CENTRAL UNIVERSITY OF HARYANA

(*Established under the Central Universities Act, 2009*)

(NAAC Accredited 'A' Grade)

CBCS and LOCF and NEP-2020 Based

Curriculum and Syllabi

Of

M.Sc. Chemistry

(w.e.f. 2021)

DEPARTMENT OF CHEMISTRY
SCHOOL OF BASIC SCIENCES

Approved by :	**BOS**	**School Board**	**Academic Council**
Approval Status :	√	√	✓
Approval Date :	09-09-2021	20-09-2021	12-10-2021

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VISION AND MISSION

i) Vision and Mission of the University

Vision

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavours, and scholarly inquiry.

Mission

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

ii) Vision and Mission of the Department

Vision

To establish a world-class teaching and research reputation of the department that contributes society through its innovative, creative and scholarly approach.

Mission

To educate the students by adopting highest academic and professional standards to meet the global competency in the field of chemical sciences. To establish and maintain a high quality of support, research facilities, multidisciplinary and skill-based learning opportunities to our staff, students and researchers to orient them to world class creative and innovative minds.

1. BACKGROUND

i) NEP-2020 and LOCF an integrated Approach

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programmes in alignment with National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted with the adoption of "Comprehensive Roadmap for Implementation of NEP-2020" in 32nd meeting of the Academic Council of the University held on April 23, 2021. The Roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and indicative timeline for major academic reforms.

The process of revamping the curriculum started with the series of webinars and discussions conducted by the University to orient the teachers about the key features of the Policy, enabling them to revise the curriculum in sync with the Policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the Policy in the revised curriculum focused on 'creating holistic, thoughtful, creative and well-rounded individuals equipped with the key 21st century skills' for the 'development of an enlightened, socially conscious, knowledgeable, and skilled nation'.

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasising upon—integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and Constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills; community and constructive public engagement; social, moral and environmental awareness; Organic Living and Global Citizenship Education (GCED); holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning;

exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering 'Knowledge of India'; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable creative combination of disciplines for study; offering multiple entry and exit points initially in undergraduate programmes; alignment of Vocational courses with the International Standard Classification of Occupations maintained by the International Labour Organization; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with local industry, businesses, artists and crafts persons; closer collaborations between industry and higher education institutions for technical , vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. In case of UG programmes in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NSQF, International Standard Classification of Occupations, Sector Skill Council and other relevant agencies/sources. The University has also developed consensus on adoption of Blended Learning with 40% component of online teaching and 60% face to face classes for each programme.

The revised curricula of various programmes could be devised with concerted efforts of the faculty, Heads of the Departments and Deans of Schools of Study. The draft prepared by each department was discussed in series of discussion sessions conducted at Department, School and the University level. The leadership of the University has been a driving force behind the entire exercise of developing the uniform template and structure for the revised curriculum. The Vice Chancellor of the University conducted series of meetings with Heads and Deans to deliberate upon the vital parameters of the revised curriculum to formulate a uniform template featuring Background, Programme Outcomes, Programme Specific Outcomes, Postgraduate Attributes, Structure of Masters Course, Learning Outcome Index, Semester-wise Courses and Credit Distribution, Course-level Learning Outcomes, Teaching-Learning Process, Blended Learning, Assessment and Evaluation, Keywords, References

and Appendices. The experts of various Boards of Studies and School Boards contributed to a large extent in giving the final shape to the revised curriculum of each programme.

To ensure the implementation of curricular reforms envisioned in NEP-2020, the University has decided to implement various provisions in a phased manner. Accordingly, the curriculum may be reviewed annually.

ii) About Chemistry

Chemistry is the science of matter and its transformations. It addresses fundamental questions about the observable matter, ranging from its components, structure, properties and interconversions. As a system of knowledge, Chemistry not only explains the existence and behavior of matter around and within us, but also empowers us to manipulate the matter into new and improved forms for our use. From the ancient practices of rasayan vidya and alchemy, modern chemistry has grown over centuries into a formidable science that touches all aspects of human life. Humanity's progress in the last three centuries is pivoted on the contributions of chemistry, chemical industry and associated endeavors. The range of influence of chemistry in our life spans from essentials such as food (agrochemicals, preservatives), shelter (cement, metals, alloys, polymers) and health (drugs, cosmetics, soap, toothpaste), to advancements such as textiles (polymers, leather), beverages (flavoring and fermentation), crime fighting (forensics), weaponry (explosives), space travel (fuel) and cosmology (element detection). The list can go on endlessly. The most visible contribution of chemistry to civilization is achieved by the advancements in modern medicine that was fuelled by organic chemistry. This led to significant improvements in the living standards, extension of human average life span and fighting of dangerous diseases such as cancer and microbial infections.

Chemistry is placed centrally between the other two major branches of science, namely physics and biology. Therefore, it is often called the *central science*. It influences the developments in these two broad realms of science as much as it is influenced by the discoveries in them. The fundamental importance of chemistry and chemical industry in

sustaining human civilization demands for a steady supply of trained and skilled manpower. Thus, it is unsurprising that it is an essential and integral department in higher education institutions.

Education in chemistry not only imparts the technical know-how about structure, reactions and properties of matter, but also empowers the learner to raise fundamental questions about various natural phenomena, address local issues and come up with sustainable solutions, identify areas of life where intervention of chemistry can bring about progress and imbibe and spread the spirit of free enquiry and scientific temper.

iii) About the Programme (Nature, Extent and Aims)

The Post-Graduate Programme in Chemistry will impart advanced knowledge of basic and applied chemical sciences to the graduates. It will prepare the students for taking up challenging assignments in academia and industry and also empower them with skill and knowledge for generating employment for their own and others. The Programme introduces the students to advanced developments in chemical sciences as well as in the field of other allied sciences, by providing them multidisciplinary and interdisciplinary courses. The design of choice-based curriculum can enrich students with analytical and problem-solving capabilities. It is designed to bring out the best of the abilities of each student, allow them to sharpen the scientific temper and be abreast with the contemporary developments in the area.

The programme includes a balanced combination of Core, Electives and Skill based Courses. The courses are designed in such a way to cover the entire spectrum of chemical sciences from fundamentals (that will bring admitted students from various backgrounds to a common level) to most recent advancements in the field (that will make them ready to take up challenging assignments in the real world).

The M.Sc. (Chemistry) Programme is of two years duration which is divided into four semesters. The teaching and learning in the Programme will involve theory (lectures), practicals, tutorial and seminar-based classes. During the whole programme about 40 %

syllabus of each course may be delivered via online mode and with a blended teaching-learning approach.

The curriculum will be taught through formal lectures with the aid of pre-made presentations, audio and video tools whenever necessary. Other teaching aids can also be used as and when required. The additional requirements like industrial visits, summer training and project work are also incorporated into the curriculum.

The Aims of the programme include

- To inculcate basic and advanced knowledge of chemical sciences among students.
- To provide higher education, disciplinary and inter/multi-disciplinary research-oriented knowledge to the students to make them lifelong learners.
- To provide a learned, skilled and creative pool of graduates who are ready to take up challenging assignments in different kinds of chemical industries, research institutions and academia.
- To mould responsible, proactive citizens who are equipped with scientific thinking and skills to address problems of their locality
- Adequate blend of theory, computation and hands-on experiments.
- Modernized lab courses – close to recent/current research.

iv) Qualification Descriptors (possible career pathways)

On successful completion of the M.Sc. Chemistry Programme, students of the department are expected to be ready to take up opportunities all around the world in areas that demand skills in chemical and allied sciences. As the chemical industry is enormously vast and diverse, numerous opportunities and challenges await the graduates. The graduates are expected to satisfactorily address the professional expectations, maintain a work-life balance and lead productive and meaningful lives. Some of the possible career paths for the postgraduate students may be:

1. Teaching and Research in academia

2. Research scientists in pharmaceutical and other chemical and material industries

3. Research scientists in other allied sciences

4. Entrepreneurship in chemical science-based ventures

5. Administrative Assignments in various government and private agencies

6. Chemist/Scientist/Technician assignments in any of the following industries: pharmaceutical, polymers, petrochemicals, materials sciences, nanotechnology, fuels, non-conventional energy, renewable resources, agrochemicals, fermentation and processing, paints and pigments, metallurgy, packaging, cosmetics, cements, natural products, forensics, explosives, and any other various allied branches of chemistry.

2. PROGRAMME OUTCOMES (POs)

The overall aims of the programme may be achieved by addressing its various components that are incorporated into the curriculum as described below. Each of these components is designed to lead to specific outcomes that are desired after the successful completion of the programme.

PO-No.	Component	Outcomes
PO-1	Basic Knowledge	Capable of delivering basic disciplinary knowledge gained during the programme.
PO-2	In-depth Knowledge	Capable of describing advanced knowledge gained during the programme.
PO-3	Critical thinking and Problem-Solving abilities	Capable of analyzing the results critically and applying acquired knowledge to solve the problems.
PO-4	Creativity and innovation	Capable to identify, formulate, investigate and analyze the scientific problems and innovatively to design and create products and solutions to real life problems.
PO-5	Research aptitude and global competency	Ability to develop a research aptitude and apply knowledge to find the solution of burning research problems in the concerned and associated fields at global level.
PO-6	Holistic and	Ability to gain knowledge with the holistic and

	multidisciplinary education	multidisciplinary approach across the fields.
PO-7	Skills enhancement	Learn specific sets of disciplinary or multidisciplinary skills and advanced techniques and apply them for betterment of mankind.
PO-8	Leadership and Teamwork abilities	Ability to learn and work in a group and capable of leading a team even.
PO-9	Environmental and human health awareness	Learn important aspects associated with environmental and human health. Ability to develop eco-friendly technologies.
PO-10	Ethical thinking and Social awareness	Inculcate the professional and ethical attitude and ability to relate with social problems.
PO-11	lifelong learning skills and Entrepreneurship	Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life. Capable to establish independent startup/innovation center etc.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs)

The post graduates shall be able to realise the following specific outcomes by the end of program studies:

Number	Programme Specific Outcomes
PSO-1	To acquire a thorough knowledge about basic theoretical concepts and experimental aspects of chemistry.
PSO-2	To fully develop the skills for using the earned knowledge within different branches of chemistry.
PSO-3	To develop the attitude for identifying and solving problems using chemistry
PSO-4	To develop the capability to search, acquire and apply recent developments in research field of chemical sciences to problems
PSO-5	To develop an overview of the role of chemical sciences and chemical industry in sustaining civilization
PSO-6	To develop the skill to adopt the learned principles in various settings and innovate with the importance of sustainability in mind, if necessary

4. Postgraduate Attributes

On completion of the post graduate programme in chemistry, students are expected to be equipped with the skills of creative, critical and rational thinking associated with chemistry and its use for human society. The following attributes are expected from the students of M.Sc. Chemistry:

No.	P.G. Attributes
PGA-1	Disciplinary knowledge and solid foundation
PGA-2	Creative, critical and reflective Thinking
PGA-3	Attitudes and values
PGA-4	Principle and practical aspects of different instruments
PGA-5	Research skills
PGA-6	Think beyond which were never thought before
PGA-7	Information/digital literacy
PGA-8	Team work

5. STRUCTURE OF MASTER'S COURSE

The M.Sc. (Chemistry) Programme is of *two years* duration which is divided into four semesters. The programme under Choice-Based Credit System (CBCS) includes a balanced combination of *Core*, *Electives* and *Skill Courses* (**Table 1**).

As per P.G. Ordinance of Central University of Haryana, total credit requirement for completion of the programme shall be 96 (±4).

Total credit requirement of the present P.G. programme is **98**, however, 2 additional credit may be earned by the interested students from six weeks industrial summer training course (Programme Structure).

Table 1

Sr. No.	Types of Courses	Nature	Total Credit 98 (2 optional)	% (approx)
1	Core Courses (CC)	Compulsory Courses	48	49
2	Elective Courses (EC)	Discipline Specific Elective Courses	32	33
		Discipline Centric Elective Courses	4	4
		Generic Elective Courses	8	8
3	Skilled-based courses/ Self-study based courses	Discipline Centric Skill Courses	4	4
4	Swachh Bharat Internship at Institute Level	Compulsory	2	2
			98	100
5	Industrial Summer Training	Optional for interested students	2 (additional)	2

PROGRAMME STRUCTURE

Choice Based Credit System (CBCS) Based Course Structure of M.Sc. Chemistry Programme (2 Years) in Consonance with NEP-2020 and LOCF

YEAR 1

Semester-I

Course	Credit	Hrs.
IC-I (CC)	4	4
ICP-I (CC)	2	4
OC-I (CC)	4	4
OCP-I (CC)	2	4
PC-I (CC)	4	4
PCP-I (CC)	2	4
DCEC*	2	2
GEC§	4	4
Total Credit and Hrs.	**24**	**30**

IC-I: Inorganic Chemistry-I
ICP-I: Inorganic Chemistry Practical-I
OC-I: Organic Chemistry-I
OCP-I: Organic Chemistry Practical-I
PC-I: Physical Chemistry-I
PCP-I: Physical Chemistry Practical-I
*Can be chosen from the list of courses available
§GEC (Generic elective course) will be available for students from other Departments

Semester-II

Course	Credit	Hrs.
IC-II (CC)	4	4
ICP-II (CC)	2	4
OC-II (CC)	4	4
OCP-II (CC)	2	4
PC-II (CC)	4	4
PCP-II (CC)	2	4
DCSC*	2	2
GEC§	4	4
Total Credit and Hrs.	**24**	**30**

IC-II: Inorganic Chemistry-II
ICP-II: Inorganic Chemistry Practical-II
OC-II: Organic Chemistry-II
OCP-II: Organic Chemistry Practical-II
PC-II: Physical Chemistry-II
PCP-II: Physical Chemistry Practical-II
*Can be chosen from the list of courses available
§GEC (Generic elective course) will be available for students from other Departments

YEAR 2

Specialization will be offered at the beginning of semester-III (Specializations: Inorganic Chemistry/Organic Chemistry/Physical Chemistry)

Semester-III

Course	Credit	Hrs.
Molecular Spectroscopy (CC)	4	4
Research Methodology and Software Applications (CC)	2	2
IC-III/OC-III/PC-III (DSEC-1)	4	4
IC-IV/OC-IV/PC-IV (DSEC -2)	4	4
DCEC*	2	2
Two Options (OPTION 1 and OPTION 2) are available. Students may choose any one in the beginning of Sem-III of second year)		
OPTION 1		
ICP-III/OCP-III/PCP-III (DSEP-I)	3	6
ICP-IV/OCP-IV/PCP-IV (DSEP-2)	3	6
Seminar	2	2
OPTION 2		
Dissertation–I (To be continued in Sem-IV)	8	14
Total Credit and Hrs.	**24**	**30**

IC-III and IV: Inorganic Chemistry-III and IV
OC-III and IV: Organic Chemistry-III and IV
PC-III and IV: Physical Chemistry-III and IV
ICP-III and IV: Inorganic Chemistry Practical-III and IV
OCP-III and IV: Organic Chemistry Practical-III and IV
PCP-III and IV: Physical Chemistry Practical-III and IV
*Can be chosen from the list of courses available

Semester-IV

Course	Credit	Hrs.
Applications of Spectroscopy (CC)	4	4
Seminar (Research paper based) (CC)	2	2
DCSC*	2	2
IC-V/OC-V/PC-1 (DSEC -3)	4	4
IC-VI/OC-VI/PC-VI (DSEC -4)	4	4
Options chosen in Sem-III shall be continued in Sem-IV		
OPTION 1		
ICP-V/OCP-V/PCP-V (DSEP-3)	3	6
ICP-VI/OCP-VI/PCP-VI (DSEP-4)	3	6
Scientific Report Writing in Emerging/Advanced Areas	2	2
OPTION 2		
Dissertation-II (Continued from Sem-III)	8	14
Total Credit and Hrs.	**24**	**30**

IC-V and VI: Inorganic Chemistry-V and VI
OC-V and VI: Organic Chemistry-V and VI
PC-V and VI: Physical Chemistry-V and VI
ICP-V and VI: Inorganic Chemistry Practical-V and VI
OCP-V and VI: Organic Chemistry Practical-V and VI
PCP-V and VI: Physical Chemistry Practical-V and VI
*Can be chosen from the list of courses available

Total Credit: 96 + 2 (Will be allotted randomly during the semesters-I to IV in order to implement Swachh Bharat Internship Programme) = **98** and 2 credits are optional
Total Marks for M.Sc. Programme = **2400**
Total Core Course Credit = **48**;Total Elective Course Credit = **50** (including 8 credit from GEC)
CC = Core Course; DCEC = Discipline Centric Elective Course; DSEC = Discipline Specific Elective Course; DSEP = Discipline Specific Elective Practical; DCSC = Discipline Centric Skill-based Course

Note:

1) A 02 Credit Summer Training (Optional) Self-study/Skill-based Course of six weeks will be available to interested students at the end of Semester-II.
2) A 02 Credit Course on the basis of Swachh Bharat Internship Programme will be available and mandatory to all students. The course will be allotted to the students in a batch-wise manner to earn max 02 credits in the duration of two years.
3) Students may choose option 2 in Sem-III on the basis of their interest in consultation with concerned faculty member(s). The students shall continue the dissertation work under the supervision of the same faculty member(s) to carry out second part of the dissertation in semester-IV.
4) **Choice Based Credit System (CBCS) based M.Sc. Chemistry programme will be awarded with a minimum of 98 credit (compulsory), although it can be a maximum of 100 credit.**

6. LEARNING OUTCOME INDEX

6.1 Programme Outcomes (POs) and Programme Specific Outcomes (PSOs)

PSOs ⇨	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
POs ⇩						
PO1	√	√	X	X	X	X
PO2	√	√	√	√	X	√
PO3	√	√	√	√	√	√
PO4	√	√	√	√	√	√
PO5	√	√	√	√	√	√
PO6	X	√	√	√	√	√
PO7	X	√	X	√	√	√
PO8	√	√	√	√	√	√
PO9	√	X	√	√	√	√
PO10	X	√	√	√	√	√
PO11	X	√	√	√	√	√

6.2 Core Courses with PSOs

PSOs ⇨	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
Core Course No. ⇩						
CH-01	√	√	√	X	√	√
CH-02	√	√	√	X	√	√
CH-03	√	√	√	X	√	√
CH-04	√	√	√	X	√	√
CH-05	√	√	√	X	√	√
CH-06	√	√	√	X	√	√
CH-07	√	√	√	X	√	√
CH-08	√	√	√	X	√	√
CH-09	√	√	√	X	√	√
CH-10	√	√	√	X	√	√
CH-11	√	√	√	X	√	√
CH-12	√	√	√	X	√	√
CH-13	√	√	√	X	√	√
CH-14	√	√	√	√	√	√
CH-15	√	√	√	√	√	√
CH-16	√	√	X	√	√	√

