Bose-Einstein distributions. Gibbs paradox and Sackur – Tetrode equation. Concept of thermal wavelength. Molecular partition functions – transitional, rotational, vibrational, electronic, nuclear. Equipartition theorem and its validity. Problems and their Solutions. System of interacting molecules – Imperfect gas. Specific heat of electron gas, Bose condensation

UNIT-IV

Non-equilibrium Thermodynamics (15L)

Thermodynamic criteria for non-equilibrium States-Phenomenological Laws and Onsager's Reciprocity relations, Coupled and Non-coupled reactions, Entropy production and entropy flow. Electro-kinetic Phenomenon.

Introductory Computational Chemistry: Introduction to the computational chemistry and molecular modelling, Coordinate systems, Concept of 2D and 3D structure, molecules, Surfaces, Molecular energetic profile, Brief idea about the computational softwares for drawing, visualization and simulation of small and large molecules. Basic concept of Cheminformatics, 3D-Structure file system and Databases.

SUGGESTED TEXT BOOKS

1. Physical Chemistry-P. Atkins and J. D. Paula, 9th Edn. Oxford University Press (2010).
2. D. Chandler, Introduction to Modern Statistical Mechanics, Oxford University Press, 1987.
3. A Textbook of physical Chemistry Vol- 2,3 and 6 K. L. Kapoor 5th edition McGraw Higher Ed (2015).
4. Thermodynamics, Statistical Thermodynamics and Kinetics by Thomas Engel & Philip

Reference books:

1. Thermodynamics, by Rajaraman and Kuriacose, East-West Press, (1986).
2. Statistical Thermodynamics, M. C. Gupta (Wiley Eastern Ltd.) 1993.
3. Elementary Statistical Thermodynamics, N. D. Smith, Plenum Press, NY, (1982).
4. Elements of Classical and Statistical Thermodynamics, L. K. Nash, Addison-Wiley, (1979).

Elective Basket 'A'

For DE

Course Details
Course Title: Basics of Supramolecules and its advancement

Course Code	**10704**	**Credits (L + T + P)**	**4(3+1+0)**
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To acquaint students with the fundamentals of supramolecule and macromolecule
- To impart knowledge and skills for the synthesis of supramolecular structures
- To introduce the concept of self-assembly and its mechanistic aspects
- To make students aware of device applications of supramolecular structures

Learning Outcomes: After completion of the course the learners will be able to:

- Explain the binding interactions in supramolecular structures
- Write the synthesis scheme and structures of crown ethers, host-guest compounds
- Apply the concept of 'self-assembly' to make supramolecular structures
- Discuss the relevance of supramolecular structures in daily life and its applications in molecular devices, medicine, and catalysis.

UNIT-I

Supramolecular interactions **(15L)**

Definition of supramolecular interaction. Nature of binding interactions in supramolecular structures: ion-ion, Ion-dipole, dipole-dipole, H-bonding, cation-p, anion-p, p-p, and van der Waals interactions. Host Guest interactions, preorganization and complementarity, lock, and key analogy. Binding of cationic, anionic, ion pair and neutral guest molecules. The role of solvents in supramolecular systems.

UNIT-II

Synthesis and Structure of Supramolecules **(15L)**

Self-assembly molecules: design, synthesis and properties of the molecules, self-assembling by H-bonding, metal-ligand interactions, and other weak interactions, metallomacrocycles, catenanes, rotaxanes, helicates and knots. Synthesis and structure of crown ethers, lariat ethers, podands, cryptands, spherands, calixarenes, cyclodextrins, cyclophanes, cryptophanes, carcerands and hemicarcerands.

UNIT-III

Applications of Supramolecules **(15L)**

Molecular devices: molecular electronic devices, molecular wires, molecular rectifiers, molecular switches, molecular logic, molecular tweezers. Supramolecules as mimic for biological systems: cyclodextrins as enzyme mimics, ion channel mimics, supramolecular catalysis etc. Supramolecular gel and polymerization.

UNIT-IV

Recent advancement in supramolecular chemistry **(15L)**

Supramolecular system chemistry: equilibrium assemblies, kinetically trapped assemblies, far-from equilibrium assemblies, dissipative non-equilibrium self-assembly, supramolecular metal organic framework.

Supramolecular adaptive chemistry: molecular information, recognition, and receptors. Criteria for the selection of self-organization, supramolecular dynamic non-covalent interactions, supramolecular dynamics, constitutional dynamic synthesis of supramolecules.

SUGGESTED TEXT BOOKS

1. Supramolecular Chemistry- Concepts and Perspectives (Wiley-VCH, 1995), J.-M.Lehn.
2. Bioorganic, Bioinorganic and Supramolecular Chemistry, P. S. Kalsi and J. P. Kalsi. New Age International Publishers

SUGGESTED REFERENCE BOOKS

1. P. D. Beer, P. A. Gale, D. K. Smith; Supramolecular Chemistry (Oxford University Press, 1999).
2. J. W. Steed and J. L. Atwood; Supramolecular Chemistry (Wiley, 2000).

Course Details			
Course Title: Green Chemistry I: Solvents & Synthesis			
Course Code	**20704**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To make students understand the principles and goals of green chemistry
- To acquaint with the concept of green solvents and to understand the need for alternative solvents
- To develop an understanding of supercritical fluids, biphasic systems and ionic liquids
- To equip the students with necessary skills to do radiation-based synthesis

Learning Outcomes: After completion of the course the learners will be able to:

- Distinguish between a green-process and non-green process
- Design alternative routes of synthesis which is greener, cleaner and cost-effective
- Perform radiation-based synthesis such as sonochemical and microwave
- Conduct solvent-less synthesis

UNIT-I

Introduction **(10L)**

Need for Green chemistry – Goals of green chemistry; principles of green chemistry with their explanations and examples – Designing a green synthesis – Prevention of waste / by products – Atom economy (maximum incorporation of materials used in the process) – Minimization of hazardous / toxic products – prevention of chemical accidents

UNIT-II

Green Solvents **(20L)**

Role of solvents in chemical synthesis, Environmental and health concerns of organic solvents, Need for Alternative/Cleaner solvents, Criteria for selection and design of green solvents

Water: The natural solvent on earth, organic reactions: hydrophobic effects enhancing the reaction selectivities, low solubility of O_2 in water, water soluble catalysts, challenges in using water as solvent,

Ionic liquids: physicochemical properties, Synthesis of Ionic Liquids, Directed Inorganic and Organometallic Synthesis, formation of oxides, electrochemical synthesis in ionic liquids,

Glycerol: solvent properties, volatility, polarity, availability, glycerol as a solvent combining the advantages of water and ionic liquids, enhancement of reaction selectivity, glycerol as a solvent for catalyst design and recycling, separation processes and material synthesis in glycerol, examples of synthesis of transition metal and metal oxide crystals

Supercritical fluids: supercritical CO_2 and its properties, advantages of using CO_2 as solvent, Synthesis of metal nanoparticles, CO_2 as solvent for coatings and lithography, biomaterial processing, other supercritical fluids.

Biphasic systems: Liquid-liquid interface, aqueous biphasic systems, phase- and micelle forming polymers for clean separation processes, Fluorous biphasic catalysis (FBC)

UNIT-III

Radiation based techniques in green synthesis **(15L)**

Microwave: microwave as a form of electromagnetic radiation, interaction of materials with microwaves and dielectric heating, microwave reactors, Different types of reactions involved in microwave synthesis (i) direct reactions, including those involving the use of simple compounds; Hoffann Elimination, Diels Alder reaction, (ii) preparation of solids which involve decompositions and combinations giving rise to solids of complex composition; (iii) nitridation reactions; (iv) reactions brought about in liquid media; (v) preparation of glasses; (vi) selective deoxidation reactions;and (vii) plasma-assisted reactions. Microwave synthesis of zeolite membranes & other examples.

UNIT-IV

Sonochemical **(15L)**

Ultrasound waves, basic principles of sonochemistry, acoustic cavitation phenomenon, Stable and transient cavitation, Temperatures of cavitation, Cold sono-fusion, Hydrodynamic cavitation, From cavitation to chemistry, generation of free radicals, sonochemical reactions, sono-oxidation, sono-reduction, sonication in ionic liquids, ultrasound and photochemistry, Combined use of ultrasound and microwaves, some examples of sonochemical synthesis. Esterification, Saponification

SUGGESTED TEXT BOOKS

1. Ionic Liquids in Synthesis, Peter Wasserscheid and Tom Welton, WILEY-VCH Verlag GmbH & Co. KGaA, 2008.
2. Green Chemistry and Catalysis, R.A. Sheldon, I. Arends and U. Hanefeld, WILEY-VCH Verlag GmbH & Co. KGaA (2007).
3. Green Solvents for Chemistry: Perspectives and Practice, William M. Nelson Oxford University Press (2003).
4. Biocatalysis for Green Chemistry and Chemical Process Development, Junhua Tao and Romas Joseph Kazlauskas, WILEY-VCH Verlag GmbH & Co. KGaA (2011).
5. Green chemistry for chemical synthesis, Chao-Jun Li and Barry M. Trost, Proceedings of National Academy of Sciences (USA), year 2008, vol. 105, pages 13197–13202.
6. Advances in inorganic chemistry, Elsevier, Vol. 58, (2006).
7. Green Catalysis, Masaya Matsuoka and Masakazu Anpo, Wiley-VCH Verlag GmbH & Co. KGaA (2010).
8. A primer on electrocatalysis, J.O'M. BOCKRIS, J. Serb. Chem. Soc. 70 (3) 475–487 (2005).
9. Direct Electrochemistry of Hemoglobin and Its Electrocatalysis Based on Hyaluronic Acid and Room Temperature Ionic Liquid, Electroanalysis 20, 2008, No. 23, 2537 – 2542.
10. Photocatalysis. A multi-faceted concept for green chemistry, D.Ravelli, D. Dondi,M. Fagnonia and A. Albini, Chem. Soc. Rev., 2009, 38, 1999–2011.
11. Synthesis of Inorganic Solids Using Microwaves, K. J. Rao, B. Vaidhyanathan, M. Ganguli, and P. A. Ramakrishnan, Chemistry of Materials, 1999, 11, 882-895.
12. Sonochemistry and sonoprocessing: the link, the trends and (probably) the future, Timothy J. Mason, Ultrasonics Sonochemistry 10 (2003) 175–179.

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Course Details			
Course Title: Solid State and Structural Chemistry			
Course Code	**30804**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To acquaint the students with the electronic and magnetic properties of the solids
- To introduce the emerging concepts of piezoelectricity, ferrolelectricity and dielectrics
- To equip the students with necessary skills in geometrical crystallography
- To make students learn the concepts and techniques of structure determination [x-ray diffraction (XRD), neutron diffraction (ND), electron diffraction (ED)]

Learning Outcomes: After completion of the course the learners will be able to:

- Identify the symmetry elements in a solid and assign a point group
- Explain the band structure of solids
- Understand and apply concepts of piezoelectricity, ferroelectricity in daily life
- Determine the crystal structure using XRD & ED

UNIT-I

Electronic structure of solids (25L)

Bonding in solids: Ionic, covalent, metallic and molecular solids free electron theory, Fermi sphere, Fermi-Dirac statistics, Ohm's law, limitations of the free electron theory.

Electrons in a weak periodic potential (Independent electron model), energy levels in extended, repeat and reduced zone schemes

Electrical and Magnetic Properties of Solids Metals: calculation of density of states, origin of resistivity, weak paramagnetism Semiconductors: Intrinsic and extrinsic- p and n-types, Hall Effect, Junctions and their applications- metal-metal, metal-semiconductor, semiconductor-semiconductor types and transistors.

Insulators- dielectric properties, piezo and inverse piezoelectric effects, ferroelectricity, ferroelectric transitions in $BaTiO_3$, ionic conductivity applications of band theory to TiO and NiO: Limitations of the Independent electron model, modelling electron correlation.

UNIT-II

Geometric Crystallography (25L)

Symmetry elements, Bravais lattices, Screwaxes and glide planes, point groups, and space groups and nomenclature. Law of Interfacial angle (Euler's construction).

Diffraction theory and Single Crystal X-ray diffraction

X-rays, Bragg's law, assignment of diffraction peaks, diffraction pattern of aprimitive cubic lattice, space group extinctions, Scattering factor and structure factor, intensities from atomic positions for BCC and FCC lattices; Ewald's sphere of reflection, Reciprocal Lattice concept, Electron density function, Fourier synthesis, Fourier transform of the structure factor, Phase problem and Patterson synthesis.

UNIT-III

Experimental Methods (5L)

Rotation, Oscillation, Weissenberg and Precession methods. Debye-Scherrer method (Powder method), Determination of lattice parameters from these methods.

