VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF ADVANCED SCIENCES
DEPARTMENT OF CHEMISTRY

M.Sc Chemistry

(MSH)

Curriculum & Syllabi

(2020-2021 Admitted students)

VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- **World class Education**: Excellence in education, grounded in ethics and critical thinking, for improvement of life.
- **Cutting edge Research**: An innovation ecosystem to extend knowledge and solve critical problems.
- **Impactful People**: Happy, accountable, caring and effective workforce and students.
- **Rewarding Co-creations**: Active collaboration with national & international industries & universities for productivity and economic development.
- **Service to Society**: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF SCHOOL OF ADVANCED SCIENCES

To be an internationally renowned science school in research and innovation by imparting futuristic education relevant to the society.

MISSION STATEMENT OF SCHOOL OF ADVANCED SCIENCES

- To nurture students from India and abroad by providing quality education and training to become scientists, technologists, entrepreneurs and global leaders with ethical values for a sustainable future.

- To enrich knowledge through innovative research in niche areas.

- To ignite passion for science and provide solutions for national and global challenges.

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M.Sc Chemistry

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be practitioners and leaders in their chosen field.
2. Graduates will function in their profession with social awareness and responsibility.
3. Graduates will interact with their peers in other disciplines in their work place and society and contribute to the economic growth of the country.
4. Graduates will be successful in pursuing higher studies in their chosen field.
5. Graduates will pursue career paths in teaching or research.

M.Sc Chemistry

PROGRAMME OUTCOMES (POs)

PO_01: Having a clear understanding of the subject related concepts and of contemporary issues.

PO_02: Having problem solving ability to address social issues.

PO_03: Having a clear understanding of professional and ethical responsibility.

PO_04: Having cross cultural competency exhibited by working in teams.

PO_05: Having a good working knowledge of communicating in English.

M.Sc Chemistry

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M.Sc. Chemistry programme, graduates will be able to

PSO1: Apply advanced concepts of organic, analytical, physical and inorganic chemistry to solve complex problems to improve human life.

PSO2: Design experiments, analyze, synthesize and interpret data to provide solutions to different industrial problems by working in the pure, inter and multi-disciplinary areas of chemical sciences.

PSO3: Able to independently carry out research / investigation to solve practical problems and write / present a substantial technical report/document.

M.Sc Chemistry

CREDIT STRUCTURE

Category-wise Credit distribution

Category	Credits
University core (UC)	**29**
Programme core (PC)	**23**
Programme elective (PE)	**22**
University elective (UE)	**06**
Bridge course (BC)	**-**
Total credits	**80**

M.Sc. Chemistry

DETAILED CURRICULUM

University Core

S. No.	Course Code	Course Title	L	T	P	J	C
1.	MAT5001	Foundations of Mathematics	2	0	2	0	3
2.	RES5001	Research Methodology	2	0	0	0	2
3.	SET5001	Science, Engineering and Technology Project – I	0	0	0	0	2
4.	SET5002	Science, Engineering and Technology Project – II	0	0	0	0	2
5.	SET5003	Science, Engineering and Technology Project – III	0	0	0	0	2
6.	CHY6099	Master's Thesis	0	0	0	0	14
7.	ENG5003/ GER5001/ FRE5001	English for Science and Technology/Foreign Language	0	0	4	0	2
8.	STS4001	Soft Skills	3	0	0	0	1
9.	STS4002	Soft Skills	3	0	0	0	1
Total Credits							**29**

M.Sc. Chemistry

DETAILED CURRICULUM

Programme Core

S. No.	Course Code	Course Title	L	T	P	J	C
1.	CHY5001	Physical Chemistry	3	0	0	0	3
2.	CHY5002	Organic Chemistry	4	0	0	0	4
3.	CHY5003	Physical Chemistry Practical-I	0	0	4	0	2
4.	CHY5004	Organic Chemistry Practical-I	0	0	4	0	2
5.	CHY5005	Inorganic Chemistry	4	0	0	0	4
6.	CHY5006	Analytical Chemistry	3	0	0	4	4
7.	CHY5007	Inorganic Chemistry Practical-I	0	0	4	0	2
8.	CHY5008	Analytical Chemistry Practical-I	0	0	4	0	2
Total Credits							**23**

M.Sc. Chemistry

DETAILED CURRICULUM

Programme Elective (Total -22 Credits - Specialization-wise)

S. No.	Course Code	Course Title	L	T	P	J	C
1.	CHY6012	Advanced Organic Chemistry	3	0	0	4	4
2.	CHY6013	Chemistry of Heterocyclic Compounds	3	0	0	4	4
3.	CHY6014	Organic Synthesis and Methodologies	3	0	0	0	3
4.	CHY6015	Photochemistry and Pericyclic Reactions	4	0	0	0	4
5.	CHY6016	Organic Chemistry Practical II	0	0	4	0	2
6.	CHY6017	Organic Chemistry Practical III	0	0	4	0	2
7.	CHY6018	Electroanalytical and Separation Techniques	3	0	0	4	4
8.	CHY6019	Environmental and Industrial Analytical Chemistry	3	0	0	4	4
9.	CHY6020	Bioanalytical and Forensic Analysis	4	0	0	0	4
10.	CHY6021	Analytical Quality Assurance for Process Industry	3	0	0	0	3
11.	CHY6022	General Organic and Inorganic Chemistry Practical I	0	0	4	0	2
12.	CHY6023	Analytical Chemistry Practical III	0	0	4	0	2
13.	CHY6024	Advanced Inorganic Chemistry	3	0	0	4	4
14.	CHY6025	Materials Chemistry	3	0	0	0	3
15.	CHY6026	Nanomaterials and Characterization Techniques	3	0	0	4	4
16.	CHY6027	Inorganic Photochemistry	4	0	0	0	4
17.	CHY6028	Inorganic Chemistry Practical II	0	0	4	0	2
18.	CHY6029	Inorganic Chemistry Practical III	0	0	4	0	2
19.	CHY6030	Pharmaceutical Quality control and Quality Assurance	4	0	0	0	4
20.	CHY6031	Process Chemistry in Pharmaceutical Industry	3	0	0	4	4

21.	CHY6032	Pharmacognosy and Phytochemistry	3	0	0	4	4
22.	CHY6033	Medicinal Chemistry	3	0	0	0	3
23.	CHY6034	Medicinal Chemistry Practical	0	0	4	0	2
24.	CHY6035	Pharmacognosy and Phytochemistry Practical	0	0	4	0	2
25.	CHY6036	Advanced Physical Chemistry	4	0	0	0	4
26.	CHY6039	Analytical and Physical Chemistry Practical II	0	0	4	0	2
27.	CHY6040	Group Theory and Molecular Spectroscopy	3	0	0	0	3

University Elective Baskets (Total Credits-6)

S.No	Code	Title	L	T	P	J	C
1	CHY6001	NMR, EPR and Mass spectrometry	3	0	0	0	3
2	CHY6002	Bioorganic Chemistry	3	0	0	0	3
3	CHY6003	Chemistry of Natural Products	3	0	0	0	3
4	CHY6004	Green Chemistry	3	0	0	0	3
5	CHY6005	Polymer Chemistry	3	0	0	0	3
6	CHY6006	Intellectual Property Rights	3	0	0	0	3
7	CHY6007	Drug Design	3	0	0	0	3
8	CHY6008	Biophysical Chemistry	3	0	0	0	3
9	CHY6009	Organometallics and Industrial Applications	3	0	0	0	3
10	CHY6010	Nanomaterials	3	0	0	0	3
11	CHY6011	Computational Chemistry	3	0	0	0	3

University Core

Course code	Foundations of Mathematics	L	T	P	J	C
MAT5001		2	0	2	0	3
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives

1. Enhancing the basic understanding of the concepts of matrices, and trigonometry
2. Understanding of the subject related concepts of engineering and its applications.
3. Comprehending the context of a stated problem and describing the mathematical characteristics of a problem.
4. Demonstrating the computation-based strategies using numeric or symbolic processing.

Expected Course Outcome: student will be able to

1. Formulate and solve practical problems by matrices, solve a system of linear equations and apply it in application problems.
2. Describe the importance of Trigonometry, Complex numbers and its applications.
3. Application of derivatives as rates of change, max-min problems, integration techniques and its applications to areas and volumes.
4. Evaluationof LinearOrdinary Differential Equations.
5. Analyse the computational skills in Algebraic and Transcendental Equations and Solutions of a linear system.
6. demonstrate MATLAB programming for scientific problems

Module:1	Matrices	4 hours

Matrices - types of matrices - operations on matrices -determinants - Adjoint matrix- inverse of a matrix-solution of a system of linear equations by inversion method–elementary transformations–rank of a matrix-consistency and inconsistency of system of linear equations

Module:2	Trigonometry	4 hours

Review of complex numbers. De-Moiver's theorem and its applications. Expansion of Sin nθ , Cos nθ, in terms of sinθ and cosθ, Expansion of tan nθ in terms of tanθ . Expansion of sin nθ cos nθ in terms of sines and cosines of multiples of θ. Hyperbolic functions and inverse hyperbolic functions.

Module:3	Differential Calculus	5 hours

Differentiation offunctions of single variable – differentiation techniques- physical interpretations - differentiation of implicit functions – higher order derivatives – Taylor' s series -maxima and minima of functions of a single variable.

Module:4	Integral Calculus:	5 hours

Partial fractions – Integration-integration techniques - integration by parts – definite integrals – properties- evaluation of area and volume by integration.

Module:5	Linear Ordinary Differential Equations:	4 hours

Differential equations -definition and examples - format ion of differential equation- solving differential equations of first order - solving second order homogenous differential equations with constant coefficients.

Module:6	**Algebraic and Transcendental Equations**	**3 hours**
General iterative method- Secant method - Newton – Raphson method.		
Module:7	**Solutions of a linear system**	**4 hours**
Gaussian elimination- Inverse of a matrix by Gauss – Elimination, Gauss – Seidel methods-Solutions to system of linear equations.		
Module:8	**Expert Lecture**	**1 hour**
Matrices and its application to physical problems in science.		
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Engineering Mathematics, K.A. Stroud and Dexter J. Booth, 7th Edition, Palgrave Macmillan (2013)
2.	Introductory Methods of Numerical Analysis, S. S. Sastry, PHI Pvt. Ltd, 5th Edition, New Delhi (2015).
Reference Books	
1.	Elementary Engineering Mathematics, B.S. Grewal , 42nd edition, Khanna Publications (2012).
2.	Higher Engineering Mathematics, B.S. Grewal, 43rd edition, Khanna Publishers, (2015).
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Challenging Experiments (Indicative)		
1.	a) Introduction to MATLAB through matrices	3 hours
	b) Plotting and visualizing general functions, rates of change of functions/ tangent line.	3 hours
2.	Understanding integration as Area under the curve Solving Homogeneous differential equations	2 hours
3.	Solving non-homogeneous differential equations Evaluate integrals	2 hours
4.	Evaluating line integrals Numerical solution to algebraic equations	2 hours
5.	Application of the concepts to a minimum of 5 engineering problems from a common pool of problems	3 hours
	Total Laboratory Hours	15 hours

Mode of Evaluation: weekly Assignment/ FAT			
Recommended by Board of studies	25-02-2017		
Approved by Academic Council	44	**Date**	16-03-2017

Course Code	Research Methodology	L	T	P	J	C
RES5001		2	0	0	0	2
Pre-requisite		Syllabus version				
None		v. 1.0				

Course Objectives:

1. Impart skills to develop a research topic and design
2. Define a purpose statement, a research question or hypothesis and a research objective
3. Analyze the data and arrive at a valid conclusion
4. Compile and present research findings

Expected Course Outcome: student will be able to

1. Explain the basic aspects of research and its ethics
2. Outline research problems, their types and objectives
3. Formulate good research designs and carry out statistically relevant sampling
4. Collect, collate, analyze and interpret data systematically
5. Experiment with animals ethically
6. Make use of literature and other search engines judiciously for research purposes

Module:1	Introduction and Foundation of Research	2 hours

Meaning, Objectives, Motivation, Utility for research. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method –Understanding the language of research.

Module:2	Problem identification and formulation	4 hours

Scientific Research: Problem, Definition, Objectives, Types, Purposes and components of Research problem

Module:3	Research Design	4 hours

Concept and Importance in Research : Features of a good research design, Exploratory Research Design and Descriptive Research Designs

Module:4	Sampling	6 hours

Sampling methods, Merits and Demerits. Observation methods, Sampling Errors (Type I and Type II). Determining size of the sample. Experimental Design: Concept of Independent & Dependent variables.

Module:5	Data analysis and Reporting	6 hours

Fundamentals of Statistical Analysis and Inference, Multivariate methods, Concepts of Correlation and Regression; Research Reports: Structure, Components, Types and Layout of Research report and articles, Writing and interpreting research results, Figures and Graphs

Module:6	Animal handling	2 hours

Guidelines-animal ethical committee, animal models, various routes of drug administrations, LD_{50}, ED_{50}

Module:7	**Use of encyclopedias and tools in research**	**4 hours**
Research Guides, Handbook, Academic Databases for Biological Science Discipline. Methods to search required information effectively.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Catherine Dawson, Introduction to research methods : a practical guide for anyone undertaking a research project, Oxford : How To Books, Reprint 2010
2.	Julius S. Bendat, Allan G. Piersol, Random Data: Analysis and Measurement Procedures, 4th Edition, ISBN: 978-1-118-21082-6, 640 pages, September 2011
3.	Research in Medical and Biological Sciences, 1st Edition, From Planning and Preparation to Grant Application and Publication, Editos: Petter Laake Haakon Benestad Bjorn Olsen, ISBN: 9780128001547, Academic Press, March 2015
Reference Books	
1.	John Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, Fourth Edition (March 14, 2013)
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

Recommended by Board of Studies		03-08-2017	
Approved by Academic Council	No. 46	**Date**	24-08-2017

Course code	SCIENCE, ENGINEERING AND TECHNOLOGY PROJECT– I	L	T	P	J	C
SET 5001		0	0	0	0	2
Pre-requisite		Syllabus Version				
Anti-requisite		1.10				

Course Objectives:

- To provide opportunity to involve in research related to science / engineering
- To inculcate research culture
- To enhance the rational and innovative thinking capabilities

Expected Course Outcome:

On completion of this course, the student should be able to:

1. Identify a research problem and carry out literature survey
2. Analyse the research gap and formulate the problem
3. Interpret the data and synthesize research findings

Modalities / Requirements

1. Individual or group projects can be taken up
2. Involve in literature survey in the chosen field
3. Use Science/Engineering principles to solve identified issues
4. Adopt relevant and well-defined / innovative methodologies to fulfill the specified objective
5. Submission of scientific report in a specified format (after plagiarism check)

Student Assessment : Periodical reviews, oral/poster presentation

Recommended by Board of Studies		17-08-2017	
Approved by Academic Council	No. 47	**Date**	05-10-2017

Course code	SCIENCE, ENGINEERING AND TECHNOLOGY PROJECT– II	L	T	P	J	C
SET 5002						2
Pre-requisite		Syllabus Version				
Anti-requisite		1.10				

Course Objectives:

- To provide opportunity to involve in research related to science / engineering
- To inculcate research culture
- To enhance the rational and innovative thinking capabilities

Expected Course Outcome:

On completion of this course, the student should be able to:

1. Identify a research problem and carry out literature survey
2. Analyse the research gap and formulate the problem
3. Interpret the data and synthesize research findings

Modalities / Requirements

1. Individual or group projects can be taken up
2. Involve in literature survey in the chosen field
3. Use Science/Engineering principles to solve identified issues
4. Adopt relevant and well-defined / innovative methodologies to fulfill the specified objective
5. Submission of scientific report in a specified format (after plagiarism check)

Student Assessment : Periodical reviews, oral/poster presentation

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	**Date**	05-10-2017

Course code	SCIENCE, ENGINEERING AND TECHNOLOGY PROJECT– III	L	T	P	J	C
SET 5003						2
Pre-requisite		Syllabus Version				
Anti-requisite		1.10				

Course Objectives:

- To provide opportunity to involve in research related to science / engineering
- To inculcate research culture
- To enhance the rational and innovative thinking capabilities

Expected Course Outcome:

On completion of this course, the student should be able to:

1. Identify a research problem and carry out literature survey
2. Analyse the research gap and formulate the problem
3. Interpret the data and synthesize research findings

Modalities / Requirements

1. Individual or group projects can be taken up
2. Involve in literature survey in the chosen field
3. Use Science/Engineering principles to solve identified issues
4. Adopt relevant and well-defined / innovative methodologies to fulfill the specified objective
5. Submission of scientific report in a specified format (after plagiarism check)

Student Assessment : Periodical reviews, oral/poster presentation

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	**Date**	05-10-2017

Course Code	Masters Thesis	L	T	P	J	C
CHY6099		0	0	0	0	14
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

To provide sufficient hands-on learning experience related to the area of specialization with a focus on research orientation

Expected Course Outcome:

At the end of the course the student will be able to

1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints
2. Perform literature search and / or patent search in the area of interest
3. Develop a suitable solution methodology for the problem
4. Conduct experiments / Design & Analysis / solution iterations and document the results
5. Perform error analysis / benchmarking / costing
6. Synthesise the results and arrive at scientific conclusions / products / solution
7. Document the results in the form of technical report / presentation

Contents

1. Can be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, correlation and analysis of data, software development, applied research and any other related activities.
2. Project can be for one or two semesters based on the completion of required number of credits as per the academic regulations.
3. Should be individual work.
4. Carried out inside or outside the university, in any relevant industry or research institution.
5. Publications in the peer reviewed journals / International Conferences will be an added advantage

Mode of Evaluation: Periodic reviews, Presentation, Final oral viva, Poster submission

Recommended by Board of Studies		04.03.2016	
Approved by Academic Council	40th AC	**Date**	18.03.2016

Course code	English for Science and Technology (for MCA & M.Sc., programmes)	L	T	P	J	C
ENG5003		0	0	4	0	2
Pre-requisite	Cleared EPT	Syllabus version				
		v. 1.1				

Course Objectives:

1. To enable students communicate effectively in social, academic and professional contexts thereby enhancing their interpersonal, managerial, problem-solving, and presentation skills.
2. To facilitate students develop their listening competency and critically evaluate and review documentaries, talks and speeches.
3. To Assist students read and comprehend News Articles and Scientific Texts; effectively interpret tables and graphs; write and proof-read official correspondences.

Expected Course Outcome: student will be able to

1. Make effective presentations and display their interpersonal skills in academic and professional contexts.
2. Emerge as good listeners and critically evaluate oral communication.
3. Excel in reading, comprehending and interpreting technical reports, texts and data.
4. Able to write effectively in English and also display their proof-reading abilities.
5. Face real interviews and handle personal and professional conflicts effectively.

Module:1	Career Goals	4hours

Short term and long term career goals
Activity: SWOT Analysis/ Comprehending speeches

Module:2	Interpersonal Skills	4 hours

Interpersonal Communication in/with Groups (Corporate Etiquette: Journey from Campus to corporate)
Activity: Role Plays/Mime/Skit

Module:3	Listening Skills	4 hours

Listening to Documentary
Activity: Critically evaluate/Review a documentary/TED Talk

Module:4	Reading Skills	4hours

Skimming, Scanning, Intensive & Extensive reading
Activity: Reading News Papers/Magazines/Scientific Texts

Module:5	Report Writing	4hours

Language and mechanics of writing report
Activity: Writing a Report/Mini Project

Module:6	Study Skills	4hours

Summarizing the report
Activity: Abstract, Executive Summary, Digital Synopsis

Module:7	**Interpreting skills**	**4hours**
Interpret data in tables and graphs Activity: Transcoding		
Module:8	**Editing Skills**	**4hours**
Proof Reading Sequencing Activity: Editing any given text		
Module:9	**Presentation Skills**	**4 hours**
Oral Presentation using digital tools Activity: Oral presentation on the given topic using appropriate non-verbal cues		
Module:10	**Group Discussion**	**4 hours**
Intra group interaction (avoid, accommodate, compete, compromise, collaborate) Activity: Group discussion on a given topic		
Module:11	**Professional Skills**	**4 hours**
Résumé Writing Activity: Prepare an Electronic Résumé		
Module:12	**Skill-Gap Analysis**	**4 hours**
Tailor your skills to suit the Job needs Activity: Write a SoP for higher Studies/Purpose Statement for job		
Module:13	**Interview Skills**	**4 hours**
Placement/Job Interview Activity: Mock Interview		
Module:14	**Managerial Skills**	**4 hours**
Official Meeting to organize events Activity: Writing Agenda, Minutes of Meeting (video conferencing) and Organizing an event		
Module:15	**Problem Solving Skills**	**4 hours**
Conflict Management & Decision Making Activity: Case analysis of a challenging Scenario		
	Total Lecture hours	**60 hours**

Text Book(s)

1. Kuhnke, E.Communication Essentials For Dummies.(2015).First Edition. John Wiley & Sons.
2. Hewings, M. Advanced Grammar in Use Book with Answers and CD-ROM: A Self-Study Reference and Practice Book for Advanced Learners of English. (2013). Third Edition. Cambridge University Press. UK.

Reference Books	
1.	Churches, R. Effective Classroom Communication Pocketbook. Management Pocketbooks. (2015). First Edition. USA.
2.	Wallwork, A. English for Writing Research Papers. (2016). Second Edition. Springer.
3.	Wood, J. T. Communication in Our Lives. (2016). Cengage Learning. Boston. USA.
4.	Anderson, C. TED Talks: The Official TED Guide to Public Speaking. (2016). First Edition.Boston. Houghton Mifflin. New. York.
5.	Zinsser, William. On writing well. HarperCollins Publishers. 2016. Thirtieth Edition. New York.
6.	Tebeaux, Elizabeth, and Sam Dragga. The essentials of Technical Communication. 2015. First Edition Oxford University Press. USA.

Mode of Evaluation: Mini Project, Flipped Class Room, Lecture, PPT's, Role play, Assignments Class/Virtual Presentations, Report and beyond the classroom activities

List of Challenging Experiments (Indicative)		
1.	Setting short term and long term goals	2 hours
2.	Mime/Skit/ Activities through VIT Community Radio	6 hours
3.	Critically evaluate / review a documentary/ Activities through VIT Community Radio	4 hours
4.	Mini Project	10 hours
5.	Digital Synopsis	4 hours
6.	Case analysis of a challenging Scenario	4 hours
7.	Intensive & Extensive reading of Scientific Texts	4 hours
8.	Editing any given text	8 hours
9.	Group discussion on a given topic / Activities through VIT Community Radio	8 hours
10.	Prepare a video résumé along with your video introduction and then create a website (in Google Sites/Webly/Wix) showcasing skills and achievements.	10 hours
	Total Laboratory Hours	**60 hours**

Mode of evaluation: Mini Project, Flipped Class Room, Lecture, PPT's, Role play, Assignments Class/Virtual Presentations, Report and beyond the classroom activities

Recommended by Board of Studies	22-07-2017		
Approved by Academic Council	No. 47	**Date**	24.08.2017

Course code	Deutsch für Anfänger	L	T	P	J	C
GER5001		2	0	0	0	2
Pre-requisite		Syllabus version				
None		v.1				

Course Objectives:

The course gives students the necessary background to:

1. enable students to read and communicate in German in their day to day life
2. become industry-ready
3. make them understand the usage of grammar in the German Language.

Expected Course Outcome: Students will be able to

1. Create the basics of German language in their day to day life.
2. Understand the conjugation of different forms of regular/irregular verbs.
3. Understand the rule to identify the gender of the Nouns and apply articles appropriately.
4. Apply the German language skill in writing corresponding letters, E-Mails etc.
5. Create the talent of translating passages from English-German and vice versa and to frame simple dialogues based on given situations.

Module:1	3 hours

Einleitung, Begrüssungsformen, Landeskunde, Alphabet, Personalpronomen, Verb Konjugation, Zahlen (1-100), W-fragen, Aussagesätze, Nomen – Singular und Plural

Lernziel:

Elementares Verständnis von Deutsch, Genus- Artikelwörter

Module:2	3 hours

Konjugation der Verben (regelmässig /unregelmässig) die Monate, die Wochentage, Hobbys, Berufe, Jahreszeiten, Artikel, Zahlen (Hundert bis eine Million), Ja-/Nein- Frage, Imperativ mit Sie

Lernziel :

Sätze schreiben, über Hobbys erzählen, über Berufe sprechen usw.

Module:3	4 hours

Possessivpronomen, Negation, Kasus- AkkusatitvundDativ (bestimmter, unbestimmterArtikel), trennnbare verben, Modalverben, Adjektive, Uhrzeit, Präpositionen, Mahlzeiten, Lebensmittel, Getränke

Lernziel :

Sätze mit Modalverben, Verwendung von Artikel, über Länder und Sprachen sprechen, über eine Wohnung beschreiben.