6.3 Elective and Other Courses with PSOs

PSOs ⇨	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
Course No. ⇩						
CH-17	√	√	√	√	√	√
CH-18	√	√	√	√	√	√
CH-19	√	√	√	X	√	√
CH-20	√	√	√	X	√	√
CH-21	√	√	√	X	√	√
CH-22	√	√	√	X	√	√
CH-23	√	√	√	X	√	√
CH-24	√	√	√	X	√	√
CH-25	√	√	√	X	√	√
CH-26	√	√	√	X	√	√
CH-27	√	√	√	X	√	√
CH-28	√	√	√	X	√	√
CH-29	√	√	√	√	√	√
CH-30	√	√	√	√	√	√
CH-31	√	√	√	X	√	√
CH-32	√	√	√	X	√	√
CH-33	√	√	√	X	√	√
CH-34	√	√	√	√	√	√
CH-35	√	√	√	X	√	√
CH-36	√	√	√	X	√	√

CH-37	√	√	√	√	√	√
CH-38	√	√	√	√	√	√
CH-39	√	√	√	X	√	√
CH-40	√	√	√	X	√	√
CH-41	√	√	√	X	√	√
CH-42	√	√	√	√	√	√
CH-43	√	√	√	X	√	√
CH-44	√	√	√	X	√	X
CH-45	√	√	√	√	√	√
CH-46	√	√	√	X	√	√
CH-47	√	√	√	X	√	√
CH-48	√	√	√	√	√	√
CH-49	√	√	√	√	√	√
CH-50	√	√	√	√	√	√
CH-51	√	√	√	√	√	√
CH-52	√	√	√	X	√	√
CH-53	√	√	√	√	√	√
CH-54	√	√	√	√	√	√
CH-55A	√	√	√	√	√	√
CH-55B	√	√	√	√	√	√
CH-56	X	√	X	X	√	√
CH-57	√	√	X	X	√	√
CH-58	√	√	√	X	√	√
CH-59	√	√	√	X	√	√

CH-60	√	√	√	X	√	√
CH-61	√	√	√	X	√	√
CH-62	√	√	√	X	√	X

7. SEMESTER-WISE COURSES AND CREDIT DISTRIBUTION

A. LIST OF COURSES OFFERED BY DEPARTMENT OF CHEMISTRY

Sr. No	Course No	Course Name	Course Code	Course Type	Credit	Semester
CORE COURSES (CC)						
1	**CH-01**	Inorganic Chemistry-I	SBS CH 010101 C 4004	**CC**	**04**	**I**
2	**CH-02**	Organic Chemistry-I	SBS CH 010102 C 4004	**CC**	**04**	**I**
3	**CH-03**	Physical Chemistry-I	SBS CH 010103 C 4004	**CC**	**04**	**I**
4	**CH-04**	Inorganic Chemistry Practical-I	SBS CH 010104 C 0042	**CC**	**02**	**I**
5	**CH-05**	Organic Chemistry Practical-I	SBS CH 010105 C 0042	**CC**	**02**	**I**
6	**CH-06**	Physical Chemistry Practical-I	SBS CH 010106 C 0042	**CC**	**02**	**I**
7	**CH-07**	Inorganic Chemistry-II	SBS CH 010207 C 4004	**CC**	**04**	**II**
8	**CH-08**	Organic Chemistry-II	SBS CH 010208 C 4004	**CC**	**04**	**II**
9	**CH-09**	Physical Chemistry-II	SBS CH 010209 C 4004	**CC**	**04**	**II**
10	**CH-10**	Inorganic Chemistry Practical-II	SBS CH 010210 C 0042	**CC**	**02**	**II**
11	**CH-11**	Organic Chemistry Practical-II	SBS CH 010211 C 0042	**CC**	**02**	**II**
12	**CH-12**	Physical Chemistry Practical-II	SBS CH 010212 C 0042	**CC**	**02**	**II**
13	**CH-13**	Molecular Spectroscopy	SBS CH 010313 C 4004	**CC**	**04**	**III**
14	**CH-14**	Research Methodology and Software Applications	SBS CH 010314 C 2002	**CC**	**02**	**III**
15	**CH-15**	Applications of Spectroscopy	SBS CH 010415 C 4004	**CC**	**04**	**IV**
16	**CH-16**	Seminar (Research paper based)	SBS CH 010416 C 4004	**CC**	**02**	**IV**
DISCIPLINE SPECIFIC ELECTIVE COURSES (DSEC)						
17	**CH-17**	Inorganic Chemistry-III	SBS CH 010301 DSE 4004	**DSEC**	**04**	**III**
18	**CH-18**	Inorganic Chemistry –IV (Advanced Inorganic Chemistry)	SBS CH 010302 DSE 4004	**DSEC**	**04**	**III**
19	**CH-19**	Inorganic Chemistry Practical-III	SBS CH 010303 DSE 0063	**DSEC**	**03**	**III**

20	**CH-20**	Inorganic Chemistry Practical-IV	SBS CH 010304 DSE 0063	**DSEC**	**03**	**III**
21	**CH-21**	Organic Chemistry-III (Heterocycles and Natural Products)	SBS CH 010305 DSE 4004	**DSEC**	**04**	**III**
22	**CH-22**	Organic Chemistry-IV (Reagents and Reactions)	SBS CH 010306 DSE 4004	**DSEC**	**04**	**III**
23	**CH-23**	Organic Chemistry Practical-III	SBS CH 010307 DSE 0063	**DSEC**	**03**	**III**
24	**CH-24**	Organic Chemistry Practical-IV	SBS CH 010308 DSE 0063	**DSEC**	**03**	**III**
25	**CH-25**	Physical Chemistry-III (Statistical Mechanics, Surface and Interface Chemistry)	SBS CH 010309 DSE 4004	**DSEC**	**04**	**III**
26	**CH-26**	Physical Chemistry-IV (Solid State Chemistry & Electro-Analytical Methods)	SBS CH 010310 DSE 4004	**DSEC**	**04**	**III**
27	**CH-27**	Physical Chemistry Practical-III	SBS CH 010311 DSE 0063	**DSEC**	**03**	**III**
28	**CH-28**	Physical Chemistry Practical-IV	SBS CH 010312 DSE 0063	**DSEC**	**03**	**III**
29	**CH-29**	Inorganic Chemistry-V	SBS CH 010413 DSE 4004	**DSEC**	**04**	**IV**
30	**CH-30**	Inorganic Chemistry-VI (Frontiers in Inorganic Chemistry)	SBS CH 010414 DSE 4004	**DSEC**	**04**	**IV**
31	**CH-31**	Inorganic Chemistry Practical-V	SBS CH 010415 DSE 0063	**DSEC**	**03**	**IV**
32	**CH-32**	Inorganic Chemistry Practical-VI	SBS CH 010416 DSE 0063	**DSEC**	**03**	**IV**
33	**CH-33**	Organic Chemistry-V (Organic Synthesis)	SBS CH 010417 SE 4004	**DSEC**	**04**	**IV**
34	**CH-34**	Organic Chemistry-VI (Medicinal Chemistry)	SBS CH 010418 DSE 4004	**DSEC**	**04**	**IV**
35	**CH-35**	Organic Chemistry Practical-III	SBS CH 010419 DSE 0063	**DSEC**	**03**	**IV**
36	**CH-36**	Organic Chemistry Practical-IV	SBS CH 010420 DSE 0063	**DSEC**	**03**	**IV**
37	**CH-37**	Physical Chemistry-V (Polymer & Surface Chemistry)	SBS CH 010421 DSE 4004	**DSEC**	**04**	**IV**
38	**CH-38**	Physical Chemistry-VI (Applied Electrochemistry)	SBS CH 010422 DSE 4004	**DSEC**	**04**	**IV**
39	**CH-39**	Physical Chemistry Practical-V	SBS CH 010423 DSE 0063	**DSEC**	**03**	**IV**

40	**CH-40**	Physical Chemistry Practical-VI	SBS CH 010424 DSE 0063	**DSEC**	**03**	**IV**
41	**CH-41**	Seminar	SBS CH 010425 DSE 2002	**DSEC**	**02**	**III**
42	**CH-42**	Scientific Report Writing in Emerging/Advanced Areas	SBS CH 010426 DSE 2002	**DSEC**	**02**	**IV**
DISCIPLINE CENTRIC ELECTIVE COURSES (DCEC)						
43	**CH-43**	Reaction Mechanism: Structure and Reactivity	SBS CH 010101 DCEC 2002	**DCEC**	**02**	**I**
44	**CH-44**	Nuclear Chemistry	SBS CH 010102 DCEC 2002	**DCEC**	**02**	**I**
45	**CH-45**	Green Chemistry	SBS CH 010303 DCEC 2002	**DCEC**	**02**	**III**
46	**CH-46**	Carbohydrate Chemistry and its Applications	SBS CH 010304 DCEC 2002	**DCEC**	**02**	**III**
47	**CH-47**	Asymmetric Catalysis: Fundamentals to Frontiers	SBS CH 010305 DCEC 2002	**DCEC**	**02**	**III**
48	**CH-48**	Supramolecular Chemistry	SBS CH 010306 DCEC 2002	**DCEC**	**02**	**III**
49	**CH-49**	Introduction to Nanomaterials	SBS CH 010307 DCEC 2002	**DCEC**	**02**	**III**
50	**CH-50**	Molecular Magnetism	SBS CH 010308 DCEC 2002	**DCEC**	**02**	**III**
DISCIPLINE CENTRIC SKILL-BASED COURSES (DCSC)						
51	**CH-51**	Computational Chemistry	SBS CH 010201 DCSC 2002	**DCSC**	**02**	**II**
52	**CH-52**	Analytical Techniques in Chemistry	SBS CH 010202 DCSC 2002	**DCSC**	**02**	**II**
53	**CH-53**	Process Development of Active Pharmaceutical Ingredients	SBS CH 010403 DCSC 2002	**DCSC**	**02**	**IV**
54	**CH-54**	Chemistry of Industrially Important Products	SBS CH 010404 DCSC 2002	**DCSC**	**02**	**IV**
DISSERTATION						
55	**CH-55A**	Dissertation-I	SBS CH 010311 SE 001408	**DSEC**	**8**	**III**
56	**CH-55B**	Dissertation-II	SBS CH 010412 SE 001408	**DSEC**	**8**	**IV**
SWACHH BHARAT INTERNSHIP PROGRAMME (MANDATORY)						
57	**CH-56**	Activities at Department and University Level	SBS CH 010105 DCSC 2002	**DCSC**	**02**	**I-IV**
SUMMER TRAINING (OPTIONAL)						

58	**CH-57**	Summer Training (6 weeks)	SBS CH 010206 DCSC 2002	**DCSC**	**02**	**At end of Sem-II**
GENERIC ELECTIVE COURSE (GEC) [FOR STUDENTS OF OTHER DEPARTMENTS]						
59	**CH-58**	Chemistry for Biologists	SBS CH 010101 GE 4004	**GEC**	**04**	**I**
60	**CH-59**	Chemistry of Materials	SBS CH 010102 GE 4004	**GEC**	**04**	**I**
61	**CH-60**	Medicinal Chemistry	SBS CH 010203 GE 4004	**GEC**	**04**	**II**
62	**CH-61**	Drug, Design and Discovery	SBS CH 010304 GE 4004	**GEC**	**04**	**III**
63	**CH-62**	Magneto Nuclear Chemistry	SBS CH 010405 GE 4004	**GEC**	**04**	**IV**

B. GEC COURSE

- Various available GEC courses can be selected from other Departments.

8. COURSE-LEVEL LEARNING OUTCOMES

INORGANIC CHEMISTRY COURSES

THEORY COURSES

Course No: CH-01	**Course Name:** Inorganic Chemistry-I				**Course Code:** SBS CH 010101 C 4004		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** I	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Basic understanding of coordination chemistry, geometries and bonding models of coordination compounds.					
Course Objectives	*To provide students with basic understanding of symmetry, coordination chemistry, magnetic properties of coordination complexes, metal carbonyl/nitrosyl and metal clusters.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Knowledge of molecular symmetry and point groups **CO2:** Understanding bonding models in coordination compounds **CO3:** Application the theories and models of chemical bonding in coordination compounds **CO4:** Understanding of skeleton electron pairs in non-transition compounds **CO5:** Introduction to metal carbonyls, nitrosyls and related compounds **CO6:** Scope of inorganic compounds						

COURSE SYLLABUS

NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	**Contents**	**Contact Hrs.**
I	**MOLECULAR SYMMETRY, POINT GROUPS AND CHARACTER TABLES** Symmetry elements and symmetry operations, symmetry groups with examples from inorganic compounds, groups of very high symmetry, molecular dissymmetry and optical activity, molecular symmetry for compounds having coordination number 2 to 9, matrix representations of symmetry operators and their products. The great orthogonality theorem and its importance, character tables and there use in spectroscopy.	15
II	**BONDING MODELS** Valence bond theory, electroneutrality principle and its limitations. Crystal field theory, splitting of *d*-orbitals in octahedral, tetragonal, square planar and tetrahedral ligand environments. Ligand field theory, molecular orbital theory. MO treatment of simple diatomic (homo & hetero) and polyatomic systems. Spectroscopic electronegativity, concept of chemical hardness (η). Walsh diagrams (triatomic systems).	15

III	**CHEMISTRY OF NON-TRANSITION ELEMENTS** Structures and acidic behaviour of boron halides, Types and nomenclature of boron hydrides (boranes), Wade's polyhedral skeleton electron pair theory (PSEPT). W. N. Lipscomb's STYX rules and semi-topological structures of boranes. Preparation, and properties of boron hydrides, carboranes, metalloboranes and metallocarboranes. Preparation, structure and properties of boron-nitrogen, phosphorous-nitrogen, phosphorus-oxygen, sulphur-nitrogen compounds, silicates, interhalogens, chlorofluorocarbons, pseudohalides and noble gas compounds.	15
IV	**METAL CARBONYLS, NITROSYLS AND CLUSTERS** Molecular orbital diagram of carbonyl, classification of metal carbonyls, bonding in metal carbonyl, valence electron count (EAN rules), preparation and properties of mononuclear and polynuclear carbonyl complexes, bond lengths and stretching frequencies, carbonylate ions, carbonyl hydride complexes, isolobal fragments, structure and important reactions of transition metal nitrosyls. Bonding, preparation and properties of dinuclear metal cluster (dirhenium complex $[Re_2Cl_8]^{2-}$ ions), trinuclear and hexanuclear metal clusters.	15

Suggested Readings:

1. G. L. Miessler, P. J. Fischer and D. A. Tarr, Inorganic Chemistry, 5th Edition. *Pearson*, 2014.
2. B. N. Figgis and M. A. Hitchman, Ligand Field Theory and Its Applications, *Wiley-India*, 2010.
3. J. E. House, Inorganic Chemistry, *Academic Press*, 2008.
4. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4thEdition. *Pearson Education*, 2006.
5. F. A. Cotton and Wilkinson, Advanced Inorganic Chemistry, 6thEdition. *John Wiley*, 2006.
6. D. F. Shriver, P.W. Atkins and C.H. Landgord, Inorganic Chemistry, 3rd Edition. *Oxford University Press*, 1998.
7. N. N. Greenwood and E. A. Earnshaw; Chemistry of elements, 2ndEdition. *Butterworth- Heinemann*, 1997.
8. J. D. Lee, Concise Inorganic Chemistry, *Chapman & Hall Ltd*., 1991.
9. F. A. Cotton, Chemical Applications of Group Theory, 3rd edition. *John Wiley & Sons*, 1990.

Course No:	Course Name:				Course Code:		
CH-07	Inorganic Chemistry-II				SBS CH 010207 C 4004		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
2021 Onwards	M.Sc. Chemistry	**II**	4	0	0	4	**Total Hrs.: 60**

Total Evaluation Marks: 100 **CIE: 30** Marks **TEE: 70** Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Basic understanding of electronic spectroscopy, magnetic properties and reaction mechanisms in coordination compounds.
Course Objectives	*To provide an understanding of the fundamentals of electronic spectroscopy of coordination compounds and advanced topics such as, reaction mechanism in complexes. Introductory nuclear chemistry and its theory will be discussed as well.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understanding of electronic properties of coordination compounds **CO2:** Knowledge of term symbols and Orgel diagrams **CO3:** Able to predict the allowed transitions between various molecular energy levels **CO4:** Understanding of anomalous magnetic behaviour **CO5:** Understanding of reaction mechanisms in coordination compounds **CO6:** Understanding of metal-ligand equilibria in solution in coordination compounds

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**ELECTRONIC SPECTROSCOPY AND MAGNETIC PROPERTIES-I** Spectroscopic ground states and the evaluation of energies of various *J* states of free ions, Term symbols, splitting of *S*, *P*, *D* and *F* terms under octahedral and tetrahedral electrostatic potential, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), calculations of *Dq*, *B* and β parameters, charge transfer spectra of complexes (both metal to ligand and ligand to metal). Spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information.	15
II	**ELECTRONIC SPECTROSCOPY AND MAGNETIC PROPERTIES-II** Brief review of different types of magnetic behaviors, spin-orbit coupling, quenching of orbital angular moments, temperature independence paramagnetism, anomalous magnetic moments. Crystal field theory and its application to explain magnetic properties of coordination compounds. Magnetic interactions in polynuclear systems, canting, spin frustration.	15
III	**REACTION MECHANISMS OF TRANSITION METAL COMPLEXES** Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes,	15

	kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism, anation reactions, reactions without metal ligand bond cleavage. Substitution reaction in square planar complexes, *trans* effect, mechanism of the substitution reactions. Redox reactions, mechanism of inner-outer sphere type reactions, cross reactions and Marcus-Hush theory.	
IV	**METAL-LIGAND EQUILIBRIA IN SOLUTION** Stepwise and overall formation constants and their interaction, trends in stepwise constants, factors influencing stability of metal complexes dependent on size and charge, metal class, ligand preference, nature of transition metal ions, basic strength, chelate effect, ring size, steric strain, macrocyclic effect, thermodynamic and kinetic stability, determination of formation constants by pH-metry and spectrophotometry.	15

Suggested Readings:

1. G. L. Miessler, P. J. Fischer and D. A. Tarr, Inorganic Chemistry, 5th Edition. *Pearson*, 2014.
2. B. N. Figgis and M. A. Hitchman, Ligand Field Theory and Its Applications, *Wiley-India*, 2010.
3. J. E. House, Inorganic Chemistry, *Academic Press*, 2008.
4.
5. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4thEdition. *Pearson Education*, 2006.
6. F. A. Cotton and Wilkinson, Advanced Inorganic Chemistry, 6thEdition. *John Wiley*, 2006.
7. D. F. Shriver, P.W. Atkins and C.H. Landgord, Inorganic Chemistry, 3rd Edition. *Oxford University Press*, 1998.
8. N. N. Greenwood and E. A. Earnshaw; Chemistry of elements, 2ndEdition. *Butterworth- Heinemann*, 1997.
9. J. D. Lee, Concise Inorganic Chemistry, *Chapman & Hall Ltd*., 1991.