UNIT-IV

Electron diffraction (5L)

Experimental technique, Wierl equation, Radial-Distribution method**.**

Neutron diffraction: Principle and Theory, advantages and uses.

SUGGESTED TEXT BOOKS

1. Introduction to Solids, L.V. Azaroff, McGraw Hill Book Co., New York, 1960.
2. Solid State Physics, N.W.Ashcroft and N.D.Mermin, Holt Saunders International Ltd., New York (1976).
3. Physical Chemistry, G.M. Barrow, McGrawHill (2^{nd} ISE) (1966).
4. An Introduction to X-ray Crystallography, M. M. Woolfson, Cambridge University Press-Vikas Publishing House, New Delhi (1980).

5. Principles of the Solid State, H. V. Kheer, Wiley Eastern Ltd., New Delhi (1993).
6. Dynamics of Atoms in Crystals, W.Cochran, Edward Arnold, London,1973.(Pages24-37)
7. Vibrational Spectroscopy of Solids, P.M.A. Sherwood, University Press, Cambridge, 1972. (pages: 1-45)
8. Phase Transitions, C.N.R. Rao and K.J. Rao, Cambridge University Press
9. X-ray Structure determination: A practical guide, George H Stoutand Lyle H Jenson, Macmillan Publishing Co.Inc and Collier Macmillan Publishers

SUGGESTED REFERENCE BOOKS

1. R. West, Solid State Chemistry and its Applications, John Wiley & Sons, 1984.
2. L. Smart and E. Moore, Solid State Chemistry - An Introduction, Chapman & Hall, 1992.
3. H. V. Keer, Principles of the Solid State, Wiley Eastern Limited, 1993.
4. K. Chakrabarty, Solid State Chemistry, New Age Publishers, 1996.

Course Details			
Course Title: Green Chemistry II: Catalysis			
Course Code	**20804**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To make students understand catalysis as one of the fundamental pillars of green chemistry
- To acquaint the students with the fundamentals of electrocatalysis in biological systems and water-splitting reactions
- To develop a thorough understanding of photocatalysts and their different modes of action
- To familiarize with bio-catalysis with respect to bioremediation of contaminates and to understand the enzyme-based methods of energy production

Learning Outcomes: After completion of the course the learners will be able to:

- Explain how biomimetic metal complexes are used as catalysts for various processes
- Design a catalyst to make a process greener
- Discuss the examples of naturally occurring photocatalytic reactions
- Underscore the importance of photocatalysts in exploiting the solar energy to drive difficult reactions
- Understand electrocatalysis with respect to water-purification and water-splitting reactions

- Discuss the bioremediation of contaminants and enzyme-catalyzed reactions for generating energy and bio-fuels

UNIT-I

Catalysts in Green Chemistry **(15L)**

Catalysis as one of the fundamental pillars of green chemistry, Catalyst design, Cu, Zn, Fe, Mn complexes as catalysts, Biomimetic Cu complexes for green oxidation of alcohols, catalysts that activate the natural oxidant hydrogen peroxide, TAML activators and its applications, aluminophosphate molecular sieve catalyst with cobalt(III) and Mn(III) ions, solid acid catalysts and the uses thereof, metal loaded silica as catalysts, Rh catalysts containing bisphosphanes and bisphosphites as chelating ligand, kaolinitic clay as catalyst.

UNIT-II

Electrocatalysis **(10L)**

Electron Transfer Process, Multi-step Reactions, Electrolysis of water, Mechanism of hydrogen evolution, Choice of electrocatalysts for h.e.r, Electrocatalytic oxidation of NAD(P)H at mediator-modified electrodes, Electrocatalysis of Hemoglobin in ionic liquid, thin films and membranes, Electrocatalytic reduction of bromate ions for water purification.

UNIT-III

Photocatalysis **(15L)**

Photocatalysis and green chemistry, photocatalytic processes in nature eg., photosynthesis, three basic ways of exploiting solar energy, photocatalysts and their modes of action, electron transfer, H abstraction, photocatalytic activity: the effect of surface area and electron-hole recombination,designa of photocatalysts of high activity Photocatalysis for producing hydrogen, TiO_2, other metal oxides, sulfides as photocatalysts, Photocatalysis in synthesis, photooxidation, photo-oxygenation, photoreduction, photocatalytic formation of C-C, C-N, C-X bonds, Photocatalytic remediation of environment, heterogeneous & homogeneous photocatalysis: the case of semiconductors and dyes.

UNIT-IV

Biocatalysis **(20L)**

Biocatalysis platform for green processes, Bioremediation of persistent contaminants, Microbial bioremediation, Enzymatic bioremediation, Laccases: blue enzymes for green chemistry, Laccases and chemical mediators: mimicking nature, laccases as biocatalysts for chemical reactions, optimum reaction condition for the enzyme, laccases in manufacturing industries, hyperthermophilic enzymes for biocatalysis, biophysical properties of the enzymatic breakers, Galactomannan as the supporting matrix for hydraulic fracturing of oil/gas wells, Enzymes for clean energy production, Amylolytic enzymes and bioethanol production, Biodiesel, biohydrogen and biofuel cells, High fructose corn syrup (HFCS) production, Thermophilic esterases, biocatalysis in ionic liquids, enzyme discovery

SUGGESTED TEXT BOOKS

1. Green Chemistry and Catalysis, R.A. Sheldon, I. Arends and U. Hanefeld, WILEY-VCH Verlag GmbH & Co. KGaA (2007).

2. Biocatalysis for Green Chemistry and Chemical Process Development, Junhua Tao and Romas Joseph Kazlauskas, WILEY-VCH Verlag GmbH & Co. KGaA (2011).

3. Green chemistry for chemical synthesis, Chao-Jun Li and Barry M. Trost, Proceedings of National Academy of Sciences (USA), year 2008, vol. 105, pages 13197–13202.

4. Advances in inorganic chemistry, Elsevier, Vol. 58, (2006).

5. Green Catalysis, Masaya Matsuoka and Masakazu Anpo, Wiley-VCH Verlag GmbH & Co. KGaA (2010).

6. A primer on electrocatalysis, J.O'M. BOCKRIS, J. Serb. Chem. Soc. 70 (3) 475–487 (2005)

7. Direct Electrochemistry of Hemoglobin and Its Electrocatalysis Based on Hyaluronic Acid and Room Temperature Ionic Liquid, Electroanalysis 20, 2008, No. 23, 2537 – 2542.

8. Photocatalysis. A multi-faceted concept for green chemistry, D. Ravelli, D. Dondi, M. Fagnonia and A. Albini, Chem. Soc. Rev., 2009, 38, 1999–2011.

9. Synthesis of Inorganic Solids Using Microwaves, K. J. Rao, B. Vaidhyanathan, M. Ganguli, and P. A. Ramakrishnan, Chemistry of Materials, 1999, 11, 882-895.

10. Sonochemistry and sonoprocessing: the link, the trends and (probably) the future, Timothy J. Mason, Ultrasonics Sonochemistry 10 (2003) 175–179.

Course Details			
Course Title: Nucleoside, Advances in Nucleic Acid and Proteins			
Course Code	**20904**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To understand structures and functions of nucleic acid and proteins with a perspective of chemistry and biology and further integrate this for use in drug discovery and biotechnology.

Learning Outcomes: After doing the course, students will be able to:

- Explain the structure and function of nucleoides, DNA and RNA use it several biomedical applications

UNIT-I

Nucleoside **(20L)**

Modified nucleoside as a new drugs as antiviral and anticancer agent.

Nucleic acids: Definition, structure and properties, different type of base pairing, double helices, Sugar-Phosphate Chain conformations, conformation of DNA, physical properties and stability of DNA. DNA replication, genetic information storage, transcription, translation, transmission and gene expression, DNA intercalation, chemical synthesis of oligonucleotides, hybridization with synthetic oligonucleotides, characterization and purification techniques, nucleic acids as molecular probes. Catalytic RNA, siRNA, micro RNA, DNA damages, mutations and repair. Modified nucleic acids: Peptide nucleic acids (PNAs), LNAs, synthesis of PNAs, doubly labeled PNAs as probes for the detection of point mutations. Single Nucleotide Polymorphism (SNPs).

UNIT-II

(20L)

Advanced-level chemical reactivity and metal binding properties, advanced methods for synthesis, purification and characterization of DNA/RNA, non-canonical DNA/RNA structures and functions, self-assembly of functional nucleic acid-based materials, chemical and fluorescence-based methods for probing nucleic acids in vitro and in vivo, in vitro evolution of functional nucleic acids for biotechnology, and diagnostic and therapeutic applications of modified nucleic acids. Catalytic RNA molecules; and technological applications of RNA.

UNIT-III

Proteins **(20L)**

Different strategies and methods for the production, isolation, structure determination, functional analysis and modification of proteins, analyse and interpret protein sequences and structures and use such information to predict protein function, understanding of fundamental concepts of proteomics and hands-on experience with techniques used in current proteomics. Use of protein for production and development of drugs, for biotechnological and other industrial and scientific purposes and explanation how this is facilitated by knowledge of the structure and function of proteins.

SUGGESTED BOOKS

1. C.M. Dobson, J.A. Gerrard and A.J. Pratt., Foundations of Chemical biology, Oxford University Press 2002.
2. A. Miller and J. Tanner, Essentials of Chemical Biology, Willey & Sons Ltd. 2008. References: 1. S. L. Schreiber, T. Kapoor and G. Wess, Chemical Biology: from small molecules to systems biology and drug design, Wiley – VCH Verlag GmbH & Co. 2007.
3. S. L. Schreiber, T. Kapoor and G. Wess, Chemical Biology: from small molecules to systems biology and drug design, Wiley – VCH Verlag GmbH & Co. 2007.
4. Stryer, L.; Berg, J. M.; Tymoczko, J. L. In Biochemistry, 5th Ed. (Hardcover).
5. Lehninger Principles of Biochemistry, 5th Ed. by Nelson and Cox.
6. McLaughlin, L. W.; Wilson, M.; Ha, S. B. Use of Nucleoside Analogues to probe Biochemical Processes (a) Wojciechowski, F.; Leumann, C. J. Chem. Soc. Rev. 2011,

40, 5669. (b) Jan Stambasky, Michal Hocek and Pavel Kotovsky Chem. Rev., 2009, 109, 6729.

7. (a) Kool, E. T.; Morales, J. C.; Guckian, K. M. Angew. Chem. Int. Ed. 2000, 39, 990. (b) Kool, E. T. Acc. Chem. Res. 2002, 35, 936. (c) Teo, Y. N.; Wilson, J. N.; Kool, E. T. J. Am. Chem. Soc. 2009, 131, 3923. (d) Schweitzer, B. A.; Kool, E. T. J. Am. Chem. Soc. 1995, 117, 1863. (e) Kool, E. T. Annu. Rev. Biochem. 2002, 71, 191. (f) Jarchow-Choy, S. K.; Sjuvarsson, E.; Sintim, H. O.; Eriksson, S.; Kool, E. T. J. Am. Chem. Soc. 2009, 131, 5488.

Course Details			
Course Title: Chemistry of Natural Products			
Course Code	**21004**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objective:

- To give students an awareness of the richness and diversity of plants and animal around us. To make students aware of the many pharmaceutically active products of natural origin. To learn the origin of natural products, their characterization and synthesis.

Learning Outcomes: At the end of the course, students should be able to: The knowledge of the students is enhanced with the clear information about the natural products which are having medicinal importance.

- Identify and characterize various classes of natural products by their structures;
- Appreciate the biogenesis of many natural products of importance.

UNIT-I

(15L)

Basics of Metabolism (primary & secondary), Reactive Intermediates in Biosynthesis, Role of ATP and other important important coenzyme, catabolism, anabolism, biosynthesis of terpenoids alkaloids, and other natural products.

UNIT-II

Terpenoids and Carotenoids **(15L)**

Classification, nomenclature, occurrence, and isolation. Isoprene rules. Stereochemistry of citral, farnesol, limonene, 1, 8-cineole, menthols and borneols. Correlation of configurations of terpenoids.

Structure elucidation of camphene, pinene, caryophyllene, santonin and gibberrillic acid. Synthesis and biosynthesis of the following: Linalool,-terpineol, Commercial synthesis of camphor.

UNIT-III

Alkaloids (15L)

Definition, nomenclature, occurrence, isolation, classification, General methods of structure elucidation. Synthesis and biosynthesis of the following alkaloids: Ephedrine, hygrine, coniine and cocaine.

Steroids: Occurrence. Nomenclature, basic skeleton, Diels hydrocarbon and stereochemistry. Isolation, structure and structural elucidation of sterols and bile acids, Cholesterol.

UNIT-IV

Porphyrins andvitaminB12 (15L)

Structure elucidation and synthesis of haemin, chlorophyll-a and vitamin-B12

Prostaglandins: Introduction, nomenclature, classification and biological role of prostaglandins. Synthesis of PGE1 and PGE2 by Corey's and Stork's approaches.