Module:4	6 hours

Übersetzungen : (Deutsch – Englisch / Englisch – Deutsch)

Lernziel :

Grammatik – Wortschatz – Übung

Module:5	5 hours

Leseverständnis,Mindmap machen,Korrespondenz- Briefe, Postkarten, E-Mail **Lernziel :** Wortschatzbildung und aktiver Sprach gebrauch			
Module:6	.		**3 hours**
Aufsätze : Meine Universität, Das Essen, mein Freund oder meine Freundin, meine Familie, ein Fest in Deutschland usw			
Module:7			**4 hours**
Dialoge: e) Gespräche mit Familienmitgliedern, Am Bahnhof, f) Gespräche beim Einkaufen ; in einem Supermarkt ; in einer Buchhandlung ; g) in einem Hotel - an der Rezeption ;ein Termin beim Arzt. Treffen im Café			
Module:8			**2 hours**
Guest Lectures/Native Speakers / Feinheiten der deutschen Sprache, Basisinformation über die deutschsprachigen Länder			
	Total Lecture hours:	**30 hours**	

Text Book(s)	
1.	**Studio d A1 Deutsch als Fremdsprache, Hermann Funk, Christina Kuhn, Silke Demme : 2012**
Reference Books	
1	Netzwerk Deutsch als Fremdsprache A1, Stefanie Dengler, Paul Rusch, Helen Schmtiz, Tanja Sieber, 2013
2	Lagune ,Hartmut Aufderstrasse, Jutta Müller, Thomas Storz, 2012.
3	Deutsche SprachlehrefürAUsländer, Heinz Griesbach, Dora Schulz, 2011
4	ThemenAktuell 1, HartmurtAufderstrasse, Heiko Bock, MechthildGerdes, Jutta Müller und Helmut Müller, 2010
	www.goethe.de wirtschaftsdeutsch.de hueber.de, klett-sprachen.de www.deutschtraning.org
Mode of Evaluation: CAT / Assignment / Quiz / FAT	

Recommended by Board of Studies	04-03-2016		
Approved by Academic Council	No. 41	**Date**	17-06-2016

Course code	Francais Fonctionnel	L	T	P	J	C
FRE5001		2	0	0	0	2
Pre-requisite		Syllabus version				
Nil		v.1				

Course Objectives:

The course gives students the necessary background to:

1. demonstrate competence in reading, writing, and speaking basic French, including knowledge of vocabulary (related to profession, emotions, food, workplace, sports/hobbies, classroom and family).
2. achieve proficiency in French culture oriented view point.

Expected Course Outcome: Students will be able to

1. Remember the daily life communicative situations via personal pronouns, emphatic pronouns, salutations, negations, interrogations etc.
2. Create communicative skill effectively in French language via regular / irregular verbs.
3. Demonstrate comprehension of the spoken / written language in translating simple sentences.
4. Understand and demonstrate the comprehension of some particular new range of unseen written materials.
5. Demonstrate a clear understanding of the French culture through the language studied.

Module:1	Saluer, Se présenter, Etablir des contacts	3 hours

Les Salutations, Les nombres (1-100), Les jours de la semaine, Les mois de l'année, Les Pronoms Sujets, Les Pronoms Toniques, La conjugaison des verbes réguliers, La conjugaison des verbes irréguliers- avoir / être / aller / venir / faire etc.

Module:2	**Présenter quelqu'un, Chercher un(e) correspondant(e), Demander des nouvelles d'une personne.**	3 hours

La conjugaison des verbes Pronominaux, La Négation,L'interrogation avec 'Est-ce que ou sans Est- ce que'.

Module:3	**Situer un objet ou un lieu, Poser des questions**	4 hours

L'article (défini/ indéfini), Les prépositions (à/en/au/aux/sur/dans/avec etc.), L'article contracté, Les heures en français, La Nationalité du Pays, L'adjectif (La Couleur, l'adjectif possessif, l'adjectif démonstratif/ l'adjectif interrogatif (quel/quelles/quelle/quelles), L'accord des adjectifs avec le nom, L'interrogation avec Comment/ Combien / Où etc.,

Module:4	**Faire des achats, Comprendre un texte court, Demander et indiquer le chemin**	6 hours

La traduction simple :(français-anglais / anglais –français)

Module:5	**Trouver les questions, Répondre aux questions générales en français.**	5 hours

L'article Partitif, Mettez les phrases aux pluriels, Faites une phrase avec les mots donnés, Exprimez les phrases données au Masculin ou Féminin, Associez les phrases

Module:6	**Comment ecrire un passage**	**3 hours**
Décrivez : La Famille /La Maison, /L'université /Les Loisirs/ La Vie quotidienne etc.		
Module:7	**Comment ecrire un dialogue**	**4 hours**
Dialogue: a) Réserver un billet de train b) Entre deux amis qui se rencontrent au café c) Parmi les membres de la famille d) Entre le client et le medecin		
Module:8	**Invited Talk: Native speakers**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Echo-1, Méthode de français, J. Girardet, J. Pécheur, Publisher CLE International, Paris 2010.
2	Echo-1, Cahier d'exercices, J. Girardet, J. Pécheur, Publisher CLE International, Paris 2010.
Reference Books	
1.	CONNEXIONS 1, Méthode de français, Régine Mérieux, Yves Loiseau,Les Éditions Didier, 2004.
2	CONNEXIONS 1, Le cahier d'exercices, Régine Mérieux, Yves Loiseau, Les Éditions Didier, 2004.
3	ALTER EGO 1, Méthode de français, Annie Berthet, Catherine Hugo, Véronique M. Kizirian, Béatrix Sampsonis, Monique Waendendries , Hachette livre 2006.

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
Recommended by Board of Studies		26-2-2016	
Approved by Academic Council	No 41	**Date**	17-6-2016

Course code	Essentials of Business etiquettes	L	T	P	J	C
STS4001		3	0	0	0	1
Pre-requisite		Syllabus version				
		2				

Course Objectives:

- Having problem solving ability- solving social issues and engineering problems
- Having Computational thinking

Expected Course Outcome:

1. Enabling students to use relevant aptitude and appropriate language to express themselves
2. To communicate the message to the target audience clearly

Module:1	Business Etiquette: Social and Cultural Etiquette and Writing Company Blogs and Internal Communications and Planning and Writing press release and meeting notes	9 hours

Value, Manners, Customs, Language, Tradition, Building a blog, Developing brand message, FAQs', Assessing Competition, Open and objective Communication, Two way dialogue, Understanding the audience, Identifying, Gathering Information,. Analysis, Determining, Selecting plan, Progress check, Types of planning, Write a short, catchy headline, Get to the Point –summarize your subject in the first paragraph., Body – Make it relevant to your audience,

Module:2	Study skills – Time management skills	3 hours

Prioritization, Procrastination, Scheduling, Multitasking, Monitoring, Working under pressure and adhering to deadlines

Module:3	Presentation skills – Preparing presentation and Organizing materials and Maintaining and preparing visual aids and Dealing with questions	7 hours

10 Tips to prepare PowerPoint presentation, Outlining the content, Passing the Elevator Test, Blue sky thinking, Introduction , body and conclusion, Use of Font, Use of Color, Strategic presentation, Importance and types of visual aids, Animation to captivate your audience, Design of posters, Setting out the ground rules, Dealing with interruptions, Staying in control of the questions, Handling difficult questions

Module:4	Quantitative Ability -L1 – Number properties and Averages and Progressions and Percentages and Ratios	11 hours

Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position, Averages, Weighted Average, Arithmetic Progression, Geometric Progression, Harmonic Progression, Increase & Decrease or successive increase, Types of ratios and proportions		
Module:5	**Reasoning Ability-L1 – Analytical Reasoning**	**8 hours**
Data Arrangement(Linear and circular & Cross Variable Relationship), Blood Relations, Ordering/ranking/grouping, Puzzle test, Selection Decision table		
Module:6	**Verbal Ability-L1 – Vocabulary Building**	**7 hours**
Synonyms & Antonyms, One word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies		
	Total Lecture hours:	**45 hours**

Reference Books

1.	Kerry Patterson, Joseph Grenny, Ron McMillan, Al Switzler(2001) Crucial Conversations: Tools for Talking When Stakes are High. Bangalore. McGraw- Hill Contemporary
2.	Dale Carnegie,(1936) How to Win Friends and Influence People. New York. Gallery Books
3.	Scott Peck. M(1978) Road Less Travelled. New York City. M. Scott Peck.
4.	FACE(2016) Aptipedia Aptitude Encyclopedia. Delhi. Wiley publications
5.	ETHNUS(2013) Aptimithra. Bangalore. McGraw-Hill Education Pvt. Ltd.

Websites:

1.	www.chalkstreet.com
2.	www.skillsyouneed.com
3.	www.mindtools.com
4.	www.thebalance.com
5.	www.eguru.ooo

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays, 3 Assessments with Term End FAT (Computer Based Test)			
Recommended by Board of Studies			
Approved by Academic Council	No. 45th AC	Date	15/06/2017

Course code	Preparing for Industry	L	T	P	J	C
STS4002		3	0	0	0	1
Pre-requisite		Syllabus version				
None		2				

Course Objectives:

1. Having problem solving ability- solving social issues and engineering problems
2. Having a clear understanding of professional and ethical responsibility

Expected Course Outcome:

1. Enabling students to simplify, evaluate, analyze and use functions and expressions to simulate real situations to be industry ready.

Module:1	Interview skills – Types of interview and Techniques to face remote interviews and Mock Interview	3 hours

Structured and unstructured interview orientation, Closed questions and hypothetical questions, Interviewers' perspective, Questions to ask/not ask during an interview, Video interview, Recorded feedback, Phone interview preparation, Tips to customize preparation for personal interview, Practice rounds

Module:2	Resume skills – Resume Template and Use of power verbs and Types of resume and Customizing resume	2 hours

Structure of a standard resume, Content, color, font, Introduction to Power verbs and Write up, Quiz on types of resume, Frequent mistakes in customizing resume, Layout - Understanding different company's requirement, Digitizing career portfolio

Module:3	Emotional Intelligence - L1 – Transactional Analysis and Brain storming and Psychometric Analysis and Rebus Puzzles/Problem Solving	12 hours

Introduction, Contracting, ego states, Life positions, Individual Brainstorming, Group Brainstorming, Stepladder Technique, Brain writing, Crawford's Slip writing approach, Reverse brainstorming, Star bursting, Charlette procedure, Round robin brainstorming, Skill Test, Personality Test, More than one answer, Unique ways

Module:4	Quantitative Ability-L3 – Permutation- Combinations and Probability and Geometry and mensuration and Trigonometry and Logarithms and Functions and Quadratic Equations and Set Theory	14 hours

Counting, Grouping, Linear Arrangement, Circular Arrangements, Conditional Probability, Independent and Dependent Events, Properties of Polygon, 2D & 3D Figures, Area & Volumes, Heights and distances, Simple trigonometric functions, Introduction to logarithms, Basic rules of logarithms, Introduction to functions, Basic rules of functions, Understanding Quadratic Equations, Rules & probabilities of Quadratic Equations, Basic concepts of Venn Diagram

Module:5	**Reasoning ability-L3 – Logical reasoning and Data Analysis and Interpretation**	**7 hours**
Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic, Data Sufficiency, Data interpretation-Advanced, Interpretation tables, pie charts & bar chats		
Module:6	**Verbal Ability-L3 – Comprehension and Logic**	**7 hours**
Reading comprehension, Para Jumbles, Critical Reasoning (a) Premise and Conclusion, (b) Assumption & Inference, (c) Strengthening & Weakening an Argument		
	Total Lecture hours:	**45 hours**

Reference Books

1.	Michael Farra and JIST Editors(2011) Quick Resume & Cover Letter Book: Write and Use an Effective Resume in Just One Day. Saint Paul, Minnesota. Jist Works
2.	Daniel Flage Ph.D(2003) The Art of Questioning: An Introduction to Critical Thinking. London. Pearson
3.	David Allen(2002) Getting Things done : The Art of Stress -Free productivity. New York City. Penguin Books.
4.	FACE(2016) Aptipedia Aptitude Encyclopedia.Delhi. Wiley publications
5.	ETHNUS(2013) Aptimithra. Bangalore. McGraw-Hill Education Pvt. Ltd.

Websites:

1.	www.chalkstreet.com
2.	www.skillsyouneed.com
3.	www.mindtools.com
4.	www.thebalance.com
5.	www.eguru.ooo

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays, 3 Assessments with Term End FAT (Computer Based Test)

Recommended by Board of Studies			
Approved by Academic Council	No. 45th AC	**Date**	15/06/2017

Programme Core

Course code	Physical Chemistry	L	T	P	J	C
CHY5001		3	0	0	0	3
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

The course is aimed at

[1] Enriching the understanding of the significance of laws of thermodynamics and understand the calculationsof absolute entropy and fugacity.

[2] Appreciating the significance of the kinetics of complex reactions, theories of unimolecular gaseousreactions, homogeneous and heterogeneous catalysis and enzyme catalysis.

[3] Understand mathematical aspects of quantum chemistry and their applications.

[4] Recall Nernst equation and understand Debye-Huckel theory of electrolytic conductance, Kohlrausch's lawand understand the theory of conductometric and potentiometric titrations.

Course Outcomes:

At the end of the course the student should be able to

[1] Recall the knowledge about the concepts of a Carnot theorem for the heat engines. In addition, they shouldbe able to calculate the thermodynamic properties of ideal and real gases and also the absolute entropy of a system.

[2] Analyze kinetics of complex, unimolecular and chain reactions using different theories of reaction ratesapplying steady state approximation and evaluate the kinetics of homogeneous, heterogeneous and enzymecatalyzed reactions.

[3] Realize the requirements of quantum mechanics for chemical systems and Create a platform for solvingproblems in quantum chemistry.

[4] Understand the quantum mechanical aspects of particle in box, harmonic oscillator, rigid rotator and workout solutions for hydrogen like atoms

[5] Deduce Nernst equation and apply Debye-Huckel theory of electrolytic conductance, Kohlrausch's law andbe able to perform conductometric and potentiometric titrations

[6] Solve problems related to electronically excited state dynamics and derive equations and functionsrepresenting kinetic behavior of chemical systems in ground and electronically excited states.

[7] Recall the concepts on adsorption isotherms, kinetics of surface reactions and thermodynamics of surfaces.

[8] Explain the properties of surface active agents and their thermodynamics of micellazation.

Module:1	Classical Thermodynamics-I	5 hours

Review of laws of thermodynamics- Carnot cycle, Efficiency of heat engine, Entropy, entropy calculations –Free energy, criteria for spontaneity, Free energy as function of Temperature and Pressure. Chemical potential – Fugacity - Activity coefficient – Applications of free energy.3rd law of thermodynamics – Absolute entropy.

Module:2	Chemical Kinetics I	7 hours
Empirical Rate Laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants - Lindemann and Rice-Ramsperger- Kassel (RRK); unimolecular reactions; Kinetics of parallel – opposing reactions - chain reactions (hydrogen-halogen reactions). Catalysis-Homogeneous catalysis-heterogeneous catalysis-enzyme catalysis-Michaelis-Menton kinetics, salt effects – Inhibition effects - Autocatalysis.		
Module:3	**Quantum Chemistry I**	**6 hours**
Wave-particle dualism, Uncertainty principle. Operators for dynamic variables – Eigen values and Eigen functions; Postulatory basis of quantum mechanics; Schrödinger wave equation.		
Module:4	**Quantum Chemistry II**	**7 hours**
Particle in a box, one and three-dimensional, quantum numbers, zero point energy, orthogonalisation and normality, finite potential barrier – tunneling. The Rigid Rotator, One Dimensional Harmonic Oscillator, Solutions to hydrogen atom. Variation theorem – Time dependent wave function.		
Module:5	**Electrochemistry I**	**5 hours**
Nernst equation, redox systems, electrochemical cells; Debye-Huckel theory; electrolytic conductance – Kohlrausch's law and its applications; ionic equilibria; conductometric and potentiometric titrations		
Module:6	**Photophysical Chemistry I**	**7 hours**
Review of concepts and laws of photochemistry- Brief review of electronic transition, Frank-Condon principle, selection rules, construction of Jablonski diagram, electronic transitions and intensity of absorption bands; Excited state kinetics, quantum yield expressions, excimer and exciplex, kinetics of luminescence quenching: Phosphorescence, fluorescence quenching: concentration quenching, static and dynamic, deviation from Stern-Volmer kinetics.		
Module:7	**Surface Chemistry and Colloids**	**6 hours**
Surface tension, adsorption on solids, Thermodynamics of surfaces, Gibbs Adsorption Isotherm, Heat and Entropy of adsorption. Study of surfaces – Freundlich, Langmuir and BET adsorption isotherms - study of kinetics of surface reactions. Properties and stability of colloids, surface active agents, reverse micelles, critical micellar concentration (CMC), factors affecting CMC of surfactants, thermodynamics of micellazation, microemulsions.		
Module:8	**Contemporary issues**	**2 hours**
	Industry Expert Lecture	
	Total Lecture hours:	**45 hours**

Text Book(s)

1. P. W. Atkins and Julio de Paula, *Atkins' Physical Chemistry*, 2018, International 11th Edition, Oxford University Press, United Kingdom.
2. Ira N. Levine, *Quantum Chemistry*, 7th Edition, 2014, Pearson Prentice Hall, London.

Reference Books

1. K. J. Laidler, Chemical Kinetics, 1987, 3rd Edition, Harper & Row, New York.
2. R. J. Silbey, R. A. Alberty, and M. G. Bawendi, Physical Chemistry, 2015, 4th Edition, Wiley, India.
3. R. S. Berry, S. A. Rice and J Ross, Physical Chemistry, 2001, 3rd Edition, Wiley, New York.

	4. A.K. Chandra, Quantum Chemistry, 4th edition, McGraw Hill Education, 2017, India.		
Mode of evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies		24.06.2020	
Approved by Academic Council	No. 59	**Date:**	24.09.2020

Course code	Organic Chemistry	L	T	P	J	C
CHY 5002		4	0	0	0	4
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

The course is aimed at

[1] Understanding the basic concepts about how the organic reactions are carried out and also to make the students understand the mechanisms of different organic reactions including various stereochemical, mechanistic and conformational aspects

[2] Imparting knowledge in the theory and applications of various spectroscopic techniques which are very important characterization techniques for different fields of science.

Course Outcomes:

At the end of the course, the student should be able to

[1] Recall the fundamental principles of organic reactions.

[2] Understand the concepts related to nomenclature, isomerism and stereochemistry.

[3] Apply their understanding about the organic reactions of industrial significance with respect to the chemoselectivity, regioselectivity and enantioselectivity.

[4] Analyze the product distribution and the stereochemistry of various organic products.

[5] Evaluate the organic reactions based on the influence of the substituents on substrate molecules and nature of solvent and the NMR spectral analysis.

[6] Design new organic reactions in order to achieve the required product(s).

Module:1	Art of arrow pushing and reactive intermediates	10 hours

Flow of electrons – electron source (nucleophile) and electron sink (electrophile), bond making and bond breaking. Common mistakes in arrow pushing – Backward arrow, not enough arrow, hypervalency, mixed media error, conservation of charge, oxidation state and delocalization

General aspects, structure, stability and fate of the intermediates and chemical reactions involving classical and non-classical carbocations, carbanions, free radicals, carbenes, nitrenes and arynes.

Module:2	Introduction to Stereochemistry and conformational analysis	12 hours

Assigning *R* & *S* configuration at chiral centers – one & two chiral center, *meso* compounds. Illustrations of erythro and threo nomenclature.

Atropisomersm in Sp^2 and Sp^3 carbons with specific example. Racemic mixture, optical purity - enantiomeric excess, Cis-Trans geometrical isomerism and E, Z notations. Introduction to akamptisomerism. Conformational analysis of acylic, mon cyclic and bicylic system: simple 1,2 disubstituted ethane derivatives, cyclohexane, mono, di and tri-substituted cyclohexane, cis and trans decalins. S-cis and s-trans conformations in butadiene

Module:3	Substitution and elimination reactions	9 hours

Mechanism - Effect of substrate, nucleophile and solvents on - S_N1, S_N2, S_Ni, S_N1', S_N2', S_Ni' reactions with specific examples. Aromatic Nucleophilic Substitution - Vicarious mechanism – Nucleophilic substitution involving diazonium ions – Balz Schimann reaction-Von-Richter rearrangement.

Elimination reactions -1,2; 1,3, 1,4 and pyrolytic–eliminations- E1, E1cB, E2 mechanism, stereo-selectivity in E2 reaction, Saytzeff vs. Hoffmann elimination.

Module:4	Electrophilic and nucleophilic addition reaction to C-C double bond	6 hours

Syn and anti-additions. Reaction mechanisms in hydroboration, addition of alcohols, dienes, thiols, hydrogen cyanide, bisulphite anions and hydride ions. Conversion of alkenes to diols (Manganese, Osmium based), Prevost reaction and Woodward modification.		
Module 5	**Aromatic Electrophilic substitution**	**6 hours**
Electrophilic substitution in mono and disubstituted aromatic systems : Nitration, bromination and Friedel Craft reaction		
Module:6	**Addition to carbon-hetero atom multiple bond**	**6 hours**
Aldol and Knoevenagel reactions and its stereoselectivity (syn- & anti-), reactions of enamine, Mannich reaction, Perkin reaction, Addition of Grignard reagent, and Stobbe reactions, Claisen ester condensation, Benzoin condensation, Darzens glycidic ester condensation, Reformatsky reaction, McMurry coupling, Michael addition and Robinson annulation.		
Module:7	**Structural elucidation using spectroscopic techniques**	**9 hours**
Fundamental principles of the following spectroscopic techniques can be discussed: UV- Vis, IR, NMR and Mass spectrometer. Application of these spectroscopic techniques in problem solving for organic molecules.		
Module:8	**Contemporary issues**	
	Industry Expert Lecture	2 hours
	Total Lecture hours:	**60 hours**

Text Books

1. Ernest L.Eliel, Stereochemistry of carbon compounds, Tata McGrawhill Edition, 2001.
2. J. March and M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edition, Wiley, 2013.
3. Peter Sykes, A Guidebook to Mechanism in Organic Chemistry, 6th Edition, Pearson Education Ltd., England, 2013.

Reference Books

1. I. L. Finar, Organic Chemistry Vol. I & Vol. II, Longman (Cambridge), 2011.
2. W. Carruthares, Iain coldham, Modern Methods of Organic Synthesis South Asia Edition, Cambridge University Press, Fourth Edition, 2015.
3. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part B: Reaction and Synthesis, Springer, 5th Edition, 2010.
4. R. M. Silverstein, G. C. Bassler, T. C. Morril, Spectrometric identification of Organic Compounds, John Wiley & Sons, Inc, 2010.

Mode of Evaluation :Written Examinations, Quiz and Assignments

Recommended by Board of Studies	24-06-2020		
Approved by Academic Council	No. 59	**Date**	24-09-2020

Course code	Physical Chemistry Practical	L	T	P	J	C
CHY 5003		0	0	4	0	2
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

1. Impart training in operating different instruments used in the analysis of various chemical constituents.

Expected Course Outcome: student will be able to

1. Design experiments in Physical Chemistry and Analytical Chemistry using potentiometry, conductometry, fluorimetry, colorimetry, kinetics and chromatography
2. Apply concepts of Physical Chemistry and Analytical Chemistry through experimentation

Experiments		
1.	Estimation of Ferrous ion by Potentiometry	4 hours
2.	Construction of phase diagram of three component system	4 hours
3.	Conductometric titration of mixture of acids against a strong base	4 hours
4.	Adsorption of acetic acid on charcoal - Verification of Freundlich adsorption isotherm	4 hours
5.	Decomposition of Diacetone alcohol - Dilatometry method	4 hours
6.	Determination of specific rotation by polarimetry- Kinetics of inversion of sucrose in normal sugar and refined sugar samples	4 hours
7.	Evaluation of Arrhenius parameters : Activation Energy and Frequency Factor	4 hours
8.	Kinetics of oxidation of Iodide by Persulphate	4 hours
9.	Determination of solubility product by potentiometry – concentration cell Method	4 hours
10.	Determination of the distribution coefficient for iodine between different immiscible solvents	4 hours
	Total Laboratory Hours	**40 hours**

Mode of Evaluation: Continuous Assessment in lab, Viva-Voce & FAT

Recommended by Board of Studies	31.05.2019		
Approved by Academic Council	No. 55	**Date**	13.6.2019

Course code	Organic Chemistry Practical I	L	T	P	J	C
CHY5004		0	0	4	0	2
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

1. Impart training in synthesis of organic molecules and in analysis of chemical and instrumental methods.
2. Understand importance of different instrumental methods in chemical analysis of materials.

Expected Course Outcome: student will be able to

1. Recall the importance of the analysis of organic molecules.
2. Understand the qualitative analysis of mixtures, the functions of various reagents and reaction mechanisms.
3. Analyze the product distribution and the dependence of reaction conditions.
   Evaluate the properties of synthesized organic products and their derivatives through spectroscopic and analytical data.