Course No:	Course Name:				Course Code:		
CH-17	Inorganic Chemistry-III				SBS CH 010301 DSE 4004		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
2021 Onwards	M.Sc. Chemistry	**III**	4	0	0	4	**Total Hrs.: 60**

Total Evaluation Marks:100 **CIE: 30** Marks **TEE: 70** Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course:** To provide basic theory of various spectroscopic techniques (IR, Raman, ESR, Mossbauer, NQR) and photophysical processes involved in molecules.
Course Objectives	*To provide exposure with various spectroscopic techniques required to characterize inorganic complexes and coordination compounds. Also covered an introduction of photoinorganic chemistry involving various photophysical processes.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of IR, Raman, ESR, Mossbauer, NQR **CO2**: Basic theory of photophysical processes **CO3**: To understand spin orbit coupling **CO4**: To get insight of bond strength **CO5**: Mechanistic phenomenon **CO6**: Application of IR, Raman, ESR, Mossbauer, NQR

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**INFRARED AND RAMAN SPECTROSCOPY** Molecular vibrations, force constants, molecular vibrations and absorption of Infrared radiations. Raman spectroscopy, polarized Raman lines. Use of symmetry considerations to determine the number of lines in IR and Raman Spectra. Structural studies involving IR and Raman Spectroscopy of coordination compounds containing the following molecules/ions and ligands: NH_3, H_2O, OH, SO_4^{2-}, ClO_4^-, COO^-, NO_2, CN^-, SCN^-, NO, O_2, halides, acetylacetone. Hydrogen bonding and infrared spectra, metal ligand and related vibrations. Application of resonance Raman spectroscopy to structural elucidation of the active sites of heme and non-heme oxygen carriers.	15
II	**ELECTRON SPIN RESONANCE SPECTROSCOPY** Basic principle, selection rules, presentation of spectra, origin and interpretation of Lande's factor(g), factor affecting 'g-value', isotropic and anisotropic hyperfine coupling, super hyperfine coupling, spin-orbit coupling, line shape, zero field splitting, Kramer's degeneracy,	15

	quadrupolar interactions, ESR analysis of organic compounds, transition metal complexes of vanadium, chromium, manganese, iron, copper, cobalt and iron. Application of ESR spectroscopy: structure determination, interpretation of ESR spectra of simple organic radicals like benzene, naphthalene, toluene and xylene radical ions, study of unstable paramagnetic species.	
III	**MÖSSEBAUER AND NUCLEAR QUADRUPOLE RESONANCE SPECTROSCOPY** Mössebauer Spectroscopy: Introduction to Mössebauer effect-Basic principles, recoilless emission & absorption of γ-rays. Mössebauer experiment - Instrumentation, scheme of Mössebauer spectrometer, Mössebauer spectrum. Isomer shift, quadrapole splitting and hyperfine interactions, application of Mössebauer effect to the investigations of compounds of iron and tin. Nuclear Quadrupole Resonance Spectroscopy: Principle, nuclear quadrupole resonance experiment, structural information from NQR spectra, Interpretation of nuclear quadrupole coupling constants.	15
IV	**PHOTOINORGANIC PHENOMANON** Interaction of electromagnetic radiation with matter, Grotthus-Draper law, Stark-Einstein law of photochemical equivalence and Lambert-Beer's law, quantum yield, photodissociation, predissociation, photochemical reactions: photoreduction, photooxidation, photodimerization, photochemical substitution, photoisomerization, photosensitized reaction. Electronic transition, Frank-Condon principle, selection rules, electronically excited singlet states, life time of electronically excited state, construction of Jablonski diagram, electronic transitions and intensity of absorption bands, photophysical pathways of excited molecular system (radiative and non-radiative), chemiluminescence, phosphorescence and fluorescence.	15

Suggested Readings:

1. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan; Introduction to Spectroscopy, 5th Edition. C*engage* India, 2015.
2. K. K. Rohatgi and K. K. Mukherjee; Fundamentals of Photochemistry, 3rd Edition. *New Age International (P) Ltd*., 2014.
3. N. J. Turro, V. Ramamurthy and J. C. Scaiano; Modern Molecular Photochemistry of Organic Molecules, 1st Edition. *University Science*, 2010.
4. K. Nakamoto; Infrared and Raman Spectra of Inorganic and Coordination Compounds, Part A and B, 6th Edition. *Wiley*, 2008.
5. J. R. Lakowicz, Principles of Fluorescence Spectroscopy, 3rd Edition. *Springer*, New York, 2006.
6. C. N. Banwell and E. M. McCash; Fundamentals of Molecular Spectroscopy, 4th Edition. *Tata McGraw Hill*, 1994.
7. I. Ninomiya and T. Naito; Photochemical Synthesis, 1st Edition. *Academic Press*, New York, 1989.

Course No: CH-18	Course Name: Inorganic Chemistry–IV (Advanced Inorganic Chemistry)				Course Code: SBS CH 010302 DSE 4004		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **III**	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE: 30** Marks **TEE: 70** Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Basic knowledge of coordination chemistry, bioinorganic chemistry and supramolecular chemistry.					
Course Objectives	*To provide exposure of (i) various biomolecules containing metal ions that comprises many important proteins and enzymes (ii) supramolecular chemistry of life. This course would be highly beneficial for students who had minimal exposure of bioinorganic chemistry at the undergraduate level.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Importance of metal ions in biology **CO2:** Understanding of membrane potential and its functions **CO3:** Knowledge of various enzymes and its activities **CO4:** Advanced applications of bioinorganic chemistry with regard to energy applications **CO5:** Understanding of supramolecular chemistry of life **CO6:** Knowledge of supramolecular accessories in biological systems						

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**BIOINORGANIC CHEMISTRY-I** Mineral origin of life. Archaeal, Eucarial and Bacterial domain. Transition metal ions in biology. Metallobiomolecules. Electron carriers, oxygen carriers, enzymes. Specific examples: Hemoglobin, Myoglobin, Hemocyanin, Hemrythrin, Cytochromes, Fe-S proteins, Cytochrome P-450, Nitrophorin, Ferritin, blue copper proteins, di- and tricopper proteins, ceruloplasmin.	15
II	**BIOINORGANIC CHEMISTRY-II** NO-synthase, peroxidase, catalase, cytochrome-C oxidase, Other enzymes like, hydrogenase, methane monooxygenase, dioxygenases, dehydratase, nitrogenase, molybdenum containing oxidase and reductase class of enzymes like sulfite oxidase, xanthine oxidase, nitrate reductase, DMSO reductase. Zn enzymes like carbonic anhydrase, carboxypeptidase, DNA and RNA polymerases, role of manganese in water splitting.	15

III	**DEVELOPING FACETS OF MODERN INORGANIC CHEMISTRY** Oxidative generation of molecular oxygen from water during photosynthesis, Its importance from the standpoint of non-conventional energy research, Reductive cleavage of the dioxygen bond, Reductive cleavage of dioxygen bond and novel organic transformations including methane to methanol performed by a large number of Fe containing metalloenzymes.	15
IV	**SUPRAMOLECULAR CHEMISTRY OF LIFE** Biological Inspiration for Supramolecular Chemistry; Alkali Metal Cations in Biochemistry; Membrane Potentials; Membrane Transport; Rhodopsin: A Supramolecular Photonic Device; Porphyrins and Tetrapyrrole Macrocycles; Supramolecular Features of Plant Photosynthesis; The Role of Magnesium Tetrapyrrole Complexes; Neurotransmitters and Hormones; Semiochemistry in the Natural World; Structure of DNA and its Function; Site-Directed Mutagenesis; Biochemical Self-Assembly.	15

Suggested Readings:

1. J. W. Steed, Supramolecular Chemistry: From Molecules to Nanomaterials, 8 Volume Set Edition. *John Wiley & Sons*, 2012.
2. J. W. Steed and J. L. Atwood, Supramolecular Chemistry, 2nd Edition. *Wiley*, 2009.
3. J. E. House, Inorganic Chemistry, *Academic Press*, 2008.
4. F. A. Cotton and Wilkinson, Advanced Inorganic Chemistry, 6thEdition. *John Wiley*, 2006.
5. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4thEdition.*Pearson Education*, 2006.
6. J.-M. Lehn, Supramolecular Chemistry: Concepts and Perspectives. *Wiley*, 2006.
7. D. F. Shriver, P.W. Atkins and C.H. Landgord, Inorganic Chemistry, 3rd Edition. *Oxford University Press*, 1998.
8. S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry. *University Science Book, Mill Valley*, 1994.
9. I. Bertini, H.B. Gray, S. J. Lippard and J.S. Valentne, Bioinorganic Chemistry. *University Science Books, Mill Valley,* 1994.

Course No: CH-29	Course Name: Inorganic Chemistry-V						Course Code: SBS CH 010413 DSE 4004
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **IV**	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks:100 **CIE: 30** Marks **TEE: 70** Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Detailed study of bonding, structure, synthesis and reactions of various types of organometallic complexes. Metal complexes of carbons at various oxidation levels will be discussed. Synthesis and stability, precautions in handling, characterization techniques and utility or TM-complexes will be studied. The applications of metal complexes in catalysis will be studied in detail.					
Course Objectives	*Fundamental understanding of organometallic compounds, reactions of various organometallics and their usefulness.*						
Course Outcomes :	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of organometallic compounds **CO2**: Synthesis of organometallic compounds **CO3**: Structural analysis of organometallic compounds **CO4**: To understand fluxional behavior in organometallic compounds **CO5**: To understand mechanistic study involved in organometallic compounds **CO6**: Scope of organometallic compounds						

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**METAL-ALKYLS, ARYLS, CARBENES AND CARBYNES** Synthesis, structure and bonding considerations of Zeise's salt; synthesis, stability and decomposition pathways of organocopper in organic synthesis; synthesis and reactivity of alkyl lithium; synthesis and reactivity of organozinc compounds. Metal carbenes: preparation, reactivity, structure and bonding considerations of Fischer and Schrock carbene complexes, Tebbe's reagent, Grubb's reagent, Petasis reagent, Metal carbynes: synthesis, reactivity, structure and bonding considerations of Fischer and Schrock carbyne complexes.	15
II	**TRANSITION METAL PI-CYCLIC COMPLEXES** Half and bent sandwich compounds, molecular orbitals of metallocenes, structures of cyclopentadienyl compounds, covalent versus ionic bonding, 18 electron rule, synthesis, structure, aromatic behaviour of Ferrocene, reactions such as metallation, Friedel Craft, Mannich reaction, sulphonation, nitration, halogenations reactions, Synthesis, structure and reactions of other metallocenes (with Cr, Ni and Zr metals).	15

III	**FLUXIONAL ORGANOMETALLIC COMPOUNDS AND COUPLING REACTIONS** Rates of rearrangement and techniques of study, NMR study of Fluxional behavior, Classification of fluxional organometallic Compounds, Mechanism of fluxionality in compounds of η^1-cyclopentadienyls and η^3–allyls. Stereochemical non-rigidity in case of coordination numbers- 4 & 5 (*cis-trans*, atomic inversion, Berry Pseudorotation). Tsuji-Trost, Mizoroki-Heck, Miyaura-Suzuki, Stille, Negishi, Sonogashira, Kumada, Hiyama, Buchwald-Hartwigamination or coupling reactions.	15
IV	**CATALYTIC PROCESSES INVOLVING TRANSITION METAL ORGANOMETALLIC COMPOUNDS** Oxidative addition, reductive elimination, insertion-migration reactions, C-H bond activation catalytic mechanism of hydrogenation, hydroformylation, oxidation and isomerization of alkenes, Monsanto acetic acid synthesis, olefin metathesis, Fischer-Tropsch synthesis and Ziegler-Natta polymerization of alkenes, water gas shift reaction, asymmetric and supported organometallic catalysis.	15

Suggested Readings:

1. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 3rdEdition. *Pearson*, 2018.
2. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, 5thEdition. *John Wiley*, 2009.
3. R. C. Mehrotra and A. Singh, Organometallic Chemistry, 2nd Edition. *New Age International*, 2007.
4. R. B. Jordan, Reaction Mechanism of Inorganic and Organometallic systems; 3rdEdition.*Oxford University Press*, 2007
5. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4thEdition.*Pearson Education*, 2006.

Course No: CH-30	Course Name: Inorganic Chemistry-VI (Frontiers in Inorganic Chemistry)				Course Code: SBS CH 010414 DSE 4004		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **IV**	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE:** **30** Marks **TEE:** **70** Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Basic idea of coordination chemistry, bonding models and lanthanides.					
Course Objectives	*To impart knowledge about advanced application of inorganic compounds as semiconductors, in imaging techniques, as solid adsorbents for energy applications.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Knowledge of solid state inorganic materials and bonding models **CO2:** Application of inorganic compounds as superconductors **CO3:** Application of lanthanides as chemosensors and in imaging **CO4:** Preliminary knowledge about X-ray and its use in structural determination **CO5:** Introduction hybrid materials or coordination polymers **CO6:** Use coordination polymers in catalysis and energy applications						

COURSE SYLLABUS

NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**INORGANIC MATERIALS** Brief introduction of solid state, metallic bond, Band theory (Zone model, Brillouin Zones, Limitations of the Zone model); Defects in solids, p-type and n-type; Inorganic semiconductors, its use in transistors, IC, etc.; Properties of inorganic materials: Electrical, Optical, Magnetic and Thermal. Superconductors, with special emphasis on the synthesis and structure of high temperature superconductors.	15
II	**ADVANCED APPLICATION OF LANTHANIDES** **Luminescence-based Chemosensors and Bio-imaging with Lanthanide Complexes:** Modulation of lanthanide luminescence and quenching, Chemosensor design principle, Time-resolved luminescence, Ln-based bioimaging, cellular imaging probes. **Lanthanide-base MRI Contrast Agents:** Principles of MRI, Contrast agents, Gadolinium-chelates as MRI contrast agents, water-exchange kinetics, Relaxivity, relaxation time, molecular parameters for relaxivity in MRI probes, Sensitivity and Selectivity of MRI probes, New generation MRI contrast agents.	15

III	**CRYSTAL AND MOLECULAR STRUCTURE DETERMINATION** Generation of X-rays, monochromators, safety, Concept of direct and reciprocal lattices, Bragg's law of X-ray diffraction in direct and reciprocal lattice, crystal systems, point groups, Bravais lattices, Rotational axes of symmetry, screw axes, glide planes, equivalent points, systematic absences, space groups.	15
IV	**COORDINATION POLYMERS** Introduction, Classification of Coordination Polymers, Design Strategies of Coordination Polymers-Metal Nodes and Linkers, Secondary Building Unit Concept, Topology and Interpenetration, Synthesis of Coordination Polymers-Solvothermal/Hydrothermal, Sonochemical, Microwave, Mechanochemical. Characterization: Diffraction and Spectroscopic Methods. Applications of Coordination Polymers in Gas Storage, Gas Separation, Catalysis and Drug Delivery.	15

Suggested Readings:

1. P. Martin-Ramos, M. Ramos-Silva, Lanthanide-Based Multifunctional Materials. *Elsevier*, 2018.
2. A. de Bettencourt–Dias, Luminescence of Lanthanide Ions in Coordination Compounds and Nanomaterials. *John Wiley and Sons*, 2014.
3. P. Hänninen, H. Härmä, Lanthanide Luminescence: Photophysical, Analytical and Biological Aspects. *Springer*, 2011.
4. S. R. Batten, S. M. Neville and D. R. Turner, Coordination Polymers: Design, Analysis and Application. *RSC Publishing*, 2009.
5. M.-C. Hong and L. Chen, design and Construction of Coordination Polymers. *Wiley*, 2009.
6. S. Cotton, Lanthanide and Actinide Chemistry. *John Wiley & Sons*,2006.
7. M. Ladd and R. Palmer, Structure Determination by X-ray Crystallography. *Kluwer Academic/Plenum, N.Y.*, 2003.
8. H. V. Keer, Principles of the Solid State. *Wiley Eastern Ltd.: New Delhi*, 1993.
9. A. R. West, Solid State Chemistry and its Applications. *John Wiley & Sons*, 1987.
10. J. P. Glusker and K. N. Trueblood, Crystal Structure Analysis- A Primer. *OUP, N.Y.*, 1985.
11. N. Hannay, Treatise on Solid State Chemistry. *Plenum*, 1976.
12. G. H. Stout and H. L. Jensen, X-ray Structure Determination- A Practical Guide. *Macmillan, N.Y.*, 1968.

PRACTICAL COURSES

Course No: CH-04	**Course Name:** Inorganic Chemistry Practical-I				**Course Code:** SBS CH 010104 C 0042		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** I	**L** 0	**T** 0	**P** 4	**Credit** 2	**Contact Hrs. per Week: 04** **Total Hours: 60**
Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks	**Examination Duration:** 6 Hrs. **Pre-requisite of course:** Knowledge of bonding models in coordination compounds, handling of glassware and plastic ware in laboratory.						
Course Objectives	*To impart knowledge about water analysis and preparation of popular coordination complexes.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Analysis of water samples available routinely **CO2:** Determination DO, COD and BOD in water samples **CO3:** Determination of solid impurity and turbidity present in water samples **CO4:** Preparation of coordination complexes **CO5:** Appreciate the morphology and color of coordination complexes **CO6:** Basic knowledge of inorganic preparation						

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	**Contents**	**Contact Hrs.**
I	**WATER ANALYSIS** 1. Determination of dissolved oxygen, DO of a given water sample. 2. Determination of chemical oxygen demand, COD of a given water sample. 3. Determination of biological oxygen demand, BOD of a given water sample. 4. Determination of total suspended solids and total dissolved solids. 5. Determination of turbidity of a water sample by nephlometer. 6. Determination of presence of Ca^{2+}, Mg^{2+}, Fe^{3+} and Fe^{2+} ions of a given water sample.	25
II	**PREPARATIONS AND RELATED COMPLEMENTARY WORK (ANY SIX)** 1. Reinecke Salt 2. $VO(acac)_2$ 3. $Mn(acac)_3$ 4. Prussian Blue/Turnbull's Blue 5. $Hg[Co(NCS)_4]$ 6. Potassium trioxalatoferate (III) Trihydrate 7. Potassium trioxaltochromate (III) 8. Cis, trans-dichlorobis(ethylenediammine)cobalt(III)chloride.	35

Suggested Readings:

1. J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, Vogel's Textbook of Quantitative Analysis, revised, 5thEdition.*ELBS*, 1989.
2. G. Svehla, Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, 5thEdition.Longman, 1979.
3. Marr and Rocket, Practical Inorganic Chemistry, *Van Nostrand Reinhold*, 1972.