Insect pheromones: Introduction, classification. Pheromones in pest control. Syntheses of (one synthesis should be stereo-selective synthesis)

SUGGESTED BOOKS

1. Natural products: Their chemistry and biological Significance-J. Mann, R. S. Davidson, J. B. Hobbs, D. V. Banthorpe & J. B. Harborne, Longman, UK, 1994.
2. Terpenes, J. Verghese, Tata McGraw-Hill, New Delhi, 1982.
3. Chemistry of terpenes and terpenoids, A.Newman, Academic Press, London, 1975.
4. Handbook of naturally occurring compounds Vol.II: Terpenes, T.K. Davon, A.I. Scott, Academic Press, NY, 1972.
5. Natural products chemistry Vol.I & II, K.Nakanishi, T. Goso, S.Ito, S. Natori & S. Nozoe, Academic Press, NY, 1974.
6. Total synthesis of natural products Vol.I & VI, Apsimon, John Wiley, NY, 1973-1981.
7. Organic chemistry Vol.II, I.L.Finar, 6^{th} Edn. Longman, 1992.
8. Chemistry of natural products Vol. I & II, O. P. Aggarwal, Goel Publishing House, 6^{th} Edn. 1982.
9. Total synthesis of natural products: The chiral approach Vol.III, S. Hanessian Pergamon Press, 1983.
10. Total synthesis of steroids, Akhaun & Titov, Jerusalem, 1969.
11. Medicinal natural products: A biosynthetic approach, P. M. Dewick. John Wiley, Chichester, 1997.
12. Chemistry of natural products: A unified approach, N. R. Krishnaswamy, University Press, India, 1999.
13. Medicinal natural products: A biosynthetic approach, P. M. Dewick. John Wiley, Chichester, 1997.

Course Details			
Course Title: Agrochemicals			
Course Code	**21104**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objective:

- To provide an appreciation of the importance of modern agrochemicals and the factors involved in their discovery.
- To impart knowledge about the mechanism of acton of various agrochemicals

Learning Outcomes: At the end of the course, students should be able to:

- Identify and characterize various classes of agrochemicals by their structures;
- Explain the mechanism of action of pesticides, insectisides and fungicides

UNIT-I

Introduction to pesticides **(15L)**

i) Definition, Classification and importance of pesticides

ii) Pest control: Different methods –chemical –insecticides, fungicides, herbicides, rodenticides, fumigants, chitin synthesis inhibitors and insect repellents.

General Mode of Action of Pesticides:

Insecticides: Disrupters of the nervous system, insect growth regulators, respiration inhibitors, photosynthesis disrupters, hormone mimics, inhibitors of amino acid synthesis, inhibitors of lipid synthesis.

Fungicides: Membrane disrupters, inhibitors of energy production, inhibitors of cell division, inhibitors of sterol synthesis.

UNIT-II

Synthetic insecticides **(15L)**

(i) Organochlorine insecticides- synthesis and mode of action of methoxychlor, perthan, Dicofol, Heptachlor, Dieldrin and Endosulfan.

(ii) Organophosphorous insecticides –synthesis and mode action of Phosphoric acid derivatives, phosdrin, Dichlorophos, parathion, Zolone, Aninphomethyl, TEPP and Sachradan.

(iii) Carbamate insecticides- synthesis and mode of action of carbamyl, Furadan, Baygon, Aldicarb and Zectron.

(iv) Formulation and residue analysis of organochlorine, organophophorous and carbamate

UNIT-III

Natural insecticides and herbicides **(15L)**

i**) Insecticides of palnt origin** –synthesis and importance of pyrethrins (I and II), Rotenone and Nicotine. Main constituents Neem-structural formula of Azadirachtin. Synthesis of polygodial and warbunganol (Antifeedants).

ii) Synthesis of pyrethroids: synthesis of Allethrin, Bioallethrin, Cypermethrin, Fenvalerate, Decemethrin and pyrithrelone.

iii) Concept of Bioinsecticides – Bacillus thiuringiensis.

iv) Concept of pro-insecticides-structure and mode of action of pro-pheremones andpre-pro-insecticides.

v) Herbicides – synthesis, applications and mode of action of the following

a) Aryloxyalkyl carboxylic acid derivative: 2,4-D, MCPA,2,4,5-T and 2,4,5-TP. b) Carbamatespropham and chloropham, c) Urea derivatives–Monouron and diuron, d) Aliphatic acids-Dalapon, TCA, e) Aromatic acids -2,3,6-TBA, Dicomba and Amiben, f) Nitrogen heterocyclic dericvatives–Simazine, Atrazine, Amitrole, Maleic hydrazide Diquat and paraquat, g) Phenols-PCP and Dinoseb, h) Benzonitrile compounds.

UNIT-IV

Fungicides and Rodenticides **(15L)**

i) Fungicides: classification, synthesis application and mode of action of the following classes:

a) Carbamates, b) Quinones-chloranil, Dichlone and Benquinox, c) perchloromethylmercaptan derivative–captan, folpet, Difolatan and Mesulfan d) Benzimidazoles-carbendazim, Benomyl and Thiabandazole

ii) Rodenticides, a) Anticoagulents-synthesis and application of warfarin, Coumachlor, Vacor, Coumatetrallyl, Dicoumarol and Bromodiolen. b) Acute poisons- application of pindone, Ratindan, Sodium Fluoroacetate, Barium fluoroacetate, Antu, Tetramine, pindone and castrix.

TEXT BOOKS:

1. Insecticides for future: Jacobson
2. Insect juvenile harmone chemistry and action: J. J Mann and M.Beroza
3. Insect antifeedants: S.V.ley&P. L Toogood, chemistry in Britain, Jan 1990 P.31
4. Synthesis of Insecticides: Metcalf
5. Fungicides-Nene
6. Crop protection agents from Nature: leonard G Copping
7. Insecticides and Fungicides: U Sriramulu.
8. Organo chlorine insecticides: persistent organic pollutants: F. Moriary
9. Pesticide formulations: Van Valkenburg
10. Pesticides managements and insecticide resistance: Watson and brown

REFRENCE BOOKS

1. Pesticide Chemistry- G. Matolcsy, M. Nádasy, V. Andriska, Elsevier.
2. Chemistry and mode of action of cope protection agents, I. G. Copping, RSC, 1998.
3. Insecticides with novel modes of action, I. Ishya and D. Degheele springer, 1998.

4. Insect Juvenile Hormones. Chemistry and Action (1972, Elsevier Science) - Julius Menn (Eds.)

5. The Organic Chemistry of Drug Design and Drug Action, Richard Silverman, Mark W Holladay Academic Press, 2014.

6. THE CHEMISTRY OF PESTICIDES, Walter R. Benson, Walter R. Benson, Food and Drug Administration, 1969.

Course Details			
Course Title: Nano Chemistry			
Course Code	**30904**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To acquaint the students with the fundamentals of nanoscience and nanotechnology
- To make students learn the structure and properties of different types of nanomaterials such as luminescent, superparamagnetic and plasmonic nanocrystals etc.
- To equip the students with necessary knowledge and skills in synthesis and characterization of nanomaterials
- To develop an understanding of self-assembly and nanocatalysis
- To create awareness about applications of nanotechnology for energy generation, water purification, sensing, and healthcare

Learning Outcomes: After completion of the course the learners will be able to:

- Explain the nanomaterials as low dimensional systems and explain their properties
- Discuss and describe the salient features of nanomaterials such as quantum dots, plasmonic nanoparticles, superparamgnetic particles, CNTs and graphene
- Synthesize nanomaterials and characterize it using various techniques.
- Explain how the nanoparticles can be used as building blocks to create hierarchial nano/microstructures
- Discuss the origin of enhanced catalytic efficiency of nanoparticles
- Underscore the importance of nanotechnology in daily life through applications in solar cells, water purification and diagnosis and therapy

UNIT-I

Introduction to Nanoscience & Nanotechnology (15L)

Introduction to the nano- the length scale, meaning of the terms nanomaterials, nanoscience and nanotechnology, nanotechnology currently in use, Histotical perspectives, Nature's perspectives

Nanomaterials as low dimensional systems, classification into 2D, 1D and 0D systems. Electronic structure of such systems; Stabilization of colloidal nanoparticles, electrostatic and steric stabilization, surface functionalization of nanoparticles. Classification of nanomaterials based on their properties: Semiconductor nanoparticles: Quantum confinement effects, Quantum dots, quantum wells, quantum wires; size dependent absorption and emission of light (luminescence); Magnetic nanoparticles: superparamagnetism, SPIONs, Giant magnetoresistance (GMR) Plasmonic nanoparticles: surface plasmon resonance, Carbon based nanomaterials: carbon nanotubes, fullerenes, graphenes, carbon dots, electron emission from CNTs, conductivity and enhanced catalytic activity compared to the same materials in the macroscopic state.

UNIT-II

Synthesis and Characterization of Nanomaterials (20L)

Top-down, bottom-up approach, liquid-phase synthesis, gas-phase synthesis, vapour-phase synthesis; Stabilization of nanoparticles, Surface passivation & functionalization, bioconjugation, direct absorption, covalent coupling.

Chemical Methods: - Arrested precipitation, coprecipitation; Metal nanocrystals by reduction, Sol-gel synthesis; Microemulsions or reverse micelles, solvothermal synthesis; Thermolysis routes, Microwave synthesis; Sonochemical synthesis; electrochemical synthesis; photochemical synthesis, Synthesis in supercritical fluids.

Physical Methods: Inert gas condensation, Arc discharge, Plasma arc technique, RF plasma, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapor deposition method, Physical vapor deposition, nanolithography and nano indentation.

Characterization: Structural Characterization; size shape and crystal structure, Transmission electron microscopy(TEM),Scanning electron microscopy (SEM), Electron diffraction (ED), X-ray –diffraction (XRD), Atomic force microscopy (AFM), Dynamic light scattering (DLS) , Small angle X-Ray Scattering (SAXS),Neutron Scattering, Magnetic Characterization**:** determination magnetic susceptibility, coercivity etc, by SQUID, Vibrating sample magnetometer (VSM), Optical Characterization: UV-Vis absorption spectroscopy, Luminescence Spectroscopy.

UNIT-III

Self-Assembly of nanomaterials and Nanocatalysis (10L)

Nanoparticles as building blocks, Process of self-assembly, semiconductors islands, Self-assembled Monolayers (SAMs); crystal dipole directed self-assembly of nanoparticles into one dimensional and two dimensional nanostructures, self-assembly into three dimensional superlattices, such examples of semiconductor quantum dots; Self-assembly directed by molecular recognition, protein-directed self-assembly, dendrimer directed self-assembly, nucleic acid directed self-assembly, examples of metal/metal oxides/semiconductor nanoparticles.

UNIT-IV

Applications of Nanotechnology **(15L)**

Sensing Applications: Electrochemical sensors, Chemical sensor, physical sensors, biosensors, Nanostructured Gas Sensors, Colorimetric and fluorescent sensors for trace Contaminants in water, Detection of pesticides and explosives

Biomedical Applications: Luminescent NPs for imaging of cancer cells, Superparamagnetic Magnetic NPs for MRI (Magnetic resonance imaging), Noble metal NPs for imaging applications, Targeted Drug Delivery Meosporous silica/ Polymeric nanoshells/nanopartices for drug delivery; Liposomes and micelles as nanocarriers metal/semiconductor/polymeric nanoparticles Photodynamic therapy (PDT), Photothermal therapy (PTT) by plasmonic nanomaterials, Hyperthermia treatment by magnetic NPs.

Energy Applications: Solar energy for electricity production: photovoltaic nanotechnology, artificial photosynthesis Nanotechnology for: Hydrogen production, Hydrogen transport and storage, Hydrogen conversion, fuel.