Experiments

1.	Separation and qualitative Organic analysis of binary mixture I	4 hours
2.	Separation and qualitative Organic analysis of binary mixture II	4 hours
3.	Separation and qualitative Organic analysis of binary mixture III	4 hours
4.	Separation and qualitative Organic analysis of binary mixture IV	4 hours
5.	Separation and qualitative Organic analysis of binary mixture V	4 hours
6.	Training on Separation/purification techniques (TLC, column and distillation)	4 hours
7.	Training on Separation/purification techniques (recrystallization, extraction, Soxhlet extraction, etc.)	4 hours
8.	Synthesis, Characterization of Endo-cis-1,4- endoxo -2,3-dicarboxylic acid (IR , UV , GCMS, NMR)	4 hours
9.	Synthesis, Characterization of 3-Pyridyl-4(3H)quinazolone (IR, UV, GCMS, NMR)	4 hours
10.	Synthesis, Characterization of Flavone using Baker-Venkatraman Synthesis (IR, UV, GCMS, NMR)	4 hours
11.	Synthesis and Characterization of Anthracene-Maleic anhydride adduct (IR, UV, GCMS, NMR)	4 hours
	Total Laboratory Hours	**44 Hours**

Text/ Reference Books:

1. Vogel A. I. Practical Organic Chemistry, Longman Group Ltd.
2. Bansal R. K. Laboratory Manual of Organic Chemistry, Wiley-Eastern.
3. Ahluwalia V. K. and Aggarwal R. Comprehensive practical organic chemistry,University press.
4. Nad A. K.; Mahapatra B. and Ghoshal A. An advanced course in practical chemistry, New Central Book Agency (P) Ltd.
5. Techniques and Experiments for Organic Chemistry, by Addison Ault, University Science Book, 6th Edition.
6. Instrumental techniques for Analytical Chemistry by Frank Settle, Printice
7. G. Mann and B. C. Saunders: Practical Organic Chemistry
8. J. Leonard, B. Lygo and G. Proctor: Advanced Practical Organic Chemistry.
9. Addison Ault: Techniques and Experiments for Organic Chemistry, University Science Book
10. R. L. Shriner and D. Y. Curtin: The Systematic Identification of Organic Compounds

Mode of Evaluation: Continuous Assessment in lab, Viva-Voce & FAT			
Recommended by Board of Studies	31.05.2019		
Approved by Academic Council	No. 55	**Date**	13.6.2019

Course code	Inorganic Chemistry	L	T	P	J	C
CHY5005		4	0	0	0	4
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

The course is aimed at

[1] Understanding structure, bonding and reaction mechanism involved in inorganic solids and metal complexes.

[2] Applying practical aspects of inorganic chemistry in research and development.

Course Outcomes:

At the end of the course the student should be able to

[1] Compare the trends in the properties of main group elements and discuss the chemistry of Si, B, C- based compounds.

[2] Examine and apply the structural arrangement in metals, ionic, covalent compounds and inorganic solids

[3] Understand and differentiate different theories of coordination chemistry

[4] Explain the reaction mechanism of different metal complex reactions

[5] Discuss the concepts of organometallic and nuclear chemistry

[6] Justify the implication of nuclear chemistry in energy generation

Module:1	Chemistry of p-block elements	8 hours

Introduction-Periodic trends- Silicones, silicates, silanes, phosphazenes. Boranes: Synthesis, bonding and structure. Carboranes and borazines. Sulfur Nitride $(SN)_x$, Carbon Nitride $(CN)_x$, Boron Carbon Nitride $(BCN)_x$, HSAB Theory.

Module:2	Structure and bonding	8 hours

Close packing: Types of close packing in metals, packing in ionic crystals. Ionic solids: Pauling's rules for ionic crystals - ionic radii and covalent radii. Metal Clusters. Metallic bonding and Hydrogen bonding.

Module:3	Inorganic solids	6 hours

Ionic solids - NaCl, CsCl, TiO_2, CaF_2 and ZnS – 3D structure -polyhedral approach**.** Defects in Crystal: Frenkel, Schottky and other defects.

Covalently bonded compounds - CdI_2, NiAs, MoS_2.

Module:4	Coordination chemistry-I	12 hours

Introduction-CFT: splitting of d orbitals under various geometries, factors affecting splitting-spectrochemical series – Jahn-Teller distortion - application to spinels - limitations of CFT.

Ligand Field Theory and MO theory: types of complexes - sigma - pi bonding of complexes, back bonding (carbonyls) - Nephelauxetic effects.

Module:5	Coordination chemistry-II	8 hours

Reaction mechanisms: Labile and inert complexes - ligand displacement reactions in octahedral and square planar complexes. Trans effect: theory and applications. Electron transfer reactions: Inner sphere and outer sphere process.

Module:6	**Organometallic Chemistry**		**8 hours**
Types of ligands in organometallic compounds - eighteen Electron rule, alkyl compounds, metal carbonyls, isolobal concepts. Metallocenes: Ferrocene.			
Module:7	**Nuclear chemistry**		**8 hours**
Stability of nuclides, Nuclear energy, isotope separation (specific to U), Types of decay, radioactive equilibrium, different types of nuclear reactions, q value and nuclear reaction cross section, neutron activation analysis			
Module:8	**Contemporary issues**		
	Industry Expert Lecture		**2 hours**
	Total Lecture hours:		**60 hours**
Text Book(s)			
1. D.F. Shriver and P.W. Atkins, Inorganic Chemistry, Oxford University Press, 5th Edition, 2010. 2. J. D. Lee, Concise Inorganic Chemistry, Oxford University Press, 5th Edition, 2014. 3. F.A. Cotton and G. Wilkinson Advanced inorganic Chemistry, John Wiley & Sons, 6th Edition, 1999.			
Reference Books			
1. J.E. Huheey, E.A. Kelter and R.L. Kelter, Principles of structure and reactivity, Inorganic Chemistry, Harper Collins College Publishers, 4th Edition, 2011. 2. C.N.R. Rao, Muller and A. K. Cheetham, Chemistry of Nanomaterials, Vol. I & II, Wiley VCH Verlag GmbH KGaA, 2014. 3. Lesley E. Smart, Elaine A. Moore, Solid State Chemistry: An Introduction, CRC Press, 4th Edition, 2012. 4. Walter D. Loveland, David J. Morrissey, Glenn T. Seaborg, Modern Nuclear Chemistry, Wiley-Interscience, 1st edition, 2001.			
Mode of Evaluation : Written Examinations, Quiz and Assignments			
Recommended by Board of Studies	24-06-2020		
Approved by Academic Council	**No. 59**	**Date**	24-09-2020

Course code	Analytical Chemistry	L	T	P	J	C
CHY5006		3	0	0	4	4
Pre-requisite		Syllabus Version				
None		1.1				

Course Objectives:

The course is aimed at

[1] Making students understand the insights of statistical methods in qualitative and quantitative analysis and usage of different analytical instruments for chemical analysis.

[2] Learning the importance of thermal analysis as well as absorption and emission spectroscopic analysis.

[3] Understand the principles and applications of surface analytical techniques.

[3] Learn the principles and usage of Electroanalytical techniques.

[4] Get insight into basics of different chromatographic techniques.

Course Outcomes:

At the end of the course, the student should be able to

[1] Analyze different errors using statistical methods in Chemical analysis.

[2] Evaluate errors in chemical analysis through statistical treatment of data through F-test, T-test and Q-test.

[3] Analyze thermal behavior of different organic and inorganic materials using TGA, DTA and DSC

[4] Apply absorption and emission techniques for trace element analysis from different matrices.

[5] Visualize characteristics of nanomaterials using different diffraction and microscopic techniques.

[6] Analyze electroactive species using different voltammetric techniques.

[7] Adopt TLC and Paper chromatographic techniques for monitoring and detection of important organic and inorganic materials.

[8] Identify and Separate different fragment from organic compounds using GC and HPLC techniques.

Module:1	Errors and Statistical treatment	8 hours

Errors in chemical analysis. Classification of errors- systematic and random, additive and proportional, absolute and relative. Accuracy and precision. Mean, median, average deviation and standard deviation. Significant figures and rules to determine significant figures. Calculations involving significant figures. Confidence limit, correlation coefficient and regression analysis. Comparison of methods: F-test and T-test. Rejection of data based on Q-test. Least squares method for deriving calibration graph. Fitting of data to hypothesis.

Module:2	Thermoanalytical methods	6 hours

Types – Thermogravimetric Analysis (TGA) – Factors influencing TGA – Instrumentation of TGA - Applications of TGA for analysis of inorganic compounds and polymers.

Differential thermal analysis (DTA) – Theory - instrumentation and applications in food and pharmaceutical industry.

Differential Scanning Calorimetry (DSC) –Theory – instrumentation and applications in polymer and pharmaceutical industries.

Module:3	Atomic Absorption, Flame Emission and Inductively coupled plasma Analysis	5 hours

Atomic Absorption spectroscopy and Flame Emission Spectroscopy - Basic principles– Instrumentation – analytical applications. ICP-MS/OES - Basic principles- sources of radiation – instrumentation – analytical applications.		
Module:4	**Material Characterization Techniques**	**6 hours**
XRD, SEM, TEM, EDAX, AFM - Basic Principles, instrumentation and their utility in characterization of nanomaterials		
Module:5	**Electroanalytical Techniques**	**6 hours**
Polarography - Introduction, Dropping mercury electrode (DME), Instrumentation, Ilkovic equation and its verification, Determination of half wave potential, applications. Voltammetry –A three electrode system concept – diffusion-controlled and adsorption-controlled electron-transfer reactions; Single sweep voltammetry, cyclic voltammetry – Randles-Sevcik equation, Criteria for reversible and irreversible processes - applications.		
Module:6	**Basics of TLC and Paper Chromatography**	**6 hours**
Thin-layer chromatography (TLC): Principle, methodology selection of stationary and mobile phases-preparation of plates, spotting, development, identification and detection, measurement of RF values, Qualitative and quantitative applications. **Paper chromatography (PC): T**heory and principle; techniques: one, two-dimensional and circular PC, mechanism of separation, structure of cellulose and types of paper, methodology, sample preparation, choice of solvents, location of spots and measurement of RF value, factors affecting RF values, advantages and applications		
Module 7	**Introduction to HPLC and GC**	**6 hours**
Gas chromatography (GC): Principle, instrumentation columns - packed and tubular, factors affecting separation, applications. **High pressure liquid chromatography (HPLC)*:*** Apparatus, pumps, column packing, detectors-UV, IR and fluorescence detectors, advantages and applications.		
Module:8	**Contemporary issues**	**2 hours**
	Industry Expert Lecture	
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Gary D. Christian, Purnendu (Sandy) Dasgupta, Kevin Schug, Analytical Chemistry, Wiley & sons, 7th Edition, 2013.
2. Douglas A Skoog, Donald M West, F James Holler, Stanley R.Crouch, Fundamentals of Analytical Chemistry, Wadsworth Publishing Co Inc., 9th Edition, 2014.
3. H.A. Willard, L.L.Merrit, J.A. Dean, Von Nostrand, Instrumental Methods of Analysis, 7th Edition, CBS Publishers, 1986.

Reference Books

1. S.M. Khopkar, Analytical Chemistry: Problems and Solutions, New Age International Pvt. Ltd., 2nd Edition, 2010.

2. J. Basset, R.C. Denny, C.H. Jaffery and J. Mendhan, Vogel's Text Book of Quantitative Chemical Analysis, ELBS, Longman Group Publishers, 6h Edition, 2009.			
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	Yes, 24-06-2020		
Approved by Academic Council	No.59	**Date**	24-09-2020

Course code	Inorganic Chemistry Practical I	L	T	P	J	C
CHY5007		0	0	4	0	2
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. Apply the concepts of qualitative and quantitative analyses of inorganic samples and acquire the skill of synthesis and characterization of nanomaterials

Expected Course Outcome: student will be able to

1. Understand and apply the principle of analysis of salt mixture
2. Estimate the metal content in alloy specimens
3. Develop the skill of nanomaterial synthesis
4. Design a methodology for real time sample analysis

	Experiments	
1.	**Qualitative analysis of inorganic cations** Semi-micro qualitative analysis of a mixture of salts containing two common cations (Pb, Bi, Ca, Cd, Fe, Cr, Al, Co, Ni, Mn, Zn, Ba, Sr, Mg) and less common cations (W, Se, Mo, Ce, Th, Zr, V, Li): simple salt mixtures	28 hours
2.	**Quantitative Analysis of Inorganic Materials** 1. Determination of copper and nickel in an alloy 2. Simultaneous spectrometric determination of chromium and manganese in an alloy steel	4 hours 4 hours
3.	**Synthesis and Characterization of** 1. Prussian blue 2. Silver nanoparticles	4 hours 4 hours
4.	**Challenging Experiment** Synthesize a chalcogenide or oxide based phosphor material used in displays. (i) Confirm the composition by appropriate techniques (ii) Prove the phosphorescence of the material.	4 hours
	Total Laboratory Hours	**48 hours**

Mode of Evaluation: Continuous Assessment in lab, Viva-Voce & FAT

Recommended by Board of Studies	31-05-2019		
Approved by Academic Council	No. 55	**Date**	13-06-2019

Course Code	Analytical Chemistry Practical I	L	T	P	J	C
CHY5008		0	0	4	0	2
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

1. Impart training in operating different instruments used in the analysis of various chemical constituents.

Expected Course Outcome: Student will be able to

1. Design chromatographic and titrimetric methods for identification of species
2. Analyze different constituents through instrumental methods of analysis
3. Evaluate different contaminants in materials using turbidimetry and conductivity measurements

Experiments		
1.	Separation of (a) mixture of Azo dyes by TLC (b) mixture of metal ions by Paper chromatography	4 hours
2.	Determination of concentrations of Potassium and calcium in real samples using Flame Photometry	4 hours
3.	Estimation of chlorophyll in leaves by colorimetry	4 hours
4.	Determination of chloride by precipitation titration using conductometry	4 hours
5.	Determination of quinine and riboflavin by Fluorimetry and comparison of quantum efficiencies	4 hours
6.	Estimation of Fe(II) by 1,10 phenonthroline using spectrophotometry CO-01	4 hours
7.	Determination of Sulphate Ion by Turbidimetry	4 hours
8.	Estimation of phosphate in waste water using colorimetry.	4 hours
9.	Extraction and iodometric estimation of copper in different alloys	4 hours
10.	Determination of stoichiometry of metal complexes using spectrophotometry (Job's method)	4 hours
	Total Laboratory Hours	**40 hours**

Mode of Evaluation: Continuous Assessment in lab, Viva-Voce & FAT

Recommended by Board of Studies	31.05.2019		
Approved by Academic Council	No. 55	**Date**	13.6.2019

Programme Elective

Course code	Advanced Organic Chemistry	L	T	P	J	C
CHY6012		3	0	0	4	4
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

The course is aimed at:

[1] Understanding basic concepts about synthesis and reaction mechanisms of various organic reactions with respect to their the configuration, asymmetry and various stereo-chemical, mechanistic and conformational aspects

[2] Imparting knowledge in the theory and applications of various spectroscopic techniques which are very important characterization techniques for different fields of science

Course Outcomes:

At the end of the course, students should be able to

[1] Recall the fundamental principles of organic reactions.

[2] Understand the concepts related to synthesis, mechanisms and the functions of various reagents or catalysts.

[3] Apply their understanding about the organic reactions of industrial significance.

[4] Analyze the product distribution and the stereochemistry of various organic products through spectroscopic data.

[5] Evaluate the organic reactions based on the influence of the substituents on substrate molecules and nature of solvent and the parametric conditions.

[6] Design new organic reactions in order to achieve the required product(s).

Module:1	Classical to modern oxidation methods	7 hours

Oxidation of alcohols - Chromium, Manganese, Aluminum, Silver, Ruthenium. Swern, Dess-Martin periodinane and TEMPO based reagents, N-hydroxypthalimide reagent

Alkene to epoxides - Sharpless, Jacobsen and Shi epoxidation (chiral). Ketones to ester and lactones.

Module:2	Oxidative cleavage and addition	6 hours

Oxidative cleavage of alkenes - Manganese, Osmium, Ruthenium, Lead, Ozone

Oxidative addition of alkenes - hydroboration, Wacker oxidation, Selenium, Chromium based allylic oxidation

Module: 3	Reduction by metals	8 hours

Heterogeneous - Palladium/Platinum/Rhodium/Nickel

Homogeneous: Wilkinson; Noyori asymmetric hydrogenation.

Reduction by alkali metals – Li / Na in liquid ammonia – Birch reduction

Reduction by transition metals : Zinc and Titanium reagents, SmI_2 (Acyloin formation, dehalogenation and deoxygenations)

Reduction by metal catalyst - Meerwein-Pondorff-Verley reduction

Enantioselective reductions - Chiral Boranes, Corey-Bakshi-Shibata reduction

Module:4	Reduction by metal hydrides	6 hours

Reduction by metal hydrides - $NaBH_4$, triacetoxyborohydride, $LiAlH_4$, L-selectride, K-selectride, Luche reduction; DIBAL-H, and Red-Al, Trialkylsilanes and Trialkylstannane,

Module:5	Rearrangement reactions	5 hours

Carbocation - Pinacol-pinacalone, Wagner Meerwin, Demjanov Carbanion – Favorskii (5-9 membered ring systems), Stevens, Neber Carbene – Wolff rearrangement; Nitrene - Hoffman, Curtius, Schmidt. N-Heterocyclic Carbenesin Metal Catalysis and organo catalysis.		
Module:6	**Carbohydrates and peptides in organic synthesis**	**8 hours**
Reactivity at carbon center - reactions at anomeric carbon and epimeric carbons, ring expansions and contractions. Protection and deprotection methods in carbohydrate. Chemical and enzymatic glycosylations to oligosaccharides - Modification of sugars into carbocycles and heterocycles and their applications in medicinal chemistry (one example each). Peptides: Synthesis of peptides, protection and deprotection methods in peptide synthesis.		
Module:7	**Modern Synthetic Methods**	**4 hours**
Baylis-Hillman reaction, Henry reaction, Sakurai reaction, Tishchenko reaction and Ugi reaction. Tebbe olefination. Metal mediated C-C and C-X coupling reactions: Heck, Suzuki, Negishi		
Module:8	**Contemporary issues:**	
	Industry Expert Lecture	2 hours
	Total Lecture hours:	**45 hours**

Text Book(s)

1. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part B: Reaction and Synthesis, Springer, 5th Edition, 2010.
2. J. March and M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edition, Wiley, 2013.
3. L. Kuerti and B. Czako, Strategic Applications of named Reactions in Organic Synthesis, Elsevier Academic Press, 2005.

Reference Books

1. I. L. Finar, Organic Chemistry Vol. I & Vol. II, Longman (Cambridge), 2011.
2. W. Carruthares, Iain coldham, Modern Methods of Organic Synthesis South Asia Edition, Cambridge University Press, Fourth Edition, 2015.
3. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part B: Reaction and Synthesis, Springer, 5th Edition, 2010.
4. R.M. Silverstein, G. C. Bassler, T. C. Morril, Spectrometric identification of Organic Compounds, John Wiley & Sons, Inc, 2010.
5. a) Nolan, S. P. N-Heterocyclic Carbenes in Synthesis; Wiley-VCH; Weinheim, 2006, pp 1-304 (b) Glorius, F. N-Heterocyclic Carbenes in Transition Metal Catalysis; Topics in Organometallic Chemistry; Springer-Verlag: Berlin Heidelberg, 2006, Vol. 21, pp 1-218
N-Heterocyclic Carbene Complexes in C–H Activation Reactions. Qun Zhao, Guangrong Meng, Steven P. Nolan, and Michal Szostak. Chemical Reviews 2020 120 (4), 1981-2048
DOI: 10.1021/acs.chemrev.9b00634

Mode of Evaluation : Written Examinations, Quiz and Assignments

Recommended by Board of Studies	24.06.2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course code	Chemistry of Heterocyclic Compounds	L	T	P	J	C
CHY6013		3	0	0	4	4
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

The course is aimed at

[1] Imparting knowledge in the theory and applications of various heterocyclic compounds and their physical and chemical behavior in order to synthesize them, this can be further put to medicinal use.

[2] Learning and understanding the principles behind physical and chemical nature of heterocyclic compounds and their reaction mechanisms

Expected Course Outcomes:

At the end of the course, students should be able to

[1] Recall the significance of fundamental aspects of heterocyclic compounds.

[2] Understand the concepts related to the nomenclature, structural aspects, synthesis, reaction mechanisms and the functions of various reagents or catalysts.

[3] Apply their understanding about the organic and heterocyclic reactions of industrial significance.

[4] Analyze the product distribution and the stereochemistry of various heterocyclic products through spectroscopic data.

[5] Evaluate the heterocyclic reactions based on the influence of the substituents on substrate molecules and nature of solvent and the parametric conditions.

[6] Create new heterocyclic reactions in order to achieve the required product(s).

Module:1	**Systematic nomenclature of heterocycles**	**3 hours**

Hantzsch-Widman system for monocyclic, fused and bridged heterocycles

Module:2	**Aliphatic and carbocylic aromatic heterocyclic compounds**	**8 hours**

Carbocyclic aromatic system-six members and fused, tautomerism in heterocycles-spectroscopic properties of heterocyclic systems (any two)

Three-membered and four-membered heterocycles-synthesis and reactions of aziridines, oxiranes, oxetanes, thietanes. Corey-Chaykovsky epoxidation. Darzen, Aza Darzen condensation, De Kimpe - thiranes, azetidines

Module:3	**Five membered Heterocyles**	**5 hours**

Synthesis and reactions of Furans: Fiest Benary furan synthesis, Knorr and Paal-Knorr pyrrole synthesis, Pyrroles and pyrrolidines-Barton. Zard reaction. Hofmann-Loffler-Freytag reaction. Thiophenes-Hinsberg synthesis of thiophene derivatives. Oxazoles and isoxazoles- Robinson-Gabrial ring closure. Cornforth rearrangement. Larock synthesis.

Module:4	**Six and Large Membered Heterocycles**	**8 hours**

Pyridines- Hantzsch (Dihydro)-pyridine synthesis, Doebner von Miller reaction, pyrimidines-Biginelli reaction, Chichibabin (Tschitschibabin) pyridine synthesis. Synthesis and reactions of

azepines, oxepines, thiepines, diazepines (1,2 and 1,4), thiazepines, azocines.(any four)		
Module:5	**Heterocycles with fused 5 membered rings**	**6 hours**
Synthesis and reactions of heterocycles with fused 5 membered ring benzopyrroles, benzofurans and benzothiophenes, Indoles: Fischer, Madelung, Nenitzescu syntheses.		
Module:6	**Heterocycles with fused 6 membered rings**	**7 hours**
Heterocycles with fused 6 membered ring Quinolines and isoquinolines- Bischler-Napieralski reaction. Friedlander synthesis. Meth-Cohn quinolone synthesis. Pfitzinger quinoline synthesis., Skraup synthesis, Coumarins, chromones, quinolizinium ions		
Module:7	**Industrial and Medicinal Applications of Heterocyclic Compounds**	**6 hours**
PEDOT and polypyrroles as conducting polymers Bipyridine in dye sensitized solar cells (DSC). Nicotinic acid (Lipid modulating drug), 3,5-pyrazolidinedione (anti-inflammatory drug), Captopril (anti-hypertensive agent) and Ciprofloxacin (antibiotic).		
Module:8	**Contemporary issues:**	
	Industry Expert Lecture	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. John A. Joule (Author), Keith Mills, Heterocyclic Chemistry At A Glance, Wiley-Blackwell; 2nd Revised edition, 2012.
2. Eicher, T.; and Hauptmann, S.; The Chemistry of Heterocycles, Wiley-VCH, Weinheim, 3rd Ed, 2012.
3. Acheson, R. M. An Introduction to the Chemistry of Heterocyclic Compounds, 3rd Ed, Wiley India Pvt Ltd, 2008.
4. Gilchrist, T. L., Heterocyclic Chemistry, Prentice Hall, 3rd Edition, 2005.

Reference Books

1. Jonathan Clayden, Nick Greeves, and Stuart Warren. "Organic Chemistry," Oxford University Press, 2014.
2. The Essence Of Heterocyclic Chemistry, Parikh, Arun, New Age International, 1st Edition, 2013
3. Heterocyclic Chemistry, V. K. Ahluwalia, Alpha Science International, 2012
4. Advanced Organic Chemistry: Structure and Mechanisms (Part A &B). Frances A Carey and Richard J Sundberg, Springer, 2015
5. Heterocyclic chemistry, R. K. Bansal, New Age International Private Limited; Fifth edition, 2017.
6. Name reactions in heterocyclic chemistry-By Jie Jack Li, Wiley India Pvt Ltd, 2012.

Mode of Evaluation : Written Examinations, Quiz and Assignments

Recommended by Board of Studies	**24-06-2020**		
Approved by Academic Council	No. 59	**Date**	24-09-2020

Course code	Organic Synthesis and Methodologies	L	T	P	J	C
CHY6014		3	0	0	0	3
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

The course is aimed at

[1] Providing various methodologies used in organic synthesis, which enable the student to think different possible ways to synthesis an organic compound including retrosynthetic analysis and understanding about the disconnection approach for the organic synthesis and asymmetric synthesis

[2] Knowing the synthetic various metallic reagents used in chemical transformations in the production various natural and synthetic drugs, materials.

Course Outcomes:

At the end of the course, students should be able to

[1] Recollect the fundamental principles of organic reactions.

[2] Understand the concepts related to synthesis, mechanisms and the functions of various reagents.

[3] Apply their understanding about the retrosynthetic approaches involved in organic reactions of industrial significance.

[4] Analyze the product distribution and the stereochemistry of various organic products through spectroscopic data.

[5] Evaluate the organic reactions and methodologies based on the influence of the substituents on substrate molecules and nature of solvent and the parametric conditions.

[6] Design new organic reactions in order to achieve the required retro-synthesis product(s).