Course No: CH-10	Course Name: Inorganic Chemistry Practical-II				Course Code: SBS CH 010210 C 0042		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** II	**L** 0	**T** 0	**P** 4	**Credit** 2	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 50 **CIE: 15** Marks **TEE: 35** Marks	**Examination Duration:** 6 Hrs. **Pre-requisite of course:** Basic knowledge of quantitative estimation and radical analysis gained during undergraduate courses.						
Course Objectives	*To impart knowledge of volumetric-redox and complexometric estimations and analysis of mixture of radicals, both acidic and basic.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Detailed understanding of quantitative estimations **CO2:** Knowledge of volumetric-redox titrations **CO3:** Knowledge of complexometric titrations **CO4:** Advanced knowledge of qualitative analysis **CO5:** Analysis of acidic and basic radicals from mixture of radicals **CO6:** Analysis of interfering radicals present in a mixture of ions						

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**QUANTITATIVE ESTIMATION** Quantitative estimation (involving volumetric-redox and complexometry) of constituents in two and three component mixtures.	30
II	**SEMIMICRO QUALITATIVE ANALYSIS** Complete systematic analysis of Inorganic mixtures containing six ions including the interfering radicals.	30

Suggested Readings:

1. J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, Vogel's Textbook of Quantitative Analysis, revised, 5thEdition. *ELBS*, 1989.
2. G. Svehla, Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, 5thEdition. *Longman*, 1979.
3. Marr and Rocket, Practical Inorganic Chemistry. *Van Nostrand Reinhold*, 1972.

Course No: CH-19	Course Name: Inorganic Chemistry Practical-III				Course Code: SBS CH 010210 DSE 0063		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **III**	**L** 0	**T** 0	**P** 6	**Credit** 3	**Contact Hrs. per Week: 06** **Total Hrs.: 90**
Total Evaluation Marks: 75 **CIE:** **22.5** Marks **TEE:** **52.5** Marks		**Examination Duration:** 8 Hrs. **Pre-requisite of course:** Basic idea of oxidation and reduction process in inorganic complexes, vibrational and electronic spectroscopy.					
Course Objectives	*To impart knowledge of experimental spectroscopic techniques and oxidation-reduction processes in coordination complexes. The students will also be introduced about single-crystals, their synthesis and characterization.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Experimental knowledge of UV-Visible and FTIR spectroscopy **CO2:** Protocol of characterizing coordination complexes by these techniques **CO3:** Experimental knowledge of oxidation-reduction reactions in coordination compounds **CO4:** Analyse and quantify inorganic samples using oxidation-reduction titrations **CO5:** Detailed understanding about single-crystals **CO6:** Synthesis and characterization of single-crystals						

COURSE SYLLABUS

NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**SPECTROSCOPIC STUDIES** Measurement of FTIR and UV-Visible Spectra of coordination compounds, data plotting, analysis and characterization of coordination complexes/compounds using Infrared and UV-Visible Spectroscopy.	30
II	**OXIDATION-REDUCTION TITRATIONS** (i) Preparation of 0.1M cerium (IV) sulphate and its standardization with ammonium iron(II) sulphate or sodium oxalate. (ii) To determine the concentration of the nitrite ions in the sample solution using standardized cerium (IV) sulphate. (iii) To determine the percentage purity of the $NaNO_2$ using standardized cerium (IV) sulphate.	30
III	**SINGLE-CRYSTALS** Methods of growing single-crystals: (i) Diffusion method; (ii) Hydrothermal and Solvothermal method; (iii) Slow evaporation method. To grow single-crystals of molecular compounds, metal-organic cages and metal-organic higher dimensional compounds. Identification of single-crystals under polarizing optical microscope.	30

Suggested Readings:

1. J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, Vogel's Textbook of Quantitative Analysis, revised, 5th Edition. *ELBS*, 1989.
2. Marr and Rocket, Practical Inorganic Chemistry. *Van Nostrand Reinhold*, 1972.
3. K. Nakamoto; Infrared and Raman Spectra of Inorganic and Coordination Compounds, Part A and B, 6th Edition. *Wiley*, 2008.
4. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan; Introduction to Spectroscopy, 5thEdition. *Cengage India*, 2015.

Course No: CH-20	Course Name: Inorganic Chemistry Practical-IV				Course Code: SBS CH 010304 DSE 0063		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **III**	**L** 0	**T** 0	**P** 6	**Credit** 3	**Contact Hrs. per Week: 06** **Total Hrs.: 90**
Total Evaluation Marks: 75 **CIE: 22.5** Marks **TEE: 52.5** Marks		**Examination Duration:** 8 Hrs.					
		Pre-requisite of course: *Preliminary knowledge of electrochemistry, chromatography and quantitative analysis.*					
Course Objectives	*To gain knowledge about various techniques for the characterization of inorganic and coordination compounds through hands-on-practice.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of chromatography **CO2**: Development of experimental skills to separate ions from mixtures **CO3**: Basic understanding of volumetric and gravimetric methods **CO4**: Characterization of compounds **CO5**: Estimation of metals from samples **CO6**: Interpretation of outcomes						

COURSE SYLLABUS

NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**CHROMATOGRAPHY** Separation of binary mixtures in the given solution by paper chromatography, visualizing solution: concentrated ammonia, ascending chromatography.	30
II	**GRAVIMETRY** To prepare solutions of different metal ions and estimate the metal ions gravimetrically. Three component metal ion analysis (one volumetric and two gravimetric method).	30
III	**IODIMETRIC TITRATIONS** Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically). Estimation of (i) arsenite and (ii) antimony iodimetrically Estimation of available chlorine in bleaching powder iodometrically	30

Suggested Readings:

1. J. A. I. Mendham, Vogel's Quantitative Chemical Analysis, 6thEdition. *Pearson*, 2009.
2. J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, Vogel's Textbook of Quantitative Analysis, revised, 5thEdition. *ELBS*, 1989.
3. G. Svehla, Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, 5thEdition. *Longman*, 1979.
4. Marr and Rocket, Practical Inorganic Chemistry, *Van Nostrand Reinhold*, 1972.

Course No:	Course Name:				Course Code:		
CH-31	Inorganic Chemistry Practical-V				SBS CH 010415 DSE 0063		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 06**
2021 Onwards	M.Sc. Chemistry	**IV**	0	0	6	3	**Total Hrs.: 90**
Total Evaluation Marks: 75 **CIE: 22.5** Marks **TEE: 52.5** Marks		**Examination Duration:** 8 Hrs. **Pre-requisite of course:** Basic knowledge of preparation, estimation and characterization of inorganic compounds.					
Course Objectives	*To enable students analyse and characterize the given inorganic sample with knowledge of spectroscopy and titrations.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1: Determination of absorbance of an inorganic sample** **CO2: Determine the concentration of sample with the help of absorbance** **CO3: Knowledge of precipitation titrations** **CO4: Determination of chloride in neutral solution using precipitation titrations** **CO5: Knowledge of titrations** **CO6: Interpretation of electronic and magnetic properties of inorganic complexes**						

COURSE SYLLABUS

NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**EXPERIMENTAL DETERMINATIONS WITH ULTRAVIOLET /VISIBLESPECTROPHOTOMETERS** (i) Determination of the absorption curve and concentration of a Substance (potassium nitrate) (ii) Simultaneous spectrophotometric determination (chromium and manganese)	30
II	**PRECIPITATION TITRATIONS** (i) Preparation of 0.1M silver nitrate and its standardization with Mohr's method using potassium chromate/adsorption indicator. (ii) Determination of chloride in neutral solution by titration with standard 0.1 M silver nitrate.	30
III	**PREPARATION, CHARACTERIZATION AND ESTIMATION (ANY TWO)** (i) Preparation of hexamminecobalt(III) chloride and determine the percentage of cobalt in the product iodimetrically. (ii) Preparation of chloropentaammine cobalt (III) chloride and interpretation of electronic spectrum and magnetic properties. (iii) Preparation of $[Co(acac)_3]$ and interpretation of electronic spectrum and magnetic properties.	30

Suggested Readings:

1. J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham,Vogel's Textbook of Quantitative Analysis, revised, 5th Edition. *ELBS*, 1989.
2. G. Svehla, Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, 5th Edition. *Longman*, 1979.
3. Marr and Rocket, Practical Inorganic Chemistry. *Van Nostrand Reinhold*, 1972.
4. Pass, G.; Sutcliffe Practical Inorganic Chemistry, 1st Edition.*Chapmann and Hall Ltd.*, 1968.
5. Jolly, W.L. Synthetic Inorganic Chemistry, 2nd Edition.*Prentice Hall, Inc.*, 1961.

Course No: CH-32	Course Name: Inorganic Chemistry Practical-VI				Course Code: SBS CH 010416 DSE 0063		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **IV**	**L** 0	**T** 0	**P** 6	**Credit** 3	**Contact Hrs. per Week: 06** **Total Hrs.: 90**
Total Evaluation Marks: 75 **CIE:** **22.5** Marks **TEE:** **52.5** Marks	**Examination Duration:** 8 Hrs. **Pre-requisite of course:** Basic knowledge of ores, alloys and rare earth elements. Knowledge of qualitative and quantitative analysis.						
Course Objectives	*To train students to analyse ores and alloys and extract/separate rare earth elements. Also impart knowledge to analyse and estimate selected inorganic compounds.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Knowledge of analysis of ores and alloys **CO2**: Practical analysis of samples of ores and alloys **CO3**: Analysis of selected inorganic complexes **CO4**: Knowledge of purification and structural elucidation **CO5**: Knowledge of rare earth samples **CO6**: Extraction and separation of rare earth from the given samples						

COURSE SYLLABUS

NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**ANALYSIS OF ORES, ALLOYS BY QUALITATIVE AND QUANTITATIVE METHODS** Chemical methods for analysis of ores and alloys by qualitative and quantitative methods like gravimetric, radical analysis, titrimetric Ore Analysis (At least two of the following): • Determination of Silica and Manganese in pyrolusite • Determination of Copper and iron from chalcopyrite • Determination of iron from hematite Alloy Analysis (At least two of the following): • Determination of tin & lead from solder • Determination of iron & chromium from mild steel • Determination of copper and nickel from cupronickel	30
II	**ANALYSIS OF INORGANIC SUBSTANCES BY QUALITATIVE AND QUANTITATIVE METHODS** Preparation, purification and structural elucidation of some of the complexes from the following by available physicochemical and spectral methods: (i) $[Co(Py)_2Cl_2]$; (ii) $[Ni(NH_3)_6]Cl_2$; (iii) $Ni(dmg)_2$; (iv) $[Cu(NH_3)_4]SO_4.H_2O$; (v) Bis (cyclopentadienyl) iron (II); (vi) Ferrocene; (vii) Fe-Phenanthroline complex.	30
III	**DETERMINATION OF INDIVIDUAL CATIONS** Determination of aluminium, barium and bismuth by back titration. Determination of	30

	copper, iron(III) and nickel by direct titration.	

Suggested Readings:

1. G. Marr and B. W. Rockett, Practical Inorganic Chemistry.*Van Nostrand Reinhold*, 2019.
2. T.Dutta, K. H. Kim, M. Uchimiya, E. E. Kwon, B. H. Jeon, A. Deep and S. T. Yun, Global demand for rare earth resources and strategies for green mining. *Environ. Res.* 2016, 150, 182-190.
3. J. Derek Woolins, Inorganic Experiments. *Wiley VCH,* 2014.

ORGANIC CHEMISTRY COURSES

THEORY COURSES

Course No: CH-02	Course Name: Organic Chemistry-I				Course Code: SBS CH 010102 C 4004		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** I	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course**: Basic knowledge of chemical bonding, theories of bonding, stereochemistry, reaction mechanisms and reactive intermediates.					
Course Objective	*To provide the basics in Organic Chemistry at the beginning of the semester. At the end of this course, students will gain the knowledge about the nature of bonding in organic molecules, delocalized chemical bonding, aromaticity, stereochemistry, such as conformation and configuration, RS and EZ notations and mechanistic aspects of aliphatic and aromatic nucleophilic substitution and electrophilic aromatic substitutions and elimination reactions.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Advanced understanding of the concepts delocalisation, conjugation and aromaticity **CO2**: Advanced knowledge of supramolecular chemistry and non-covalent bonding **CO3**: Advanced knowledge of conformational analysis, dynamic stereochemistry and asymmetric synthesis **CO4**: In-depth understanding of all classes of nucleophilic substitution reactions **CO5**: Fundamental and advanced knowledge elimination reactions and its stereochemical aspects **CO6**: Detailed mechanistic knowledge of aromatic substitution reactions						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**NATURE OF BONDING IN ORGANIC MOLECULES** Delocalized chemical bonding-conjugation, cross conjugation, resonance, rules of resonance, effect on reactivity, hyperconjugation, tautomerism; Energy level of π–molecular orbitals, Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Hückel's rule, annulenes, anti-aromaticity, homo-aromaticity; bonding in fullerenes. Fundamentals of Supramolecular Chemistry, Bonds weaker than covalent- addition compounds, crown ether complexes and cryptands, inclusion compounds, cyclodextrins, catenanes and rotaxanes.	15
II	**STEREOCHEMISTRY** ***Conformational analysis***: Simple alkanes, cycloalkanes, A values, decalins, conformational lock, ring strain, effect of conformation on reactivity.	15

	***Chirality*:** Basic principles, molecules with more than one chiral center, threo and erythroisomers, Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes); Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus. Methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Asymmetric synthesis: basic principles, chiral pool, auxiliary, substrate, reagent and catalyst controlled.	
III	**ALIPHATIC NUCLEOPHILIC SUBSTITUTION AND ELIMINATION REACTIONS** ***a) Aliphatic Nucleophilic Substitution Reactions:*** The S_N2, S_N1, mixed S_N1 and S_N2 and SET Mechanisms. The neighbouring group mechanism, neighbouring group participation by π and σ bonds. Classical and nonclassicalcarbocations, phenonium ions, norbornyl system, common carbocation rearrangements. The S_N^i mechanism. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity. ***b) Elimination Reactions:*** The E2, E1 and E1cB mechanisms. Orientation of the double bond. Reactivity – effects of substrate structures, attacking base, the leaving group and the medium.	15
IV	**AROMATIC SUBSTITUTION REACTIONS** ***a) Aromatic Electrophilic Substitution:*** The arenium ion mechanism, orientation and reactivity. The *ortho/para* ratio, *ipso* attack, orientation in other ring systems. Friedel-Crafts reaction, Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction. ***b) Aromatic Nucleophilic Substitution:*** The S_N^{Ar}, diazonium salts and benzyne mechanisms. Reactivity–effect of substrate structure, leaving group and attacking nucleophile. The *von* Richter, Sommelet-Hauser and Smiles rearrangements.	15

Suggested Readings:

1. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Revised Edition. (Revised by S. P. Singh and Om Prakash). *TRINITY Press*, An Imprint of Laxmi Publications Pvt. Ltd., 2015.
2. R. N. Boyd, R. T. Morrison and S. K. Bhattcharjee, Organic Chemistry, 7thEdition. *Pearson*, 2014.
3. M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 7thEdition. *Wiley*, 2013.
4. J. Clayden, N. Geeves and S. Warren, Organic Chemistry, *Oxford University Press*, 2012.
5. E. L. Eliel and S. H. Wilen, Stereochemistry of Organic Compounds, *Wiley India*, 2008.
6. F. A. Carey and R. J. Sundburg, Advanced Organic Chemistry PART A, *Springer* 2007.
7. P. Y. Bruice, Organic Chemistry, 7thEdition. *Pearson,* 2007.
8. D. Nasipuri, Stereochemistry of Organic Compounds, Second Edition. *New Age International*, 2005.
9. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, *Longman*, 1985.

Course No:	Course Name:				Course Code:		
CH-08	Organic Chemistry-II				SBS CH 010208 C 4004		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs. per Week: 04**
2021 Onwards	M.Sc. Chemistry	**II**	4	0	0	4	**Total Hrs.: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** **3 Hrs.** **Pre-requisite of course:** Basic knowledge about the structure and reactions of various alkenes and carbonyl compounds; formation, stability and reactions of free radicals; fundamentals of interaction of light with matter; basic knowledge of conjugation and molecular orbital diagrams.
Course Objective	*To provide advance knowledge of organic chemistry reactions such as addition reactions, free radical, photochemistry and pericyclic reactions. At the end of this course, students will be trained in solving the problems related to addition reactions, free radical reactions, photochemistry and pericyclic reactions.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: In-depth understanding of electrophilic addition reaction of alkenes, alkynes and allenes **CO2**: Thorough knowledge of the addition, substitution and condensation reactions of carbonyl compounds **CO3**: Advanced knowledge of formation, stability and reactions of free radicals **CO4**: In-depth knowledge of various photochemical reactions in organic chemistry **CO5**: Ability to understand, explain and predict various aspects of pericyclic reactions such as electrocyclic reactions and cycloadditions. **CO6**: Theoretical treatments and applications of sigmatropic rearrangements and chelotropic reactions

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**ADDITION REACTIONS OF CARBON-CARBON AND CARBON-HETEROATOM MULTIPLE BONDS** ***a) Polar addition to Carbon-Carbon Multiple Bonds:*** Mechanistic and stereochemical aspects of following **electrophilic addition reactions**: hydrohalogenation, hydration, epoxidation, Woodward and Prevost dihydroxylations, halogenation, halocyclizations, oxymercuration, hydrogenation, hydroboration and carbene cyclopropanation. General aspects of addition reactions of alkynes and allenes. Addition of **nucleophiles** to alkenes, Michael reaction, nucleophilic epoxidation and cyclopropanation. ***b) Addition to Carbon-Heteroatom Multiple Bonds:*** Reactivity of various carbonyl compounds, Mechanistic and stereochemical aspects of	15

	following nucleophilic addition reactions to carbonyl compounds**:** hydration, acetalization, imine and enamine formation, Grignard, organozinc and organolithium reagents, Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions, Addition of ylides (Wittig, Julia and Peterson reactions), hydride reductions of various carbonyl compounds. Hydrolysis of acetals, esters, amides and nitriles.	
II	**FREE RADICAL REACTIONS AND ORGANIC PHOTOCHEMISTRY** ***a) Free radicals:*** Generation of free radicals, structure and stability, persistent radicals, common initiators and uses (peroxides, UV light, AIBN-tin hydride), radical anions and cations (One electron redox reactions), radical chain reactions, radical scavengers, Types of free radical reactions: substitution (halogenation, Sandmeyer reaction), addition (to unsaturated systems, radical cyclization), fragmentation (Hunsdiecker reaction), intramolecular H-abstraction (Hofmann-Loeffler and Barton reactions), oxidation (auto-oxidation of aldehydes) and dimerization (Pinacol, McMurry, acyloin and Glaser reactions) ***b) Organic Photochemistry*****:** Fundamentals of organic photochemistry, Photochemical reactions of alkenes: photo-cycloaddition, Paterno-Buchi reaction, di-pi-methane rearrangement) Photochemical reactions of carbonyl compounds: Norrish type I and II reactions, di-pi methane and oxa-di-pi methane rearrangements. Basics of visible light photocatalysis.	15
III	**PERICYCLIC REACTIONS I- ELECTROCYCLIC AND CYCLOADDITION REACTIONS** Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene, allyl and pentadienyl systems. Classification of pericyclic reactions. FMO approach. **Electrocyclic reactions**: conrotatory and disrotatory modes and effect on stereochemistry, 4n, 4n+2, allyl and pentadienyl systems, Nazarov cyclization. **Cycloaddition reactions:** antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, Detailed treatment of Diels-Alder reactions (types of Diels-Alder reactions, common dienes and dienophiles, endo/exo selectivity, catalysis, synthetic applications, intramolecular and hetero Diels-Alder reactions), **1,3-dipolar cycloadditions**: structure, methods of preparation andsynthetic applications of nitrones, nitrile oxides and azides.	15
IV	**PERICYCLIC REACTIONS II- SIGMATROPIC, ENE AND CHELOTROPIC REACTIONS** **Sigmatropic rearrangements**: General considerations, suprafacial and antarafacial shifts of H and alkyl groups, 1,3, 1,5, 3,3 and 2,3-sigmatropic rearrangements. Valence tautomerism (divinylcyclopropane and bullvalene), Detailed treatment of Claisen (Eschenmoser, Johnson, Ireland and aromatic variants), Cope (oxy-Cope and anionic oxy-Cope) rearrangements. Wittig, aza-Wittig and Sommelet-Hauser rearrangements, concerted syn-eliminations. **Ene reactions**: General features, carbonyl and oxy-ene reactions, intramolecular ene reactions. **Chelotropic eliminations**: Definition, examples involving nitrogen, sulfur dioxide and carbon monoxide extrusions.	15

Suggested Readings:

1. S. Kumar, V. Kumar and S. P. Singh, Pericyclic Reactions, A Mechanistic and Problem-Solving Approach, Ist Edition. *Elsevier*, 2015.
2. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Revised Edition. (Revised by S. P. Singh and Om Prakash). *TRINITY Press*, An Imprint of Laxmi Publications Pvt. Ltd., 2015.
3. Michael B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7th Edition. *Wiley*, 2013.
4. J. Clayden, N. Geeves and S. Warren, Organic Chemistry, *Oxford University Press*, 2012.
5. Morrison, Boyd and Bhattacharjee, Organic Chemistry, 7thEdition. *Pearson*, 2010.
6. F. A. Carey and R. J. Sundburg, Advanced Organic Chemistry PART A and PART B, *Springer* 2007.
7. S. Sankararaman, Pericyclic reactions-A Textbook, 1st Edition. *Wiley-VCH, Weinheim*, 2005.
8. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanism, *Harcourt (India) Pvt. Ltd*., 2001.
9. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, *Longman*, 1985.