SUGGESTED TEXT BOOKS

1. A Textbook of Nanoscience and Nanotechnology, T. Pradeep, Tata McGraw Hill Education Private Limited, New Delhi (2012).
2. Nanochemistry: A Chemical Approach to Nanomaterials, Geoffrey A. Ozin, André C. Arsenault, Ludovico Cademartiri, Royal Society of Chemistry (2009).
3. Concepts of Nanochemistry, Ludovico Cademartiri, Geoffrey A. Ozin, Jean-Marie Lehn, WILEY-VCH Verlag GmbH & Co. KGaA, (2009).
4. Nano: theEssenstials, T. Pradeep, Tata McGraw Hill Education Private Limited, New Delhi (2007)
5. Environmental Applications of Nanomaterials, Glen Fryxell and Guozhong Cao, Imperial College Press, London (2007).
6. Introduction to nanotechnology, C. P. Poole Jr, F. J. Owens, 2nd edition, Wiley-India, Delhi, 2008.
7. Nanostructures and nanomaterials, G. Cao, Imperial College Press, University of Washington, USA, 2004.
8. Nanotechnology Fundamentals and applications, M. Karkare, I. K. international publishing house pvt. Ltd., Bangalore, 2008.
9. Springer Handbook of Nanotechnology, B. Bhusan, 3rd edition, Springer-Verlag, 2009.
10. Chemistry of Nanomaterials: Synthesis, Properties and Applications, CNR Rao and T. Cheetham, Wiley & Sons, 2005.
11. Nanoparticles: From Theory to Application, Günter Schmid, WILEY-VCH Verlag GmbH &Co. KGaA, (2011).
12. Nanoparticles: synthesis, stabilization, passivation, and functionalization, Ramanathan Nagarajan, T. Allan Hatton, Publisher: American Chemical Society (2008).
13. Magnetic nanoparticles, S. P. Gubin, WILEY-VCH Verlag GmbH & Co. KGaA,(2009)

14. Multifunctional Nanoparticles for Drug Delivery Applications: Imaging, Targeting, and Delivery, Sonke Svenson, Robert K. Prud'Homme, Springer (2012).

Elective Basket 'B'

For DE

Course Details			
Course Title: Inorganic Materials and Their Applications			
Course Code	**10804**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To enhance the understanding of the electronic structure of solids
- To acquaint the students with the advanced level concepts in magnetochemistry such as magnetic anisotropy and single molecule magnets
- To familiarize the students with the concepts of piezoelectricity, ferrolelectricity, dielectrics and superconductivity
- To impart the knowledge and skills in electrochemical aspects of inorganic systems

Learning Outcomes: After completion of the course the learners will be able to:

- Distinguish between piezoelectric and ferroelectric effects in inorganic systems
- Understand and apply concepts of piezoelectricity, ferroelectricity in daily life
- Determine the magnetic anisotropy and susceptibility in inorganic systems
- Apply the advanced concepts in designing single molecule magnets
- Apply the concepts of defects-engineering to obtain enhanced features of inorganic systems
- Explain the electrochemical processes occurring in biological systems
- Apply the concepts for protection from corrosion

UNIT-I

Electronic structure of solids **(15L)**

Bonding in solids: Ionic, covalent, metallic and molecular solids. Free electron theory, Fermi sphere, Fermi-Dirac statistics, Ohm's law, limitations of the free electron theory Electrons in a weak periodic potential (Independent electron model), energy levels in extended, repeat and reduced zone schemes

Electrical and Magnetic Properties of Solids: Metals: calculation of density of states, origin of resistivity, weak paramagnetism Semiconductors: Intrinsic and extrinsic- p and n-types, Hall Effect, Junctions and their applications- metal-metal, metal-semiconductor semiconductor-semiconductor types and transistors.

Insulators- dielectric properties, piezo and inverse piezoelectric effects, ferroelectricity, ferroelectric transitions in $BaTiO_3$, ionic conductivity applications of band theory to TiO and NiO: Limitations of the Independent electron model, modelling electron correlation.

UNIT-II

Advanced Magnetochemistry (15L)

Definition of magnetic properties, types of magnetic bodies, Curie equation, Curie's law and Curie-Weiss law. Anisotropy in magnetic susceptibility, diamagnetism in atoms and polyatomic system, Pascal's constants, two sources of paramagnetism, spin and orbital effects, spin-orbit coupling, Lande interval rule, energies of J levels, first order and second order Zeeman effects, temperature independent paramagnetism, simplification and application of van Vleck susceptibility equation, quenching of orbital moment, magnetic properties of transition metal complexes, low spin, high-spin crossover, magnetic behavior of lanthanides and actinides, magnetic exchange interactions. Molecular magnets, Single Molecule Magnets (SMMs), 3d, 4f and 3d-4f based SMMs. Experimental arrangements for determination of magnetic susceptibility: SQUID.

UNIT-III

Dynamics of Atoms in a Solid (15L)

Dispersion curves of an elastic structureless medium, Longitudinal and Transverse modes, Optical and Acoustic modes of a crystal, total vibrational energy of a crystal. Case study of calcite.

Defects in Solids: Point defects, Line defects and Plane defects, Stacking faults and grain boundaries.

Superconductivity: Superconductivity, Meisner effect, Type I and type II superconductors, features of superconductors, Frolich diagram, Cooper pairs, Theory of low temperature superconductivity, Junctions using superconductors.

Phase Transition in Solids: Definitions, Classification of phase transitions, First and second order phase transitions: Martensitic transition, order-disorder transitions and spinodal decomposition.

UNIT-IV

Electrochemical aspects of inorganic systems (15L)

Electrochemical synthesis: Special features of electrochemical synthesis compared to conventional synthesis-reaction variables (electrode material, electrode potential, solvent, supporting electrolyte, temperature, agitation) in electrochemical synthesis. Examples of electro-inorganic and electrochemical nanoparticles synthesis with mechanism.

The electrochemical interface between biomolecules, cellular membrane, transmembrane potential, bilayer lipid membranes, electroporation, biological electron transport, electrochemistry of redox enzymes, biological membrane and membrane mimics. Biosensors-NADP, glucose, phenolic. Bioelectroanalysis: Electrolysis and Electrodialysis.

Corrosion and its prevention: use of corrosion inhibitors, use of coatings.

SUGGESTED TEXT BOOKS

1. Inorganic Electrochemistry: Theory, Practice and Application, Piero Zanello, Royal Society of Chemistry, London, 2007
2. Molecular Electrochemistry of Inorganic, Bioinorganic and Organometallic Compounds Volume 385 of Nato Science Series C:, A.J.L. Pombeiro, J.A. McCleverty, Springer Science & Business Media, 2012

3. Introduction to Magnetochemistry, Alan Earnshaw, Elsevier, 2013

4. Physical principles and applications of magnetochemistry, Sir Shanti Swarupa Bhatnagar, K. N. Mathur, Macmillan and Co., limited, 1935

5. Magnetochemistry, Richard L. Carlin, Springer Science & Business Media, 2012

6. Solid State Chemistry and its Applications, Anthony R. West, 2nd Edition, John Wiley & Sons, 2014

SUGGESTED REFERENCE BOOKS

1. Dynamics of Atoms in Crystals, W.Cochran, Edward Arnold, London,1973.(Pages 24-37)

2. Vibrational Spectroscopy of Solids, P.M.A. Sherwood, University Press, Cambridge, 1972. (Pages: 1-45)

3. Phase Transitions, C.N.R. Rao and K.J. Rao, Cambridge University Press.

4. X-ray Structure determination: A practical guide, George H Stoutand Lyle H Jenson, Macmillan Publishing Co.Inc and Collier Macmillan Publishers.

5. Solid State Chemistry: An Introduction, Fourth Edition, Lesley E. Smart, Elaine A. Moore, CRC Press, 2016

6. Electrochemistry of Metal Complexes: Applications from Electroplating to Oxide Layer Formation, Arvydas Survila, John Wiley & Sons, 2015

7. Biological Electrochemistry, Volume 1, Glenn Dryhurst, Elsevier, 2012

Course Details			
Course Title: Modern Organic Synthesis			
Course Code	**21204**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objective: Utilize the knowledge of stereochemistry to understand different stereo-controlled chemical reactions and the role of the reagents in organic transformation with their reaction mechanism. Development of knowledge for the rational mechanism-based design of synthetic strategies for novel organic reactions.

UNIT-I

Chiral substrates controlled asymmetric synthesis **(15L)**

Stereoselective Nucleophilic addition to carbonyl compounds, 1, 2-asymmetric induction, Cram's rule and Felkin-Anh model, Cyclic Model for 1,2 Asymmetric Induction. Cyclic and acyclic enolates: kinetic *vs* thermodynamic stability: Alkylations, and aldol reactions.

Chiral auxiliary controlled asymmetric synthesis: aldol reaction: Evans approach, Crimmins approach, α-hydroxylation, α-alkylation, C-N and C-X-Bond forming reactions.

Reagent controlled asymmetric synthesis: aldol reaction: Ian Paterson Approach, 1,2 Asymmetric Induction: Diastereoselective Allylation with Chiral Boron Reagents. Brown allylation, reductions. Chiral catalyst controlled Diastereoselective transformation.

UNIT-II

Oxidizing Reagents **(15L)**

Metal based and non-metal-based oxidations of (a) **alcohols to carbonyls**: (i) Chromium based Cr(IV) Oxidants: Jones reagent, CrO_3, PCC, PDC, Manganese, aluminium, silver, and ruthenium. (ii) **DMSO oxidants:** Moffatt-Pfitzner Oxidation, swern oxidation, Torrsell oxidation, Parikh-Doering Oxidation, Corey–Kim oxidation, Kornblum Oxidation (iii) **Hypervalent iodine:** IBX, DMP and TEMPO based reagents, and TPAP. (b) **Alkenes to epoxides** (peroxides/per acids based), Sharpless asymmetric epoxidation, Jacobsen epoxidation, Shi epoxidation. (c) **Alkenes to diols** (Manganese, Osmium based), Sharpless asymmetric dihydroxylation, Prevost reaction and Woodward modification, (d) **alkenes to carbonyls with bond cleavage:** Manganese, Osmium, Ruthenium and Lead. (e) **Oxidation of active C-H bonds:** SeO_2, DDQ, CAN, NBS.

UNIT-III

Reducing Reagents **(15L)**

Reduction: (a) **Catalytic hydrogenation** (Heterogeneous: Palladium / Platinum / Rhodium / Nickel etc; Homogeneous: Wilkinson). Noyori asymmetric hydrogenation. (b) Dissolving metal reductions: Li/Na/Ca in liquid ammonia, Sodium, Magnesium, (Birch, Pinacol formation, McMurry, Acyloin formation, (c) **Hydride transfer reagents/ nucleophilic metal hydrides:** from Group III and Group IV in reductions. (i) Al based reagents: $LiAlH_4$, DIBAL-H, and Red-Al; $NaBH_4$, and its derivatives such as triacetoxyborohydride, L-selectride, K-selectride, Luche reduction; Trialkylsilanes and Trialkylstannane,) (ii) Stereo/enantioselectivity reductions (Chiral Boranes, Corey-Bakshi-Shibata), iii) **Electrophilic metal hydrides:** AlH_3, BH_3

Coupling reagents for functional groups: for alcohols, amines and acids**:** EDCI, DCC, HATU, HOBt, HBTU, HCTU, Yamaguchi lactonization.

UNIT-IV

I)**Protecting Groups** **(15L)**

(i) **Protection of alcohols** as ethers: (a) MOMCl, MEMCl, etc., (b) silyl ether TMSCl, TESCl, TBDPSCl, TIPSCl, TDPSCl, and (c) ester formation: Boc, Cbz. (ii) **Methods for deprotections** of Silyl, Cbz, Boc (ii) **Protection of 1,2-diols and 1,3-diols**, (iii) **Protection of amines:** by benzyloxy carbonyl, *t*-butyloxycarbonyl, fmoc and triphenyl methyl groups. (iv) Protection of carbonyls by acetal, ketal and thiol acetal (Umpolung) groups. (v) Protection of carboxylic acids by ester.

II) Organic Retrosynthesis and its application to natural product synthesis: Disconnection Approach: An introduction to synthons, retrons and synthetic equivalents, Functional group transposition, Functional group inter-conversions, disconnection approach, the importance of the order of events in organic synthesis, one group and two group C-X disconnections, one

group C-C and two group C-C disconnections, illogical disconnections, linear and convergent synthesis. Chemoselectivity, regioselectivity, reversal of polarity (umpolung).

Synthesis of some complex molecules: synthetic routes based on retrosynthetic analysis.

SUGGESTED TEXT BOOKS

1. F. A. Carey and R. I. Sundberg, Advanced Organic Chemistry, Part A and B, 5th Edition, Springer, 2009.
2. M. B. Smith, Organic Synthesis, 2nd Edition, 2005
3. S. Warren, Organic Synthesis, The disconnection Approach, John Wiley & Sons, 2004.
4. I. Ojima, Catalytic Asymmetric Synthesis, 2nd edition, Wiley–VCH, New York, 2000.
5. W. Carruthers, Modern Methods of Organic Synthesis, Cambridge University Press, 1996.
6. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, Oxford University Press, 2001.
7. R. Noyori, Asymmetric Catalysis in Organic Synthesis, John Wiley & Sons, 1994.
8. Nasipuri D. Stereochemistry of Organic Compounds, New Age Publications.
9. Protective groups in organic synthesis 4th Ed. 2007 - Greene &Wuts

SUGGESTED REFERENCE BOOKS

1. The Logic of Chemical Synthesis by E. J. Corey & X-M. Cheng
2. Classics in Stereoselective Synthesis by Carreira, E. M.; Kvaerno, L, Wiley VCH, 2009
3. Classics in Total Synthesis by K. C. Nicolaou & E. J. Sorensen, VCH, 1996.
4. Classics in Total Synthesis II, K. C. Nicolaou & S. A. Snyder, VCH, 2003
5. J. Tsuji, Palladium Reagents and Catalysts, New Perspectives for the 21st Century, John Wiley & Sons, 2003.
6. L. Kuerti and B. Czako, Strategic Applications of named Reactions in Organic Synthesis, Elsevier Academic Press, 2005
7. Protective Groups in Organic Synthesis 3rd Ed - Peter G. M. Wuts
8. Gawley R. E. and Aube J. Principles of Asymmetric Synthesis, Pergamon.
9. Eliel E. L. Stereochemistry of Organic Compounds, Wiley.