Module:1	**C-C & C-X Disconnection approach**	**8 hours**
An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter conversions. One group and two group C-X disconnections in 1,2-, 1,3-, 1,4- and 1,5-difunctional compounds. One group and two group C-C Disconnections; Alcohols and carbonyl compoundsregioselectivity, Diels-alder reaction, 1,3-di functional compounds.		
Module:2	**Planning and execution of retrosynthesis**	**5 hours**
Retro synthesis of alkenes, acetylenes, nitro and amine compounds with specific example to synthesis of simple molecule for each functional group		
Module:3	**Strategies of alcohols and carbonyl disconnections**	**4 hours**
Alcohols and carbonyl compounds with specific example to synthesis of simple molecule for each functional group		
Module:4	**Retro-synthesis of carbonyl and heterocyclic compounds**	**5 hours**
Unsaturated carbonyl compounds, control in carbonyl condensations, Michael addition and Robinson annulation. Retro synthesis of aromatic heterocycles of 5 and 6 membered rings.		
Module:5	**Types of Asymmetric synthesis**	**4 hours**
Asymmetric synthesis – Substrate, auxiliary, reagent, catalyst controlled methods		
Module:6	**Reagents in Organic Synthesis & Synthetically important name reactions**	**7 hours**

Dicyclohexylcarbodiimide (DCC), EDCI, DDQ organozinc (Reformatsky reaction), Organo lithium (Shapiro reaction, LDA), Organocopper(Gillman reagent, Ullmann) , Organopalladium (Sonogashira and Stille), Organosilicon (Peterson synthesis), Organotin (AIBN)			
Module:7	**Protection, deprotection and total synthesis**		**10 hours**
Alcohol, acid, amine, ketone and aldehyde. Total synthesis of Camptothecins, Longifolene and Cubane			
Module:8	**Contemporary issues**		
	Industry Expert Lecture		**2 hours**
	Total Lecture hours:		**45 hours**

Text Book(s)

1. Stuart Warren and Paul Wyatt, Organic synthesis, the disconnection approach, 2nd edition, Wiley, 2012.
2. Jie Jack Li, E. J. Corey, Total Synthesis of Natural Products: At the Frontiers of Organic Chemistry, First Edition, 2012. ISBN: 978-3-642-34065-9. Springer.
3. Rainer Mahrwald, Enantioselective Organocatalyzed Reactions, 322 & 386 Pages, 1st Edition, 2011
ISBN: 978-90-481-3864-7 & 978-90-481-3866-1, Springer.
4. K. C. Nicolaou, E. J. Sorensen-Classics in total synthesis- 4th edition, Wiley-VCH (1996)
5. Michael B Smith, Organic synthesis, 4th Edition, Academic Press (2016)

Reference Books

1. I. L. Finar, Organic Chemistry Vol. I & Vol. II, Longman (Cambridge), 2011.
2. W. Carruthares, Iain coldham, Modern Methods of Organic Synthesis South Asia Edition, Cambridge University Press, Fourth Edition, 2015.
3. Michael B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure.7th Edition, 2017. Wiley publications.
4. L. S. Starkey, Introduction to Strategies for Organic synthesis. Wiley & Sons, Inc., Hoboken, New Jersey and Canada. 2012

Mode of Evaluation : Written Examinations, Quiz and Assignments

Recommended by Board of Studies	24.06.2020		
Approved by Academic Council	No. 59	**Date**	24-09-2020

Course code	Photochemistry and Pericyclic Reactions	L	T	P	J	C
CHY6015		4	0	0	0	4
Pre-requisite		Syllabus version				
None		1.2				

Course Objectives:

The course is aimed at

[1] Imparting knowledge in the theory and applications of various aspects of photochemistry and pericyclic reactions.

[2] Understanding the synthesis and mechanisms of various reactions related to the synthesis by cycloaddition, photochemistry.

Course Outcomes:

At the end of the course, students should be able to

[1] Recall the fundamental principles of photochemical reactions.

[2] Understand the concepts related to light induced organic synthesis, mechanisms and the functions of various reagents.

[3] Apply their understanding about the photochemical reactions of industrial significance.

[4] Analyze the product distribution and the stereochemistry of various organic products derived from photochemistry.

[5] Evaluate the photochemical reactions based on the influence of the substituents on substrate molecules.

[6] Design new photochemical reactions in order to achieve the required product(s).

Module:1	Principles of photochemical reactions:	11 hours

Molecular energies and Jablonski diagram. Photochemical reactions and their applications in organic synthesis; Hund's and Frank Condon principle, Photochemistry of carbonyl compounds, Paterno-Buchi reaction, Norrish type I and II reaction, Photoreduction, Photochemistry of α,β unsaturated compounds, olefins and isomerization,

Module:2	Photo rearrangements	5 hours

Di-π-methane, oxa di-π- and aza di-π-methane, aromatic hydrocarbons, Wolf and Fries rearrangements.

Module:3	Significant Photoreactions	11 hours

Photocycloaddition, Photochemical aromatic substitution reaction; Reactions with singlet oxygen, ene reactions (ene with oxygen, alkenes, carbonyl, alkynes, amines etc.); Photochemical methods for protection and deprotection.-Barton reaction and Hoffman-Loffler-Freytag reactions, The mechanisms of reactions involving free radicals- Sandmayer, Gomberg- Bachmann, Pschorr and Hunsdiecker reactions. Photo-elimination reactions

Module:4	Aromaticity and cross-conjugated Systems	6 hours

Aromaticity in benzenoid and non-benzenoid compounds. Huckel's (4n+2) and 4n rules, annulenes, anti-aromaticity and homo-aromaticity. Annulenones, Annulenequinones, Fulvenes. Polycyclic Systems-Cyclopropenyl Aromatic Systems-Pentalenes, Heptalenes, Azulenes, Other Systems-Cyclobutadiene and cyclooctateraene.

Module:5	Molecular Orbital Symmetry	7 hours

Frontier orbital of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system, Wood-ward Hoffman correlation diagrams, FMO and PMO approach, electrocyclic reactions, - conrotatory and dis rotatory motions, 4n , 4n+2 and allyl systems			
Module:6	**Sigma-tropic rearrangement**		**7 hours**
Supra and antarafacial shifts of H Sigmatropic shifts involving carbon moieties,3,3 and 5,5 sigmatropic rearrangement and Claisen and Cope , Oxa and Aza Cope rearrangement- HOMO-LUMO orbital symmetry analysis. Cheletropic Reactions			
Module:7	**Cycloaddition**		**11 hours**
Supra and antra facial additions, 4n and 4n+2 systems, 2+2 additions of ketenes, 1,3-dipolar cycloaddition and chelotropic reactions. Ene reaction. **Diels-Alder reactions**: retro Diels-Alder reaction- FMO mechanism for *endo*- and *exo*-selectivity, stereochemistry, inter- and intramolecular reactions. Correlation diagrams and FMO method, Allowed and forbidden reactions. Nazarov and Iso Nazarov reactions			
Module:8	**Contemporary issues**		
	Industry Expert Lecture		2 hours
	Total Lecture hours:		**60 hours**

Text Book(s)

1. Orbital interactions in chemistry, Thomas A Albright, Jeremy Burdett, Myung – HwanWhangbo, Wiley, Second edition
2. Pericyclic reactions-A Textbook: Reactions Applications and Theory. S Sankararaman,iley-VCH 2015.
3. Organic Photochemistry and Peri Cyclic Reactions, S. Kalaivanai, MJP Publishers, 2011.

Reference Books

1. Pericyclic reactions, Sunil Kumar, Vinod Kumar, S.P. Singh, Elsevier, 2016.

Mode of Evaluation: Written Examinations, Quiz and Assignments

Recommended by Board of Studies	24.06.2020		
Approved by Academic Council	No. 59	**Date**	24-09-2020

Course code	Organic Chemistry Lab-II	L	T	P	J	C
CHY6016		0	0	4	0	2
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

1. Imparting training in analysis of chemical and instrumental methods.
2. Understanding importance of different instrumental methods in chemical analysis of materials.

Expected Course Outcome: students will be able to

1. Recall the importance of various organic molecules and their synthetic utility.
2. Understand the preparation methods of various organic molecules and reaction mechanisms.
3. Analyze the laboratory procedures about the formation of products and the reaction conditions.
4. Evaluate the properties of synthesized organic products and their derivatives through spectroscopic and analytical data.

Experiments		
1.	Estimation of Phenol	4 h
2.	Estimation of Aniline	4 h
3.	Estimation of Glucose	4 h
4.	Estimation of Methyl Ketone	4 h
5.	Estimation of carbonyl group (percentage purity of carbonyl compound)	4 h
6.	Synthesis, characterization of phenytoin from benzoin- two step reactions (IR, UV, GCMS, NMR)	6 h
7.	Synthesis, characterization of 2,3-diphenyl quinoxaline (from benzil) (IR, UV, GCMS, NMR)	4 h
8.	Synthesis characterization of 2-phenylindole from acetophenone –two step reactions (IR, UV, GCMS, NMR)	6 h
9.	Synthesis, characterization of tetrahydrocarbazole from cyclohexanone- (Fischer Indolization) (IR, UV, GCMS, NMR)	4 h
10.	Synthesis, characterization of methyl cinnamate from malonic acid through cinnamic acid two step reactions(IR, UV, GCMS, NMR)	4 h
	Total Laboratory Hours	**44 h**

Text/ Reference Books:

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

<table>
<tr><td colspan="3">5. Techniques and Experiments for Organic Chemistry, by Addison Ault, University Science Book, 6th Edition.
6. Instrumental techniques for Analytical Chemistry by Frank Settle, Printice
7. G. Mann and B. C. Saunders: Practical Organic Chemistry
8. J. Leonard, B. Lygo and G. Proctor: Advanced Practical Organic Chemistry.
9. Addison Ault: Techniques and Experiments for Organic Chemistry, University Science Book
10. R. L. Shriner and D. Y. Curtin: The Systematic Identification of Organic Compounds</td><td></td></tr>
<tr><td colspan="4">Mode of Evaluation: Continuous Assessment in lab, Viva-Voce & FAT</td></tr>
<tr><td>Recommended by Board of Studies</td><td colspan="3">31.05.2019</td></tr>
<tr><td>Approved by Academic Council</td><td>No.55</td><td>Date</td><td>13.06.2019</td></tr>
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Course code	Organic Chemistry Lab-III	L	T	P	J	C
CHY6017		0	0	4	0	2
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

1. Imparting training in analysis of chemical and instrumental methods.
2. Understand importance of different instrumental methods in chemical analysis of materials.

Expected Course Outcome: students will be able to

1. Recall the importance of synthetic organic chemistry and the applications in chemical industries.
2. Understand the preparation methods, the functions of various reagents and the reaction mechanisms.
3. Analyze the selectivity in product distribution and the influence of reaction conditions in terms of yields.
4. Evaluate the properties of synthesized organic products and their derivatives through spectroscopic and analytical data.

Experiments		
1.	Synthesis, characterization of methyl salicylate from salicylic acid: one-step (IR, UV, GCMS, NMR)	4 h
2.	Synthesis, characterization of methyl red from anthranillic acid: two-step process (IR, UV, GCMS, NMR)	4 h
3.	Synthesis, characterization of α, β -Unsaturated acid from anisaldehyde – two step Knoevenagel condensation/hydrolysis (IR, UV, GCMS, NMR)	4 h
4.	Synthesis, characterization of Poly Halo-arene (1-iodo-2,4,6-tribromo benzene from aniline) – two step (IR, UV, GCMS, NMR)	4 h
5.	Synthesis, characterization of trimethylquinoline from p-toluidene- two step (IR, UV, GCMS, NMR)	4 h
6.	Multi step synthesis: 2-aminobenzophenone- 2-methyl-3-aceylquinoline- 2-methylquinoline chalcone	4 h
7.	Multi step synthesis: Cinnamaldehyde- cinnmamyl alcohol-cinnamylbromide – allyl aryl ether	4 h
8.	Extraction and characterization of Lactose from Milk	4 h
9.	Extraction and characterization of Lycopene from Tomatoes	4 h
10.	Separation of binary mixture by column chromatography - non-polar and polar compounds	8 h
	Total Laboratory Hours	**44 hours**

<table>
<tr><td colspan="3">Text/ Reference Books:
1. Vogel A. I. Practical Organic Chemistry, Longman Group Ltd.
2. Bansal R. K. Laboratory Manual of Organic Chemistry, Wiley-Eastern.
3. Ahluwalia V. K. and Aggarwal R. Comprehensive practical organic chemistry, University press.
4. Nad A. K.; Mahapatra B. and Ghoshal A. An advanced course in practical chemistry, New Central Book Agency (P) Ltd.
5. Techniques and Experiments for Organic Chemistry, by Addison Ault, University Science Book, 6th Edition.
6. Instrumental techniques for Analytical Chemistry by Frank Settle, Printice
7. G. Mann and B. C. Saunders: Practical Organic Chemistry
8. J. Leonard, B. Lygo and G. Proctor: Advanced Practical Organic Chemistry.
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</table>

Course code	Electroanalytical and Chromatographic Techniques	L	T	P	J	C
CHY6018		3	0	0	4	4
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

The course is aimed at

[1] Get insight into advanced voltammetric and amperometric technique in analysis of electroactive species.

[2] Monitor the theoretical aspects of different types of ion-selective electrodes.

[3] Understand the theoretical principles and practical applications of different chromatographic techniques.

Expected Course Outcomes:

At the end of the course the student should be able to

[1] Apply different advanced voltammetric techniques for understanding the electrode processes.

[2] Utilize the working principles of ion selective electrodes for evaluating toxic metal ions and anions.

[3] Apply GC and GC-MS techniques for the analysis of volatile organic compounds in predicting the fragments and structures of compounds.

[4] Evaluate different chiral and bio molecules by separating them using HPLC, UPLC and hyphenated techniques like LC-MS.

[5] Apply the principles and working of super critical fluid chromatography for extraction of super critical fluids.

[6] Purify biological molecules using affinity chromatography.

[7] Apply the principles of capillary electrophoresis for evaluating biological applications.

Module:1	Advanced Voltammetric Techniques	6 hours

Normal pulse voltammetry, Differential pulse voltammetry, Square wave voltammetry & Stair case voltammetry – Principle, procedure and applications.

Stripping voltammetry – Anodic & Cathodic stripping – Applications.

Amperometry: Basic principles, instrumentation, nature of titration curves, and analytical applications.

Module:2	Ion Selective Electrodes	6 hours

Working principles and applications– theoretical considerations - types of ion-selective electrodes – properties of ion-selective electrodes – sources of errors – construction and working of cation specific electrodes for analysis of cadmium, lead, arsenic and anion specific electrodes for fluoride, chloride and sulphide ions.

Module:3	Gas Chromatography	7 hours

Instrumentation - Carrier Gas – Packed and Capillary Column, Types of Stationary Phases and Column Selection). Injection Methods (On-column, Split/Split-less and Programmed Temperature Vaporizer) Temperature Control - Common detector systems.

Sampling Methods - Sample Selection & Preparation and Injection -. GC Method Development - Troubleshooting - Quantitative and Qualitative Applications – Hyphenated Systems (GC/MS).

Module:4	**Liquid Chromatography**	**8 hours**
HPLC Columns - Types, Packing Characteristics and Modern Column Trends of HPLC Columns - Specialty Columns (Chiral and Bio-Separation). Stationary Phases (Normal and Reverse-phase) - Mobile Phases (Selection of Mobile Phase, Isocratic and Gradient Elution) - Sample Preparation and Introduction- HPLC Method Development – Preparative HPLC - Troubleshooting – Quantitative and Qualitative Applications – Hyphenated Systems (LC/MS).		
Module:5	**UPLC and Super critical fluid chromatography**	**7 hours**
UPLC: Ultra performance liquid chromatography, stationary phases for UPLC, specific applications. Supercritical Fluid chromatography: Principle - super critical fluids, properties of supercritical fluids-Instrumentation, detectors, injection techniques, pressure restrictors, specific applications. Ion Chromatography: principle, applications in qualitative and quantitative analysis.		
Module:6	**Affinity Chromatography**	**4 hours**
Definitions, separation mechanism-matrices, matrix activation, role of spacer arms and applications in purification of biological molecules.		
Module 7	**Capillary Electrophoresis**	**5 hours**
Overview, types, the basis for electrphoretic separations, migration rates and plate heights, electroosmotic flow, instrumentation, capillary zone electrophoresis, capillary gel electrophoresis, capillary isoelectrophoresis, capillary isoelectric focusing, applications.		
Module:8	**Contemporary issues:**	**2 hours**
Industry Expert Lecture		
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Richard G. Compton and Craig E. Banks, Understanding Voltammetry, 2nd Revised Edn., World Scientific Publishers, 2011.
2. Konstantin N. Mikhelson, Ion-Selective Electrodes, Springer-Verlag, 2013.
3. Gary D. Christian, Purnendu K. Dasgupta and Kevin A. Schug, Analytical Chemistry, 7th Edn., John Wiley & Sons, Inc., 2014.
4. Daniel C. Harris and Chucky Lucy, Quantitative Chemical Analysis, 9th Edn., W.H. Freeman, 2015.
5. Mark F. Vitha, Chromatoraphy: Principles and Instrumentation, John Wiley & Sons, Inc., 2017.
6. A. Braithwaite and F.J. Smith, Chromatographic Methods, 5th Edition, Blackie Academic & Professional (Chapman & Hall), 2009.

Reference Books

1. Danilo Corradini, Handbook of HPLC, CRC Press Taylor and Francis, 2011.
2. C.F. Poole, Gas Chromatography, Elsevier Inc., 2012.
3. Yuki Saito and Takumi Kikuchi, Voltammetry – Theory, Types and Applications, Nova Science Publishers, Inc. 2014.
4. M. Anderson, A. Fitch and J. Stickney, Chemically Modified Electrodes, Electrochemical Society, 2015
5. Douglas A. Skoog, F. James Holler and Stanley R. Crouch, Principles of Instrumental Analysis, 7th Edn., Cengage Learning Publishers, 2018.
6. C.F. Poole S.K. Poole, Chromatography Today, 5th Edition, Elsevier Science, 1991.
7. Hans-Joachim Hubschmann, Hand Book of GC-MS, Fundamentals and Applications, Wiley-VCH, 2009.
8. Robert E. Ardrey, Liquid Chromatography-Mass Spectrometry-An Introduction, Wiley, 2003.

Mode of evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Recommended by Board of Studies	Yes, 24-06-2020		
Approved by Academic Council	No. 59	**Date**	24-09-2020

Course code	Environmental & Industrial Analytical Chemistry	L	T	P	J	C
CHY6019		3	0	0	4	4
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. Understanding the insights of soil analysis, soil based waste management.
2. Learning the different aspects of pollutants in water, air and food and their analysis.
3. Identifying the different industrial pollutants and their prevention methods.

Expected Course Outcome: student will be able to

1. Analyze different trace elements.in soil by Chemical analysis.
2. Evaluate parameters to be controlled in solid waste and adopt methods for reduction and recycling of solid waste.
3. Analyze water quality through different analytical methods.
4. Apply absorption and emission and chemical analysis analyzing water pollutants and understand their impact.
5. Analyze different parameters in Air quality monitoring and adopt methods for their reduction.
6. Evaluate the industrial pollutants, understand their effects and adopt methods to reduce them.
7. Demonstrate their knowledge in evaluating different contaminants in food through water, pesticides and additives.

Module:1	Chemical analysis of soil	5 hours

Soil/Sediment analysis: a brief idea of chemistry of soil. Trace element analysis in soil - B, Cd, Cu, Fe, Mn, Mo, Zn, Pb. Standard specifications for soil

Module:2	Soil based Waste Management	5 hours

Waste Management: waste management approaches - waste reduction, recycling, disposal. Management of hazardous wastes, household waste, municipal and industrial wastes-collection, transportation and disposal options.

Module:3	Water quality assessment	6 hours

Determination of pH, EC,TDS, DO, colour, turbidity, total solids, conductivity, acidity, alkalinity hardness, chloride, fluoride, sulphate, nitrite, nitrate, phosphorous (total inorganic and organic), BOD, COD, TOC, pesticides.

Module:4	Water pollutants & their Impact	6 hours

Sources of water pollution - domestic, industrial, agricultural, soil and radioactive wastes as sources of pollution. Contamination by inorganic and organic materials - parameters for analysis. Impact of heavy metal pollution- Assessment of toxic metal ions in water; Impact of organic pollutants - Assessment of dyes and other organic pollutants in water.

Module:5	**Air quality monitoring**	**6 hours**
Air quality; Air Analysis: atmospheric pollution, classification of air pollutants, sources of air pollution and methods of control, sampling of aerosols, sampling of gaseous pollutants, analysis of SO_2, NO_2, CO-CO_2, hydrocarbons, particulates, effects of air pollutants on animals, ozone layer, chlorofluorocarbons, acid rain and greenhouse effect.		
Module:6	**Industrial pollutants and prevention**	**7 hours**
Pollutants from Pigment and paint, textile industries, tannery, cosmetics, ceramics and glass, chemical and pharmaceutical, explosives, electroplating industries, food processing industries. Pollution prevention strategies in industrial processes.		
Module:7	**Food ingredients, additives and contaminants**	**8 hours**
Water in food, crude protein and amino acids - functional properties; lipids - classification and use of lipids in food - physical and chemical properties, nutritive value; carbohydrates-functional properties in food; minerals, vitamins, ash content. Pesticide analysis in food products. Food additives; chemistry, role and application of preservatives; emulsifying, stabilizing, buffering, bleaching, maturing agents and starch modifiers, food color, flavors, anti-caking agents. Common adulterants in food, contamination of food stuffs.		
Module:8	**Contemporary issues:**	**2 hours**
	Industry Expert Lecture	
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Pradyot *Patnaik, Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil and Solid Wastes*, 3rd Edition, CRC Press, Taylor & Francis Group, Boca Raton, FL, 2018.
2. Timothy J. Sullivan, Alan T. Herlihy and James R. Webb, *Air Pollution and Freshwater Ecosystems: Sampling, Analysis, and Quality Assurance*, CRC Press, Boca Raton, FL, Taylor & Francis Group, LLC, 2015.

Reference Books

1. Eugene W. Rice, Rodger B. Baird, Andrew D. Eaton, Lenore S. Clesceri, *Standard Methods for Examination of Water and Wastewater*, 22nd Edition, American Public Health Association , 2012.
2. Leo M.L. Nollet , Leen S. P. De Gelder, *Handbook of Water Analysis*, 3rd Edition CRC Press, Taylor & Francis Group, Boca Raton, FL, 2013.
3. Leo M.L. Nollet and Fidel Toldra, *Handbook of Analysis of Active Compounds in Functional Foods*, CRC Press, Boca Raton, FL, Taylor & Francis Group, 2012.
4. Sadhana Chaurasia, Anand Dev Gupta , Hand Book of Water, Air and Soil Analysis, International E- Publication, 2014.
5. Bernie Goldman, *Air Pollution and Environmental Analysis*, Callisto Reference, 2017.
6. Paul Mac Berthouex, Linfield C. Brown, *Chemical Processes for Pollution Prevention and Control*, 1st Edition, CRC Press, Taylor & Francis Group, Boca Raton, FL, 2018.

Mode of Evaluation : Written Examinations, Quiz and Assignments

Recommended by Board of Studies	08-03-2016		
Approved by Academic Council	No. 40	**Date**	18-03-2016

Course code	Bioanalytical and Forensic Analysis	L	T	P	J	C
CHY6020		4	0	0	0	4
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

The course is aimed at

[1] Understanding the principles of antigen-antibody interactions, immunoanalytical techniques,Immunodiffusion and immunofluorescent assays.

[2] Getting insight into forensic toxicology and biochemical, physical and chemical methods offorensic analysis.

Course Outcomes:

At the end of the course, the student should be able to

[1] Demonstrate Knowledge of Antigen-Antibody interactions and Apply them in biological analysis.

[2] Analyze samples using immunodiffusion and electrophoresis techniques in biochemical analysis.

[3] Apply radioisotope dilution techniques in Tracer analysis.

[4] Evaluate biological samples through ELISA, ELISPOT and Western Blotting techniques.

[5] Analyze biological samples using fluorescent immunoassays using DELFIA, SLFIA, FACS andPACIA techniques.

[6] Demonstrate Knowledge about fundamental aspects of forensic toxicology.

[7] Analyze narcotics, stimulants, depressants, hallucinogens, alcohol, metabolites in blood andother matrices

[8] Apply destructive and non-destructive physical and chemical methods of analysis of forensicmaterials.

Module:1	Antigen-Antibody/Protein-ligand Interactions: Principles and Applications	10 hours

Introduction, Antigens, Antibodies, Structure and characteristics of antibodies, polyclonal and monoclonal antibodies, Concepts and applications of Antigen-Antibody Interactions, Strength and Characteristics of Antigen - Antibody Interaction; Zone of Equivalence and its significance in Analysis- Antibodies and Enzymes as analytical reagents. Cross-Reactivity - quantitative and
qualitative analysis of antigens.

Module:2	Immunoanalytical Techniques	8 hours

Immunodiffusion – The principle of single and double immunodiffusion. Electrophoresis - Gel,SDS-PAGE, Immuno and Capillary. Isotope dilution techniques - Principles and applications-
radioisotope dilution techniques - Use of radioisotope tracer techniques in biochemicalexperiments and their detection.