Course No: CH-14	Course Name: Research Methodology and Software Applications				Course Code: SBS CH 010314 C 2002		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** III	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week: 02** **Total Hrs.: 30**
Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks		**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Basic knowledge of various methods used in research, literature review skills, finding and drafting research problems and various software used to conduct research smoothly.					
Course Objective	*Guiding philosophy of knowledge creation and dissemination will be discussed in this course. Features of various approaches to research, data collection, analysis and inference will be taught. Principles of formulating research problems, designing experiments and documentation will form a major part of the course. Specific objectives and techniques of chemical sciences research will also be presented.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of various types of methodologies used during research. **CO2**: Basic idea of literature review and defining problems **CO3**: Basic knowledge of working hypothesis. **CO4**: Basic knowledge of various software used during research **CO5**: Skills for writing a research report **CO6**: Basic knowledge for writing dissertation						

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**METHODS AND TYPES OF RESEARCH** Research methods vs Methodology. Types of research, Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical. Research proposals- design and components.	7
II	**LITERATURE REVIEW** Importance of literature review in defining a problem, Primary and secondary sources, reviews, treatise, monographs-patents, Defining and formulating the research problem, Selecting the Problems, Development of working hypothesis.	8

III	**SCIENTIFIC SOFTWARES IN RESEARCH DESIGN** Data Analysis using Tools like MS Excel, ChemDraw and MATLAB, google scholar, chemspider, scifinder, scopus, reaxys, research gate; using advanced search techniques, web resources, e-journals, e-books, journal access, subscribing TOC alerts, hot articles, citation index, h-index and i-index, Impact factor	7
IV	**REPORTING, DOCUMENTATION AND PRESENTATION** Scientific Document; Organization and writing of research papers, short communications, review articles, monographs, peer reviewing, ethics in publishing, predatory journals and publishers, technical and survey reports, authored book and edited books and dissertation.	8

Suggested Readings:

1. A. Fink, Conducting Research Literature Reviews: From the Internet to Paper, *Sage Publications*, 2009.
2. M. Graziano, A.M. Anthony and M. L. Raulin, Research Methods: A Process of Inquiry, *Allyn and Bacon*., 2009.
3. W. M. K. Trochim, Research Methods: the concise knowledge base, *Atomic Dog Publishing*, 2005.
4. P. D. Leedy and J. E. Ormrod, Practical Research: Planning and Design, *Prentice Hall*, 2004.
5. B. L. Garg, R. Karadia, F. Agarwal and U. K. Agarwal, An introduction to Research Methodology, *RBSA Publishers*, 2002.
6. R. A. Day, How to Write and Publish a Scientific Paper, *Cambridge University Press*, 1992.
7. C. R. Kothari, Research Methodology: Methods and Techniques*, New Age International*, 1990.
8. S. M. Coley and C. A. Scheinberg, Proposal Writing, *Sage Publications*, 1990.

Course No:	Course Name:				Course Code:		
CH-21	Organic Chemistry-III (Heterocycles and Natural Products)				SBS CH 010305 DSE 4004		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
2021 Onwards	M.Sc. Chemistry	**III**	4	0	0	4	**Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course:** Basic and advanced knowledge of the chemistry of heterocycles and natural products.					
Course Objective	*This paper will provide a basic and advanced knowledge of the chemistry of heterocyclic and natural products including heterocycle reactivity, synthesis and chemical reactions of small to large member heterocycles and their importance in the field of medicine, natural product isolation and its structure determination, synthesis and biosynthesis and its uses during the drug discovery and development process.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic and advance knowledge of understanding heterocylic chemistry: the synthesis, chemical transformation and reaction mechanism **CO2**: Basic and advance knowledge about different class of natural products **CO3**: Skills for analyzing and developing new sustainable methods **CO4**: Skills for developing industrially important methods **CO5**: Development of alternate and new eco-friendly synthetic pathways to chemicals **CO6**: Application and importance in drug discovery and development process.						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION AND CHEMISTRY OF SMALL RING HETEROCYCLES** Introduction, nomenclature, spectral characteristics, reactivity of heterocyclic compounds. Synthesis and reactions of three, four and five membered heterocycles (aziridines, oxiranes, thiiranes, azetidines, oxetanes and thietanes, pyrrore, thiophene and furan).	15
II	**CHEMISTRY OF SIX MEMBERED AND BENZOFUSED HETEROCYCLES** Synthesis and reactions of six membered heterocycles, pyridine, pyrylium salts, pyridinium&thiopyrirylium salts. Chemistry of bicyclic compounds containing one or more heteroatom. Benzofused five and six membered rings: synthesis and reactions of indoles, benzofuran, benzothiophene, quinlolin, Isoquinoline, quinolones, isoquinolines, benzotriazoles, quinolinizium and benzopyrylium salts.	15

III	**CHEMISTRY OF NATURAL PRODUCTS: TERPENOIDS, CAROTENOIDS AND STEROIDS** ***Terpenoids and Carotenoids***: Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Stereochemistry, Synthesis (chemical/biosynthesis) of the following representative molecules: Citral, α-Terpeneol, Farnesol, Santonin, Phytol and β-carotene. ***Steroids***: Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry. Isolation and biosynthesis of Cholesterol. Synthesis of Testorosterone, Progesterone, Oestrone.	15
IV	**CHEMISTRY OF NATURAL PRODUCTS: ALKANOIDS AND FLAFONOIDS** ***Alkaloids***: Definition, nomenclature, occurrence, isolation, general methods of structure elucidation, classification based on nitrogen heterocyclic ring. Stereochemistry, synthesis and biosynthesis of the following: Ephedrine, Nicotine, Atropine and Quinine. ***Flavonoids***: Introduction, isolation and purification of flavonoids, General methods of structural determination of flavonoids, Biosynthesis of flavonols and related polyphenols.	15

Suggested Readings:

1. J. Clayden, B. Greeves and S. Warren, Organic Chemistry, Second Edition, *Oxford University Press*, 2012.
2. B. A. Bohm, Introduction to Flavonoids, *Harwood Academic Publishers*, 2011.
3. I. L. Finar, Organic Chemistry, Vol. 2*, ELBS*., 2009
4. Atta-ur-Rahman and Choudhary, Chemistry, *Harwood Academic Publishers*, 2008.
5. E. S. Coffey, Rodd's Chemistry of Carbon Compounds, *Elsevier*, 2005
6. J. A. Joule, Heterocyclic Chemistry, *ELBS*, 2005
7. Mann, Davidson, Hobbs, Banthrope and Harborne, Natural products: Chemistry and Biological Significance, *Longman*, Essex., 2004.
8. T. Eicher and S. Hauptmann, The Chemistry of Heterocycles, *Thieme*, 2002.
9. G. R. Newkome and W. W. Paudler, Contemporary Heterocyclic Chemistry, *Wiley-Interscience*, 1995.
10. T. L. Gilchrist, Heterocyclic Chemistry*, Longman Scientific Technical*, 1990.
11. R. M. Acheson, An Introduction to Heterocyclic Chemistry, *John Wiley*, 1980
12. A. R. Katritzky and C. W. Rees, Comprehensive Heterocyclic Chemistry, *Pergamon Press*, 1970.

Course No: CH-22	Course Name: Organic Chemistry-IV (Reagents and Reactions)				Course Code: SBS CH 010306 DSE 4004		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** III	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hrs. Pre-requisite of course: Basic knowledge of the classical reagents and reactions used commonly in organic synthesis					
Course Objective	*To provide the advanced knowledge of organic synthesis in general and classical and modern reagents and methods in synthesis in particular. In-depth knowledge of metal-mediated reactions and common metal-based reagents, oxidation-reduction reactions and reagents and rearrangement reactions will be gained. At the end of the course students are expected to predict reagents and conditions needed for specific conversions.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Advanced knowledge of modern methods of manipulations of carbonyl compounds, theoretical explanations of and reactivity including stereochemistry **CO2**: In-depth understanding of the use of various transition metal-based catalysts in coupling reactions **CO3**: Modern, classical and green methods of oxidation of various functional groups **CO4**: Common reduction methods in organic synthesis **CO5**: Environmentally friendly and stereoselective modern processes in organic synthesis **CO6**: Thorough understanding of various rearrangement reactions and their applications in synthesis						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**USE OF METALS IN ORGANIC SYNTHESIS** Selective enolate generation using LDA, LHMDS, KHMDS; Modern aldol reactions (lithium, boron, and titanium enolates), Zimmerman-Traxler TS; McMurry and Tebbe olefinations; Gilman cuprates, Samarium Iodide, Palladium mediated reactions: Wacker process, Heck reaction, Stille coupling, Suzuki coupling, Negishi coupling, Sonagashira reaction and Buchwald-Hartwig amination.	15
II	**OXIDATION REACTIONS** Common oxidizing agents (transition metal oxidant, sulphur based, peroxide and peracid,	15

	modern catalytic oxidations using TEMPO) for oxidation of alcohols, ketones and aldehydes; Oxidation of C-C bonds [ozone, $KMnO_4$, $Pb(OAc)_4$, dimethyldioxirane, Ce(IV) andMn(III)] and saturated carbons, hypervalent iodine reagents, DDQ, Major methods for asymmetric epoxidations and dihydroxylations.	
III	**REDUCTION REACTIONS** Common reducing agents such as dissolving metal reductions (Birch reduction), various Aluminum and Boron derived hydrides, catalytic/transfer hydrogenations (Homogeneous and Heterogeneous), diimide, Bu_3SnH, low valent Ti species, and Wolf-Kishner reduction. Asymmetric reduction using Corey's oxazaborolidine (CBS catalyst) and Noyori's hydrogenation.	15
IV	**REARRANGEMENT REACTIONS** General mechanistic considerations, nature of migration, migratory aptitude and mechanistic study of the following rearrangements: Pinacol-pinacolone, Wagner-Meerwin, Benzil-Benzilic acid, Favorskii, Arndt-Ester synthesis, Demyanov, Beckmann, Hofmann, Curtius, Schmidt, Baeyer-Villiger, Shapiro reaction, Dienone-Phenol, Pummerer, Smiles, Sommelet-Hauser and Achmatowicz rearrangements.	15

Suggested Readings:

1. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Revised Edition. (Revised by S. P. Singh and Om Prakash). *TRINITY Press, An Imprint of Laxmi Publications Pvt. Ltd*., 2015.
2. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part A and Part B: Reaction and Synthesis, 5thEdition. *Springer Verlag*, 2012.
3. V. K. Ahluwalia, Oxidation in Organic Synthesis, *CRC press*, 2012.
4. J. H. Hartwig, Organotransition Metal Chemistry: From Bonding to Catalysis, 1stEdition. *University Science Books*, 2009.
5. L. Kurti and B. Czako, Strategic Applications of Name Reactions in Organic Synthesis, *Elsevier Academic Press* , 2005.
6. R. H. Crabtree, The Organometallic chemistry of the transition metals, *John Wiley*, 2005.
7. W. Carruthers and Iain Coldham, Modern Methods of Organic Chemistry, 4thEdition. *Cambridge University Press,* 2004.
8. Warren, S.; Greeves, N.; J. Clayden and P. Wothers, Organic Chemistry, 2ndEdition. *Oxford University Press*, 2001.
9. Michael B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7thEdition. *Wiley*, 2013.
10. S. Warren, Organic Synthesis, *Wiley*, 1982.
11. H. O. House, W. A. Benjamin, Modern Organic Synthesis, Inc., New York, 1965.

Course No: CH-15	Course Name: Applications of Spectroscopy				Course Code: SBS CH 010415 C 4004		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** IV	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course**: An advanced knowledge of common and important reactions and reagents used in functional group transformations in organic synthesis. An ability to analyse complex chemical structures and find out key structural features.					
Course Objective	*To provide the advance knowledge and understanding of organic spectroscopy. At the end of this course, students will acquire both the theoretical and application aspect of various spectroscopic techniques (UV-Visible, IR, NMR spectroscopy and mass spectrometry) to the solve problems related to structure determination of organic compounds.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: An uptodate knowledge of modern reagents used in synthesis for FGIs and macrocycle formation **CO2**: Understanding of modern trends in synthesis such as multicomponent reactions, click chemistry, CH activation and organocatalysis **CO3**: Development of ability to consider and analyze the sustainability, economics, safety and toxicity aspects of organic synthesis **CO4**: Ability to analyse complex molecular structures to identify key structural features and devise ways of constructing them **CO5**: Understanding of strategies and tactics of organic synthesis such as protection, deprotection, umpolung, order of events etc. CO6: Ability to read and independently understand modern synthetic endeavours and appreciate various aspects such as efficiency and aesthetics of design. Ability to design synthetic routes						

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**ULTRAVIOLET AND VISIBLE SPECTROSCOPY AND MASS SPECTROMETRY** ***UV-Visible spectroscopy****:* Various electronic transitions, Beer-Lambert law, visible spectrum &colour, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugatedpolyenes. Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds. ***Mass spectrometry****:* Introduction, ion production–EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic	15

	compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule. High resolution mass spectrometry (HRMS).	
II	**INFRARED SPECTROSCOPY** Instrumentation and sample handling. Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance	15
III	**NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY** General introduction and definition, theory of NMR, chemical shift, shielding and deshielding mechanism, magnetic anisotropy, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), spin-spin interaction, Spin systems, Pople notation, complex spin-spin interaction between two, three and four nuclei (first order spectra), virtual coupling. chemical exchange, effect of deuteration, Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra, nuclear magnetic double resonance, contact shift reagents. Fourier transform technique, nuclear Overhauser effect (nOe), COSY.	15
iV	**CARBON-13 NMR SPECTROSCOPY AND COMBINED APPLICATIONS** ***Carbon-13 NMR Spectroscopy*:** General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroarmatic and carbonyl carbon), coupling constants and DEPT ^{13}C NMR spectra. General introduction to two-dimensional NMR spectroscopy- HETCOR and NOESY. Resonance of other nuclei-F, P. ***Combined problems*:** Combined problems relating to structure elucidation by UV, IR, NMR Spectroscopy and Mass Spectrometry.	15

Suggested Readings:

1. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5thEdition. *Cengage India*, 2015.
2. R. Kakkar, Atomic and Molecule Spectroscopy: Basic Concepts and Applications, *Cambridge University Press,* 2015.
3. W. Kemp, Organic Spectroscopy, 3rdEdition. *Mac publishers*, 2011.
4. D. H. Williams, I. Fleming, Spectroscopic Methods in Organic Chemistry, *Tata McGraw-Hill*, 2010.
5. J. R. Dyer, Application of Spectroscopy of Organic Compounds, *Prentice Hall*, 2009.
6. R. J. Abraham, J. Fisher and P. Loftus, Introduction to NMR Spectroscopy, *Wiley*, 2005.
7. J. Mohan, Organic Spectroscopy, *Narosa Publishers*, New Delhi, 2002.
8. R. M. Silverstein, G. C. Bassler and T. C. Morrill, Spectrometric Identification of Organic Compounds, *John Wiley*, 1995.
9. C. N. Banwell and E. M. McCash; Fundamentals of Molecular Spectroscopy, 4thEdition, *Tata McGraw Hill*, 1994.