Course Details			
Course Title: Applied Electrochemistry			
Course Code	**31004**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours

Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)

Course Objectives

- To acquaint students with applications of electrochemistry in daily life
- To make students proficient in advanced level electroanalytical methods such as polarography and cyclic voltammetry
- To make students aware of various methods of electrochemical energy conversion and storage.
- To make students learn techniques of electroplating and metal finishing
- To impart knowledge about corrosion and its prevention

Learning Outcomes: After completion of the course the learners will be able to:

- Apply the concept of polarography and voltammetry to solve problems in daily life
- Explain the construction and working of various types of batteries and fuel cells
- Distinguish between various electroplating techniques and use it for different purposes
- Use electrochemical techniques to prevent corrosion

UNIT-I

APPLIED ELECTROCHEMISTRY **(20L)**

Electroanalytical methods: Voltametry: Definition, concentration polarization, ideal and non-ideal polarized electrodes, Faradaic and non-faradaic currents.

Polarography- Construction of dropping mercury electrode (DME), advantages and limitations. Principle of normal dc polarography, half-wave potential, and qualitative analysis using polarograms. Types of currents obtained at a DME. Ilkovic equation, factors affecting diffusion controlled current, quantitative analysis based on Ilkovik equation. Current-potential relation for ac athodic wave, anodic wave and composite wave, test for their versibility of a process at DME, factors that set the sensitivity and selectivity limits in normal dc polarography.

Advanced polarographic techniques: Tast polarography, normal pulse polarography, differential pulse polarography, ac polarography.

Stripping voltametry: Hanging drop mercury electrode (HDME), principles and applications of cathodic and anodic stripping voltammetry.

A: **Cyclic voltammetry:** Principle, experimental setup, quantitative analysis. Diagnostic criteria for reversible, quasi- reversible and irreversible processes. Study of coupled chemical reactions like ErCr, CrEr and ErCiEr.

B.**Chronomethods:** Basic concepts, methodology and applications of chronoamperometry, chronopotentiometry and chronocoulometry.

C. **Hydrodynamic electrodes:** Construction and use of rotating disc and rotating ring disc electrodes in the electrochemical studies.

D.**Membrane electrodes:** Ion-selective membrane electrodes-construction and applications of solid state and liquid membrane electrodes, ion selective field effect transistor and Molecular (gas) sensing probes.

E. Problems solving.

UNIT-II

Electrochemical energy conversion and storage **(20L)**

Batteries: History and basics, classification, characteristics with units-voltage, current, capacity, electricity storage density, energy density, power density, energy efficiency, cycle life, shelf life. Primarybatteries: Construction, reactions and uses of Leclanche dry cell, alkaline Leclanche cell, zinc- silver oxide cell.

Secondary batteries: Construction, working (charge-discharge reactions), applications advantages and of Pb-acid and Ni-Cd batteries.

Hybrid Batteries:Metal-air batteries-meaning, Zn-air battery, Fe-air battery, Charging of metal- air battery, Metal oxide-hydrogen / hydride batteries, advantages and limitations of these cells *Lithium batteries:* Primary and secondary lithium battery, Li-ion battery and Lithium ion- polymer battery.

Electrochemical supercapacitors*:* comparative meaning of capacitor, electrolytic (super) capacitor and ultracapacitors, materials for construction, applications, advantages and limitations.

Fuel cells*:* Energy efficiency of electrochemical and thermal conversion (Carnot limitation). Definition of fuel cell, classification. Fuel cell efficiency- thermodynamic, electrochemical, practical efficiency. Electrode (anode and cathode) mechanism of fuel cell, Brief description on construction, working principle and applications of each type fuel cells. An account of electrocatalysts, proton exchange membrane (PEM) fuel cells and direct methanol fuel cell. Problems solving.

UNIT-III

Surface Modification techniques (Metal finishing): **(10L)**

Definition, important processes of metal finishing, technological importance of metal finishing. *Electroplating:* Definition, theory and mechanism of electroplating, effect of plating variables on the properties of electrodeposits, comparative account of complexing and non-complexing baths (general treatment), additives in the platingbath and their significance.

Metallic coating: Preparation of substrate surface, electroplating of Cuand Cr. Applications of Au and Ag platings.

Solar selective coatings: Characteristics, methods of preparation and applications.

Techniques of electroplating: Galvanizing, Anodizing, Phosphating, Chromating. Electrolessplating: Definition, advantages overelectroplating, pretreatment of substrates, an account of electroless plating of Ni including applications.

UNIT-IV

Corrosion and its Prevention **(10L)**

Introduction, dry and wet corrosion, theories and mechanisms of wet (electrochemical) corrosion, thermodynamic aspects of corrosion, kinetic aspects- determination of rates of corrosion by linear polarization, Tafel extrapolation and impedance techniques. Factors influencing the rate of corrosion-metal and environmental.

Methods of corrosion prevention: Cathodic protection, anodic protection, use of corrosion inhibitors, use of organic coatings.

Passivity: Definition, corrent potential diagram, characteristics of passivity, theory and mechanism of passivation, flade potential, transpassivity, Use of ellipsometric technique in the study of passivating films. Problems solving

SUGGESTED TEXT BOOKS

1. Modern Electrochemistry, Vol.1, 2 A and 2 B by Bockris and Reddy, Plenum, N.Y (2000).
2. Polarography and Allied Techniques by V Suryanarayana Rao, Universities Press (India) Pvt. Ltd., Hyderadad (2002).
3. Basicconcepts of Analytical Chemistry by SM Khopkar, New Age Internatonal Publishers, third edition, New Delhi, 2008.
4. Electrochemical Methods- Fundamentals and Applications, 2nd Edn, by A J Bard and LR Faulkner, John Wiley & Sons Inc., New York (2001).
5. Chemical and Electrochemical Energy systems by Narayan and Viswanathan, Hyderabad, Universities Press (India) Pvt. Ltd., Hyderadad (2002).
6. Understanding Batteries, RM Delland DAJ Rand, 2001.6. Fuel cells andtheir applications, Karl kordesh, gunter, Simader, VCH-Weinheim, Cambridge, 1996.
7. Fundamentals of electrochemical deposition, Milan Paunovic and Mordechay Schlesinger, Wiley-interscience publications, New York, 199
8. Electrodeposition and Corrosion Control, J.M.West,J. WileyW. Revie (ed.): Corrosion Handbook, Electrochemical Society Series, John Wileyand Sons (2000)
9. Electrochemistry and corrosion science, Nestor Perez, Springer pvt. Ltd., 2004
10. Principles and Prevention of Corrosion, D. A. Jones, Macmillan Publ.Co. (1996).
11. Bioelectrochemistry: Fundamentals, experimental techniques and application, P. N. Bartlett, Wiley & Sons (2008).
12. Synthetic organic Electrochemistry by A MFry, 2nd Edn, Wiley1989.

Course Details			
Course Title: Inorganic Reaction Mechanism, Organometallics and Advance Bioinorganic Chemistry			
Course Code	**10904**	**Credits (L + T + P)**	**4(**3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To develop comprehensive understanding of reaction mechanism involving metal complexes
- To make students understand the role of organometallics in industrial catalysis and medicine
- To impart knowledge of structure and functions of metalloproteins
- To make the students understand the mechanism of metal ion transport across the cell membrane and discuss the toxicity of metals

- To impress upon the students, the versatility and efficiency of the oxygen transport systems and nitrogen fixation in biology

Learning Outcomes; After completion of the course the learners will be able to:

- Explain the electron transfer processes involving metal complexes
- Analyse the role of organometallics in catalysis and medicine and design new ones
- Analyse the structure and functions of metalloproteins
- Elaborate the oxygen transport system in various biosystems
- Illustrate the detoxification scheme for heavy metals and chelation therapy

UNIT-I

Reaction mechanism **(15L)**

Substitution in square planar complexes-factors affecting substitution, mechanism of substitution reaction-associative, dissociative, interchange associative, interchange dissociative, trans-effect, Application of trans-effect in the synthesis of complexes. Mechanism of ligand substitution in octahedral complexes- kinetics, factors affecting substitution in octahedral complexes: Leaving group, chelate and metal effects. Examples of Labile, inert, stable and unstable complexes. Mechanism of isomerization reactions in octahedral complexes with and without bond breaking.

Electron transfer reactions, complementary and non-complementary, outer sphere electro Transfer-Marcus's equation, Inner sphere electron transfer- one and two electron transfer, use of electron transfer reactions for the synthesis of complexes.

UNIT-II

(15L)

Synthesis, Structure and Bonding of metal carbonyl complexes, carbonylate ions, metal carbonyl hydride complexes, Vasaka's complex, Nitrosyl complexes, Isoelectronic and isolobal fragments, Fischer and Schrock carbene and carbyne. Metal alkene, alkyne and carbide complexes, Allyl and pentadienyl complexes, Metallocene.

Reactivity and Catalysis: Oxidative addition and Reductive elimination, Agostic interaction, Insertion and Elimination reaction, Nucleophilic and electrophilic attack of coordinated ligands, Wilkinson's catalyst, Homogeneous catalysis: Hydrogenation, asymmetric hydrogenation; hydroformylation-cobalt and modified catalysts, Wacker process-acetaldehyde from ethylene; Monsanto acetic acid process, Olefin metathesis; water gas shift reaction; Fischer Tropsch Process; Ziegler Natta catalysis, medicinal applications of organometallic complexes. Oxidative addition, reductive elimination, isomerization, migratory insertion reactions.

UNIT-III

Metalloproteins **(15L)**

Introduction, Iron protein: Heme, Protoporphyrin IX, Structure and functions of haemoglobin and myoglobin, Cooperativity, Perutz mechanism, dioxygen binding, Bohr Effect, Hill equation, non-porphyrin systems- hemerythrin and hemocyanin. Cytochromes, Mitochondrial flow of electrons from NADH to oxygen, cytochrome C, Cytochrome C oxidase. Iron sulphur protein: Rubredoxins, Ferredoxins- 2Fe-2S, Rieskecenters, 3Fe-4S, 4Fe-4S, 8Fe-8S.

Metalloenzymes: Structure and Reactivity-Zinc enzymes: carboxypeptidase, carbonic anhydrase, alcohol dehydrogenase. Cu enzyme: superoxide dismutase. Mo enzyme: Xanthine oxidase, nitrate reductase. Fe enzymes: catalase, peroxidise, acid phosphate and cytochrome P-450. Vitamin B_{12}: Coenzyme: B_{12r}, B_{12s}, biochemical functions of cobalamins; Biomethylation.

UNIT-IV

Photosynthesis and nitrogen fixation (15L)

Nitrogenase: structural aspects and functions, nitrogen fixation. Photosynthesis: Chlorophyll- structural features, role of Mg^{2+}, Z scheme of photosynthesis-PS-I and PS-II.

Metals in transport, fixation and medicine: Na^+/K^+ transport across cell membranes, ionophores, Na^+/K^+ pump. Iron storage and transport: siderophores, transferrin and ferritin. Metal ion deficiency and treatment (Fe, Zn, Cu, Mn); toxicity of Fe, Cu, Heavy Metals-As, Hg, Pb and Cd; detoxification; chelation therapy; Biological roles of Ca: Binding sites of Ca^{2+} in proteins, importance of Ca^{2+} in muscle contraction and in blood clotting process. Metal complexes as anticancer and antiarthritic drugs.