Module:3	Immunodiffusion and Immunoassays	6 hours

Principles of Enzyme-linked immunoassays – Types - Direct, Indirect, Sandwich and Competitive ELISA Techniques - Use of Chemiluminescence in ELISA - ELISPOT Assay; Western blotting – Principles, procedures and applications.

Module:4	Fluorescence immunoassays	6 hours

Principles of Fluorescence immunoassays- Substrate labelled fluorescent immunoassay (SLFIA)- Delayed enhanced lanthanide fluorescence immunoassay (DELFIA)- Flow cytofluorimetry and fluorescence-activated cell sorting (FACS)- Particle counting immunoassays (PACIA).

Module:5	**Introduction to forensic analysis and Forensic toxicology**	**10 hours**
Introduction to forensic science, Role of a forensic scientist, Theory of forensic analysis: Comparative analysis, Classification of poisons based on physical states; Study of common poison; Mode of action, chemical properties; Methods of administration and their action in the body. Analysis of drug of abuse: opiates, Hallucinogens, depressants, stimulants and club drugs; Breath testing of alcohol, Collection and preservation of drug evidence, Qualitative and quantitative analysis by colour tests, microcrystalline tests. Simultaneous analysis of multianalytes.		
Module:6	**Forensic Analysis of Biological Samples**	**8 hours**
Analysis of biological samples (Qualitative and Quantitative): Blood, Semen, Urine and Saliva. Blood spatter analysis, DNA analysis. Hairs and Fiber analysis, Fingerprint analysis; Isolation, sample preparation.		
Module:7	**Physical and chemical methods of analysis in Forensic Science**	**10 hours**
Forensic Analysis of explosives and gunshot residues, paints, Arsons, and questioned documents. Lie detection – introduction, process, merits and demerits. Application of mass, GC-MS, FT-IR, SEM in forensic analysis. Applications Non-destructive testing probes including radiography, Xera–radiography Surface penetrations methods (SEM and Laser Probes), application of spectroscopic, chromatographic techniques such as GC-MS, FT-IR, UV-Visible spectroscopy, Atomic absorption spectroscopy for forensic sample analysis.		
Module:8	**Contemporary issues**	**2 hours**
Industry Expert Lecture		
	Total Lecture hours:	**60 hours**

Text Books

1. Introduction to forensic science and criminalistics, Howard Harris, Henry C Lee, Publisher:CRC Publishers, 2019, Second edition, ISBN-13: 978-1498757966.
2. Immunology: An Introductory Textbook, Anil K Sharma, Publisher: Pan Stanford Publishing Ltd, 2019, ISBN- 978-981- 4774-51-2

Reference Books

1. Forensic Chemistry by A Lucas, Publisher: Forgotten Books (5 May 2017),ISBN-13: 978 - 1330672037
2. Forensic Chemistry (Advanced Forensic Science Series) by Max M. Houck,Publisher: Academic Press (12 January 2015), ISBN-13: 978-0128006061
3. Criminalistics: An Introduction to Forensic Sciences, Richard Saferstein,Publisher: Pearson Education, 2015, ISBN: 13:978-0-13-345882-4
4. Kuby Immunology by Judith A. Owen, Jenni Punt, Sharon A. Stranford, Patricia P. Jones, Publisher: W H Freeman & Co (Sd); 7 edition (25 January 2013), ISBN-13:978-1429219198
5. Roitt′s Essential Immunology (Essentials) by by Peter J. Delves and Seamus J. Martin, Publisher:Wiley-Blackwell; 13 edition, 2017, ISBN-13: 978-1118415771

Mode of evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Recommended by Board of Studies	Yes, 24.06.2020		
Approved by Academic Council	No. 59	**Date**	24-09-2020

Course code	Analytical Quality Assurance for Process Industry	L	T	P	J	C
CHY6021		3	0	0	0	3
Pre-requisite		Syllabus version				
		1.1				

Course Objectives:

The course is aimed at

[1] Understanding the importance of different methods that are used for assuring quality in different process industries

[2] Getting inputs on existing Quality Assurance methods used in different process industries including Good manufacturing practices.

[3] Knowing the significance of Quality assurance in automated process industries.

Course Outcomes:

Students will be able to

[1] Evaluate the parameters to be maintained to achieve consistent quality in process industry
[2] Apply the principles of ISO 9000 for management of quality in industry
[3] Establish SOPs and GLPs in setting up Quality Management System
[4] Derive appropriate sampling methods for chemical analysis
[5] Apply Statistical Quality control methods to solve quality issues in industry
[6] Create flow sheets for automated processes and quality assurance

Module:1	Basic concepts of Quality Assurance	5 hours

Basic concepts, Principles or prescription; Needs, requirements and expectations; The characteristics of quality; Achieving, sustaining and improving quality; Quality dimensions and costs of quality.

Module:2	Quality Assurance	6 hours

Elements of quality Assurance, Quality Management System Quality management concepts and principles: ISO 9001:2000
QMS Case studies on ISO 9001: 2000 in chemical industries. ISO 14000 Series of Standards

Module:3	TQM and Six sigma	8 hours

TQM in Chemical Industry. Six Sigma Approach to Quality: Applying Six Sigma to chemical Industries. - Good Laboratory Practices: Principles of GLP, GMP in Drugs and Pharmaceutical Industries - Standard operating procedure (SOP) Accreditation of QC laboratories:
Requirements of QMS; Establishing a QMS; Validation of methods and related case studies.
Tools and Mechanisms ICH Guidelines on Drug substances and Products

Module:4	Sampling	5 hours

Measurement, analysis and methods of improvement; Basics of sampling; Sampling procedures; Sampling based on physical state and hazards in sampling pre-concentration methods.

Module:5	Statistical Quality Control	6 hours

Statistical Quality Control Techniques: Statistical treatment of data. Control charts, Performance Evaluation uncertainties in measurement. Validation of analytical methods- Role of SQC in QCQA of process industry.

Module:6	Industrial QA	6 hours

Outlines of QA in chemical industries; Flow sheet preparations; Principles of process selection and unit operation. Outlines of QA in chemical industries; Flow sheet preparations; Principles of process selection and unit operation.

Module:7	**Quality Assurance and Automation**	**7 hours**
Automated and Automatic Process control; Automation in chemical process industry; Methods of automation: Flow injection and Sequential Injection; Quality assurance through automation.		
Module:8	**Contemporary issues**	**2 hours**
Industry Expert Lecture		
	Total Lecture hours:	**45 hours**

Text Book(s)

1. R. Pannerselvam, Production and Operations Management, Prentice Hall India Learning Pvt. Ltd 3rd Edition, 2012.
2. Mehmet Savsar, Quality Assurance and management, InTech-Croatia, 2012, ISBN 978-953-51-0378-3
3. D.C. Montgomery, Statistical Quality Control, John Wiley & Sons, 5th edition, 2005.
4. M. K. Starr, Production and Operations Management, Biztantra, Delhi, 2004.
5. D.H. Shah, QA Manual, Business Horizons, 2000
6. D.H. Besterfield, C. Besterfield-Michna, G.H. Besterfield, M. Besterfield -Sacre, Total Quality Management, Pearson Education, Inc., 3rd Edition, 2003.

Reference Books

1.Piotr Konieczka and Jack Namiesnik Quality Assurance and Quality Control in the Analytical Chemical Laboratory: A Practical Approach, Ist Edition, CRC press 2009.

2. David Hoyle, ISO 9000 Quality Systems Handbook, Fifth Edition, Butterworth-Heinemann-Elsevier, New York, 2006.

3.Elizabeth Prichard and Victoria Barwick, Quality Assurance in Analytical Chemistry, John Wiley & Sons, 2007.

4. Y. Anjaneyulu and R. Marayya, Quality Assurance and Quality Management in Pharmaceutical Industry, Pharma Book Syndicate, 2005.

3.A. K. Chakraborty, P. K. Basu, S.C. Chakravarty, Guide to ISO 9001: 2000, Asian Books Pvt. Ltd., 2005.

4. B.W. Wenclawiak, M.Koch and E. Hadjicostas (Eds.), Quality Assurance in Analytical Chemistry, Springer, 2004.

Mode of evaluation : CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	Yes, 24-06-2020		
Approved by Academic Council	No. 59	**Date**	24-09-2020

Course code	General Organic & Inorganic Chemistry Practical I Synthesis and Characterization	L	T	P	J	C
CHY6022		0	0	4	0	2
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. Impart training in synthesis of inorganic material, characterization and chemical analysis
2. Understand the importance of different instrumental methods in chemical analysis of materials.

Expected Course Outcome: Student will be able to

1. Understand the synthetic methodologies adopted for different types of compounds.
2. Demonstrate the principle of complex and natural products syntheses
3. Apply the different methods of material synthesis for oxide preparation
4. Evaluate the nature of products through characterization

	Experiments	
1	**Estimation of the following:** a) Estimation of Glucose b) Estimation of Methyl Ketone	8 hours
2	**Synthesis of the following drug molecules:** a) Synthesis of phenytoin b) Synthesis of 2,3-diphenyl quinoxaline c) Synthesis of 2-phenylindole	12 hours
3	**Extraction of natural products:** a) Caffeine from Tea leaves **b) Piperine from Black pepper**	8 hours
4	**Coordination Complexes:** a) Preparation of Chloropentaammine cobalt(III) chloride, $[Co(NH_3)_5Cl]Cl_2$ b) Preparation of Potassium bisoxalatocuprate(II)dihydrate, $K_2[Cu(C_2O_4)_2].2H_2O$	8 hours
5	**Synthesis of oxides:** **a) $YBa_2Cu_3O_7$ by ceramic method** **b)** SnO_2 by precipitation method **c)** Ruby by combustion method	12 hours
	Total Laboratory Hours	**48 hours**

Mode of Evaluation: Continuous Assessment in lab, Viva-Voce & FAT

Recommended by Board of Studies	31.05.2019		
Approved by Academic Council	No. 55	**Date**	13.06.2019

Course code	Analytical Chemistry Practical III	L	T	P	J	C
CHY6023		0	0	4	0	2
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

The course is aimed at

[1] Understanding the procedures of analysis of different organic, inorganic materials in real samples by instrumental methods of analysis

[2] Knowing the procedures for analysis of different contaminants in water and other matrices

Course Outcomes:

Students should be able to

[1] Design experiments for determination of metals in different matrices using instrumental methods

[2] Analyze real samples and effluent samples for knowing the levels of different contaminants

[3] Evaluate drugs, soft drinks using different titrimetric and instrumental methods of analysis

	Experiments	**CO - 1,2,3**
1.	Isolation and estimation of chromium from waste water by spectrophotometry	4 hours
2.	Analysis of oils and fats - Saponification and acid value	4 hours
3.	Determination of nitrate in different soil and water samples by spectrophotometry	4 hours
4.	Extraction and estimation of benzoic acid in fruit juices	4 hours
5.	Heavy metal analysis in textiles and textile dyes by AAS	4 hours
6.	Study of degradation of organic dyes by hydrogen peroxide catalyzed by copper and iron nanoparticles	4 hours
7.	Determination of caffeine in soft drinks by HPLC	4 hours
8.	Extraction of copper by diethyl dithiocarbomate and it spectrophotometric determination	4 hours
9.	Analysis of water quality through COD, DO, BOD measurements	4 hours
10.	Assay of Riboflavin and Iron in tablet formulations by spectrophotometry	4 hours
	Total Laboratory Hours	**40**

Mode of evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Recommended by Board of Studies	Yes, 24.06.2020		
Approved by Academic Council	No. 59	**Date**	24-09-2020

Course code	Advanced Inorganic Chemistry	L	T	P	J	C
CHY6024		3	0	0	4	4
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

The course is aimed at

[1] Applying the knowledge of structure, bonding and reactivity of transition metals, rare metals, organometallics, bio-inorganic and inorganic photochemistry

[2] Analyzing real time problems and provide solutions

Expected Course Outcomes:

At the end of the course the student should be able to

[1] Recollect the principles of electronic structure, bonding, and reactivity of coordination complexes

[2] Understand the concept of synthesis and stability of transition metal organometallic complexes

[3] Develop the possible catalytic pathways leading to desired products

[4] Apply the principles of transition metal coordination complexes in understanding functions of biological systems

[5] To feel the sense of inorganic compounds which exhibit various applications.

[6] Unravel and interpret the photochemical and electronic properties of coordination complexes

Module:1	Descriptive chemistry of transition metals and rare earths	6 hours

Periodic trends – comparison of periodic properties by electronic configuration. Oxidation states – chemistry of various oxidation states, stabilization of unusual oxidation states. Heavier transition elements. Chemistry of uranium-compounds of uranium and their chemical properties.

Module:2	Inorganic –Clusters and polyacids	5 hours

Isopoly and heteropoly acids. Clusters - Polynuclear carbonyls- synthesis, reactivity, molecular Structure, stereochemical non-rigidity and Polyhedral Skeletal Electron-Pair Theory (PSPET).

Module:3	Organometallic Catalysis	6 hours

Catalytic cycles-oxidative addition and reductive elimination. Hydrogenation of olefins - hydroformylation of olefins - Fischer - Tropsch process - polymerisation of alkenes - Ziegler–Natta Catalyst - mechanistic Studies - Single-Site Catalysts - Metallocenes - Nonmetallocene Catalysts - olefin metathesis

Module:4	Bioinorganic systems	7 hours

Porphyrin systems: Dioxygen Transport - Hemoglobin, Hemerythrin and Hemocyanin. Cooperativity in O_2 binding, O_2 and CO discrimination. Inorganic model compounds. Oxygen Metabolism - Oxygen atom transfer by cytochromes-P450 - Nitrogenases - Carbonic anhydrase - Carboxypeptidase - Alcohol dehydrogenase – Photosystem

Module:5	Medicinal applications of bioinorganic Compounds	5 hours

Metal complexes in medicine- Cisplatin and its mode of action. Gold and Lithium compounds as drugs - Metal complexes as probes of nucleic acid, metal ions in genetic regulations, metal DNA and RNA interaction – Potential binding sites.

Module:6	**Advanced and emerging materials**	**8 hours**
2D Layered advanced Materials - Graphene, Graphene Oxide, MXenes, MoS_2, BN, BCN – synthesis, structural features, characterization, selected applications – electronic devices, water splitting - photocatalysis - energy storage. Perovskite – Structure - Oxide to Halide Perovskites – Types of inorganic – organic perovskite solar cells – Stability; Manganese-doped cadmium selenide / cadmium sulphide quantum dots/ nanocrystals - Photomagnetic effects.		
Module:7	**Inorganic Photochemistry**	**6 hours**
Photochemistry of Ru(II) and Cr(III) complexes – Porphyrin-based photosensitizers for photodynamic therapy - Photoactivation of small molecules like CO_2 and H_2O by transition metal complexes		
Module:8	**Contemporary issues:**	**2 hours**
Industry Expert Lectures		
	Total Lecture hours:	**45 hours**

Text Book(s)

1. D. F. Shriver and P.W. Atkins, Inorganic Chemistry, Oxford University Press, 5th Edition, **2010**.
2. J. D. Lee, Concise Inorganic Chemistry, Oxford University Press, 5th Edition, **2014**.
3. Dieter Rehder. Bioinorganic Chemistry: An Introduction, Oxford University Press; 1st Edition, **2014**.
4. S. Bhaduri, D. Mukesh-Homogeneous Catalysis - Mechanisms and Industrial Applications-Wiley, 2nd Edition, **2014**.
5. K. Sridharan, Spectral Methods in Transition Metal Complexes, Elsevier, 1st Edition, **2016**.
6. Paul van der Heide, X-ray photoelectron spectroscopy: An Introduction to Principles and Practices, Wiley-Blackwell, 1st Edition, **2012**.

Reference Books

1. J.E. Huheey, E. A. Kelter and R.L. Kelter, Principles of structure and reactivity, Inorganic Chemistry, Harper Collins College Publishers, 4th Edition, **2011**.
2. C.N.R. Rao, Muller and A. K. Cheetham, Chemistry of Nanomaterials, Vol. I & II, Wiley VCH Verlag GmbH KGaA, **2014**.
3. D. Rehder, E. Nordlander, Bioinorganic chemistry, Oxford University Press India, **2014**.
4. Van Eldik, Grazyna Stochel, Inorganic Photochemistry, Academic Press, **2011**.
5. 2D Inorganic materials beyond Graphene, Editors: C. N. R. Rao & U.V. Waghmare, World Scientific Publishing Company, **2017**.
6. 2D Metal Carbides and Nitrides (MXenes) Structure, Properties and Applications, Editors: Babak Anasori & Yury Gogotsi, Springer, Cham, **2019**.
7. R. Beaulac, L. Schneider, P. I. Archer, G. Bacher, D. R. Gamelin, Light-Induced Spontaneous Magnetization in Doped Colloidal Quantum Dots, Science, **2009**, 325, 973-9
8. G. Niu, X. Guo, L. Wang, J. Mater. Chem. A, **2015**, 3, 8970-8980

Recommended by Board of Studies	24-6-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course code	Materials Chemistry	L	T	P	J	C
CHY6025		3	0	0	0	3
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. Understanding the basic aspects of various structure types, polymeric, composite materials and materials synthesis.
2. Correlating the structure and property of materials for transport, optical and dielectric properties.

Expected Course Outcome: Student should be able

1. Recognize and categorize any new compound into a structure type
2. Compare the different methods of materials synthesis on the pure phase formation of agiven compound
3. Apply the concept of composite materials for various properties
4. Unravel and interpret the reason behind the functioning of a given material
5. Identify appropriate material for a given application in conducting, magnetic, optical and dielectric applications
6. Fabricate a device using suitable material for practical application

Module:1	Symmetry and structural aspects of solids	9 hours

Symmetry elements - point groups, space groups. Fundamentals and applications of X-ray diffraction, indexing of cubic system. AB_2 -pyrite, cuprite - A_2B_3 - Al_2O_3 (Corundum type) and rare-earth oxides, AB_3 - ReO_3, pervoskites, K_2NiF_4, $A_2B_2O_7$ (pyrochlores), AB_2O_4 (Spinels), Zeolites. Alloys-Cu-Ni, Cu-Zn, amorphous and glass materials.

Module:2	Preparative Strategies Basics	6 hours

Chemistry behind solid state synthesis – thermodynamic and kinetic aspects, phase transitions in solids. Techniques high temperature solid state synthesis- Co-precipitation, precursor, sol-gel, combustion, intercalation, chimie douce, ion- exchange, microwave, electrochemical, sonochemical, hydrothermal -High temperature and high pressure synthesis.

Module:3	Polymers and Composite Materials	6 hours

Polymer structure – chain structure – micro structure – crystal structure crystallinity – determination of crystallinity, size and orientation of crystallites using X-Rays-conformation and configuration. Composite materials - metal matrix, ceramic -matrix, polymers matrix – properties and applications

Module:4	Transport Properties	8 hours

Non- stoichiometry : Preliminary aspects**,** Defects in solids: Stoichiometric and non-stoichiometric defects - point defects - Schottky and Frenkel defects and properties- color centers.

Electronic conductors – metals, semiconductors, superconductors - Ionic conductors – fast ion conductors, solid electrolytes, mixed conductors- measurements - two and four probe measurements, impedance measurements.

Module:5	**Magnetic Properties**	**4 hours**
Magnetic properties- Dia, para, ferro, anti-ferro and ferri magnetism – spinels and garnets- measurements- magnetic moment and magnetic susceptibility.		
Module:6	**Optical and Dielectric Properties**	**6 hours**
Optical properties- Optical absorption and band gaps – luminescence- lasers : principle, characteristics and materials, Dielectric properties- ferro, anti-ferro, piezo and pyro electric properties- relationship and applications		
Module:7	**Thermoelectric and Battery materials**	**4 hours**
Thermoelectric materials- intermetallics and oxides. Lithium battery materials – electrode and electrolyte materials. Solid Oxide Fuel Cells- material aspects		
Module:8	**ContemporaryIssues**	**2 hours**
Industry Expert Lectures		
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Anthony R. West, Solid State Chemistry and its Applications, 2nd Ed., John Wiley & Sons, 2014.
2.	Bradley D. Fahlman, Materials Chemistry, 2nd Ed., Springer, 2011.

Reference Books

1.	Lesley E. Smart and Elaine A. Moore, Solid State Chemistry-An Introduction , 4th Ed., CRC Press, Taylor and Francis Group, 2012.
2.	Richard J. D. Tilley, Understanding Solids: The Science of Materials, 2nd Ed., Wiley, 2013.
3.	Chawla K Krishnan, Composite Materials –Science and Engineering, Springer, 2012.
4.	Robert J. Young and Peter A. Lovell, Introduction to Polymers, 3rd Ed., CRC Press, 2011.

Mode of Evaluation : Written Examinations, Quiz and Assignments

Recommended by Board of Studies	08.03.2016		
Approved by Academic Council	No. 40	**Date**	18.03.2016

Course code	Nanomaterials and Characterization Techniques	L	T	P	J	C
CHY6026		3	0	0	4	4
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. Understanding different types of nanomaterials, syntheses and characterization
2. Applying the knowledge of nanomaterials in science and technology

Expected Course Outcome: student will be able to

1. Define different types of nanomaterials based on dimensionality and structure
2. Propose preparation methods for different nanomaterials
3. Analyse nanomaterials using characterization techniques
4. Explain the structural and chemical properties of carbon based nanomaterials
5. Suggest nanomaterials for specific optical, electronic and energy storage applications
6. Relate structure of nanomaterials with their property

Module:1	Zero-Dimensional Nanostructures	6 hours

Quantum dots and hollow spheres: uniform and heterogeneous particle arrays, core-shell quantum dots and hollow spheres - synthesis and characteristics. LED, solar cell and laser applications.

Module:2	One-Dimensional Nanostructures	6 hours

Carbon nanotubes (CNTs), nanowires and nanofibers: synthesis and characteristics, functionalization of CNTs, role of 1D nanostructure as inter-connects in electronics.

Module:3	Two-Dimensional Nanostructures	6 hours

Thin films, nanosheets and nanodisks: preparation and characteristics, Role of a spin coater in nanoscale film formation, 2D nanostructures as templates.

2. Having a clear understanding of the subject related concepts and of contemporary issues
9. Having problem solving ability- solving social issues and engineering problems
18. Having critical thinking and innovating skills

Module:1	Zero-Dimensional Nanostructures	6 hours

Quantum dots and hollow spheres: uniform and heterogeneous particle arrays, core-shell quantum dots and hollow spheres - synthesis and characteristics. LED, solar cell and laser applications.

Module:3	Two-Dimensional Nanostructures	6 hours

Thin films, nanosheets and nanodisks: preparation and characteristics, Role of a spin coater in nanoscale film formation, 2D nanostructures as templates.

Module:4	Three-Dimensional Nanostructures	6 hours

Dendrites, nanopillers, nanoflowers and Core-shell materials: preparation methods and characteristics, applications as catalysts and electrode material in batteries.

Module:5	Energy Conversion and Storage Materials	6 hours

Fuel cells: Hydrogen storage cells, Piezoelectric materials: principle and working mechanism. Fabrication of a piezoelectric sensor using electrospun nanofiber web.

Module:6	Nanomaterials Characterization – 1	6 hours

Powder X-Ray diffraction- peak broadening and particle size analysis, N_2 adsorption -surface area, pore size analysis, thermal analysis using TGA and DTA.		
Module:7	**Nanomaterials Characterization – 2**	**7 hours**
UV-Vis spectroscopy- surface plasmon resonance, morphology and particle size analysis - SEM, AFM and HR-TEM, Raman spectroscopy – application for carbon nanomaterials.		
Module:8	**Contemporary issues:**	**2 hours**
Industry Expert Lectures		
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	G. Cao and Y. Wang (Ed), Nanostructures and Nanomaterials: Synthesis, Properties, and Applications, 2nd Ed., World Scientific Publishers, 2011.
2.	D. Vollath (Ed), Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd Ed, Wiley VCH, 2013.

Reference Books

1.	J.N. Tiwari et al., 0D, 1D, 2D and 3D nanostructured materials for advanced electrochemical energy devices, Prog. in Mater. Sci., 57, 724, 2012.
2.	S.J. Lee et al., Piezoelectric polymer and piezocapacitive nanoweb based sensors for monitoring vital signals and energy expenditure in smart textiles, J. Fiber Bioeng. Inform. 6, 369, 2013.
3.	Q. Zhang et al., Nanomaterials for energy conversion and storage, Chem. Soc. Rev., 42, 3127, 2013.
4.	L. Persano et al., High performance piezoelectric devices based on aligned arrays of nanofibers of P(VDF- co-TrFE), Nature Commun., 4, 1633, 2013.
5.	S.J. Lee et al., Piezoelectric properties of electrospun poly(L-lactic acid) nanofiber web, Mater. Lett., 148 58, 2015.

Recommended by Board of Studies		08-03-2016	
Approved by Academic Council	No. 59	**Date**	18-03-2016

Course Code	Inorganic Photochemistry	L	T	P	J	C
CHY6027		4	0	0	0	4
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

The course is aimed at

[1] Applying the principles of photochemistry such as photosynthesis, solar energy conversion and medical photochemistry.

[2] Development of devices based on photochemistry for solar energy conversion and medical applications.

Course Outcomes:

At the end of the course the student should be able to

[1] Understand the mechanism of photochemical and photophysical processes.