Course No:	Course Name:				Course Code:		
CH-33	Organic Chemistry-V (Organic Synthesis)				SBS CH 010417 DSE 4004		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
2021 Onwards	M.Sc. Chemistry	IV	4	0	0	4	**Total Hrs.: 60**

Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks	**Examination Duration:** 3 Hrs. **Pre-requisite of course**: An advanced knowledge of common and important reactions and reagents used in functional group transformations in organic synthesis. An ability to analyse complex chemical structures and find out key structural features.
Course Objective	*To gain an in-depth understanding of various functional group transformations, classical and modern techniques in synthetic chemistry, synthetic planning and targeted synthesis of complex molecules. Detailed information and analysis of common synthetic techniques and methods will be gained. Using this knowledge, exercises on the planning of synthesis of complex scaffolds and targets will be carried out. Breakdown of complex molecules into simple building blocks for synthesis will be learned. A few case studies of total synthesis to understand the actual application of synthetic methods in real life problem solving will also be learned. Students are expected to design retrosynthesis and forward synthesis of complex targets at the end of the course.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: An uptodate knowledge of modern reagents used in synthesis for FGIs and macrocycle formation **CO2**: Understanding of modern trends in synthesis such as multicomponent reactions, click chemistry, CH activation and organocatalysis **CO3**: Development of ability to consider and analyze the sustainability, economics, safety and toxicity aspects of organic synthesis **CO4**: Ability to analyse complex molecular structures to identify key structural features and devise ways of constructing them **CO5**: Understanding of strategies and tactics of organic synthesis such as protection, deprotection, umpolung, order of events etc. **CO6**: Ability to read and independently understand modern synthetic endeavours and appreciate various aspects such as efficiency and aesthetics of design. Ability to design synthetic routes

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**FUNCTIONAL GROUP TRANSFORMATIONS USING MISCELLANEOUS REAGENTS AND REACTIONS** Amide coupling reagents (DCC, DIC, EDC, BOP, HOBt), macrolactonization, Mukiyama reagent; Mitsunobu reaction; Silyl and stannyl hydrides, Burgess reagent, Lawesson's	15

	reagent, CH_2N_2, $TMSCHN_2$, Finkelstein reaction, Eschenmoser-Tanabe, Ohira-Bestmann reagent.	
II	**CLASSICAL AND MODERN METHODS IN SYNTHESIS** Illustration of the following concepts with examples; Multicomponent reactions (Strecker, Mannich, Biginelli, Passerini and Ugi reactions), click chemistry, cascade and domino processes for multiple C-C bond forming reactions (radical cyclisations, electrocyclic cascades, polyenecyclizations), CH-activation and remote functionalisation, asymmetric organocatalysis (proline, NHCs), biocatalysis, Reusable reagents, biomimetic synthesis	15
III	**RETROSYNTHESIS AND DISCONNECTION APPROACH** Concept of retrosynthesis, disconnection approach, introduction to synthons and synthetic equivalents, linear and convergent synthesis, types of transforms, functional group inter-conversions, classification of disconnections, chemoselectivity, control of stereochemistry, reversal of polarity (umploung), common building blocks, the importance of the order of events in organic synthesis, applications of alkynes, aliphatic nitro compounds, bifunctional compounds, Protecting groups, representative examples for O, N, COOH and carbonyl protection/deprotections.	15
iV	**CASE STUDIES-TOTAL SYNTHESIS** Total synthesis, Semi synthesis, formal synthesis, overall yield, concept of ideal synthesis, Detailed case study of the following classical/modern total syntheses: Periplanone B (W. C. Still), Estrone (K. P. C. Vollhardt), Quinine (G. Stork).	15

Suggested Readings:

1. S. Caron, Practical Synthetic Organic Chemistry: reactions, Principles and Technique, 2nd Edition. *Wiley*, 2020.
2. S. Warren, Designing Organic Synthesis, *Wiley*, 2011.
3. F. A. Carey and R. J. Sandburg, Advanced Organic Chemistry Part B, *Plenum Press*, 2009.
4. T. Hudlický and J. W. Reed, The Way of Synthesis, *Wiley VCH-Weinheim* 2007.
5. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis- An Introduction, *W. H. Freeman & Co*., 2007.
6. J. March, Advanced Organic Chemistry, Reactions Mechanisms and Structure, *John Wiley*, 2005.
7. R. O. C. Norman and J. M. Coxon, Principles of Organic Synthesis, *Blackie Academic & Professional*, 2002.
8. K. C. Nicolaou and E. J. Sorensen, Classics in Total Synthesis, *Wiley VCH-Weinheim*, 1996.
9. W. Carruthers, Some Modern Methods of Organic Synthesis, *Foundation Books*, 1995.
10. Fieser and Fieser, Reagents in Organic Synthesis, *Wiley*, 1993.
11. H. O. House, W.A. Benjamin, Modern Synthetic Reactions, 1990.

Course No: CH-34	Course Name: Organic Chemistry-VI (Medicinal Chemistry)				Course Code: SBS CH 010418 DSE 4004		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** IV	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course**: Basic understanding of non-covalent interactions, biomolecules and biochemical processes					
Course Objective	*This course will provide a basic understanding and fundamentals of Medicinal Chemistry. At the end of this course, students will learn about the various stages involved in drug discovery & development process and challenges encounter during the course of development of new drug which finally comes into the market, various biological drug targets, drug-target binding, mode of actions of anticancer, antibiotics, psychoactive drugs and its chemical synthesis.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: An appreciation of the history of medicinal chemistry, understanding of basic biochemical functioning of living organisms, structural and functional details of bio-macromolecules such as proteins, nucleic acids and lipids **CO2**: Advanced knowledge about structure and functions of enzymes, receptors, DNA and RNA **CO3**: Methods of inhibition of enzymes, importance of enzyme inhibition in drug development, receptors as drug targets, signal transduction, receptor theory and DNA active drugs **CO4**: Basic concepts such as hit, lead and structure activity relationships in drug developments; theories of drug activity; importance of physical properties of drugs **CO5**: Strategies and tactics of development of various anticancer agents. Examples with synthesis. **CO6**: Approaches for the development of antibiotics, their classification, synthesis, development of drugs acting on CNS						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**DRUG TARGETS** Introduction to medicinal chemistry, intermolecular binding forces, Introduction to various drug targets; Proteins- primary, secondary and tertiary structure, protein function, proteomics; Enzymes- catalytic role, active site, allosteric binding, feedback control, binding interactions, isozymes, co-factors; Receptors- types of receptors, their roles, neurotransmitters, hormones, receptor activation and regulation; Nucleic acids- DNA, primary and secondary structure of DNA, function of DNA.	15
II	**DRUG-TARGET BINDING** Introduction to Pharmacodynamics and pharmacokinetics, Enzymes as drug targets- types of enzyme inhibitors, medicinal use of enzyme inhibitors with examples; Receptors as drug	15

	targets- agonists, antagonists, allosteric modulators, partial agonists, inverse agonists, desensitization, tolerance and dependence, affinity and efficacy; Nucleic acids as drug targets- Intercalating agents, topoisomerase poisons, alkylating/metallating agents, chain cutters, chain terminators, examples of medicinal use. Miscellaneous drug targets (tubulin)	
III	**DRUG DESIGN AND DEVELOPMENT** Development of new drugs, concept of lead compounds and lead modifications, structure-activity relationship (SAR), factors affecting bioactivity, resonance, inductive effect, isosterism, bioisosterism. Theories of drug activity, Quantitative structure activity relationship, Concepts of drugs receptor, Elementary treatment of drug receptor interactions, Physico-chemical parameters: lipophilicity, partition coefficient, electronic ionization constants, steric factors.	15
IV	**MODE OF ACTION AND SYNTHESIS** Anticancer Agents: Introductory Idea of antineoplastic agents, cancer chemotherapy, common targets in cancer chemotherapy, role of alkylating agents and antimetabolites in treatment of cancer. Antiinfective Drugs (antibiotics): Cell wall biosynthesis, inhibitors, β-lactam rings, antibiotics inhibiting protein synthesis, Synthesis of penicillin G, amoxicillin, Introductory idea of tetracycline and streptomycin. Psychoactive Drugs: Introductory idea of CNS depressants, general anaesthetics, hypnotics, sedatives, anti-anxiety drugs. Anti-fertility Drugs: Introductory idea of anti-fertility drugs and mode of action.	15

Suggested Readings:

1. R. B. Silverman, The Organic Chemistry of Drug Design and Drug Action, 3rd Edition. *Academic Press*, 2014.
2. G. L. Patrick, An Introduction to Medicinal Chemistry, 5th Edition. *Oxford University Press*, 2013.
3. D. Van Vranken and G. Weiss, Introduction to Bioorganic Chemistry and Chemical Biology, *Garland Science*, 2013.
4. D. Sriram and P. Yogeshwari, Medicinal Chemistry, 2nd Edition. Pearson, 2012.
5. Ed Robert F Dorge, Wilson and *Gisvold's TextBook* of Organic Medicinal and Pharmaceutical Chemistry, 12th Edition. 2010.
6. Ed. M E Wolff, Burger's Medicinal Chemistry and Drug Discovery, Vol. 1, 7th Edition. *John Wiley,* 2010
7. G. Thomas, Medicinal Chemistry, 2nd Edition, *John Wiley & Sons*, 2007.
8. S. Warren, N. Greeves, J. Clayden and P. Wothers, Organic Chemistry, 2nd Edition. *Oxford University Press*, 2001.
9. S. S. Pandeya and J. R. Dimmock, An Introduction to Drug Design, 1st Edition. *New Age International*, 1999.

PRACTICAL COURSES

Course No: CH-05	Course Name: Organic Chemistry Practical-I				Course Code: SBS CH 010105 C 0042		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** I	**L** 0	**T** 0	**P** 4	**Credit** 2	**Contact Hrs. per Week: 04** **Total Hours: 60**
Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks	**Examination Duration: 6 Hrs.** **Pre-requisite of course:** Basic idea of chemical laboratory safety and good practices; basic skills such as weighing, measuring, titrating, cleaning etc.						
Course Objective	*To acquire experimental skills important for various separation and purification techniques, functional group identification and drying of organic solvents. At the end of this course, students will learn the various purification methods, chromatographic separation and identification of organic compounds, solvent drying and functional group detection in organic compounds. Students would be familiarized with quantitative analysis of organic compounds to estimate the percentage of given functional groups.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Safe laboratory conduct and good practices **CO2:** Purification techniques for solids such as crystallisation, sublimation and chromatography **CO3:** Purification techniques for liquids such as distillation and chromatography **CO4:** Qualitative analysis of unknown samples to determine the functional groups **CO5:** Tests to determine the various elements present in an organic compound **CO6:** Quantitative analysis of compounds to estimate the percentage of functional groups						

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**ISOLATION AND PURIFICATION TECHNIQUES** Laboratory Safety Crystallization, recrystallization and sublimation Distillation: Simple, Steam and Vacuum Solvent Extraction Drying of ethanol/ acetone/ diethylether/THF Paper Chromatography Thin Layer Chromatography	30
II	**ANALYSIS OF ORGANIC COMPOUNDS** QUALITATIVE ANALYSIS: Chemical Tests: Chemistry and Applications Extra elements detection (N, S, X = Cl, Br, I) Functional group detection (in mono functional compounds) QUANTITATIVE ANALYSIS:	30

	Estimation of alcoholic/phenolic/amino groups in the given organic compound	

Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition. *Cengage Learning*, 2017.
2. R. K. Bansal, Laboratory Manual in Organic Chemistry, *Wiley*, 2006.
3. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5e Paperback, *Pearson*, 2003.
4. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, *Prentice Hall*, Instructor's Edition, 1992.
5. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, *Edward Arnold, London*, 1975.
6. H. Middleton, Systematic Qualitative Organic Analysis, *Edward Arnold, London*, 1959.

Course No:	Course Name:				Course Code:		
CH-11	Organic Chemistry Practical-II				SBS CH 010211 C 0042		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 04**
2021 Onwards	M.Sc. Chemistry	**II**	0	0	4	2	**Total Hours: 60**
Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks		**Examination Duration: 6 Hrs.** **Pre-requisite of course:** Skills to handle solvent extractions, distillations, crystallisations simple chromatographic experiments independently. Ability to set up reaction assemblies which may require heating/cooling, set-up and execute filtration and drying processes.					

Course Objective	*To acquire the skills to plan and carry out separation of mixtures of organic compounds by means of solvent-solvent extraction, further purification and identification of isolated components and derivative preparation. To learn how to plan a synthetic operation from simple starting materials, set-up the reaction assembly, work-up, isolate and purify the product. Develop knowledge of proper and safe waste disposal in these operations.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** To analyse and separate binary mixtures of solids using solvent extraction, to purify and identify the isolated components via derivative preparation **CO2**: To analyse and separate binary mixtures of solid and liquid using solvent extraction, to purify and identify the isolated components via derivative preparation **CO3:** To analyse and separate binary mixtures of liquids using solvent extraction, to purify and identify the isolated components via derivative preparation **CO4:** To plan and carry out single-step preparation of organic compounds **CO5:** To work-up, isolate and purify, determine the purity of the prepared compound and safe treatment and disposal of chemical waste **CO6:** To develop an exposure to industrial chemical operations via a visit

COURSE SYLLABUS

NOTE:
Two questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**QUALITATIVE ANALYSIS OF BINARY ORGANIC MIXTURES BY A SYSTEMATIC APPROACH** Chemical separation using H_2O, $NaHCO_3$, NaOH, HCl, Ether or any other reagent as per required conditions of solid-solid, solid-liquid and liquid-liquid mixtures Systematic identification of the components and preparation of at least one derivative of each.	30
II	**A. ORGANIC SYNTHESIS** Preparation of organic compound involving one-step reaction. (Prepare at least three compounds) [**Important *Note:*** *Greener protocols to be used wherever possible. Submit the recrystallised sample of the synthesized compound after checking its purity by TLC and melting points.*] **B. INDUSTRIAL VISIT**	30

	In order to get an exposure on how chemical industries function, department will arrange an industrial visit. Students to prepare a report on the industrial visit.	

Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition. *Cengage learning*, 2017.
2. H.A. Shally, Green Chemistry Laboratory Manual for General Chemistry, 1stEdition *CRC Press*, 2015.
3. R. K. Bansal, Laboratory Manual in Organic Chemistry, Wiley, 2006.
4. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5th Edition Paperback, *Pearson*, 2003.
5. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, *Prentice Hall, Instructor's Edition,* 1992.
6. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, *Edward Arnold, London*, 1975.
7. H. Middleton, Systematic Qualitative Organic Analysis, *Edward Arnold, London*, 1959.

Course No:	Course Name:				Course Code:		
CH-23	Organic Chemistry Practical-III				SBS CH 010307 DSE 0063		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 06**
2021 Onwards	M.Sc. Chemistry	**III**	0	0	6	3	**Total Hours: 90**

Total Evaluation Marks:75 **CIE:** 22.5 Marks **TEE:** 52.5 Marks	**Examination Duration: 8 Hrs.** **Pre-requisite of course:** Good skills for handling solvent extraction for isolation of samples, safe distillation of solvents and ability to purify samples by recrystallization from suitable solvents. Knowledge of various common reagents and the skill for their safe handling. Knowledge and concern about environmental impact of each operation.
Course Objective	*To gain the knowledge and skill for isolating and purifying important components from natural sources. To learn the methods to isolate and purify alkaloids, terpenoids, carotenoids and proteins from plant and animal sources. To learn the methods for synthesizing a target compound in a two-step procedure and isolating the purified product.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** General aspects of extraction of natural products from plant and animal sources **CO2:** Specific methods for the extraction and purification of alkaloids/phenols of plant origin **CO3:** Specific methods for the extraction of terpenoids, carotenoids and milk protein from the natural sources **CO4:** Planning of a two-step synthesis of a given target **CO5:** Execution of the planned synthesis by minimizing waste and environmental impact **CO6:** Isolation, purification and conformation of the structure of all the synthesized compounds

COURSE SYLLABUS

NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**EXTRACTION OF NATURAL PRODUCTS (Alkaloids and natural phenols)** ● Caffeine from tea leaves ● Nicotine from tobacco ● Piperine from black pepper ● Curcumin from turmeric	**30**
II	**EXTRACTION OF NATURAL PRODUCTS (Terpenoids, Carotenoids and Protein)** ● Limonene from citrus rind ● Lycopene from tomatoes ● β-Carotene from carrot ● Casein from milk	**30**
III	**ORGANIC SYNTHESIS INVOLVING TWO-STEP PROCEDURE** Preparation of organic compound involving two-step reaction. (Prepare at least three compounds) [**Important *Note:*** *To use greener protocols wherever possible. Submit the recrystallised sample of the synthesized compound after checking its purity by TLC and melting*	**30**

	points.]	

Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition. *Cengage learning*, 2017.
2. H.A. Shally, Green Chemistry Laboratory Manual for General Chemistry, *CRC Press*, 1stEdition, 2015.
3. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5thEdition. *Cengage India*, 2015.
4. R. M. Silverstein, G. C. Bassler and T. C. Morrill, Spectrometric Identification of Organic Compounds, 8th Edition, *Wiley India*, 2015.
5. William Kemp, Organic Spectroscopy, 3rd Edition. *Mac publishers*, 2011.
6. R. K. Bansal, Laboratory Manual in Organic Chemistry, *Wiley*, 2006.
7. Jag Mohan, Organic Spectroscopy, 2nd Edition. *CRC Press*, 2004.
8. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5e Paperback, *Pearson*, 2003.
9. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, *Prentice Hall*, Instructor's Edition, 1992.
10. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, *Edward Arnold,* London, 1975.
11. H. Middleton, Systematic Qualitative Organic Analysis, *Edward Arnold*, London, 1959.

Course No: CH-24	Course Name: Organic Chemistry Practical-IV				Course Code: SBS CH 010308 DSE 0063		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **III**	**L** 0	**T** 0	**P** 6	**Credit** 3	**Contact Hrs. per Week: 06** **Total Hours: 90**
Total Evaluation Marks:75 **CIE:** 22.5 Marks **TEE:** 52.5 Marks		**Examination Duration: 8 Hrs.** **Pre-requisite of course:** General and basic skill set for setting up and carrying out quantitative estimations. Knowledge of the working principle of UV-visible spectrophotometer. General synthetic skills acquired in previous semesters.					

Course Objective	*To acquire hands-on experience in organic synthesis particularly involving multistep reactions and to gain knowledge about quantitative analysis of organic compounds by spectroscopic methods. At the end of this course, students will understand and acquire the knowledge of various important parameters used in multistep organic synthesis preferably in greener approaches. Further, they would be able to characterize the synthesized compounds on the basis of their spectral data. Students would also learn the spectrophotometric methods used for quantitative analysis of organic compounds.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** General principles and skill of quantitative analysis using spectroscopic methods **CO2:** Specific skills of estimating important molecules by UV-visible spectroscopy **CO3:** Methods to analyse the amount of carbohydrates, vitamin C, proteins, steroids, urea and drugs like aspirin in samples **CO4:** Synthetic skills to plan and execute multi step protocols **CO5:** Monitoring of reaction progress and purification and identification of intermediates **CO6:** Conformation of the target structure and estimation of its purity level

COURSE SYLLABUS

NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**QUANTITATIVE ANALYSIS** UV-vis spectrophotometric estimations of the followings: ● Carbohydrates ● Ascorbic acid ● Amino acids	30
II	**QUANTITATIVE ANALYSIS** Estimations of the followings: ● Proteins ● Cholesterol ● Urea ● Aspirin	30

III	**MULTI-STEP ORGANIC SYNTHESIS** Prepare at least any two organic compounds by three or more step reaction. [**Important *Note:*** *Prefer to use* ***greener protocols*** *wherever possible. Monitor the progress of reaction by TLC and submit the recrystallised sample of the synthesized compound after checking its purity by TLC at each step*]	30

Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition. *Cengage learning*, 2017.
2. H.A. Shally, Green Chemistry Laboratory Manual for General Chemistry, 1stEdition. *CRC Press*, 2015.
3. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5thEdition. *Cengage India*, 2015.
4. R. M. Silverstein, G. C. Bassler and T. C. Morrill, Spectrometric Identification of Organic Compounds, 8th Edition, *Wiley India*, 2015.
5. William Kemp, Organic Spectroscopy, 3rd Edition. *Mac publishers*, 2011.
6. R. K. Bansal, Laboratory Manual in Organic Chemistry, *Wiley*, 2006.
7. Jag Mohan, Organic Spectroscopy, 2nd Edition. CRC Press, 2004.
8. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5e Paperback*, Pearson*, 2003.
9. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, *Prentice Hall*, Instructor's Edition, 1992.
10. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, *Edward Arnold*, London, 1975.