SUGGESTED TEXT BOOKS

1. The organometallic chemistry of transition metals; R. H. Crabtee; John Wiley, 6th edition.
2. Catalytic chemistry; B. C. Gates; John Wiley and sons, 1992.
3. Applied Organometallic chemistry and catalysis; Robin Whyman, Oxford Chemistry Primers, 2001
4. Reaction mechanism of inorganic and organometallic systems; J. B. Jordon, Oxford University Press 2nd edition, 1998.
5. Principles of Bioinorganic Chemistry; S. J. Lippard and J. M. Berg; Panima Pub. Corporation 1997.
6. Bioinorganic Chemistry - Inorganic Elements in the Chemistry of Life, W Kaim, 2nd Edition,
7. Wiley Inorganic Chemistry, 3rd Edition; Gary. L. Miessler and Donald. A. Tarr (2007).
8. Bio-inorganic chemistry, I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valentine, Viva Books Pvt. Ltd 1998

SUGGESTED REFERENCE BOOKS

1. F. A. Carey G. Wilkinson, C. A. Murillo and M. Bochmann, Advanced Inorganic Chemistry, Wiley Interscience, 2003.
2. C. E. Housecroft and A. G. Sharpe, Inorganic Chemistry, Prentice Hall, 2005.
3. Organometallics; Vol 1 & 2; M. Bochmann, Oxford Chemistry Primers, Oxford University Press, 1994.
4. Inorganic Chemistry; K. F. Purcell and J. C. Kotz, Saunders Company, 1977.

Course Details			
Course Title: Chemistry of Biomolecules			
Course Code	**21304**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester

Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objective: Acquire foundational knowledge of the chemistry of life. Examine the relationship between the structure and function of biological molecules. And apply this knowledge in research and development in the area of Biomedical Analysis as well as Biomedical Methods and Technology.

UNIT-I

Amino acids and Peptide **(20L)**

Amino acids, structural features, optical activity, essential and non-essential amino acids, iso-electric point, synthesis and chemical properties of α amino acids. Peptides: Structure and synthesis, Protecting and activating groups, solid phase peptide synthesis.

Proteins: classifications, primary, secondary, tertiary and quaternary structure of proteins, glycoproteins, denaturation and folding.

Enzyme: Nomenclature and classification, Remarkable properties of enzymes like catalytic power, specificity and regulation, Proximity effects and molecular adaptation, Chemical and biological catalysis. Mechanism of enzyme action: Fischer's lock and key and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors affinity labeling and enzyme modification by site directed mutagenesis.

Receptors: Type of receptors, Receptor-ligand interaction, Enzymes, agonists, partial agonist, inverse agonists, neutral antagonists and antagonist

UNIT-II

Coenzyme **(15L)**

Cofactors as derived from vitamins, coenzymes, prosthetic groups, and apoenzymes. Structure and biological functions of coenzyme A, thiamine pyrophosphate pyridoxal phosphate, NAD^+, $NADP^+$, FMN, FAD, Lipoic acid, vitamin B_{12}. Mechanisms of reactions catalyzed by the above co-factors.

Nucleosides, Nucleotides and Nucleic Acids: Nucleosides, Nucleotides, Elementary idea of nucleic acids and complementary base pairing, ATP: The Carrier of Chemical Energy, Phosphodiester bonds, Oligonucleotides and polynucleotides, Nucleic acids, Secondary and tertiary structures, the double helix

Lipids: Classification and biological importance of fatty acids and lipids, stereochemical notation in lipids, chemical synthesis of phospholipids and glycolipids, properties of lipid aggregates, micelles, bilayers, lyposomes and biological membranes.

UNIT-III

Carbohydrates **(10L)**

Types of naturally occurring sugars, deoxy sugars, amino sugars, branched chain sugars, sugar methyl ethers and acid derivatives of sugars, polysaccharides of industrial and biological importance, dextran, chemistry of sialic acids, cell-cell recognition and blood group substances.

UNIT-IV

Concept of Energy in Biosystems **(15L)**

Introduction to Metabolism (catabolism, anabolism), ATP: the universal currency of cellular energy, ATP hydrolysis and free energy change. Conversion of food into energy. Outline of catabolic pathways of Carbohydrate- Glycolysis, Fermentation, Krebs cycle. Overview of catabolic pathways of Fats and Proteins. Interrelationships in the metabolic pathways of Proteins, Fats and Carbohydrates.

SUGGESTED TEXT BOOKS

1. Dugas, H. & Penney, C. Bioorganic Chemistry: A Chemical Approach to Enzyme Action Springer-Verlag (1989).
2. Saenger, W. Principles of Nucleic Acid Structure Springer-Verlag (1984).
3. Sinden, R. P. DNA Structure and Function Academic Press (1994).

SUGGESTED REFERENCE BOOKS

1. Crowe J and Bradshaw T. (2010) Chemistry for the biosciences- The essential concepts. Oxford University Press, 2nd ed.
2. Principles of Biochemistry 6th edition, 2006 - Jeremy M. Berg, John L. Tymoczko and Lubert Stryer (W.H. Freeman & Co.)
3. Lehninger Principles of Biochemistry 5th edition, 2008 - Nelson, D. L. and M. M. Cox. (W. H. Freeman & Co.).
4. Outlines of Biochemistry 5th edition 2001- Conn, E.E., Stumpf, P. K. Bruening, G. and Doi, R.H. (John Wiley and Sons).
5. Harper's Illustrated Biochemistry - R.K. Murray et al. (McGraw Hill)

Course Details			
Course Title: Advanced Photochemistry			
Course Code	**31104**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To further enhance the understanding of photochemistry
- To make students learn the physicochemical properties of electronically excited state
- To acquaint students with the environmental effects on absorption and emission spectra
- To develop an understanding of different types of photochemical reactions
- To impart knowledge about emerging topics such as photo-eletrochemistry, photovoltaics and photo-splitting of water

Learning Outcomes: After completion of the course the learners will be able to:

- Draw Electronic, vibrational, rotational energies-potential energies diagram and explain the photochemical processes
- Distinguish between photoluminescence, electroluminescence and chemiluminesce
- Discuss the effect of solvents on absorption and emission spectra
- Analyze a photochemical reaction, determine the rate constant and photochemical quantum yield
- Discuss the role of photochemical processes in photovoltaics and generation of hydrogen energy

UNIT-I

(15L)

Importance of Photochemistry, Laws of Photochemistry: Grothus –Draper Law, Stark-Einstein's Law, Laws of light absorption, Quantum yield and numerical problems. Photochemistry and spectroscopy, units and dimensions. Electronic energy states of atoms, term symbols for atoms, energy levels for the electronic configuration of carbon and oxygen illustrating spin orbit coupling and Hunds rules, inverted multiplets as applied to simple atoms and also for inner transition metals, Laporte's selection rules. Physicochemical Properties of electronically excited molecules: Nature of changes on electronic excitation: acidity, dipole moment, redox potentials etc. Fates of excited species, Electronic, vibrational, rotational energies-potential energies diagram. Shapes of absorption band and Franck Condon principle.

UNIT-II

(15L)

Quantum mechanical formulation of Franck Condon, crossing of potential energy surfaces, Non crossing rule of Teller for potential energy surface. Emission spectra, fluorescence and phosphorescence.

Environmental effect on absorption and emission spectra, solvent red shift and blue shift in absorption spectra. Experimental techniques to determine the intermediates in photochemical reactions.

Classification of photochemical reactions, Rate constants and life times of reactive energy state Effect of light intensity on the rate of photochemical reaction Photo-fragmentation of photo Dissociation-Gas phase photolysis.

UNIT-III

(15L)

Photosensitized reaction, photofragmentation in liquid phase, photodegradation of polymers, Isomerization and other rearrangement reactions, Atmospheric photochemistry.

Some current topics in photochemistry:

Semiconductors: Bonding and conductivity, mechanism of conductivity, energy bands in semiconductors, impurity semiconductors.

UNIT-IV

Photo voltaic effect **(15L)**

p-n junction solar cells, silicon cells, GaAs solar cells, schottky barrier solar cells.

Photo-electrochemistry: Introduction, efficiency of conversion of light to chemical and electrical energy, frequently measured quantities. Photo-splitting of water using colloidal suspensions Photocatalysis: Photocleavage of waste which are environmentally hazardous by using TiO_2, Photooxidation and photoreduction reactions.

SUGGESTED BOOKS

1. Fundamentals of photochemistry, K.K. Rohatgi Mukhergee, Wiley Eastern Limited (1986)
2. Photochemistry, Carol E Wayne and Richard P Wayne, Oxford University Press (1996)
3. Introduction to Semiconductor Materials and devices M S Tyagi, John Wiley and sons (1991)
4. Organic Photochemistry, J. M. Cozen and B. Halton, Cambridge University Press (Ist Edition) 1974
5. Molecular Reactions and Photochemistry, C H Deputy and D S Chapman, Prentice Hall India, New Delhi (1st Edition), 1972.

SUGGESTED REFERENCE BOOKS

1. Principles of Fluorescence Spectroscopy, 3rd Ed., J. R. Lakowicz, Springer, New York, 2006.
2. Fundamentals of Photoinduced Electron Transfer, G. J. Kavarnos, VCH publishers Inc., New York, 1993.
3. Molecular Fluorescence: Principles and Applications, B. Valeur, Wiley-VCH Verlag GmbH, Weinheim, 2002.
4. Modern Molecular Photochemistry of Organic Molecules, N. J. Turro, V. Ramamurthy, J. C. Scaiano, University Science, Books, CA, 2010.
5. Photochemical Synthesis, I. Ninomiya, T. Naito, Academic Press, New York, 1989.

Elective Basket 'C'

For DE

Course Details			
Course Title: Chemistry of Materials			
Course Code	**11004**	**Credits (L + T + P)**	**4(**3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

- To impart knowledge about the advanced materials and its characteristics
- To equip the students with skills in materials synthesis
- To make students aware of emerging materials and conducting polymers
- To acquaint the students with the salient features of nanomaterials
- To make students learn about the structure and properties of intercalation compounds, composites and amorphous materials

Learning Outcomes

After completion of the course the learners will be able to:

- Explain the relevance of advanced materials in daily life
- Distinguish between different type of materials based on structure and properties.

- Synthesize materials using different methods such as sol-gel, spray pyrolysis, combustion, hydrothermal, electrosynthesis etc.
- Analyze properties of different types of materials such as nanomaterials, intercalation compounds, perovskites etc.

UNIT-I

Classification of materials **(15L)**

Level of structures, Principles of self-assembly: surfactant solutions, importance of non-covalent forces, the hydrophobic effect, cooperativity, statistical mechanics of one-dimensional self-assembly.

Principles and parameters of solid-state synthesis, Fundamentals of sol-gel, precipitation, hydrolysis, combustion, microwave, carbothermal and mechano synthesis. Low temperature and gas phase synthesis techniques. Molten salt synthesis. Spray pyrolysis, chemical vapour deposition and sputtering techniques.

Intercalation and deintercalation. Intercalation reactions layered structure-graphite interlayer compounds (GILC), staging of graphite, TaS_2.

UNIT-II

Nanomaterials **(15L)**

Classification, synthesis, characterization and applications of nanoparticles, nano wires and nanotubes. Elemental nanoparticles: Pure, Gold, Silicon, Silver, Cobalt, Oxide nanoparticles: Silica, Zinc oxide, Iron oxide, Alumina. Stabilization of colloidal nanoparticles.

Semiconductor nanoparticles: Quantum confinement effects, size dependent optical properties; Magnetic nanoparticles: superparamagnetism, SPIONs, Giant magnetoresistance (GMR). Carbon based nanomaterials: carbon nanotubes, graphenes, and carbon dots. Nano Composites

UNIT-III

Fullerenes and fullerides **(10L)**

Structure, synthesis, functionalization approaches, conducting properties of fullerides and applications.

High-Tc Oxides-structure, perovskite A & B, structure and synthesis of La, Sr and Ba cuprates, applications.

Conducting polymers - PA, PPP, PPS, PPY-mechanism of conduction and applications.

Microporous materials – zeolites and zeolitic materials, $AlPO_4$-$GaPO_4$.

Fibres and Composites: Synthetic inorganic polymers- zirconia and other fibre Classification, microscopic composites, dispersion strengthened, particle reinforced, Fibre-glass reinforced composites, metal-matrix, plastic matrix composites, hybrid composites.

UNIT-IV

Amorphous Materials **(20L)**

Crystalline versus amorphous solids, glass formation, Preparation techniques melt spinning, sputtering, ion implantation, and Structural models of amorphous materials, Properties of met glasses-mechanical, electronic and magnetic properties.

Liquid Crystals*:* Mesomorphic behaviour, classification, examples - thermotropic and lyotropic liquid crystals Calamitic, nematic phase A, B, smectic phase, chiral nematic phase and optical Properties of liquid crystals.

Superconducting Materials: Transition Temperature, Meissner– Ochsenfeld Effect, Type I Superconductors, Type II Superconductors synthesis and structure of high temperature super conductors; Oxyhalides, oxycarbonates, boro carbides, cuprates materials and related preparation methods, making of films of superconductor.

3-D Printing of materials and devices: Fundamentals of 3D printing (additive manufacturing), Implications of 3D printing in chemicals and biological sciences, PDMS based microfluidic devices, 3D printing of Li-ion battery, hydrogels, bone replicate materials, calcium phosphate ceramics.