[2] Apply photophysical processes for versatile applications.

[3] Analyze and interpret photoredox reactions.

[4] Examine and classify photochemical reactions in coordination complexes.

[5] Fabricate solar energy conversion devices.

[6] Design therapeutic techniques based on photochemical principles.

Module:1	Photochemistry	5 hours

Photochemical *Vs* Thermal reactions, Laws of photochemistry, Photophysical mechanism of excited states, Electronic Structure - Types of Excited States and Electronic Transitions - Absorption and Emission Bands - Jablonski Diagram, fluorescence, phosphorescence and delayed fluorescence, photosensitizers, chemiluminecence, bioluminescence internal conversion, intersystem crossing, Types of transitions in inorganic complexes.

Module:2	Binuclear Photophysical Process	9 hours

Quantum yields and experimental determination, numerical problems on quantum efficiency, Quenching of excited states, fluorescence life time, Stern–Volmer Equation, mechanism of quenching - heavy atom quenching, excimer and exciplex.

Module:3	Applications of Photophysical and Photochemical Process	7 hours

Characteristics and inorganic practical applications of fluorescence and phosphorescence, Photochemical Reactivity - Electrochemical Behavior - Polynuclear Metal Complexes, Explanation of incidents - Photosynthesis in plants, Photochemical smog, atmospheric ozone layer, vision by rhodopsin, formation of vitamin D in sunlight, photodegradation of plastics and organic pollutants.

Module:4	Inorganic Photochemistry	8 hours

otoredox reactions of Cobalt(III), models of photoredox systems–radical pair model, photoredox reactions of Iron(III) complexes, photochemistry of metal-carbonyl complexes.

Module:5	Ligand Field Photochemistry	9 hours

Photosubstitution – photoisomerisation, photoracemization, photoaquation, rearrangement reactions Photochemistry of Chromium – photolysis rules – stereochemistry photoisomerisation photoracemization, Photonation, Photoactive excited states, Cobalt(III) complex in photosensitization.

Module:6	Solar Energy Conversion	10 hours

Solar energy conversion – Introduction to three generations of solar cells - photovoltaic p-n junction solar cell - importance of silicon - single crystal, polycrystal and amorphous - Si wafer preparation; Heterojunction – photoelectrochemical- liquid junction solar cell, multiple junction solar cell, dye-sensitized solar cell; Perovskite solar cells.		
Module:7	**Medical Photochemistry**	**10 hours**
Introduction, Cells, Tissues and Light, Historical aspects, importance and applications of Photosensitization, photophysics and photochemistry of PDT, Type I and Type II Mechanism, Singlet oxygen, Generations of PDT, Cancer photodetection, Porphyrin photosensitizers for PDT.		
Module:8	**Contemporary Issues**	**2 hours**
	Industry Expert Lecture	
	Total Lecture hours:	**60 hours**

Text Book(s)

1.Julia A Wienstein, Inorganic photochemistry, Springer, 2013
2.Torn Bitterley, Photochemistry of Transition Metal Complexes, Elsevier, 2011

Reference Books

1.Rachel C Evans, Peter Douglas, Hugh D Buren, Applied photochemistry, Springer, 2013
2.B.J. Palmer, Photochemistry of Inorganic and Organometallic complexes Elsevier, 2012

Mode of Evaluation : Written Examinations, Quiz and Assignments

Recommended by Board of Studies	24.06.2020		
Approved by Academic Council	No.59	**Date**	24-09-2020

Course code	Synthesis of Inorganic Materials Practical II	L	T	P	J	C
CHY6028		0	0	4	0	2
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

1. Impart training in synthesis and chemical analysis of inorganic molecules
2. Expose them to different instrumental methods in chemical analysis of materials

Expected Course Outcome: Student will be able to

1. Understand the principle of complex synthesis
2. Apply the different methods of material synthesis for oxide preparation
3. Evaluate the principle of redox chemistry in intercalation reactions
4. Design a methodology for real time materials preparation and characterization

Experiments

I. Preparation and Analysis of Complexes (UV-Visible, FTIR, λ_{max}) Metal Analysis:	
1. Chloropentaamminecobalt (III) chloride, $[Co(NH_3)_5Cl]Cl_2$	16 hours
2. Tristhioureazinc(II)sulphate, $Zn(SC(NH_3)_2)_3OSO_3$	
3. Potassium bisoxalatocuprate(II)dihydrate, $K_2[Cu(C_2O_4)_2]. 2H_2O$	
4. Molar Conductances of $[Co(NH_3)_6]Cl_3$ and $[Co(NH_3)_5Cl]Cl_2$	
II. Synthesis of Oxides (Phase purity check by powder XRD) :	
5. $CaMnO_3$ by ceramic method	16 hours
6. $BaTiO_3$ by sol-gel method	
7. SnO_2 by precipitation method	
8. Ruby by combustion method	
III. Simple Redox Reactions	
9. Hydrogen intercalation in tungsten trioxide	4 hours
Total Laboratory Hours	**36 hours**

Mode of Evaluation: Continuous Assessment in lab, Viva-Voce & FAT

Recommended by Board of Studies	31-05-2019		
Approved by Academic Council	No.55	**Date**	13-06-2019

Course code	Characterization and Properties Measurements of Inorganic Materials Practical III	L	T	P	J	C
CHY6029		0	0	4	0	2
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. Impart training in synthesis of inorganic material, characterization and chemical analysis
2. Understand importance of different instrumental methods in chemical analysis of materials.

Expected Course Outcome: Student should be able to

1. Understand the principle of powder X-ray diffraction technique.
2. Illustrate the basic concepts of various physical properties
3. Apply powder X-ray diffraction technique for materials analysis
4. Evaluate structure property relationship of materials

Experiments

I	**Applications of powder X-ray diffraction**	
1.	Analysis of XRD data of inorganic material	10 hours
i)	Phase identification	
ii)	Latitce parameters calculation and indexing	
iii)	Theoretical Density calculation from XRD	
2.	Vegard's law verification and crystallite size calculation	10 hours
i)	Verification of Vegard's law	
a	**$Ba_{1-x}Sr_xTiO_3$**	
b	$Ca_{1-x}Sr_xTiO_3$	
ii)	Crystallite size calculation using Scherrer formula	
II	**Physical property measurements**	
3.	Resistivity measurement – Four probe method – Si band gap	28 hours
4.	Determination of magnetic parameters using Hysteresis Loop	
5.	**Photocatalysis (dye degradation)**	
6.	Measurement of dielectric constant	
7.	Oxide Semiconductor band gap – DRS – Tauc's plot	
	Total Laboratory Hours	**48 hours**

Mode of Evaluation: Continuous Assessment in lab, Viva-Voce & FAT

Recommended by Board of Studies	31.05.2019		
Approved by Academic Council	No. 55	**Date**	13.06.2019

Course code	Pharmaceutical Quality Control and Quality Assurance	L	T	P	J	C
CHY6030		4	0	0	0	4
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

- To ascertain the quality of the finished product and finally its validation to facilitate its market launch.
- To gain knowledge about ICH guidelines, i.e., the organization that sets and governs the laws and rules for all the quality tests
- To keep a direct control on the quality of the formulation and assuring the compliance of standards.

Expected Course Outcome:

- Recall the importance and methods of quality assurance in a pharmaceutical industry
- Understand the concept of auditing, quality of auditing, and personal responsibilities involved in quality control of an organization.
- Analyze the documentations associated with manufacturing, master formula, distribution, returned goods and recovered materials.
- Apply the knowledge of the validation process at different levels, including personal, equipment, and regulatory aspects.
- Evaluate the quality of various process and factors influencing the stability of products, and quality of packaging materials.
- Design to give a quality assurance and control process involving documentation, regulatory and other aspects in a pharmaceutical industry

Module:1	Concept and Philosophy	9 hours

Total Quality Management (TQM), Good Laboratory Practice (GLP), Good Manufacturing Practice (GMP)

Module:2	Quality Audit	9 hours

Quality audit, Standard Operating Procedure (SOP), International Conference Harmonization (ICH), ISO-9000, ISO14000, WHO specifications, USFDA guidelines and ICMR.

Module:3	Organization and personnel responsibilities	9 hours

Training, Hygiene, Premises: Location, Design, Plant layout, Construction, Maintenance and Sanitations. Environmental control, Sterile areas, control of contamination.

Module:4	Documentation & Handling	6 hours

Manufacturing documents, Master Formula, batch formula Record, Distribution of records, Handling of returned goods, Recovered materials and Reprocessing.

Module:5	Regulatory aspects of Pharmaceuticals	9 hours

Validation of Personnel, Equipment and Cleaning methods, Regulatory aspects of pharmaceutics New Drug Approval Process: Investigational New Drug (IND), New Drug Applications (NDA) and its approval, Drugs and Cosmetic Act, Patent Regime..

Module:6	Quality process	9 hours

In-process quality control on various dosage forms, Sterile and non- sterile operations. Factors affecting stability of formulations and shelf - life prediction, techniques to determine and improve shelf life.		
Module:7	**Quality control of packaging materials**:	**7 hours**
Types of plastics, primary and secondary packaging materials (glass, closures, cartons, blister and their control)		
Module:8	**Contemporary issues:**	**2 hours**
Industry Expert Lecture		
	Total Lecture hours:	**60 hours**

Text Book(s)	
1.	Quality Assurance of Aseptic Preparation Services: Standards Part A | Fifth edition, Alison M Beaney, Royal Pharmaceutical Society and the NHS Pharmaceutical Quality Assurance Committee,2016.
2.	Manging for quality and performance excellence ninth edition James R.Every, William M.Lindsay South-western Cengage learning 2014.
Reference Books	
1.	Sed mtiazhaider. (2011).Pharmaceutical Master Validation Plan: The Ultimate Guide to FDA
2.	Ira R. Berry, Robert A Nash (2013), Pharmaceutical process validation, 3rd Rev Edition.Marcel Dekker

Mode of evaluation: By assignments, quiz, CAT-1, CAT-2 and FAT			
Recommended by Board of Studies	24.06.2020		
Approved by Academic Council	No. 59	**Date**	24-09-2020

Course code	Introduction to Process Chemistry in Pharmaceutical Industry	L	T	P	J	C
CHY6031		3	0	0	4	4
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

- To gain the knowledge of process chemistry and importance in pharmaceutical industry
- To gain the knowledge of need to have scale up of process in pharmaceutical industry.
- To develop skills to improve the existing methods into cost effective green methods

Expected Course Outcome:

- Recall the importance of process chemistry.
- Understand the role of various solvents and solvent free reactions and its importance in process industry
- Analyze the reaction conditions in the laboratory and its scale up conditions
- Apply their knowledge in industrial safety and In process, including catalyst selection and impurity minimization
- Evaluate the validation of scale up process and finished products
- Design a process scale up process and selection of reactions and tools involved in the purification of finished product.

Module:1	Introductory level of Process Chemistry	6 hours

Introduction to process chemistry approaches to process development, Principle of process development, Route Selection, expedient and cost effective routes, Reagent selection, solvent selection, alternatives to solvents, Water as as a solvent. Various examples of reactions regularly performed in process chemistry lab.

Module:2	Selection of Solvents and solvent free reactions	6 hours

Running the reaction, assessing operating conditions for the laboratory, reaction scale selection, selection of reaction conditions, Example of various name reaction and their selection is process chemistry lab.

Module:3	Selection of Reactions	6 hours

Running the reaction, assessing operating conditions for the laboratory, reaction scale selection, selection of reaction conditions

Module:4	Industrial Safety Studies	6 hours

Purification of products; tools and techniques - crystallization and reslurrying, final product form, polymorphs.
Validation of finished products, Various purification techniques – Solvent washing, HPLC (use of chiral column), Column Chromatography, Plate layer Column chromatography

Module:5	In Process Control (IPC)	6 hours

In process control (IPC) - importance, selection of IPC, Reproducible IPC, optimization by minimizing impurities, optimization of catalytic reaction, work up of reaction.

Module:6	Purification Tools and Identification Techniques	6 hours

Purification of products; tools and techniques – crystallization, chromatographic separation, reslurrying, final product form, polymorphs, Identification of Finished product by instrumental techniques.		
Module:7	**Scale Up Process and validation of Finished products**	**7 hours**
Batch reactions, Continuous and Semi-continuous reactions, Continuous reactors to scale up of the process- Static mixers, plug floe reactors, microwave reactors, Sonochemical reactors. Validation as per ICH, EMEA and FDA guidelines		
Module:8	**Contemporary issues**	**2 hours**
Industry Expert Lectures/ Industrial visit		
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Neal G. Anderson (2012), Practical Process research and Development, 2nd Edition, Academic Press Douglas A Skoog, Donald M West, F James Holler, Stanley R.Crouch, Fundamentals of Analytical Chemistry, Wadsworth Publishing Co Inc., 9th Edition, 2012.

Reference Books

1.	Douglas S. Johnson, Jie Jack Li (2013), The Art of Drug Synthesis, John Wiley and Sons.
2	Peter J. Dunn, Andrew Wells, Michael T. Williams (2010), Green Chemistry in the Pharmaceutical Industry John Wiley & Sons.

Recommended by Board of Studies	24.06.2020		
Approved by Academic Council	No. 59	**Date**	24-09-2020

Course code	Pharmacognosy and Phytochemistry	L	T	P	J	C
CHY6032		3	0	0	4	4
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

- To develop thorough knowledge of natural products with its biological functions and pharmacological uses.
- To develop knowledge on primary and secondary metabolites and their sources
- To understand the concepts of isolation methods and separation of bioactive compounds.
- To provide the knowledge of pharmacognostical analysis of the bioactive compounds

Course Outcomes (CO):

1. Recall the sources of natural medicines and analysis of crude drugs.
2. Understand the methods of evaluation based on various parameters.
3. Analyze the isolated drugs as per ICH guidelines.
4. Apply various techniques to discover new alternative medicines.
5. Evaluate the isolated drugs for various pharmacological activities.
6. Design and synthesize new drugs based on the knowledge acquired on the natural/isolated drugs.

Module:1	Pharmacognosy	6 hours

Introduction, definition, history, scope, development and classification; Source of Drugs: Biological, marine, mineral and plant tissue cultures as source of drug. Scheme of pharmacognostic studies of a crude drug. Biosynthesis: Shikimic acid pathway and acetate pathway. Systematic analysis of Crude drugs.

Module:2	Standardization of Herbal drugs	6 hours

WHO guidelines, Sampling of crude drug, Methods of drug evaluation. Determination of foreign matter, moisture, LOD, Ash value. Extractable values, Determination of swelling index, foaming index and their significance. Phytochemical investigations : General chemical tests

Module:3	Extraction Techniques	6 hours

General methods of extraction, types – maceration, Decoction, percolation, Immersion and soxhlet extraction. Advanced techniques- counter current, steam distillation, supercritical gases, sonication, microwaves assisted extraction. Factors affecting the choice of extraction process

Module:4	Drugs containing Terpenoids and volatile oils	6 hours

Terpenoids: Classification, Isoprene rule, Isolation and separation techniques, General properties Camphor, Menthol, Eucalyptol. Volatile Oils or Essential Oils: Method of Preparations, Classifications of Volatile oils, Camphor oil, Geranium oil, Citral- Structure, uses. Pentacyclic triterpenoids: amyrines; taraxasterol: Structure and pharmacological applications.

Module:5	Drugs containing alkaloids	5 hours

Occurrence, function of alkaloids in plants, Pharmaceutical applications. Isolation Qualitative tests and general properties .General methods of structural elucidation. Morphine, Reserpine, Papaverine- structure, chemical properties and uses.

Module:6	Plant glycosides	9 hours

Glycosides: Basic ring system, classification, isolation, properties, qualitative analysis.

Pharmacological activity of Senna glycosides, Cardiac glycosides-Digoxin, digitoxin, strophanthidi Steroidal saponins glycosides- Diosgenin, hecogenin. **Plant pigments:** Occurrence, nomenclature, and general methods of structure determination, isolation and synthesis of quercetin and cyanidin		
Module:7	**Marine drugs**	**5 hours**
Selected Drug Molecules: Cardiovascular active substances, Cytotoxic compounds, Antimicrobial compounds, Antibiotic compounds, Anti-inflammatory agents. Marine toxins.		
Module:8	**Contemporary issues**	**2 hours**
Industry Expert Lectures		
	Total Lecture hours:	**45 hours**
Text Book(s)		
1. Gurdeep R Chatwal (2016), Organic chemistry of Natural products, Volume I&II, 5th edition, Himalaya publishing House. 2. S.V.Bhat, B.A. Nagasampagi, M.Sivakumar (2014), Chemistry of Natural Products, Revised edition, Narosa Publishers.		
Reference Books		
1. Jeffrey B. Harborne (2012), Phytochemical methods: A Guide to Modern Techniques of Plant Analysis, 4th edition, Indian reprint, Springer. 2. Ashutoshkar (2007), Pharmacognosy and Pharmacobiotechnology, 2nd edition, New age international (P) limited, New Delhi.		
Mode of evaluation: Assignment, CAT 1, CAT 2 and FAT		
Recommended by Board of Studies	24-06-2020	
Approved by Academic Council	No. 59	**Date** 24-09-2020

Course code	Medicinal Chemistry	L	T	P	J	C
CHY6033		3	0	0	0	3
Pre-requisite		Syllabus version				
None						

Course Objectives:

1. To show the chemistry behind the development and activity of pharmaceutical materials.
2. Students should gain the knowledge of mechanism of action and adverse effects of drugs
3. To understand the need of proper usage of antibiotics and adverse effects of erratic usage

Expected Course Outcome: Students should be able to

1. Predict a drugs properties based on its structure
2. Describe the factors that affect its absorption, distribution, metabolism, and excretion, and hence the considerations to be made in drug design.
3. Explain the relationship between drug's chemical structure and its therapeutic properties
4. Designed to give the knowledge of different theories of drug actions at molecular level and also to identify different targets for the development of new drugs for the treatment of infectious and GIT

Module:1	Introduction to receptors	6 hours

Introduction, targets, Agonist, antagonist, partial agonist.Receptors, Receptor types, Theories of Drug – receptor interaction, Drug synergism, Drug resistance, physicochemical factors influencing drug action. Isosterism and bioisosterism

Module:2	Antibiotics	9 hours

Introduction, Targets of antibiotics action, classification of antibiotics, enzyme-based mechanism of action, SAR of penicllins and tetracyclins, clinical application of penicillins, cephalosporin, Beta lactamase inhibitors, tetracyclines, Current trends in antibiotic therapy.

Module:3	Antihypertensive agents and diuretics	6 hours

Classification of cardiovascular agents, introduction to hypertension, etiology, types, classification of antihypertensive agents, classification and mechanism of action of diuretics, Furosemide, Hydrochlorothiazide, Amiloride.

Module:4	Drugs for Tuberculosis	5 hours

Classification, mechanism of action of drugs employed for the treatment of Tuberculosis Current treatment strategy for tuberculosis.

Module:5	Analgesics, Antipyretics and Anti-inflammatory Drugs	6 hours

Introduction, Mechanism of inflammation, classification and mechanism of action of NSAIDs and SAR of paracetamol, Ibuprofen, Diclofenac, naproxen, indomethacin, phenylbutazone and meperidine

Module:6	Medicinal Chemistry of Antidiabetic Agents	6 hours

Introduction, Types of diabetics, Drugs used for the treatment, chemical classification, SAR, Mechanism of action, Study the treatment strategy of diabetic mellitus. Chemistry of insulin, sulfonyl ureas		
Module:7	**Drugs for malaria**	**5 hours**
Classification, mechanism of action of drugs employed for the treatment of malaria.. Current treatment strategy for malaria.		
Module:8	**Contemporary issues:**	**2 hours**
Industry Expert Lectures		
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Wilson and Gisvold's textbook of organic medicinal and pharmaceutical chemistry, Wilson, Charles Owens,;Beale, John Marlowe ;Block, John H, Lipincott William, 12th edition, 2011.
2	An Introduction to Medicinal Chemistry - Graham L. Patrick , 5th edition, Oxford University Press, 2013.
Reference Books	
1.	Foye's Princles of Medicinal Chemistry, Lipincott Williams, Seventh Edition, 2012
2.	Burger's Medicinal Chemistry, Drug Discovery and Development, Donald J. Abraham, David P. Rotella, Alfred Burger, Academic press, 2010.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	24-06-2020		
Approved by Academic Council	No.59	**Date**	24-09-2020

Course code	Medicinal Chemistry Practical	L	T	P	J	C
CHY6034		0	0	4	0	2
						Syllabus version
						1.0

Course Objectives:

The course is aimed at

[1] Acquiring hands on training in synthesis of some drug molecules and estimation of certain parameters related to drug designing.

Course Outcomes:

At the end of the course, the student should be able to

[1] Understand the practical aspects of drug synthesis.

[2] Learn the skill to synthesize and purify the drug molecules.

[3] Assess the quality of the commercial product as per standard procedures like ICH guidelines.

[4] Learn the analytical techniques to estimate various parameters related to drug designing

List of Experiments (Indicative)		
1.	Synthesis of medicinally active compounds (Any two) from the following given compounds- Phenytoin, Benzocaine, Barbituric acid and Phenothiazine.	
2.	Synthesis of medicinally active compound; **Phenytoin** from benzoin- Step One: Benzoin to Benzil	4 hours
3.	Synthesis of medicinally active compound: **Phenytoin** Step Two: Benzil to Phenytoin Purification by column, crystallization, Characterization by spectroscopic methods	4 hours
4.	Synthesis of medicinally active compounds – **Benzocaine** Step One: p-nitro benzoic acid to p-amino benzoic acid	4 hours
5.	Synthesis of medicinally active compounds – **Benzocaine** Step Two: p-amino benzoic acid to Benzocaine Purification by column, crystallization, Characterization by spectroscopic methods	4 hours
6.	Quantification of active substance in commercial products: Assay of Isoniazid Tablets IP	4 hours
7.	Quantification of active substance in commercial products: Assay of Paracetamol Tablets IP	4 hours
8.	Quantification of active substance in commercial products: Assay of Aspirin Tablets IP	4 hours
9.	Quantification of active substance in commercial products- Assay of Sulphanilamide Tablets IP	4 hours
10.	Quantification of active substance in commercial products- Assay of Chloramphenichol Capsules IP	4 hours
11.	Substituent effects of groups in medicinally active molecules	4 hours
12.	In vitro antioxidant studies by hydrogen peroxide method	4 hours
	Total Laboratory Hours	**44 hours**

Mode of evaluation : By continuous assessment and FAT

Recommended by Board of Studies		Yes / 24-06-2020	
Approved by Academic Council	No. 59	**Date**	24-09-2020

Course code	Pharmacognosy and Phytochemistry Practical	L	T	P	J	C
CHY6035		0	0	4	0	2
Pre-Requisite		Syllabus version				
None		1.0				

Course Outcomes:

1. Understand the composition and importance of phytoconstituents.
2. Learn the skill of extraction and isolation of phytoconstituents
3. Assess the purity of the extracted or isolated phytoconstituents.
4. Learn the analytical techniques to estimate various parameters of isolated drugs and check the standards as per ICH guidelines.

List of Experiments (Indicative)		
	Extraction, Isolation and Characterization (UV/IR/NMR/MS) of the following the phytoconstituents from the Natural products	
1.	Starch from Potatoes	4 hours
2.	Caffeine from Tea Leaves/Tea Dust Powder	4 hours
3.	Lycopene from Tomato	4 hours
4.	Calcium Citrate and Citric acid from Lemon	4 hours
5.	Lawsone from Henna Powder/Leaves	4 hours
6.	Curcumin from Turmeric Powder	4 hours
7.	Extraction and detection of volatile oils by Clevenger's Method (Hydro-distillation method).	4 hours
8.	Determination of Extractive Values of some crude Drugs.	4 hours
9.	Estimation of Caffeine from Tea by Spectrophotometric/HPTLC Method	4 hours
10.	Determination of Saponification and Acid value of the Fat and Oils by taking any real sample	4 hours
11.	Estimation of Ascorbic acid from Citrus Fruits (Vitamin C)	4 hours
	Total Laboratory Hours	**44 hours**

Mode of evaluation : By continuous assessment and FAT

Recommended by Board of Studies		Yes / 24-06-2020	
Approved by Academic Council	No. 59	**Date**	24-09-2020

Course code	Advanced Physical Chemistry	L	T	P	J	C
CHY 6036		4	0	0	0	4
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

The course is aimed at

[1] Enhancing the understanding thermodynamics of chemical Equilibrium and monitoring of kinetics of fast reactions and follow electrode kinetics.

[2] Enriching the understanding of photoinduced electron transfer and photocatalytic reactions.

[3] Understanding the principles and applications statistical thermodynamics

[4] Getting insight into electric properties of molecules and interaction between molecules.

Course Outcomes:

At the end of the course the student should be able to

[1] Evaluate the thermodynamics of equilibrium and relation between equilibrium and temperature and pressure.

[2] Analyze the kinetics of fast reactions using various instrumentation techniques.

[3] Apply theories in electrochemistry to analyze electrode kinetics through Butler-Volmer and Tafel equations.

[4] Evaluate photoinduced electron transfer and analyze photocatalytic reactions including hydrogen generation reactions.

[5] Derive the most probable distributions of a system among the energy levels using the principles of statistical thermodynamics for the most probable distribution of particles.