Course No:	Course Name:				Course Code:		
CH-35	Organic Chemistry Practical-V				SBS CH 010419 DSE 0063		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 06**
2021 Onwards	M.Sc. Chemistry	**IV**	0	0	6	3	**Total Hours: 90**

Total Evaluation Marks:75 **CIE:** 22.5 Marks **TEE:** 52.5 Marks	**Examination Duration: 8 Hrs.** **Pre-requisite of course:** General and basic skill of the working principle of FTIR and NMR spectroscopy and mass spectrometry by analysing samples. General synthetic skills using microwave-mediated and mechanochemical organic synthesis.
Course Objective	To acquire knowledge and skill for the identification of samples of purified unknown organic compounds by measuring and analysing various spectra. Ability to handle spectroscopy equipment such as FTIR, UV-visible, NMR and MS. Ability to process and interpret the obtained spectral data and report it according to standard conventions. Collective use of the obtained information to arrive at a possible structure and molecular formula. Learn to execute modern green methods such as microwave and mechanochemical methods in targeted synthesis.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Theoretical and practical knowledge about various spectroscopic techniques **CO2:** Hands on skills with FTIR and UV-visible spectrophotometers **CO3:** Process, analyse and report IR and UV spectral data and use it in structure determination **CO4:** Skills to process, analyse and report NMR and MS data output and apply it for structure determination **CO5:** Plan and execute microwave mediated synthesis **CO6:** Plan and execute mechanochemical organic synthesis

COURSE SYLLABUS

NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I	**SPECTROSCOPIC IDENTIFICATION OF FUNCTIONAL GROUPS OF ORGANIC COMPOUNDS** Determine the functional groups present in the compound by measuring and analysing the FTIR and UV-visible spectra. Report the spectral data in a standard format.	30
II	**SPECTROSCOPIC ANALYSIS OF ORGANIC COMPOUNDS ON BASIS OF NMR AND MS TECHNIQUES** Obtain and interpret the NMR spectra (H, C and F if necessary), process the spectra, report it based on conventions. Obtain the mass spectra and report it in a standard format. Analyse all the available data and arrive at a possible structure and molecular formula.	30

III	**MICROWAVE-MEDIATED AND MECHANOCHEMICAL ORGANIC SYNTHESIS** Synthesis of target compounds by using non-conventional energy sources such as microwave, grinding, ball milling or sonochemical methods. Identification and purity determination of the synthesized compounds.	30

Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition. *Cengage learning*, 2017.
2. H.A. Shally, Green Chemistry Laboratory Manual for General Chemistry, 1stEdition. *CRC Press*, 2015.
3. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5thEdition. *Cengage India*, 2015.
4. R. M. Silverstein, G. C. Bassler and T. C. Morrill, Spectrometric Identification of Organic Compounds, 8th Edition, *Wiley India*, 2015.
5. William Kemp, Organic Spectroscopy, 3rd Edition. *Mac publishers*, 2011.
6. R. K. Bansal, Laboratory Manual in Organic Chemistry, *Wiley*, 2006.
7. Jag Mohan, Organic Spectroscopy, 2nd Edition. CRC Press, 2004.
8. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5e Paperback*, Pearson*, 2003.
9. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, *Prentice Hall*, Instructor's Edition, 1992.
10. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, *Edward Arnold*, London, 1975.

Course No: CH-36	Course Name: Organic Chemistry Practical-VI				Course Code: SBS CH 010420 DSE 0063		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **IV**	**L** 0	**T** 0	**P** 6	**Credit** 3	**Contact Hrs. per Week: 6** **Total Hours: 90**
Total Evaluation Marks:75 **CIE:** 22.5 Marks **TEE:** 52.5 Marks	**Examination Duration: 8 Hrs.** **Pre-requisite of course:** This course will develop basic skills for designing and synthesizing multi-step organic synthesizing and their characterization of intermediates using spectroscopic techniques.						
Course Objective	*To analyse a complex synthetic problem in its entirety. Identify the key structural elements, stereochemical features and challenges in the given target molecule. Design the strategy, tactics and execute the synthesis in shortest possible way. Isolate, purify and identify each of the intermediates. Characterise any unknown compounds completely. Confirm the identity and purity of the final compound with all available techniques.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Ability to analyse a given structure and establishing its key features **CO2:** Design the strategy and tactics of a possible synthesis **CO3:** Decide on the best possible approach by considering protecting group free, green and economically viable routes **CO4:** Execute the synthesis step by step, isolate and analyse each intermediate **CO5:** Troubleshoot and innovate when faced with roadblocks **CO6:** Isolate, purify and conform the structure of final target with all available means						

COURSE SYLLABUS

NOTE:
Three questions will be set, one from each of the UNIT. The candidates are required to attempt all the questions.

Unit No.	Contents	Contact Hrs.
I-III	**RETROSYNTHETIC ANALYSIS, SYNTHESIS, AND SPECTROSCOPIC CHARACTERISATION OF ALL INTERMEDIATES AND THE TARGET COMPOUND** [**Important *Note:*** *Prefer to use greener protocols wherever possible. Submit the recrystallised sample of the synthesized compound after checking its purity by TLC and m.pts.*]	90

Suggested Readings:

1. K. L. Williamson and K. M., Masters Macroscale and Microscale Organic Experiments, 7th Edition. *Cengage learning*, 2017.
2. H.A. Shally, Green Chemistry Laboratory Manual for General Chemistry, 1stEdition. *CRC Press*, 2015.
3. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5thEdition. *Cengage India*, 2015.
4. R. M. Silverstein, G. C. Bassler and T. C. Morrill, Spectrometric Identification of Organic Compounds, 8th Edition, *Wiley India*, 2015.
5. William Kemp, Organic Spectroscopy, 3rd Edition. *Mac publishers*, 2011.
6. R. K. Bansal, Laboratory Manual in Organic Chemistry, *Wiley*, 2006.
7. Jag Mohan, Organic Spectroscopy, 2nd Edition. CRC Press, 2004.
8. B. S. Furniss and others, Vogel's Text Book of Practical Organic Chemistry, 5e Paperback*, Pearson*, 2003.

9. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, *Prentice Hall*, Instructor's Edition, 1992.
10. H. T. Clarke revised by B. Haynee, A Hand book of Organic Analysis-Qualitative and Quantitative, *Edward Arnold*, London, 1975.

PHYSICAL CHEMISTRY COURSES

THEORY COURSES

Course No: CH-03	Course Name: Physical Chemistry-I						Course Code: SBS CH 010103 C 4004
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** I	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE: 30** Marks **TEE: 70** Marks		**Examination Duration:** **3** Hrs. **Pre-requisite of course:** Knowledge of basic chemistry up to UG level.					
Course Objectives	*To provide students with a basic understanding of thermodynamics, fugacity, phase rule, essentials of chemical kinetics and principle of quantum mechanics. This course will strengthen the fundamentals of Physical Chemistry, especially thermodynamics and quantum chemistry.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of physical chemistry. **CO2**: Use of thermodynamics and chemical kinetics in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important methods. **CO5**: Development of alternate and new theoretical methods. **CO6**: Use of advanced and recent technologies in physical chemistry.						

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts. Each part carries 3.5 marks and students need to answer any four sub-parts.

ii) Question nos. 2 to 9 are to be set from all four units, two from each unit. Every question will have two sub-parts and students need to answer any one question from each unit. Each question carries 14 marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION TO PHYSICAL CHEMISTRY AND CLASSICAL THERMODYNAMICS** Logarithmic relations, Curve sketching and linear graphs, calculation of slopes, terms of mean and median, Precision and accuracy in chemical analysis, types of error, standard deviation, Numerical Problems. ***Classical Thermodynamics:*** Its Laws, Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities like entropy, enthalpy, free energy; Gibb`s-Duhem equation; Clausius-Clapeyron equation, Nernst heat theorem, Chemical potential and Work Function.	15
II	**ACTIVITY, FUGACITY, PHASE RULE** Concepts of fugacity, fugacity of gases and its determination. Activity and activity coefficient, choice of standard states, determination of activity coefficient for solute and solvent. ***Phase Rule:*** Phase Rule and its determination, application, Phase diagram for one component system, for two completely miscible components systems like Pb-Ag system, KI+ H_2O system, Bi-Cd system, Ferric	15

	chloride + water system, Sodium chloride + water system, Na_2SO_4-H_2O system.	
III	**CHEMICAL KINETICS-I** ***Introduction to Chemical Kinetics*:** Methods of determining rate laws, Arrhenius equation and its theory, Collision theory, and activated complex theory. ***Chain Reactions*:** Hydrogen-bromine reaction, Pyrolysis of acetaldehyde, Decompositions of ethane. Photochemical reactions (hydrogen-bromine and hydrogen-chlorine reactions). General treatment of chain reaction (hydrogen- bromine reactions), Apparent activation energy of chain reactions, Chain length, Rice-Herzfeld mechanism of organic molecules decomposition (acetaldehyde).	15
IV	**PRINCIPLES OF QUANTUM MECHANICS** Introduction to Quantum Mechanical Approach, Quantum Mechanical operators, Eigenvalues of Quantum Mechanical operators, Hermitian operator, Ladder operator, commutation relations, postulates of quantum mechanics and Uncertainty Principle. Dirac delta function, Uncertainty in position and momentum, Schrödinger equation for finding wave function of a particle, Energy of a particle in One-Dimension box, Extension to Schrödinger equation for finding wave function in a three-dimensional box, Energy of a particle in Three-Dimension box, Energy levels, Eigenvalue, concept of degeneracy and selection rules.	15

Suggested Readings:

1. J.P. Lowe, and K. Peterson, Quantum Chemistry, *Academic Press*, 2019.
2. H. K. Moudgil, Textbook of Physical Chemistry, *PHI Publication House*, New Delhi, 2015.
3. P. Atkins and J. Paula, Atkins' Physical Chemistry, 10th Edition. *Oxford University Press,* 2014
4. I. N. Levine, Quantum Chemistry, 7th Edition. *Pearson Education*, 2013.
5. I. N. Levine, Physical Chemistry, 6th Edition. *Tata Mcgraw-Hill Education*, 2011.
6. D. Mcquarie and J. Simon, Physical Chemistry-A molecular approach, 1stEdition.*Viva*, 2010.
7. R. K. Prasad, Quantum Chemistry, *New Age International*, 2010.
8. A. K. Chandra, Introductory Quantum Chemistry, *Tata McGraw-Hill*, 2008.
9. K. J. Laidler, Chemical Kinetics, 3rd Edition. *Pearson Education*, 2007.
10. E. Kreyszig, Advanced Engg. Mathematics, *John Wiley & Sons, Inc*. 2006.

Course No: CH-09	Course Name: Physical Chemistry-II (Quantum Chemistry & Group Theory)				Course Code: SBS CH 010209 C 4004		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** II	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE: 30** Marks **TEE: 70** Marks		**Examination Duration:** **3** Hrs.					
		Pre-requisite of course: Knowledge of basic physical chemistry up to UG level.					
Course Objectives	*To provide students with an understanding of physical chemistry like quantum approach, enzyme kinetics, unimolecular reactions, principles of symmetry and group theory and non-equilibrium thermodynamics. This course will strengthen the essentials of Physical Chemistry, especially group theory and quantum chemistry.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of physical chemistry. **CO2**: Use of symmetry and enzyme kinetics in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important methods. **CO5**: Development of alternate and new theoretical methods. **CO6**: Use of advanced and recent technologies in Physical Chemistry.						

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts. Each part carries 3.5 marks and students need to answer any four sub-parts.

ii) Question nos. 2 to 9 are to be set from all four units, two from each unit. Every question will have two sub-parts and students need to answer any one question from each unit. Each question carries 14 marks.

Unit No.	Contents	Contact Hrs.
I	**QUANTUM APPROACH AND APPROXIMATION METHODS** ***Harmonic oscillator*:** Application to diatomic molecules and Energy levels. Properties of Legendre polynomials, Rodrigues formula, Recursion formulae, Associated Legendre polynomials, Laguerre and associated Laguerre polynomials. ***Rigid rotator*:** Model for a rotating diatomic molecule and Energy level. Solution of spherical eigen-functions, Recursion formulae, Derivation of Legendre polynomial equation. ***The Hydrogen atom*:** Schrödinger equation for hydrogen atom. Solution of radial wave function. Radial distribution curves and shapes of atomic orbitals. ***Approximate Methods*:** The linear variation principle, First order time-independent Perturbation theory for non-degenerate states. Variation theorem and variation methods. Use of these methods illustrated with some examples like particle in a box with finite barrier, anharmonic oscillator, approximation functions for particle in a box and hydrogen atom.	15
II	**ENZYME KINETICS AND THEORY OF UNIMOLECULAR REACTIONS** ***Enzyme Kinetics*:** Kinetics of (one intermediate) enzymatic reaction: Michaelis-Menton treatment,	15

	Evaluation of Michaelis's constant for enzyme-substrate binding by line weaver-Burk plot by Dixon and by Eadie-Hofstee methods. Competitive and non-competitive inhibition. ***Unimolecular reactions*:** Dynamics of unimolecular reactions (Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus [RRKM] theories of unimolecular reactions.	
III	**PRINCIPLES OF SYMMETRY AND GROUP THEORY** Symmetry elements and Symmetry operations; Definitions of groups, subgroups, and classes; Symmetry elements in Allene, H_2O_2, Benzene and Ferrocene; Determination of point groups of small molecules and Schönfliesand Hermann-Mauguin Notations; The Great Orthogonality theorem. Character table for point group C_n (C_2v and C_3v), D_n, (n=2 and 3), T_d and O_h.	15
IV	**NON EQUILIBRIUM THERMODYNAMICS** General theory of non-equilibrium processes, Entropy production and entropy flow; Thermodynamic criteria for non-equilibrium states, Entropy production in heat flow, Mass flow, Electric current, Chemical reactions, Saxen's relation, Onsager's reciprocity relation, Thermomolecular pressure difference, Electro kinetic phenomenon, Coupled reactions.	15

Suggested Readings:

1. F. A. Cotton, Chemical Application of Group Theory, 3rd Edition. *John Willey & Sons*, 2018.
2. H. K. Moudgil, Textbook of Physical Chemistry, *PHI Publication House*, New Delhi, 2015.
3. P. Atkins and J. Paula, Atkins' Physical Chemistry, 10th Edition. *Oxford University Press*, 2014.
4. I. N. Levine, Quantum Chemistry, 7th Edition. *Pearson Education*, 2013.
5. C. Kalidas and M. V. Sangaranarayanan, Non-Equilibrium Thermodynamics: Principles & Applications, *Macmillan India Ltd.*, 2012.
6. R. K. Prasad, Quantum Chemistry, *New Age International*, 2011.
7. A. K. Chandra, Introductory Quantum Chemistry, *Tata McGraw-Hill*, 2008.
8. K. J. Laidler, Chemical Kinetics, 3rd Edition. *Pearson Education*, 2007.
9. A. Katchalsky and P. F. Curren, Non-Equilibrium Thermodynamics in Biophysics, *Harvard University Press*, Cambridge, 1995.
10. G. Davidson, Group theory for Chemist, *Macmillan Physical Science*, 1991.

Course No: CH-13	Course Name: Molecular Spectroscopy						Course Code: SBS CH 010313 C 4004
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** III	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE: 30** Marks **TEE: 70** Marks		**Examination Duration:** **3** Hrs.					
		Pre-requisite of course: Knowledge of basic of molecular spectroscopy up to UG level.					
Course Objectives	*To provide students with an understanding of the basics of molecular spectroscopy like rotational, vibrational, Raman, electronic and solid state and surface spectroscopy. This course will strengthen the essentials of molecular spectroscopy, especially microwave and infrared spectroscopy*.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of molecular spectroscopy. **CO2**: Use of spectroscopy in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important spectroscopic methods. **CO5**: Development of alternate and new spectroscopic characterization methods. **CO6**: Use of advanced and recent technologies in molecular spectroscopy.						

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts. Each part carries 3.5 marks and students need to answer any four sub-parts.

ii) Question nos. 2 to 9 are to be set from all four units, two from each unit. Every question will have two sub-parts and students need to answer any one question from each unit. Each question carries 14 marks.

Unit No.	Contents	Contact Hrs.
I	**ROTATIONAL SPECTROSCOPY** ***Basics of Molecular Spectroscopy*** Electromagnetic radiation and its region, representation of spectra, signal to noise ratio, resolving power, width and intensity of spectral lines. ***Rotational (Microwave) Spectroscopy*** Rotational Spectroscopy-Rigid diatomic Rotator, Selection rule for rotational/microwave spectrum, determination of bond-length, intensity of spectral lines, effects of isotopes on rotational spectra, Non-rigid rotator, Stark effect, Rotational spectra of linear polyatomic molecules, Application of microwave spectroscopy.	15
II	**VIBRATIONAL AND RAMAN SPECTROSCOPY** ***Infrared (Vibrational) Spectroscopy*** Vibration in Diatomic molecules, Simple Harmonic Oscillator Model, Anharmonic Oscillator, Selection Rule, Population of Vibrational Energy level, Diatomic Vibrating Rotator, P-Q-R Branches of Spectra, Breakdown of Born Oppenheimer Approximation, Fundamental Vibration and their Symmetry, Overtone and Combination frequency, Applications of Infra-red spectroscopy. ***Raman Spectroscopy*** Stokes and anti-Stokes lines. Polarizability ellipsoids. Pure Rotational Raman spectra, pure vibrational	15

	Raman spectra. Selection rules. Rule of Mutual Exclusion. Polarization of light, Raman Effect, Application of Raman and Infra-red spectroscopy in structure determination	
III	**ELECTRONIC SPECTROSCOPY** Principle of electronic spectroscopy, Total electronic angular momentum, Term symbol. Vibrational Coarse Structure: Progressions, Franck-Condon Principle, Dissociation energy and dissociation products, Rotational fine structure of electronic-vibration transitions, Fortrat diagram, Pre-dissociation.	15
IV	**SOLID STATE AND SURFACE SPECTROSCOPY** Electronic Energy loss Spectroscopy (EELS), Reflection-Absorption Infrared Spectroscopy (RAIRS), Photoelectron spectroscopy (PES): X-ray PES and Ultra-violet PES, Auger Electron Spectroscopy (AES) and X-ray Fluorescence (XRF).	15

Suggested Readings:

1. C. N. Banwell and E. M. McCash, Fundamental of Molecular Spectroscopy, 4thEdition. *Tata McGraw-Hill Publishing Company Ltd.*, New Delhi, 2017.
2. D. N. Satyanarayana, Handbook of Molecular Spectroscopy: From radio waves to gamma rays, *I. K. International Publishing House*, New Delhi, 2015.
3. R. Kakkar, Atomic & Molecular Spectroscopy*, Cambridge University Press*, 2015.
4. J. M. Hollas, Modern Spectroscopy, 4th Edition. *John Wiley & Sons*, 2014.
5. G. E. Bacon, Fifty Years of Neutron Diffraction*, Hilger*, 2007.
6. B. E. Warren, X-Ray Diffraction*, Dover Publications*, 1999.
7. J. C. D. Brand and J. C. Speakman, Molecular Structure: The Physical Approach,2nd Edition. *Edward Arnold*, London, 1995.
8. W. J. Moore, Physical Chemistry, 4th Edition. *Prentice-Hall*, 1992.
9. R. Chang, Basic Principles of Spectroscopy, *McGraw-Hill*, New York, 1990.