SUGGESTED BOOKS

1. Electrochemical Methods- Fundamentals and Applications, 2nd Edn, by A J Bard and L R Faulkner, John Wiley & Sons Inc., New York (2001).
2. Modern Electrochemistry, Vol.1, 2A and 2B by Bockris and Reddy, Plenum, N.Y (2000).
3. Magnetochemistry, R.L. Carlin, Springer Verlag.
4. Dana, M. Spence, Evaluation of 3D Printing and Its Potential Impact on Biotechnology and the Chemical Sciences, Analytical Chemistry, (ACS)
5. Nanostructured Materials: Processing, Properties and Applications, ed. C. C. Koch, Willaim Andrew Publishing, New York, 2002.
6. Nanomaterials: Synthesis, properties and applications, Ed. By A. S. Edelstein and R.C. Cammarata, Inst. of Physics, UK 1966.
7. Science of Engineering Materials, C.M. Srivastava and C. Srinivasan, Wiley-Eastern Ltd. (1991).
8. Solid State Chemistry and its Applications, A.R. West, John Wiley & Sons.(1989).
9. Material Science and Engineering. W.D. Callister, John Wiley and Sons Inc. (1985).
10. Nanotubes and Nano wires CNR Rao, & A Govindaraj, RSC, London 2005.
11. NANO: The essentials T. Pradeep, McGraw-Hill, 2008.
12. Liquid Crystals, Nature's delicate phase of matter, Peter J Collings, Princeton University Press, 2002.
13. Nanochemistry, A chemical approach to Nanomaterials, Geoffrey A Ozin and Andre C Arsenault, RSC, 2006.

Course Details			
Course Title: Advanced Medicinal Chemistry			
Course Code	**21404**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature		

	but also contributing to the final grades) 70% - End Term External Examination (University Examination)

Course Objective: Be familiar with several interdisciplinary areas of biochemistry, medicinal and pharmaceutical Chemistry, and understanding the concepts in relation to application towards drug developments. To provide an appreciation of the importance of medicinal chemistry aspects in the discovery of drugs.

UNIT-I

Modern drug discovery **(25L)**

Historical development of medicine, Drugs targets: Enzymes, Proteins, receptors, nucleic acids, lipids, and carbohydrates: detailed discussion on their Structures, and functions as drug targets.

Pharmacokinetics and Pharmacodynamics: Absorption, Distribution, Metabolism and Excretion. Illustration of drug development through specific examples. Understanding pharmacodynamics by taking enzymes, receptors and Nucleic acids as a drug targets.

Structure and activity Relationship (SAR): Detailed SAR studies of Oxamniquine, Penicillins, and Cephalosporin.

Drug optimization: Factors affecting bioactivity, resonance, inductive effect, isosterism, bioisosterism, spatial considerations. Theories of drug activity: occupancy theory, rate theory, induced fit theory. lead modification: computer-aided design of lead compound, combinatorial and parallel synthesis, concepts of prodrugs and soft drugs.

UNIT-II

Antibacterial **(20L)**

Antibacterial drugs acting on cell wall biosynthesis, Such as β-lactam antibiotics, Penicillin's and their derivatives synthesis and mode of actions. Resistance to pencillins. Improved antibiotic drugs: cephalosporins, clavam and pro antibiotics. Other antibiotic drugs such as Fluoroquinolones.

Antiviral agents: Introductions to viruses, influenza, HIV and coronaviruses: Synthesis and mode of actions of: Acyclovir, Oseltamivir, remdesivir and molnupiravir.

Central Nervous System agents: Phenobarbital, Diazepam synthesis and mode of action, Cardiovascular (Glyceryl trinitrate).

Analgesics: antipyretic analgesics, opiate analgesics, non-steroidal Anti-inflammatory Drugs, mechanism of action.

Antihistamines: mechanism of action

UNIT-III

(15L)

Cancer Biology and Anti-cancer organic drugs: Causes of cancer, Strategies for Treating Cancer, Epigenetics and cancer, cancer drug targets, Structural proteins as drug targets, inhibitors of signaling pathways, drugs acting on nucleic acids, Proteolysis Targeting Chimeras (PROTCS): Proteasome and Protein degradation, Bromodomain PROTACs,

SUGGESTED TEXT BOOKS

1. The Organic Chemistry of Drug Design and Drug Action, Third edition, Richard B. Silverman and Mark W. Holladay, Elsevier, Waltham, MA 02451, USA.
2. An Introduction to Medicinal Chemistry, Fifth Edition- Graham L. Patrick.

3. The Organic Chemistry of Drug Synthesis, Daniel Lednicer, John Wiley & Sons Inc.
4. Fundamentals of Medicinal Chemistry, Gareth Thomas, John Wiley & Sons Ltd.
5. Introduction to medicinal chemistry: How drug work, Grinauz Alex,Wiley VCH.
6. Modern Drug Synthesis_ by Jie Jack Li and Douglas S. Johnson, (Wiley Series on Drug Synthesis).
7. Strategies for Organic Drug Synthesis and Design by Daniel Lednicer, Wiley.
8. Burger's Medicinal Chemistry, Drug Discovery and Development, 7th Edition, Volume

References:

1. *J. Med. Chem.* 2017 Jun 8; 60(11): 4533–4558.
2. Design and characterization of bivalent BET inhibitors. Nat Chem Biol 12, 1089–1096 (2016)
3. Future Sci OA. 2019 Mar; 5(3): FSO372.
4. Matyskiela, M.E., Clayton, T., Zheng, X. et al. Crystal structure of the SALL4–pomalidomide–cereblon–DDB1 complex. Nat Struct Mol Biol 27, 319–322 (2020). https://doi.org/10.1038/s41594-020-0405-9.
5. Degradation of target protein in living cells by small-molecule proteolysis inducer." Bioorganic & medicinal chemistry letters 14.3 (**2004**): 645-648.
6. Winter, G. E., and Bradner, J. E. *et al.* Science **2015** *348*, 1376-1381. 7. *Nat. Chem. Biol.* **2017,** 13, 514.
7.

Course Details			
Course Title: Advanced Quantum Mechanics and Surface Chemistry			
Course Code	**31304**	**Credits(L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives

Students proficient in various methods such as Heitler-London method, HF-SCF-LCAO To acquaint students with advanced level concepts in quantum mechanics

- To make method etc.
- To make students aware of various advanced level concepts in surface chemistry such as Hertz-Knudsen equation, Langmuir-Rideal mechanism, Rideal-Eley mechanism etc.
- To make students learn methods to determine surface structure such as Harkins-Jura method, radioactive tracer method and Benton and White method
- To impart knowledge about instrumental techniques such as SEM, TEM. STM and AES for surface analysis

Learning Outcomes: After completion of the course the learners will be able to:

- Apply the concept and write quantum mechanical equations for simple molecules such as H_2, H_2^+ etc.
- Write expressions in terms of wave functions for hybrid orbitals, localized and delocalized molecular orbitals in polyatomic molecules
- Determine the rate and entropy of adsorption
- Determine the surface structure using different instrumental techniques.

UNIT-I

Quantum Chemistry-I: Theories of valence **(20L)**

Introductory aspects: Linear and non-linear variation functions. Secular equations. Coulombic, exchange, normalization and overlap integrals. Secular determinants. Molecularorbital (MO) theory, LCAO-MOapproximation, application to Hydrogen molecule ion (H_2^+), energylevels of H_2^+, bonding and antibonding molecular orbitals, electron distribution, potential energy diagrams, comparison of theoretical and experimental values of energy. Valence bond (VB) theory of H2 molecule, the Heitler-London method, energy levels, energy distribution. Various modifications of the Heitler-London wave function.

Comparison of MO and VB theories. Ionic terms, fractional ionic characters and its importance, Equivalence of simple MO and VB methods ion-covalent resonance and configuration interaction. LCAO treatment of diatomic molecules, LCAO forms of simple wave function and molecular orbitals. Notations of molecular orbitals: full notation, Mulliken notation. MO configuration of homo- and hetero- nuclear diatomic molecules. Molecular electric terms. Bondorder, stability and magnetic behaviour of molecules from M.O. diagrams, isoelectronic systems. Correlation diagrams, non-crossingrule

UNIT-II

Quantum Chemistry-II **(10L)**

The HF-SCF-LCAO method. Directed valence, hybridization, Expressions for hybrid orbitals in terms of wave functions of s and p orbitals and explanation of directed valences of sp, sp^2, and sp^3 hybrid orbitals. Hybridization involving d-orbitals, Localized and non-localized molecular orbitals in polyatomic molecules (H2O).

Huckel molecular orbital theory: Outline of themethod including assumptions. Application to ethylene, allyl rdical, cyclo-propenyl radical, butadiene, cyclobutadiene, bicyclo- butadiene and benzene. Calculation of delocalization energy, charge density, π-mobile bond order and free valence

UNIT-III

SURFACE CHEMISTRY-I **(20L)**

A. Review of adsorption curves, Adsorption-desorption, Adsorption forces, Heat of adsorption-Types, Measurements of heat of adsorption (Calorimetric and Clausius Clapeyron method), Measurement of adsorption isotherms, (Volumetric and Gravimetric methods), Determination of entropy of adsorption,
B. Electrostatic adsorption, adsorption indicators and their applications. Volcanic curves. Applications of adsorption.

C. Adsorption kinetics: Kinetics of chemisorption (Hertz-Knudsen equation), Chemisorptive bond, Competitive adsorption, Mechanism of some catalyzed surface reactions, Kinetic effects of surface heterogeneity, Kinetic effects of interactions, Potential energy curves for adsorption, Transition state theory of surface reactions, Rates of desorption, Kinetics of bimolecular surface reactions, Langmuir-Hinshelwood Mechanism, Langmuir- Rideal mechanism, Rideal-Eley mechanism and their comparison.

D. Adsorption theories: Polanyi's potential theory and Polarization theory. Hysteresis of adsorption.

UNIT-IV

SURFACE CHEMISTRY-II **(10L)**

Surface structure: Surface mobility, Surface heterogeneity, Surface and its determination by Point-B method, Harkins-Juramethod, radioactive tracer method and Bentonand White method. Importance of surface area. Examination of surfaces by Interferometer method, Scanning electron microscopy (SEM), Low energy electron diffraction method (LEED method), Field Emission spectroscopy, Auger electron spectroscopy (AES), STM, and TEM.

SUGGESTED TEXT BOOKS

1. Molecular Quantum mechanics, P.W. Atkins and R.S. Friedman, Oxford University press (1997).
2. Introductory Quantum Chemistry by A.K. Chandra, Tata McGraw Hill (1994).
3. Quantum Chemistry by R.K. Prasad, 3rd Edn, New Age International (2006).
4. Quantum Chemistry by Ira N.Levine, Prentice Hall, New Jersey (1991).
5. Quantum Chemistry by Donald A McQuarrie, Viva Books Pvt. Ltd. New Delhi, India, Published in arrangement with Unversity Science books, Sausalito, CA, USA (2003).
6. Physical chemistry of surfaces by A. W. Adamson, Interscience Publishers Inc., New York (1967).
7. Surface Chemistry: Theory and Applications by J.J Bikertman, Academic Press, New York (1972).
8. Chemical Kinetics by K.J Laidler, 3rd Edn., Harper International Edn., (1987).
9. Text Book of Physical Chemistry by S. Glasstone, McMillan India Ltd. 2ndEdn. (1986).
10. Physical chemistry, R J Silbey, R.A. Alberty and M G bawendiEdn, Willey (2009).
11. Physics at surfaces, A Zangwill, Cambridge University Press (1988).
12. Surface crystallography, LJ Clarke, Wiley-Interscience (1985).

Course Details			
Course Title: Applications of spectroscopy techniques to inorganic systems			
Course Code	**11104**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours

Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)

Course Objectives

- To enhance the understanding of vibrational spectroscopy and discuss some specific cases of ambidentate, multidentate ligands and multinuclear complexes
- To lay the foundations of Raman spectroscopy
- To acquaint the students with the core concepts of photoelectron spectroscopy and NMR spectroscopy and discuss its application in inorganic chemistry
- To highlight the efficacy of ESR (Electron Spin Resonance) spectroscopy in elucidating the structure and properties of inorganic complexes and free radicals.
- To acquaint the students with these less common techniques such as Mossbauer spectroscopy, NQR and X-ray absorption spectroscopy

Learning Outcomes: After completion of the course the learners will be able to:

- Analyze the FTIR spectra of mononuclear and multinuclear metal complexes with multidentate and ambidentate ligands
- Apply Raman spectroscopy to elucidate the structure and bonding of inorganic systems including the IR inactive ones
- Use NMR and photoelectron spectroscopy to explains structure and bonding in inorganic compounds
- Determine the structure and bonding in paramagnetic complexes and free radicals using ESR spectroscopy
- Apply Mossbauer spectroscopy technique to explain the magnetic properties of iron and tin-based compounds

UNIT-I

Vibrational spectroscopy (IR and Raman) (15L)

Vibrational spectra of diatomic, linear and bent triatomic, AB_3, AB_4, AB_5 and AB_6 molecules, spectra of metal complexes: Ammine, amido, Nitro, Nitrito, lattice water, aquo and hydroxo, carbonato, nitrato, sulphatoand other acido complexes, cyano and nitrile complexes, cyanato and thiocyanato complexes, mono and multinuclear carbonyl complexes, nitrosyls, phosphines and arsines, ambidentate ligands, ethylenediamine and diketonato complexes. Structural determination using Raman and IR spectroscopy, symmetry of metal- complexes and IR spectra. Understanding hydrogen bonding through IR and Raman spectroscopy.