[6] Understand Boltzmann, Bose-Einstein and Fermi-Dirac statistics and evaluate different Partition functions for diatomic molecules.

[7] Analyze the electric properties of molecules and evaluate different types of interactions Between Molecules.

Module:1	Chemical Equilibrium	10 hours

Spontaneous chemical reactions: The Gibb's energy minimum – a) reaction Gibbs energy, b) Exergonicand endergonic reactions; Description of equilibrium – a) Perfect gas equilibria, b) The general case of a reaction, c) calculation of equilibrium constant, d) The relation between equilibrium constants, e) Molecular interpretation of the equilibrium constant, f) Equilibria in biological systems;

Response of equilibria to conditions: Change in equilibria with changes in pressure, temperature; Value of equilibrium constant at different temperatures.

Module:2	Chemical Kinetics-II	6 hours

Study of kinetics of fast reactions-stopped flow technique, relaxation method, process instrumentation, methodologies and applications;

Module:3	Electrochemistry-II	6 hours

Electrical Double layer: Theories of Double-Layer structure, diffuse-double-layer theory of Gouy and Chapman, the Stern Model; electrode kinetics-derivation of the fundamental equation of electrode kinetics. Butler-Volmer equation-low field and high field approximations-Tafel equation.

Module:4	Photophysical Chemistry II	10 hours

Photoinduced electron transfer: Reaction rates, free energy dependence of electron transfer on rate, Photoinduced energy transfer - FRET, rate and efficiency calculation of FRET - Absorption of light and nature of electronic spectra. Semiconductor as photo catalysts in photolysis reactions: Generation of hydrogen by photo catalysts - photo catalytic break down of water and harnessing solar energy - photocatalytic degradation of dyes - environmental applications.		
Module:5	**Statistical Thermodynamics I**	**8 hours**
Concepts of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical and microcanonical ensembles.		
Module:6	**Statistical Thermodynamics II**	**8 hours**
Thermodynamics and entropy, Maxwell – Boltzmann, Bose – Einstein and Fermi – Dirac statistics, partition function - rotational, translational, vibrational and electronic partition functions for diatomic molecules. Heat capacity of solids.		
Module:7	**Molecular Interactions**	**10 hours**
Electric Properties of molecules - Electric dipole moments, Polarizabilities, Polarization, Relative permittivities; Interactions between molecules: Interactions between dipoles – a) Potential energy interaction, b)Dipole-dipole interaction, c) Dipole–induced-dipole interactions, d) Induced-dipole–induced-dipole interactions, e)hydrogen bonding, f) hydrophobic interaction g) Repulsive and total interactions.		
Module:8	**Contemporary issues:**	**2 hours**
Industry Expert Lecture		
	Total Lecture hours:	**60 hours**
Text Book(s)		
1.P. W. Atkins and Julio de Paula, Atkins' Physical Chemistry, 2018, International 11th Edition, Oxford University Press, United Kingdom. 2. B. R. Puri, L. R. Sharma, M. S. Pathania, principles of physical chemistry, 47th Edition, Vishal Publishing Co., 2017. 3. Allen J. Bard and Larry R. Faulkner, Electrochemical Methods: Fundamentals and Applications, John Wiley and Sons Inc. 2001.		
Reference Books		
1. N. Levine, Physical Chemistry, 6th Edition, McGraw Hill, New York, 2011. 2. K. J. Laidler, Chemical Kinetics, 3rd Edition, Harper & Row, New York, 2013.		
Mode of evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		
Recommended by Board of Studies	Yes, 24-06-2020	
Approved by Academic Council	No. 59	**Date** 24-09-2020

Course code	Analytical and Physical Chemistry Practical II	L	T	P	J	C
CHY6039		0	0	4	0	2
Pre-requisite		Syllabus version				
None		1.2				

Course Objectives:

Analyze various chemical constituents using different instruments

Expected Course Outcome: Students will be able

1. Apply standard addition method in titrimetric analysis
2. Design experiments for analysis of inorganic and organic materials
3. Analyze constituents in materials using emission and absorption techniques
4. Apply electrochemical methods for Analysis of electroactive species

Experiments		
1.	Standard addition method for estimation of Ascorbic acid in fruit juice	4 hours
2.	Estimation of chromium in steel sample by spectrophotometry	4 hours
3.	Determination of sodium carbonate in washing soda by pH titration	4 hours
4.	Determination of Indicator constant by spectrophotometry	4 hours
5.	Determination of dissociation constant (K_a) of weak electrolyte and verification of Debye-Huckel Onsager equation using strong electrolyte	4 hours
6.	Estimation of sulphide in effluent using potentiometric titration	4 hours
7.	Determination of Stern-Volmer constant of Iodine quenching by Fluorimetry	4 hours
8.	Cyclic Voltammetry	4 hours
9.	Determination of ascorbic acid in real samples using Differential Pulse Voltammetry and comparing with specifications	4 hours
10.	Determination of protein concentration using Bradford's method	4 hours
	Total Laboratory Hours	**40 hours**

Mode of Evaluation: Continuous Assessment in lab, Viva-Voce & FAT

Recommended by Board of Studies		31.05.2019	
Approved by Academic Council	No. 55	**Date**	13.6.2019

Course Code	Group Theory and Molecular Spectroscopy	L	T	P	J	C
		3	0	0	0	3
CHY6040		Syllabus Version				
Prerequisite		1.1				
None						

Course Objectives:

The course is aimed at

[1] Applying practical aspects of quantum chemistry, spectroscopy, symmetry and group theory in different research problems.

[2] Understanding the theories behind the interpretation of rotational, vibrational and electronic spectra of molecules.

[3] Get insight into physical aspects of NMR spectroscopy.

Course Outcomes:

At the end of the course the students will be able to

[1] Remember the concepts of symmetry and symmetry operations in molecules.

[2] Explore the applications of group theory in molecular spectroscopy.

[3] Understand the practical implementation of quantum chemistry in spectroscopy.

[4] Apply the quantum chemistry, group theory and molecular spectroscopy to solve real world problems.

[5] Understand the basic physical aspects of NMR spectroscopy.

Module 1	Fundamentals of Group Theory	6 hours

Symmetry elements and symmetry operations-group multiplication table-subgroups, similarity transformations and classes- identifications of symmetry operations and determination of point groups-reducible and irreducible representations-Mullikan symbols.

Module 2	Applications of Group Theory	7 hours

Orthogonality theorem and its consequences - construction of character table for linear (CO_2, HCl, N_2) and non-linear molecules (H_2O, CH_4, XeF_4, BF_3, SF_6 and NH_3). Determination of representations of vibrational modes in linear and non-linear molecules.

Symmetry adapted linear combinations, symmetry aspects of MO theory, sigma- and pi-bonding in AB4 (tetrahedral) molecule.

Symmetry selection rules of infra-red and Raman spectra - application of group theory for the electronic spectra of ethylene and formaldehyde.

Module 3	Fundamentals of molecular spectroscopy	6 hours

The basis of absorption and emission of radiation by molecular species, the wave properties of the light, the quantumtheory of light, quantum theory of matter, molecular energies and the Born Oppenheimer approximation, the types of molecular motion and spectroscopy associated with each.

Module 4	Rotational Spectroscopy	6 hours

Classical description of molecular rotation, quantum mechanics of molecular motion, rotational spectra, determination of the bond length from rotational constants, vibrational stretching and vibrational satellites, no-rigid rotor, centrifugal distortion, degeneracies and intensities, Stark effect, selection rules, rotational spectra of polyatomic molecules.

Module 5	Vibrational Spectroscopy	6 hours

Interaction of Electromagnetic radiation with matter - The Vibrating Diatomic Molecule - harmonic and anharmonic oscillators- Diatomic Vibrating Rotator - Vibrations of polyatomic molecules-Molecular vibrations, types of molecular vibrations. Fundamentals, overtones, combination bands and fermi resonance. Application of IR in organic chemistry - characteristic group frequencies – CO stretching frequencies in metal carbonyls. Finger print region.

Module 6	**Electronic Spectra of Molecules**	**6 hours**

The Born-Oppenheimer Approximation, Vibrational Coarse structure: Progressions, Intensity of vibrational-Electronic spectra: Franck-Condon Principle, Dissociation Energy, Dissociation Products and Predissociation.

The Woodward Fisher rules – calculation of λmax for dienes, enones and polyenes – Use of UV spectroscopy in distinguishing geometrical isomers. Effect of solvents on spectra- solvatochromism. Applications of electronic spectra.

Module 7	**Magnetic resonance spectroscopy**	**6 hours**

Nuclear Spin Origins, Spin and Magnetic Properties, Nuclear Spin Angular Momentum and Quantum Numbers, Magnetic Moment of a Nucleus
Nuclear Energy Levels in a Magnetic Field, Classical Description of the NMR Experiment and the principle, Experimental Verification of Quantized Angular Momentum and of the Resonance Equation, Types of NMR spectroscopy, applications.

Module 8	**Contemporary Issues:**	**2 hours**

Industry Expert Lecture

Total lecture hours **45 hours**

Text books

1. Colin N Banwell, Elaine M. McCash, *Fundamentals of Molecular Spectroscopy*, Tata McGraw – Hill Publishing Co. Ltd., 5th Edition, 2013.
2. P. W. Atkins and Julio de Paula, *Atkins' Physical Chemistry,* 2018, International 11th Edition, Oxford University Press, United Kingdom.
3. Understanding NMR Spectroscopy, James Keeler, Wiley India Pvt Ltd; Second edition, 2013.
4. F.A. Cotton, *Chemical Applications of Group Theory*, 3rd Edition, Wiley India Edition, 2009.

Reference books

1. D. A. McQuarrie, *Quantum Chemistry*, 2nd Edition, University Science Books, 2008.
1. Hollas J. Michael Hollas, *Modern Spectroscopy*, John Wiley & Sons Inc. 4th Edition, 2003.
2. A.K. Chandra, *Introduction to Quantum Chemistry*, Tata Mc Graw Hill Publishing Company, New Delhi, 4th Edition, 2009.
3. P. S. Kalsi, *Spectroscopy of Organic Compounds*, 6th Edition. New Age International Publishers, 6th Edition, 2006.
4. F. Hammer, *Inorganic Spectroscopy and Related Topics*, Sarup & Sons, 1st Edition, 2008.
5. P. K Bhattacharya, *Group theory and its applications*, 3rd Edition, Himalaya Publishing House, 2007.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Recommended by Board of Studies		Yes, 24-06-2020	
Approved by Academic Council	No. 59	**Date**	24-09-2020

University Elective

Course code	NMR, EPR and Mass Spectrometry	L	T	P	J	C
CHY6001		3	0	0	0	3
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. To understand and familiarize with the basic principles, theory and instrumentation of ^{1}H NMR, ^{13}C NMR, 2D NMR, solid state, EPR and Mass spectrometry.
2. To impart knowledge in the theory and applications of these spectroscopic techniques which are very important characterization techniques to understand the structure of the molecules in chemistry.

Expected Course Outcome: student will be able to

1. Students will be skilled in the interpreting the one, two-dimensional NMR spectroscopy, EPR and Mass spectroscopy to derive the information regarding the structure, stereochemistry of the molecules.
2. Students will apply the learned fundamental instrumental techniques in the physical characterization of organic molecules

Module:1	Proton NMR	6 hours

Introduction, Instrumentation: Continuous wave method, Frequency sweep method, pulse technique- Rotating frame of reference-FT NMR-Chemically equivalent and non-equivalent protons- variable temperature spectra-first order spectra, second order spectra-simplification of complex spectra- NOE effects-shift reagents. chemical shift-relaxation processes-spin-spin coupling-coupling constant-the effect of proton exchange reactions- variable temperature spectra-first order spectra, second order spectra-simplification of complex spectra- NOE effects-shift reagents.

Module:2	^{13}C NMR	5 hours

History-and Problem areas-theory and experiment-sensitivity-Instrumentation – FT-NMR- Pulse technique-Behavior of magnetization subjected to RF pulse-

Module:3	^{13}C NMR applications	9 hours

Relaxations: spin-lattice and dipole-dipole relaxation and other relaxations - coupling constants-theoretical aspects of nuclear shielding such as local diamagnetic shielding, neighbour anisotropy shielding, local paramagnetic shielding, the factors affecting the Chemical shift-Coupling constants: ^{1}H &^{13}C, ^{13}C &^{13}C and coupling with other nuclei-^{1}H decoupling and decoupling methods-empirical relationships and empirical additivity rules- chemical shift reagents, solvent effect-chemical shift and structure elucidations. DEPT methods.

Module:4	Applications of two dimensional NMR	6 hours

Introduction and applications of 2D NMR techniques such as H, H-COSY, C, H-COSY, DQF-COSY, MQF-COSY, TOCSY, NOESY, ROESY, HSQC to small molecules.

Module:5	Solid state NMR	5 hours

Introduction-Origin-Basic principles and methods of high-resolution NMR of solids- Magic angle spinning- Interactions in the solid state-MAS-CP method and its advantages.

Module:6	**Mass spectrometry**	**8 hours**
Introduction- Instrumentation-Advanced Ionization techniques such as, ESI, FAB, MALDI, Field desorption-mass analyzers such as Quadrupole Analyzer, ion trap, Time-of -flight Analyzer- Applications of mass spectra to elucidate molecular formula and structure.		
Module:7	**ESR Basic Principles and Applications**	**4 hours**
Electronic zeeman effect – ESR spectrum of hydrogen atom (first order treatment) - g factors – Hyperfine constants – interactions affecting the energies of unpaired electrons in the transition metal ion complexes – zero field splitting – Kramer's degeneracy – anisotropy in the hyperfine coupling constant – nuclear quadrupole interactions - ESR of organic radicals in solution – McConnell's relation – ESR instrumentation.		
Module:8	**Contemporary issues:**	**2 hours**
Industry Expert Lecture		
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Understanding NMR Spectroscopy, James Keeler, Wiley India Pvt Ltd; Second edition, 2013.
2. Organic Spectroscopy through Solved Problems, Kali Shankar Mukherjee Bodhisattwa Mukhopadhyay, First Edition, 2013.
3. Organic Spectroscopy Principles, Problems and Their Solutions, Jaggdamba Singh and Jaya Singh, A Pragadhi Edition, 2016
4. Elementary Organic Spectroscopy, Principles and Chemical Applications, S.Chand and Company, Fifth Revised Edition, 2013
5. Introduction to Magnetic Resonance Spectroscopy Esr, NMR, Nqr, D. N. Sathyanarayana , I K International Publishing House Pvt. Ltd; 2nd edition, 2013.

Reference Books

1. Spectroscopy of Organic Compounds by P. S. Kalsi, New Age international Publishers,17th edition, 2016.
2. Spectrometric Identification of Organic Compounds, Robert M. Silverstein, Francis X. Webster, David J. Kiemle, David L. Bryce, Wiley, 8th Edition, 2015.
3. Principles of NMR Spectroscopy, David Goldenberg, University Science Books; 4 edition, 2016

Mode of Evaluation : Written Examinations, Quiz and Assignments

Recommended by Board of Studies	08-03-2016		
Approved by Academic Council	No. 40	**Date**	18-03-2016

Course code	Bioorganic Chemistry	L	T	P	J	C
CHY6002		3	0	0	0	3
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. Students should be able to understand concepts of classifications of enzymes and its functions
2. Students will be aware of synthesis and structure of nucleic acids, protein and enzymes
3. Students will be familiarized with basic concepts of bioorganic chemistry and bio chemical models and its applications in organic synthesis and industry applications.
4. To fill the bridges the gap between academia and industry

Expected Course Outcome: student will be able to

1. Aware different aspects of drug design, drug action and understand the basics of bioorganic chemistry and medicinal chemistry.

Module:1	Biocatalysts in organic synthesis	6 hours

Enzyme, Properties and Nomenclature, Classification of enzymes, pros and cons of biocatalyst, Mechanistic Aspects, Coenzymes, Enzyme Sources, Immobilized enzymes, comparisons between the homo and heterogeneous biocatalysts

Module:2	Organic transformations using biocatalysts-I	6 hours

Organic transformations using biocatalysts: Hydrolysis of esters, amides, phosphates epoxides, nitriles- Oxidations of alcohols, aldehydes, Sulfoxidation, Baeyer-Villiger oxidation, Dihydroxylation of Aromatic Compounds

Module:3	Organic transformations using biocatalysts-II	6 hours

Reduction of C=C, aldehydes, ketones- Formation of C-C bond (eg. Aldol, Acyloin, Benzoin, Machael)-Addition and Elimination Reactions by biocatalysts: Cyanohydrin Formation, Addition of Water and Ammonia - Group Transfer Reactions (eg. glycosyl and amino transfer) - Halogenation and De-halogenation reactions,

Module:4	Enzymes in Organic synthesis	5 hours

Synthesis of esters, Lactones, amides, peptides, peracid, Medium engineering

Module:5	Basics of concepts in Bioorganic Chemistry	5 hours

Basic considerations, proximity effects in organic chemistry, molecular adaptation- Bio-isosterism, molecular recognition at the supra molecular level.

Module:6	Developments in crown ether chemistry-I	8 hours

Developments in crown ether chemistry- Aza crown ethers-Lariat , Lariat pivot, Bi cyclic, tri cyclic(monoaza, bi-aza, tri-aza), pH regulation and ion-selectivity. Host-Guest complexation chemistry, membrane chemistry-micelles. Bis and Photo responsive crown ethers. Regulation of membrane transport phenomenon.

Module:7	Developments in crown ether chemistry-II	7 hours

Cyclodextrines, enzyme design using steroid template, Remote functionalization, biomemetic polyene

cyclisation. Chemical mutations and site directed mutagenesis. Chemical mutations and semi synthetic enzymes- Molecular recognition and drug design.			
Module:8	**Contemporary issues:**		**2 hours**
Lecture by Industry Experts			
	Total Lecture hours:	**45 hours**	
Text Book(s)			
1. Kurt Faber, Bio-transformations in Organic Chemistry, 7th Edition, Springer 2. An Introduction to Medicinal Chemistry- Vth Edition Graham L Patrick (Qxford 2013) 3. Burger's Medicinal Chemistry & Drug discovery, Vol 1-3, 15th Ed, 2014. 4. P. S. Kasi and J. P. Kalsi, Bioorganic, Bioinorganic and Supramolecular Chemistry, New Age Publications 3rdEdition 2017			
Reference Books			
1. John E. McMurry and Tadhg P. Begley, The Organic Chemistry of Biological Pathways, 2nd Editions, ISBN-10: 193622156X: ISBN-13: 978-1936221561). 2. Bio-organic Chemistry, Harish Kumar and Parmjit S. Panesar, published by Narosa Publishing House Pvt. Ltd., New Delhi, [2012]. 3. Foye's Principles of Medicinal Chemistry, by David A. Williams PhD, 7th Edition, 2012 4. Biocatalysts: An Industrial Perspective, Print ISBN:978-1-78262-619-0, 2017, RSC Publishers.			
Recommended by Board of Studies	08-03-16		
Approved by Academic Council	No. 40	**Date**	18-03-16

Course code	Chemistry of Natural Products	L	T	P	J	C
CHY6003		3	0	0	0	3
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. To develop thorough knowledge of natural products relating with its synthesis, properties, medicinal applications and their metabolic activities and biological functions. Become familiar with steroids and its functions with special reference to its biological functions.
2. To understand the chemistry aspects of alkaloids and their sources and also related to methods of isolation and separation of bioactive compounds, synthesis and classification of terpenoids, biosynthesis of sesquiterpenoids - their importance.

Expected Course Outcome: Students will be able to

1. Understand the chemistry, degradation, synthesis and biosynthesis of natural products like steroids, alkaloids, terpenoids, flavonoids and pigments.

Module:1	**Steroids**	**5 hours**
Classification, general structural elucidation and identification tests- Synthesis, structural elucidation, stereo chemistry and conformational aspects of cholesterol.		
Module:2	**Synthesis of Steroids**	**5 hours**
Synthesis and structural elucidation of oestrone. Conversion of cholesterol into androsterone, testosterone, progesterone and bile acids.		
Module:3	**Alkaloids**	**9 hours**
Classification, general structural elucidation and identification tests-Structural elucidation and chemistry of the following alkaloids: quinine, morphine, reserpine, mosembrine.		
Module:4	**Terpenoids**	**5 hours**
Classification, mevalonic lactose, structural elucidation and synthesis of bisabolene, longifolene and caryophyllene.		
Module:5	**Flavanoids** and **Pigments**	**9 hours**
Anthocyanins and anthocyanidines, general methods of synthesis. Synthesis and structure of flavonols, isoflavonols, isoflavones Introduction to pigments, classification, isolation and synthesis of apigenin, quercetin, diadzein, cyanidin and cyanin		
Module:6	**Vitamins**	**5 hours**
Chemistry and synthesis of Vitamin B complexes, Vitamin C and Vitamin D		
Module:7	**Carbohydrates**	**5 hours**
Pyranose and furanose forms of aldohexose and ketohexose – methods used for the determination of ring size - conformation of aldohexopyranose – structure and synthesis of maltose, lactose, sucrose and cellobiose – A brief study of starch and cellulose.		
Module:8	**Contemporary issues:**	**2 hours**
Industry Expert Lectures		
	Total Lecture hours:	**45 hours**

Text Book(s)			
1. Natural Products in the Chemical Industry. By Bernd Schaefer. Springer: New York, 2014, 2nd ed., p. 1-831, ISBN 978-3-642-54461-3. I. L. Finar, Organic Chemistry, Vol II, Stereochemistry and the Chemistry of Natural Products Fifth Edition, Pearson 2009.			
Reference Books			
1. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part-A and B, Fifth Edition, Springer, Revised 2008. 2. Michael Harmate, Strategies and Tactics in Organic Synthesis, First Edition, Elsevier, 2013. 3. O. P. Aggarwal, Organic Chemistry Natural Products, Volume II, Thirty Eight Edition, Krishna Prakashan Media (P) Ltd, 2014. 4. Medicinal Natural Products by P. M. Dewick, Third Edition, John Wiley, 2011. 5. Chemistry of Natural Products, Sujata V. Bhat, Bhimsen A. Nagasampagi, Meenakshi Sivakumar, Narosa Publishing House, 2013.			
Recommended by Board of Studies		08-03-2016	
Approved by Academic Council	No. 40	**Date**	18-03-2016

Course code	Green Chemistry	L	T	P	J	C
CHY6004		3	0	0	0	3
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. To provide various methodologies used in organic synthesis, which enable the student to think different possible ways to synthesis an organic compound in an ecofriendly way.
2. To get an idea of greener methodologies using ultrasound and microwave methodologies.
3. To know the solvent less and aquatic phase reactions.
4. Students shall able to understand the application of biocatalysts in organic synthesis
5. To understand the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances.

Expected Course Outcome: Students are able to

1. Design and execute organic synthesis using various green synthetic methods to reduce waste and hazardous material for a greener environment.

Module:1	Green Chemistry Principles	5 hours

Evaluating the effects of chemistry. Definition, tools and principles of green chemistry. Waste minimization, solvent-free and aqueous phase reactions.

Module:2	Green Chemical Approach in Conventional Synthesis	6 hours

Introduction-Diels alder-Aldol condensation-Heck, oxidation and reduction-photochemical reactions. Alternative solvents- designing a green synthesis. Industrial applications- synthesis of Ibuprofen, Sertraline and Adipic acid.

Module:3	Green Chemical Approach Under sonication	5 hours

Sonochemistry - Introduction, types of sonochemical reactions, a few synthetic applications - substitution, addition, elimination, hydrolysis, esterification, oxidation, reduction.

Module:4	Phase Transfer Catalysts	3 hours

Definition, mechanisms, reaction, preparation, advantages and types of PTC.

Module:5		7 hours

Green Chemical Approach in Conventional Synthesis with PTC

Synthesis of nitriles, alkyl halides, elimination reactions, C-alkylation, N-alkylation, oxidation using hydrogen peroxide, dihalocarbenes, heterocyclic synthesis, β-lactams synthesis, crown ethers.

Module:6	Green Approach in Solid Phase	11 hours

Introduction– solid phase organic synthesis without using any solvent- halogenation, Micheal addition, aldol condensation, Grignard reagent, Reformatsky reaction, Witting reaction, aromatic substitution reactions-nuclear bromination and nitration by Green synthetic methods.
Biochemical oxidations-biochemical reduction-enzyme catalyzed reactions in organic synthesis

Module:7	Green Approach in Extraction Process	6 hours

Extraction and separation of phyto-constituents: hydro extraction, wet steam and dry extraction, head space extraction, super critical fluid extraction, pressurized liquid extraction, Microwave assisted methods, Ultrasonication assisted extraction and simulated moving bed technology.