UNIT-II

Photoelectron spectroscopy (15L)

Basic principles- photoelectric effect, Koopman's theorem, XPS and UPS, spin-orbit coupling in core level spectra, applications of core level spectra-ESCA, chemical shift, Valence level spectra-n, and bands, Auger electron spectroscopy and applications, Electron energy loss spectroscopy-basic principles and applications to the study of solids

Mass spectrometry: Basic principles and instrumentation, mass spectral fragmentation of inorganic compounds, applications to organometallic compounds. Effect of isotopes on the appearance of a mass spectrum, molecular weight determination, thermodynamic data.

UNIT-III

NMR spectroscopy of inorganic molecules (18L)

Proton NMR spectra of metal hydride complexes NMR spectra of nuclei other than hydrogen: ^{19}F, ^{31}P, ^{11}B NMR spectra of simple compounds, Proton / hydride interactions with ^{103}Rh, ^{183}W, ^{195}Pt and ^{207}Pb in metal complexes / organometallic compounds, Solid State NMR, Berry Pseudo rotation and NMR spectra, variable temperature NMR spectra.

Electron spin resonance spectroscopy: Basic principles, the position of ESR absorption, significance of 'g' factor, determination of 'g' factor. Electron- nucleus coupling (Hyperfine splitting). ESR spectrometer, electron- electron coupling, Interpretation of ESR spectra and structure elucidation of organic radicals using ESR spectroscopy. Spin density and Mc Connell relationship. Spin polarization for atoms and transition metal ions, spin-orbit coupling and significance of g-tensors, zero/non-zero fieldsplitting, Kramer's degeneracy, application to transition metal complexes (having one to five unpaired electrons) including biological molecules and inorganic free radicals such as PH_4, F_2 and BH_3.

UNIT-IV

Mossbauer spectroscopy (12L)

Basic principles, isomer shift, quadrupole splitting and magnetic hyperfine interactions, application to the study of bonding and structures of Fe^{2+} and Fe^{3+}compounds, Sn^{2+} and Sn^{4+} compounds.

NQR spectroscopy: NQR isotopes, electric field gradients, Nuclear Quadrupole coupling constants, Experimental techniques and applications

X-ray absorption spectroscopy: Near edge measurements and EXAFS.

SUGGESTED BOOKS

1. Physical methods in Inorganic Chemistry, R. S. Drago, Affiliated East West Press Pvt. Ltd., New Delhi (1965).
2. Infrared spectra of Inorganic and Coordination Compounds, K. Nakamoto, Wiley Interscience, New York (1970).
3. Vibrational Spectroscopy: Theory and Applications, D. N. Sathyanarayana, New Age International Publishers, New Delhi (2000).
4. Electronic Absorption Spectroscopy and Related Techniques, D.N. Sathyanarayana, Universities Press, Bangalore (2001).

Course Details			
Course Title: Spectroscopy and Chiroptical properties			
Course Code	**21504**	**Credits(L + T + P)**	4(3+1+0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours

Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)

Course Objective: To develop an understanding of the basic principles of spectroscopy and to learn to apply these principles for structural elucidation of simple organic compounds. To build up a knowledge about the basic principle of catalysis in organic reactions.

UNIT-I

UV spectroscopy (10L)

Introduction, absorption laws, instrumentation, formation of absorption bands, types of electronic transitions, chromophores, auxochromes, absorption and intensity shifts, solvent effects, Woodward-Fieser rules for calculating absorption maximum in dienes and α,β-unsaturated carbonyl compounds.

IR spectroscopy: Introduction, theory of molecular vibrations, vibrational frequency, factors influencing vibrational frequencies, finger print region and applications of IR spectroscopy.

UNIT-II

Structure elucidation by NMR spectroscopy (25L)

Introduction, Magnetic properties of Nuclei-Resonance condition, Nuclear spin, population of nuclear spin levels and NMR isotopes, Relaxation methods, Instrumentation; Classical approach.

Chemical shift, Factors influencing chemical shifts: electronegativity and electrostatic effects; Mechanism of shielding and deshielding in alkanes, alkyl halides, alkenes, aromatic compounds, carbonyl compounds and annulenes. Pascal striangle-low and high resolution, Reference compounds (internal and external reference compounds) Karplus Curve, Diamagnetic and Paramagnetic effects and Magnetic anisotropy. Equivalence of protons-chemical and magnetic equivalence; Spin systems: First order and second order coupling of AB systems, Simplification of complex spectra.

Spin-spin interactions: Homonuclear coupling interactions-AX, AX_2, AX_3, AMX, AB types. Vicinal, germinal and long-range coupling-spin decoupling; Chemical shift reagents and deuterium exchange; stereochemistry and hindered rotations. Temperature effects.

^{1}H-NMR spectrums of F and P containing organic molecules.

CIDNP, Nuclear Overhauser effect (NOE), Factors influencing coupling constants and Relative intensities.

Two- dimensional NMR spectroscopy, COSY, NOESY, HMBC, HMQC, DEPT and INEPT, DOESY terminologies.

^{13}C NMR Spectroscopy: Types of CMR spectra-undecoupled, proton decoupled, off-resonance decoupled (SFORD); Selectively decoupled and gated decoupled spectra.^{13}C-chemical shifts of alkanes, alkyl halides, alkenes, alkynes, alcohols, ethers, carbonyl compounds and aromatic compounds; Factors affecting the chemical shifts. Applications of ^{13}C-NMR spectroscopy in confirmation of structure and stereochemistry of organic molecules

and in determining the reaction mechanism and dynamic processes of organic reactions– example

Applications of NMR in organic chemistry as elucidation of the structure of unknown compounds.

UNIT-III

Mass Spectrometry (15L)

Introduction, ion production—EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, and ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, Molecular ion peak, Meta-stable peak, McLafferty rearrangement. Nitrogen Rule. High-resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination. Introduction to negative ion Mass spectrometry, TOF-MALDI. Problems based upon IR, UV, NMR and mass spectroscopy.

UNIT-IV

Molecular dissymmetry and chiroptical properties (10L)

Linear and circularly polarized lights, circular birefringence and circular dichroism, ORD and CD curves, Cotton effect. The axial halo ketone rule, octant diagrams, helicity, and Lowe's rule. Application of ORD and CD to structural and stereochemical problems.

SUGGESTED TEXT BOOKS

1. Kemp, W. Organic Spectroscopy 3rd Ed., W. H. Freeman & Co. (1991).
2. Silverstein, R. M., Bassler, G. C. & Morrill, T. C. *Spectroscopic Identification of Organic Compounds* John Wiley & Sons (1981).
3. NMR Spectroscopy, H. Gunther, 2nd ed.; John Wiley and Sons, 1995.
4. ORD and CD in Chemistry and Biochemistry, 1972, PIERRE CRABBÉ.

SUGGESTED REFERENCE BOOKS

1. Electron Paramagnetic Resonance of Transition Metal ions, A. Abragam, B. Bleaney, Oxford University Press, 1970.
2. Physical Methods for Chemist, R. S. Drago, Saunders, 1992.
3. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, 4th ed, McGraw-Hill, 1994.
4. Spectroscopic methods in organic chemistry, D. H. Williams, I. Fleming, Tata McGraw Hill. 1988.
5. Symmetry, Spectroscopy, and Crystallography: The Structural Nexus, Robert Glaser, Wiley, 2015.

Course Details			
Course Title: Lasers in Chemistry			
Course Code	**40304**	**Credits (L + T + P)**	4(3 + 1 + 0)
Nature of Course	Elective	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours

Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) 70% - End Term External Examination (University Examination)

Course Objectives

To acquaint the students with the fundamentals of lasers and its use in chemistry

- To make students aware of different types of laser sources such as, solid state lasers, He-Ne Lasers, Exciplex lasers etc,
- To make students learn how lasers are integrated and used in some well-known analytical techniques such as chromatography, polarimetry etc.
- To make students learn the application of lasers in driving photochemical reactions and in inducing therapeutic effects such as photodynamic and photothermal therapy
- To develop an understanding of laser-based spectroscopy techniques such as Laser Stark Spectroscopy, Absorption Spectroscopy, Laser Magnetic Resonance, Fluorescence Spectroscopy etc.

Learning Outcomes

After completion of the course the learners will be able to:

- Distinguish between coherent and non-coherent light sources
- Explain the basic concepts involved in making and working of lasers
- Discuss the salient features of various lasers such as semiconductor lasers, exciplex lasers, solid state, molecular gas lasers etc
- Explain how advent of lasers have enhanced the efficacy of various analytical techniques such as chromatography, polarimetry etc.
- Examine and evaluate the relevance of lasers in daily life such as its use in photochemical reactions and photodynamic/photothermal therapy
- Underscore the importance of laser-based spectroscopic techniques

UNIT-I

Operation of Laser **(10L)**

The Nature of Stimulated Emission, Resonators and Pumping Processes, Coherent Radiation, Standing Waves and Modes, The Kinetics of Laser Emission: Rate Equations, Threshold Conditions, Pulsed Versus Continuous Emission; Transitions, Lifetimes and Line widths: Three-level Laser, Four-level Laser, Emission Line widths; Properties of Laser Light, and Their Applications: Beam width, Coherence, Intensity, Monochromaticity.

UNIT-II

Laser Sources **(10L)**

Solid-state Transition Metal Ion Lasers: Ruby Laser, Neodymium Lasers; Semiconductor Lasers, Atomic and Ionic Gas Lasers: Helium-neon Laser, Argon Laser, Copper Vapour Laser; Molecular Gas Lasers: Carbon Dioxide Laser, Nitrogen Laser, Chemical Lasers, Iodine Laser, Exciplex Lasers; Dye Lasers, Free-electron Lasers

UNIT-III

Laser Instrumentation in Chemistry **(15L)**

Polarizing Optics, Frequency Conversion, Pulsing Techniques: Cavity Dumping, Q-Switching, Mode-locking; Detectors, Pulse Detection Systems: Lock-in Amplifiers, Boxcar Integrators, Single-pulse Systems; Light Scattering Instrumentation: Nephelometry, Photon Correlation Measurements, Brillouin Scattering, Doppler Velocimetry, Lidar; Polarimetry, Laser Detectors in Chromatography, Laser Microprobe Instrumentation

UNIT-IV

Laser-Induced Chemistry **(10L)**

Principles of Laser-induced Chemistry: Multiphoton Infra-red Excitation, Reaction Rates and Yields; Laser Photochemical Processes: Unimolecular Laser-induced Reactions, Bimolecular Laser-enhanced Reactions, Laser-sensitised Reactions, Laser Surface Chemistry, Ultrafast Reactions, Laser Reaction Diagnostics; Isotope Separation: Photo ionisation, Photo dissociation, Photochemical Reaction, Photo deflection; Miscellaneous Applications: Purification of Materials, Production of Ceramic Powders, Photodynamic and Photothermal therapy.

UNIT-V

Spectroscopy with Lasers **(15L)**

Absorption Spectroscopy, Specialised Absorption Techniques: Excitation Spectroscopy, Ionisation Spectroscopy, Thermal Lensing Spectroscopy, Photo acoustic Spectroscopy, Optogalvanic Spectroscopy, Laser Magnetic Resonance,

Laser Stark Spectroscopy; Fluorescence Spectroscopy: Laser-induced Atomic Fluorescence, Laser-induced Molecular Fluorescence; Raman Spectroscopy

SUGGESTED TEXT BOOKS

1. D. L. Andrews, Lasers in Chemistry, Springer, Heidelberg
2. S. Chopra, Lasers in Chemical and Biological Sciences, New Age International Publishers (1992).
3. H. H. Telle, A. G. Ureña, R. J. Donovan, Laser Chemistry: Spectroscopy, Dynamics and Applications, Wiley publications (2007)
4. M. Lackner, Lasers in Chemistry, Vol. I & Vol. II., Wiley VCH (2008).