Module:8	**Contemporary issues:**		**2 hours**
Lecture by Industry Experts			
		Total Lecture hours:	**45 hours**
Text Book(s)			
1. V. K. Ahluwalia and M. Kidwai, New Trends in Green Chemistry, Anamaya Publishers, New Delhi, 2012. 2. Mike Lancaster, Green Chemistry: An Introductory Text: Edition 3, RSC, ISBN: 978-1-78262-294-9, 2016. 3. Albert S. Matlack, "Introduction to Green Chemistry" CRC press, 2010.			
Mode of Evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & FAT			
Reference Books			
1. Introduction to Renewable Energy, Solar Energy International, 2012 2. Alternative Energy Sources, Michaelides, Efstathios E. (Stathis), Springer,Germany, 2012 3. **Chemat,** Farid, **Vian,** MarylineAbert (Eds.), Alternative Solvents for Natural Products Extraction, 2014. 4. Sunita Dhingra & VK Ahluwalia, Green Chemistry in 21st Century and Beyond, Manakin Press, ISBN-13: 978-9384370480, 2017.			
Recommended by Board of Studies		08-03-16	
Approved by Academic Council	No. 40	**Date**	18-03-16

Course code	Polymer Chemistry	L	T	P	J	C
CHY6005		3	0	0	0	3
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. To understand the basic concepts about polymers/macromolecules and the polymerization techniques
2. To be able to get familiarized with almost all the basic polymer concepts
3. To learn and understand different aspects such as tacticity, reactivity ratios etc
4. To impart knowledge in the theory and applications of various instrumental techniques which are very important characterization techniques for different industrial polymers

Expected Course Outcome: Students will be able to

1. Understand the importance of macromolecules/polymers in day to day life and apply their knowledge in sustainable development of mankind.
2. Apply the learned fundamental instrumental techniques in the polymer characterization.
3. Tailor made the macromolecules as per the requirement.

Module:1	Concept of Polymer	7 hours

Definition, nomenclature, Molecular weight (Mn, Mw), PDI. DP, T_g, T_m. Polymerization Techniques: Bulk, Suspension, Emulsion Polymerization and Interfacial Polycondensation

Module:2	Chain Polymerization	8 hours

Radical, cationic, anionic and coordination polymerization (Initiation – propagation – transfer-termination- processing kinetics – termination - living / controlled), Metathesis polymerization, metallocene and Non-metallocene
Step Polymerization: Functionality monomers (monomers of type (XX + YY), XY type monomers, monomers of type (XX + YYY), examples)

Module:3	Characterization	6 hours

Methods for the characterization of Polymers: Molecular weight (Mn, Mw) and Polydispersity index (PDI) By size exclusion chromatography (GPC), Chain end analysis, Thermal analysis of polymers by DSC, TGA, TGDTA. Determination of branching

Module:4	Stereoselectivity in polymers	5 hours

Stereospecific polymerization: Stereoselective polymerization using single-site catalysts.

Module:5	Evolution in polymer chemistry	5 hours

From multisite to single site polymerization. Metathesis polymerization, ROP (ring opening polymerization).

Module:6	Controlled/Living polymerization	7 hours

polymerization techniques such as NMP (nitroxy mediated polymerization), GTP (group transfer polymerization), ATRP (atom transfer radical polymerization), RAFT (reversible addition fragmentation and chain transfer polymerization), metallocene and non-metallocene polymerization techniques			
Module:7	**Copolymers**		**5 hours**
Block copolymers, alternative and random block copolymers. Reactivity ratios. Synthesis – Applications			
Module:8	**Contemporary Issues**	**2 hours**	
Industry Expert Lectures			
	Total Lecture hours:	**45 hours**	

Text Book(s)

1. Principles of Polymerization by George Odian, 4th Edition, Wiely - **2004**
2. "Polymer Science and Technology ", by Joel R. Fried, 3rd Edition, Prentice Hall, 2014

Reference Books

1. "High Performance Polymers", By Johannes Karl Fink, Elsevier, 2nd Edition, **2014**.
2. "Handbook of Polymer Synthesis, Characterization, and Processing" by Enrique Saldivar-Guerra and Eduardo Vivaldo-Lima., Wiley-Blackwell, 2013
3. "Applications of Ionic Liquids in Polymer Science and Technology" by David Mecerreyes (Ed). Springer, **2015**.
4. "Introduction to Polymer Science and Chemistry: A Problem-Solving Approach, Second Edition", by Manas Chanda, CRC Press; 2 edition, 2013.
5. "Chemical and physical chemistry of polymers" by M. Fontanille and Y. Gnanou, Wiely-**2008**

Recommended by Board of Studies		08-03-16	
Approved by Academic Council	No. 40	**Date**	18-03-16

Course code	Intellectual Property Rights	L	T	P	J	C
CHY6006		3	0	0	0	3
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. To understand the rural relevance of various IPR tools

Expected Course Outcome:

1. To understand the implication of patent, copy rights, trade mark to an inventor and business Organizations

Module:1	Looking Back: TRIPs Ahead	5 hours

The evolutionary past, Unfolding future, Technology, Intellectual Assests and value realization, the knowledge canopy, Balancing act International Technology Trade

Module:2	Trade Marks	6 hours

Trade Marks and copy Rights ; Essentials of Trade mark- Reasons for illegal protection- Procedure for registration Infringement of Registered Trademarks, Assignments of Trade marks

Module:3	Copyrights	5 hours

Introduction, -Characteristics- Items covered under copyright- Rights copyright owner- Infringement- Remedies for infringement, CDA and TTA, IP Laws

Module:4	IPR Tool Kit	6 hours

IPR Tool and Terminology, International and regional Agreement/ Treaties in IPR, The Current Global IPR Snapshot, Global patent ownership, The patenting process

Module:5		6 hours

Inventory Homework prior to Discussion with patent Attorney, Patenting systems, Issues relating to turmeric, basmati, Neem –Inventions not patentable –Rights of patentee- current developments Infringement of patents. Article related to IPR

Module:6	Traditional Knowledge and patents in pharmaceutical Industry	6 hours

Bio piracy, Intellectual property protection of living species, Traditional knowledge and prior Art, Nurturing role of patents in pharmaceutical Industry –Recent changes in IPR Laws, impacting pharmaceutical industry, chemical industry.

Module:7	Challenges Ahead	9 hours

Knowledge assets –A case study Intellectual cooperation in the pharmaceutical industry / Chemical industry, Recent Milestone payments in Drug industry, Litigation in the pharmaceutical sector ,case study, Essential of a trade secret Controlling overuse of IPR, Exhaustion principle, parallel import- Challenges ahead, Emerging IPR Management imperatives, Implementing GRIPS

Module:8	Contemporary Issues	2 hours	

Industry Expert Lectures

	Total Lecture hours:	45 hours	

Text Book(s)			
1. Prabuddha Ganguli- Intellectual Property Rights, Unleashing the knowledge economy, Tata McGraw-Hill, 2003. 2. Srinivasalu - Intellectual Property Rights, Regal publication: 2001			
Reference Books			
1. A.K.Ahuja Law related Intellectual Property Rights Lexis Nexis 3rd Edition 2016 2. K.C.Kailasam and Ramu Vedaraman Law of Trademarks-Including International Registration under Madrid protocol and Geographical Indication,Lexis Nexis 4th Edition 2016 3. Fink carsten and meskus keithe, Intellectual Property and development lesson from recent economic research Washington D.C 2005. 4. Richard stim; Intellectual property Rights; Trade mark and patent Canada Delmar cengag learning 2001. 5. V.K.Ahuja Intellectual Property Rights in India Lexis Nexis 2nd edition,2015			
Recommended by Board of Studies		08-03-16	
Approved by Academic Council	No. 40	**Date**	18-03-16

Course Code	Drug Design	L	T	P	J	C
CHY6007		3	0	0	0	3
Prerequisites		Syllabus Version				
None		1.0				

Course Objectives:

The course is aimed at

[1] Imparting knowledge on the principles and applications of various levels of drug design and development

[2] Understanding and performing computational skill for understanding the mechanism, interaction forces in drug actions, quantitative measurement of biological responses.

Course Outcome:

At the end of the course, the student should be able to

[1] Demonstrate the steps involved in the drug discovery and design process

[2] Identify the screening methods in the design of drugs

[3] Predict the functional groups involved in drug action and modifications required for a better biological response

[4] Choose ideal targets in drug design.

[5]Differentiate the pharmacophore and perform conformational searching.

[6] Evaluate and formulate various QSAR models

Module 1	Fundamentals of drug design	6 hours

Introduction, Drugs, agonist, antagonist, inhibitors-different types, lead molecule, lead discovery, random screening, non-random screening, Drug metabolism studies, clinical observations, drug targeting without lead, natural products as lead molecules, existing drugs as lead. Drug-Likeness and other compound filter Mechanism

Module 2	Lead Modification	6 hours

Identification of the active site, pharmacophore, functional group modification, SAR, Scaffolds, Drug like molecules, Modifications- Homologation, chain elongation/branching, ring chain transformation, bioisosterims, Fragmentation of structures, Stereochemistry and Drug Action

Module 3	Targets in drug Design	6 hours

Targets in drug design: various targets in drug action, Species-specific genes as drug targets, membrane drug targets, RNA, DNA, Proteins validation of the targets, Evaluating a structure for structure based drug design.

Module 4	Pharmacophore and pharmacophore mapping	6 hours

Pharmacophore, 2D pharmacophore, 3D pharmacophore, Data bases (Cambridge, PDB) searching, conformational search, random conformational search, methods to derive pharmacophore, Pharmacophore Mapping.

Module 5	Molecular interaction	6 hours

Concept of Virtual screening, Structure-Based Virtual Screening (*in silico*), Protein–Ligand Docking, Scoring Functions for Protein–Ligand Docking, Practical Aspects of Structure-Based Virtual Screening, The Prediction of ADMET, Properties, Toxicity Prediction.

Module 6	Molecular descriptors	6 hours

Lipophilicity parameters, Measurement of partition coefficient and related parameters, Calculation of partition coefficient, Electronic parameters, Steric parameters, Polarizability, parameters, Indicator variables, Other parameters involved topological features

Module 7	**Basics of Quantitative Models in QSAR Approaches**	**6 hours**
Hansch Analysis, Free Wilson analysis, The Relationships between Hansch and Free Wilson Analysis, Nonlinear relationship, Dissociation and Ionization of Acids and Bases, Other QSAR Approaches, Applications of Hansch analysis, Free Wilson analysis.		
Module 8	Industrial invited lectures on Molecular modelling, Tools involved in molecular modelling and bioinformatics. Methods involved in drug Design.	**2 hours**
	Total lecture hours	**45 hours**

Text books

1. Kristian Stromgaard, Povl Krogsgaard-Larsen, Textbook of Drug Design and Discovery: Fourth Edition, CRC Press, 2010.
2. Richard B Silverman, The organic chemistry of drug design and drug action:, third edition, Elsevier publishers, 2014.
3. Hugo Kubinyi , QSAR: Hansch Analysis and Related Approaches, , Vol.1, VCH Publishers, 2006.

Reference Books

1. Kenneth M. Merz, Jr, Dagmar Ringe, Charles H. Reynolds, Drug Design: Structure- and Ligand- Based Approaches, Cambridge University Press, 2010.
2. Tommy Liljefors, Povl Krogsgaard-Larsen, Ulf Madsen, Textbook of Drug Design and Discovery, Third Edition, CRC Press, 2006.
3. Tomasz Puzyn, Jerzy Leszczynski, Mark T. Cronin, Recent Advances in QSAR Studies: Methods and Applications, Springer, 2010.
4. Donald J. Abraham, David P. Rotella, Alfred Burger, Burger's Medicinal Chemistry, Drug Discovery and Development Academic press, 2010

Mode of evaluation: Assignments, quiz, CAT1 and CAT 2 and FAT

Recommended by Board of Studies		Yes / 24.06.2020	
Approved by Academic Council	No. 59	**Date**	24-09-2020

Course code	Biophysical Chemistry	L	T	P	J	C
CHY6008		3	0	0	0	3
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. Demonstrate knowledge and understanding of the fundamental principles underlying the interplay between various physical phenomena and the physical properties ofbiomolecules.
2. To impart knowledge on the principles and practical applications of various biophysical techniques and macromolecular analysis.
3. Students will understand and perform biochemical assays using various biophysical methods.

Expected Course Outcome:

1. Understand the characteristics and classifications of amino acids.
2. Know the methods of quantitative and qualitative analysis of biological molecules.
3. Understand the basic principles of protein-protein and protein-nucleic acid interactions

Module:1	Intermolecular interactions:	7 hours

Hydrogen bonding, hydrophobic interactions and water as universal solvent in biological systems; Disruption of hydrophobic interactions by urea and other denaturants; Ionic interactions, hydrophobic versus ionic interactions; Disulfide bond, formation of specific disulfide link.

Module:2	Structure of biomolecules:	8 hours

Conformational properties of amino acids and peptides; Primary, secondary, tertiary and quaternary structures; Structural features and prediction of protein structures; Structural features of nucleic acids- Ramachandran plot, Central Dogma (DNA → RNA → Protein).

Module:3	Thermodynamics of biomolecules:	5 hours

Two state model of protein stability, chemical denaturation and stabilization, surface denaturation; Principles of ionization equilibrium ionization of side chain, equilibria in proteins.

Module:4	Properties of Amino Acids:	7 hours

Predicting properties from amino acid composition, unusual amino acids; Primary structure, Secondary structure, Tertiary structure, Quaternary structure; Homologies in proteins.

Module:5	Biophysical Analysis: Optical and Spectroscopic techniques:	5 hours

Optical and Spectroscopic techniques for nucleic acid and protein quantification, protein secondary structure determination, biomolecular modifications, etc, by UV-Visible spectroscopy, Fluorescence spectroscopy, IR, NMR and Mass spectroscopy, MALDI, ORD and CD.

Module:6	Biophysical Analysis: Microscopic Techniques:	6 hours

Macromolecular size determination, Microscopic techniques, Protein aggregation, Self-assembly, Surface Morphology, etc, by Light Microscopy; Fluorescence Microscopy, Atomic Force Microscope, Electron Microscope, Scanning Electron Microscopy, Transmission Electron Microscope.

Module:7	Biophysical Analysis: Chromatographic Techniques & Ultracentrifugation:	5 hours

Protein purification by size exclusion, GPC and ion exchange chromatographic techniques. Ultracentrifugation - Sedimentation velocity and equilibrium- determination of molecular weights.

Module:8	**Contemporary issues:**	**2 hours**	
Industry Expert Lectures			
	Total Lecture hours:	**45 hours**	

Text Book(s)

1. Alan Cooper, Biophysical chemistry, (2011) 2nd Edition RSC publishing, UK.

Reference Books

1. Cantor and Schimmel, Biophysical Chemistry, Vols. I - III, (2008) W. H. Freeman & Co., USA.
2. J. L. Gurth and A. Gurth, Biophysical Chemistry, (2015) 9th Edition, Pragati Prakashan, Meerut, India.
3. P Narayanan, Essentials of Biophysics, (2016) 2nd Edition, New Age International, New Delhi, India.

Recommended by Board of Studies		08-03-2016	
Approved by Academic Council	No.40	**Date**	18-03-2016

Course code	Organometallics and Industrial Applications	L	T	P	J	C
CHY6009		3	0	0	0	3
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. To understand the basic concepts about how the metal mediated reactions are carried out and also to make the students understand the mechanisms of different organometallic reactions
2. To be able to get familiarized with almost all the basic organometallic concepts
3. To learn and understand the synthetic and mechanistic aspects
4. To impart knowledge in the theory and applications of various organometallic reagents.

Expected Course Outcome: Students are able to

1. Know the synthesis, mechanisms and the functions of various organometallic reagents or catalysts.
2. Learn the requirement of new organometallic compounds.
3. Analyze the spectral data of organometallic complexes.

Module:1	Introduction	5 hours

Energy, Polarity, Lability & Reactivity aspects of main group organometallic chemistry; Transition metal compounds – The 18 valence electron rule, Nomenclature of organometallic compounds, Significance of metal-carbon bonds in catalysis

Module:2	Preparation methods, stability	5 hours

Bonding theory, synthesis and reactivity of sigma-bonded alkyls and aryls, metal carbonyls and pi-bonded organic ligands such as alkenes, alkynes, allyls, and arenes, applications.

Module:3	Metal carbonyls, metallocenes, carbenes and carbynes	5 hours

Metal Carbonyls – Preparation methods, Properties, important reaction types – Nature of carbonyl metal hydrides; Metallocenes and other sandwich, inverted sandwich, and half-sandwich compounds; Metal carbenes and carbynes (alkylidenes, alkylidynes). Nucleophilic and electrophilic carbene complexes.

Module:4	Olefin complexes, homoalkene and heteroalkene complexes	5 hours

$C_3R_3^+$, C_4H_4 and C_5H_5– ligands – Cyclopentadienyl metal carbonyls, halides and their special applications; Multi metal clusters – Formation and criteria for M-M bonds; The isolobal analogy.

Module:5	Important synthetic routes and properties	9 hours

Organosilanes, organoboranes and organometallic complexes of platinum group metals (Ru, Rh,Pd, Os, Ir and Pt), β-Hydride elimination, Reductive elimination, Oxidative addition, Agostic interactions in organometallic complexes; Organometallic polymers – synthesis, important properties and applications

Module:6	**C-C Coupling reactions**	**9 hours**
Pd catalyzed cross-coupling reactions; Boron: The Suzuki reaction; Tin: The Stille reaction; Lithium & Magnesium: The Kumada coupling; Zinc: The Negishi reaction; Silicon: The Hiyama reaction; Copper: The Sonogashira reaction; The Heck Reaction. Activation of small molecules: CO, CO_2 & CH_4		
Module:7	**Structure**	**5 hours**
Structural elucidation of organometallic complexes – fluxional molecules.		

Module:8	**Contemporary issues**	**2 hours**	
Industry Expert Lectures			
	Total Lecture hours:	**45 hours**	

Text Book(s)

1. Basic Organometallic Chemistry: Concepts, Syntheses and Applications Paperback – Dr. B.D. Gupta, Dr. Anil J. Elias, Universities Press; 2 edition, 2013.
2. Applied Homogeneous Catalysis with Organometallic Compounds: A Comprehensive Handbook in Four Volumes Hardcover – Import, 8 Nov 2017, by Boy Cornils, Wolfgang A. Herrmann, Matthias Beller, Rocco Paciello (Eds), 2017.
3. The Organometallic Chemistry of the Transition Metals by Crabtree, 6th edition, 2014, ISBN: 978-1-118-13807-6.

Reference Book(s)

1. Organic Synthesis Using Transition Metals - Second Edition 2012 – by Roderick Bates
2. A Text Book on 'Organometallics' (Christoph Elschenbroich), 3rd revised edition, WILEY-VCH, Germany, 2006.

Recommended by Board of Studies		08-03-2016	
Approved by Academic Council	No. 40	**Date**	18-03-2016

Course code	Nanomaterials	L	T	P	J	C
CHY6010		3	0	0	0	3
Pre-requisite		Syllabus version				
None		1.0				

Course Objectives:

1. Understanding the synthesis, characterization, properties and applications of nanomaterials.
2. Applying the knowledge of nanomaterials in science and technology

Expected Course Outcome: Students will be able to

1. Propose synthetic techniques for nanomaterials preparation
2. Understand the various techniques for nanomaterial characterization
3. Explain the chemistry of carbon nanomaterials
4. Give examples of nanocomposite for appropriate applications
5. Assess nanomaterials for thermal, magnetic, optical and mechanical properties
6. Fabricate nanodevices for various applications

Module:1	Synthesis of nanomaterials	6 hours

Synthesis: Top-down processes: physical processes- milling, lithographic processes, machining, vapour phase condensation, plasma assisted deposition; Bottom– up processes; micro emulsion technique.

Module:2	Characterization of nanomaterials	6 hours

UV – Visible spectroscopy- particle size calculation, particle size analyzer – basic principles - application to selected nanomaterials; Powder XRD – peak broadening, Scherer's equation.

Module:3	Carbon materials	6 hours

Graphene, Fullerene, SWNT, MWNT, Functionalised CNT – preparation, properties and applications.

Module:4	Nanocomposites	6 hours

Nanocomposites – Metal Matrix nanocomposites, Ceramics matrix nanocomposites, Polymer matrix nanocomposites, metal chalcogenides – Preparation, Properties and applications.

Module:5	Properties of Nanomaterials	6 hours

Band diagrams. Electrical transport properties, Thermal transport properties, Magnetic Properties, Optical Properties, Mechanical properties.

Module:6	Nanodevice fabrication	7 hours

Nanodevices - introduction- template fabrication, polycarbonate etched track templates, fabrication of anodized alumina membrane - Fabrication of nanostructures in the templates; electrodeposition, sol-gel, CVD methods.

Module:7	Applications of Nanomaterials	6 hours

Electronic, magnetic, thermal and biological – application with and an example for each category.

Module:8	Contemporary issues	2 hours

Industry Expert Lectures

	Total Lecture hours:	45 hours

Text Book(s)

1. G. Balasubramanian (Ed.), Advances in Nanomaterials: Fundamentals, Properties and Applications, Springer, 2017. ISBN 978-3319647159.

Reference Books

1. M. Raj Shankar (Ed.), Textbook of Nanoscience and Nanotechnology, Orient Black swan Publishers, New Delhi, 2012. ISBN: 978-8173717383.
2. D. Vollath (Ed.), Nanomaterials: An Introduction to Synthesis, Properties and Applications, Wiley, 2013. ISBN: 978-3-527-33379-0.
3. S. Singh and M.S. Ramachandra Rao (Ed.), Nanoscience and Nanotechnology: Fundamentals of Frontiers, Wiley Publishers, 2013. ISBN 978-8126542017.
4. T. Pradeep (Ed.), NANO: The Essentials: Understanding Nanoscience and Nanotechnology, McGraw Hill Education, 2017. ISBN-13: 978-0070617889.

Recommended by Board of Studies	31.05.2019		
Approved by Academic Council	No. 55	**Date**	13-06-19

Course code	Computational Chemistry	L	T	P	J	C
CHY6011		3	0	0	0	3
Pre-requisite		Syllabus version				
None		1.1				

Course Objectives:

1. Provides essential theoretical background of computational chemistry and practical/programming skills to perform scientific computations to solve chemical problems.
2. Students will have exposure on a variety of computational tools in chemical science esp related to research

Expected Course Outcome: students will be able to

1. Critically assess the applicability of computational methods to specific problems in chemistry and successfully apply appropriate computational techniques in their academic and scientific careers.
2. Hands on training in the context of currently available computational chemistry software and high-performance computer hardware.

Module:1	Introduction to Computational Chemistry	4 hours

The promise of computational chemistry, Potential Energy Surfaces, Computational Strategies-Coordinate systems, Geometry optimization, Local and Global minima, Conformational Analysis, Transition State Optimization, saddle point, vibrational frequencies, and normal mode analysis, Intrinsic Reaction Coordinate (IRC) analysis.

Module:2	Computational Chemistry methods-I	6 hours

Molecular Mechanics-Force field methods, Semi-empirical methods, Variational method, Roothaan-Hall equations, self-consistent field approach, electron spin and Pauli principle, antisymmetric wave functions and Slater determinants.

Module:3	Computational Chemistry methods-II	6 hours

Ab initio methods- Basis sets, Slater and Gaussian functions, polarization and diffuse functions, split-valence sets, correlation-consistent sets, Born-Oppenheimer approximation, Hartree-Fock theory, electron correlation problem, Perturbation theory, Koopmans theorem. Density Functional Theory (DFT) and methods.

Module:4	Molecular Dynamics Simulations	5 hours

Basic principles-Equations of motion, force calculations, integration schemes, boundary conditions, phase space and distribution functions, time step and time scale considerations, stability, Practical aspects of simulations, *ab initio* molecular dynamics. Structural and dielectric properties of a polar medium, SCF reaction field (SCRF), implicit and explicit solvation, solvent Models.

Module:5	Hybrid Methods and Relativistic Methods	5 hours

Combined methods, like the combination of quantum chemical methods and molecular mechanics (QM/MM) or ONIOM for the description of biochemical problems, for example the interaction of a drug and a receptor, relativistic quantum chemistry, relativistic effective core potential (RECP).

Module:6	Introduction to Scientific Computing with FORTRAN	8 hours

Basic elements of Modern FORTRAN programming and its applications in solving computational problems. Writing program for involving simple formulae in organic, inorganic and physical chemistry, developing the algorithm for numerical computation of chemical problems of interest.

Module:7	**Illustrating the Computational Chemistry Concepts**	**9 hours**

Geometrical Parameters, Understanding of electrostatic, van der Waals and hydrophobic interactions, Hydrogen bonding, Ground state, Excited States, Transition States - Exploring the energy landscape and its minima, charge density and electron density; Frontier Molecular orbital Analysis, Binding energy, stability constant, Wave function analysis. Structure-Activity Relationships, Descriptors of chemical reactivity and selectivity, DFT reactivity descriptors.

Module:8	**Contemporary issues:**	**2 hours**	

Industry Expert Lecture

	Total Lecture hours:	**45 hours**	

Text Book(s)

1. F. Jensen, *Introduction to Computational Chemistry*, 3rd Edition, John Wiley & Sons Ltd, UK, 2017.

2. Norman S. Clerman and Walter Spector, *Modern Fortran: Style and Usage*, Cambridge University Press, New York, USA, 2012.

Reference Books

1. A. Szabo and N. S. Ostlund, Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory, Dover Publications, New York, 2012.
2. Errol G. Lewars, Computational Chemistry: Introduction to the Theory and Applications of Molecular and Quantum Mechanics, 2nd Edition, Springer, 2011.
3. Stephen Wilson, Chemistry by Computer: An Overview of the Applications of Computers in Chemistry, Springer, 2011.

Recommended by Board of Studies	12-8-2017		
Approved by Academic Council	No. 47	**Date**	05-10-2017