Course No: CH-25	Course Name: Physical Chemistry-III (Statistical Mechanics, Surface and Interface Chemistry)						Course Code: SBS CH 010309 DSE 4004
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **III**	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE: 30** Marks **TEE: 70** Marks		**Examination Duration:** **3** Hrs.					
		Pre-requisite of course: Knowledge of basic physical chemistry up to UG level.					
Course Objectives	*To provide students with an understanding of advanced physical chemistry like statistical mechanics and thermodynamics, photochemistry and electrified interface. This course will strengthen the essentials of Physical Chemistry, statistical mechanics and photochemistry.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of advanced physical chemistry. **CO2**: Use of statistical mechanics and photochemistry in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important methods. **CO5**: Development of alternate and new theoretical methods. **CO6**: Use of advanced and recent technologies in Physical Chemistry.						

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts. Each part carries 3.5 marks and students need to answer any four sub-parts.

ii) Question nos. 2 to 9 are to be set from all four units, two from each unit. Every question will have two sub-parts and students need to answer any one question from each unit. Each question carries 14 marks.

Unit No.	Contents	Contact Hrs.
I	**STATISTICAL MECHANICS** Concept of distribution, Thermodynamic probability and most probable distribution, Canonical, grand canonical and micro canonical ensembles. Maxwell-Boltzmann statistics, Boltzmann distribution, Derivation of the Boltzmann distribution expression, Determination of the Boltzmann constant, Maxwell distribution law of velocity from Boltzmann distribution expression, The Bose-Einstein statistics, Statistics of a photon gas, Fermi-Dirac statistics and comparison of three statistics.	15
II	**STATISTICAL THERMODYNAMICS** Partition function and thermodynamic properties, Factorization of partition function, Relationship of partition function to thermodynamic properties, Translational partition function, Calculation of absolute entropy of an ideal monoatomic gas, Secure-Tetrode equation. Vibrational and rotational partition function of diatomic molecules. Calculation of contribution of vibrational, rotational partition functions towards various thermodynamic properties. Electronic partition function, Effect of change of zero-point energy on partition function. Chemical equilibrium and equilibrium constant in terms of partition functions.	15

III	**PHOTOCHEMISTRY** Transitions between states (Chemical, classical and quantum dynamics, vibronic states). Potential energy surfaces, transitions between potential energy surfaces. The Franck-Condon principle and radiative transitions. Spin-orbit coupling and spin forbidden radiative transitions, delayed fluorescence and phosphorescence. Triplet-triplet, triplet-singlet, singlet-triplet energy transfer. Multiphoton energy transfer processes. Photoelectric effect, Compton effect. Energy transfer: theory of radiation less energy transfer, energy transfer by electron exchange.	15
IV	**ELECTRIFIED INTERFACES** Thermodynamics of electrified interfaces, Electrocapillary thermodynamics, Non-polarizable interface and Thermodynamic equilibrium. Fundamental thermodynamic equation of polarizable interfaces. Determination of excess charge density on the electrode, electrical capacitance and surface excess of the interface, potential of zero charge, Helmholtz-Perrin model, Gouy-Chapman model, Stern and Devanathan model.	15

Suggested Readings:

1. B. Bagchi, Statistical Mechanics for Chemistry and Material Science, *CRC Press*, 2018.
2. T. L. Hill, An Introduction to Statistical Thermodynamics, *Dover Publication*, 2018.
3. R. K. Pathria and Paul D. Beal, Statistical Mechanics, 3rd Edition. *Elsevier*, 2016.
4. L. D. Landau and E. M. Lifshitz, Statistical Mechanics, Part I, Butterworth-Heinemann, 3rd ed., 2015.
5. P. Atkins and J. P. Atkins' Physical Chemistry, 10th Edition. *Oxford University Press*, 2014.
6. D. McQuarie and J. Simon, Physical Chemistry-A molecular approach, 1stEdition.*Viva*, 2010.
7. D. A. McQuarrie, Statistical Mechanics, *Viva Books Pvt. Ltd*., New Delhi, 2003.
8. A. Gilbert and J. Baggot, Essentials of Molecular Photochemistry, *Blackwell Scientific*, 1999.
9. N. J. Turro, Modern Molecular Photochemistry, *Univ. Science Books,* 1991.

Course No: CH-26	**Course Name:** Physical Chemistry-IV (Solid State & Electroanalytical methods)						**Course Code:** SBS CH 010310 DSE 4004
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **III**	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE: 30** Marks **TEE: 70** Marks		**Examination Duration:** **3** Hrs.					
		Pre-requisite of course: Knowledge of basic physical chemistry up to UG level.					
Course Objectives	*To provide students with an understanding of advanced physical chemistry like electrochemistry, electroanalytical and potentiometric methods and solid-state chemistry. This course will strengthen the essentials of Physical Chemistry i.e., electrochemistry and solid-state chemistry.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of advanced physical chemistry. **CO2**: Use of electroanalytical and potentiometric methods in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important methods. **CO5**: Development of alternate analytical methods. **CO6**: Use of advanced and recent technologies in electrochemistry.						

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts. Each part carries 3.5 marks and students need to answer any four sub-parts.

ii) Question nos. 2 to 9 are to be set from all four units, two from each unit. Every question will have two sub-parts and students need to answer any one question from each unit. Each question carries 14 marks.

Unit No.	Contents	Contact Hrs.
I	**ELECTROCHEMISTRY-II** Contact adsorption on the electrode, Free energy of contact adsorption, The degree of contact adsorption and the measurement of contact adsorption, The influence of the contact adsorption on the capacity of the interface, Capacity-potential curve, The position of the OHP and the constant capacity, The capacitance hump, Variation of the population of contact-adsorbed ions with electrode charge, The lateral-repulsion model and the water Flip-Flop model of contact adsorption, The contribution of adsorbed water dipoles to the capacity of the interface.	15
II	**ELECTRO-ANALYTICAL & POTENTIOMETRIC METHODS** Polarization phenomenon and its theories, Effect of concentration on cell potential. Concept of Liquid Junction potential. Reference electrodes (Calomel, Ag/AgCl, Tl/TlCl) Metallic Redox indicator electrode: Membrane and ion selective electrodes. Enzyme electrode. Constant current chronoamperometry, constant potential chronoamperometry, Pulse voltammetry. Electrocatalysis: Influence of various parameters on water splitting, HER and OER.	15
III	**SOLID STATE CHEMISTRY-I** Classification of solids, Lattice energy, Thermal decomposition reactions, Nucleation, Free energy of nucleation: Laws, Functions and growth of nuclei. Kinetic expressions for diffusion controlled,	15

	nucleation and growth-controlled reactions. Perfect and imperfect crystals, Point defects, Line and plane defects, Vacancies: Schottky and Frenkel defects, Thermodynamics of Schottky and Frenkel defect formation, Color center, non-stoichiometric defects.	
IV	**SOLID STATE CHEMISTRY-II** Evaluation of Madelung constant (NaCl), Calculation of repulsive potential exponent: Lattice heat capacity. Einstein and Debye model of lattice heat capacity, Debye T^3 law. ***X-ray diffraction:*** Bragg condition, Miller indices, Laue method, Debye-Scherrer method of X-ray structural analysis of crystals, index reflections, structure of simple lattices and X-ray intensities. JCPDS card file for corelating structure.	15

Suggested Readings:

1. H. K. Moudgil, Textbook of Physical Chemistry, *PHI Publication House*, New Delhi, 2015.
2. P. Atkins and J. Paula, Atkins Physical Chemistry, 10th Edition. *Oxford University Press*, 2014.
3. D. Mcquarie and J. Simon, Physical Chemistry-A Molecular Approach, 1stEdition.*Viva*, 2010.
4. J. M. Bockris and A. K. N. Reddy, Modern Electrochemistry-I (Ionics), *Springer*, 2006.
5. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry-II, *Springer*, 2006.
6. L. E. Smart, E. A. Moore, Solid State Chemistry-An Introduction, 3rd Edition. *CRC Press*, 2005.
7. A. R. West, Basic Solid-State Chemistry, 2nd Edition. *John Wiley & Sons*, 2005.

Course No: CH-37	Course Name: Physical Chemistry-V (Polymer & Surface Chemistry)						Course Code: SBS CH 010421 DSE 4004
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **IV**	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE: 30** Marks **TEE: 70** Marks		**Examination Duration:** **3** Hrs. **Pre-requisite of course:** Knowledge of basic physical chemistry up to UG level.					
Course Objectives	*To provide students with an understanding of advanced physical chemistry like polymer chemistry, polymer characterization and chemistry of surfactants. This course will strengthen the fundamentals of Physical Chemistry, especially polymer chemistry and chemistry of surfactants.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of advanced physical chemistry. **CO2**: Use of polymer chemistry and chemistry of surfactants in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important methods. **CO5**: Development of alternate analytical methods. **CO6**: Use of advanced and recent technologies in polymer chemistry.						

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts. Each part carries 3.5 marks and students need to answer any four sub-parts.

ii) Question nos. 2 to 9 are to be set from all four units, two from each unit. Every question will have two sub-parts and students need to answer any one question from each unit. Each question carries 14 marks.

Unit No.	Contents	Contact Hrs.
I	**POLYMER CHEMISTRY** Classification of polymers, Polymerization: Condensation, Addition, Radical chain, Ionic, Coordination and Co-polymerization. Polymerization conditions and polymer reactions. Polymerization in homogeneous and heterogeneous systems. Kinetics of polymerization. Polydispersion-average molecular weight concept. Number, weight and viscosity average molecular weights. Polydispersity and molecular weight distribution. Meaning of glass transition temperature, T_g, factors influencing the glass transition temperature and importance of glass transition temperature.	15
II	**CHARACTERIZATION AND CONDUCTING POLYEMRS** The practical significance of molecular weight. Measurement of molecular weights: End-group, Osmotic and Ultracentrifugation methods. Analysis and testing of polymers: Chemical analysis of polymers, Spectroscopic methods and Microscopy. Thermal analysis and physical testing: Tensile strength, fatigue, impact, tear resistance and hardness and abrasion resistance. ***Electrically conducting polymers:*** Factors affecting the conductivity of conducting polymers, nature of charge carriers in conducting polymers: Solitons, polarons and bipolarons. Mechanism of conduction in polymers. Organic solids, fullerenes, molecular devices: organic superconductors, doped fullerenes as	15

	superconductors and magnetism in organic materials.	
III	**CHEMISTRY OF SURFACTANTS-I** Adsorption of surface-active agents at Solid/Liquid, Liquid/Gas and Liquid/Liquid interfaces. Mechanism of adsorption, adsorption isotherm, effects of adsorption from aqueous solution on the surface properties of solid adsorbent, adsorption from non-aqueous solution. Determination of surface areas of solids. Gibb's and BET adsorption equation and its utilization to calculate surface concentration and surface area per molecule. ***Thin films and Langmuir-Blodgett films:*** Preparation techniques, evaporating/sputtering, chemical process, MOCVD, Sol-gel, Langmuir-Blodgett (LB) film, growth techniques, properties and applications of LB films.	15
IV	**CHEMISTRY OF SURFACTANTS-II** Surface active agents, classification, Critical micelle concentration (CMC), Methods of determining CMC, Factors affecting CMC, Micellar structure and shape, Micellar aggregation. CMC in non-aqueous media. hydrophobic interaction, Krafft temperature, Thermodynamic parameters of micellization. Counterion binding to micelles, solubilization, microemulsions, reverse micelles, surface films (electro kinetic phenomenon), catalytic activity at surfaces. Effectiveness of adsorption at Liquid/Gas and Liquid/Liquid interfaces, Szyszkiwski, Langmuir, Temkin, and Frumkin adsorption equations. Derivation of thermodynamics parameters of adsorption at the Liquid/Gas and Liquid/Liquid interfaces.	15

Suggested Readings:

1. V. R. Gowariker, N. V. Viswanathan and J. Sreedhar, Polymer Science, *New Age Internat. Pvt. Ltd*., 2015.
2. F. W. Billmeyer Jr., Textbook of Polymer Science, *Wiley India Pvt. Ltd*., 2014.
3. M. J. Rosen, Surfactants and Interfacial Phenomenon, 4thEdition. *Wiley*, 2012.
4. P. Becher, Emulsions: Theory and Practice, *American Chemical Society*, 2019.
5. H. R Alcock and F. W. Lamb, Contemporary Polymer Chemistry, *Prentice Hall*, 2017.
6. J. M. G. Cowie, Physics and Chemistry of Polymers, *Blackie Academic and Professional*, 2014.
7. F. Wold, Macromolecules: Structure and Function, *Prentice Hall of India*, 2001.
8. K. Takemoto, R. M. Ottanbrite and M. Kamachi, 2nd Edition. Functional Monomers and Polymers, *CRC press*, 1997.
9. P.C. Hiemenz, R. Rajagopalan, Principles of Colloid and Surface Chemistry, Revised and Expanded (Undergraduate Chemistry: A Series of Textbooks, 3rd Edition. *CRC Press*, 2007.
10. G. A. Somorjai, Y. Li, Introduction to Surface Chemistry and Catalysis, 2nd Edition. *Wiley*, 2010.

Course No: CH-38	Course Name: Physical Chemistry-VI (Frontiers in Electrochemistry)				Course Code: SBS CH 010422 DSE 4004		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **IV**	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE: 30** Marks **TEE: 70** Marks		**Examination Duration:** **3** Hrs.					
		Pre-requisite of course: Knowledge of basic physical chemistry up to UG level.					

Course Objectives	*To provide students with an understanding of applied physical chemistry like Electrodics, Fuel cell, Supercapacitors and rechargeable Batteries, current potential laws and Corrosion of metals and their alloys, Liquid crystals. This course will strengthen the applications of Physical Chemistry, especially Fuel cells and Batteries and Corrosion.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: An understanding of advanced Physical Chemistry. **CO2**: Use of Fuel cells and Batteries and Corrosion in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important methods. **CO5**: Development of alternate analytical methods. **CO6**: Use of advanced and recent technologies in Batteries and Corrosion.

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts. Each part carries 3.5 marks and students need to answer any four sub-parts.

ii) Question nos. 2 to 9 are to be set from all four units, two from each unit. Every question will have two sub-parts and students need to answer any one question from each unit. Each question carries 14 marks.

Unit No.	Contents	Contact Hrs.
I	**ELECTRODICS** Rate of charge transfer reactions under zero field, under the influence of an electric field. The equilibrium exchange current density, the non-equilibrium drift-current density (Butler-Volmer) equation. High-field and low-field approximations. Physical meaning of the symmetry factor (β), A simple picture of the symmetry factor and its dependence on over potential. Polarizable and nonpolarizable interfaces.	15
II	**FUEL CELLS, SUPERCAPACITORS AND BATTERIES** The maximum intrinsic efficiency, Actual efficiency and Current-Potential relation in an electrochemical energy converter. Factors influencing the electrochemical energy conversion, The power output of an electrochemical energy converter. Electrochemical electricity generators (fuel cells). Brief idea about H_2-O_2 fuel cell, Hydrocarbon-air fuel cells, and Natural gas, CO-air fuel cells, Supercapacitors, and Lithium ion batteries. Electricity storage: Some important quantities in electricity storage (like electricity storage density, energy density and power), Desirable conditions for an ideal storrer, Storage of electricity using the lead-acid battery, Dry cell, Silver-Zinc cell and	15

	Sodium-Sulfur cell.	
III	**CORROSION** Electrochemistry of corrosion of metals, Factors affecting corrosion, Electrochemical cell formation, Polarization of metal electrode *i.e*. Concentration, Resistance and Activation polarization. Anodic and cathodic polarization curves (Evan's diagram). Electrochemical measurement of corrosion current density, corrosion potential and mixed potential theory and Tafel slope. Impedance spectroscopy technique, Anodic passivation and passivation potential. Passivity theory. Methods of protecting metal and their alloys from corrosion (anodic protection, cathodic protection, sacrificial protection, barrier protection, use of chemical inhibitors, environment modifiers).	15
IV	**CURRENT POTENTIAL LAWS AND LIQUID CRYSTALS** Comparison of electrolytic interface to other type of charged interfaces *i.e.* semiconductors *p-n* junctions. The current across biological membranes, Hot and cold emission of electrons from a metal into vacuum. Dye sensitized solar cells. Liquid crystals: Mesomorphic behavior, thermotropic liquid crystals, positional order, bond orientational order, nematic and smetic mesophases, Smectic-nematic transition, twisted nematics, chiral nematics, optical properties of liquid crystals.	15

Suggested Readings:

1. M. G. Fontana, Corrosion Engineering, *McGraw Hill*, 2017.
2. H. K. Moudgil, Textbook of Physical Chemistry, *PHI Publication House*, New Delhi, 2015.
3. S. Glasstone, An introduction to Electrochemistry, *Est West Press Ltd*., 2016.
4. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry-I, *Springer*, 2009.
5. R. Narain, An Introduction to Metallic Corrosion, *Oxford and IBH Pub Co.*, 1993.
6. P. Atkins and J. Paula, Atkins' Physical Chemistry, *Oxford University Press*, 10th ed., 2014.
7. D. Mcquarie and J. Simon, Physical Chemistry-A Molecular Approach, 1stEdition. *Viva*, 2010.
8. J. O**.** M. Bockris and A. K. N. Reddy, Modern Electrochemistry-I (Ionics), *Springer*, 2006.
9. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry-II, *Springer*, 2016.

PRACTICAL COURSES

Course No: CH-06	Course Name: Physical Chemistry Practical-I						Course Code: SBS CH 010106 C 0042	
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** I	**L** 0	**T** 0	**P** 4	**Credit** 2	**Contact Hrs. per Week:** 04	**Total Hrs.:** 60
Total Evaluation Marks: 50 **CIE:** **15** Marks **TEE:** **35** Marks	**Examination Duration:** 6 Hrs. **Pre-requisite of course:** Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to UG level.							
Course Objectives	*To train students with introductory physical chemistry practical like adsorption, saponification value, molecular weight determination, surface tension, viscosity, distribution law and thermochemistry.*							
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of practical physical chemistry. **CO2**: Use of surface tension, viscosity, adsorption in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important practical methods. **CO5**: Development of alternate analytical methods. **CO6**: Use of advanced and recent techniques in experimental chemistry.							

COURSE SYLLABUS

NOTE:
Depending on availability of time and equipment some experiments may be added/deleted.

Unit No.	Contents	Contact Hrs.
I	**HANDS ON TRAINING IN PHYSICAL CHEMISTRY EXPERIMENTS** *Partial Molar Quantities* ● To determine the partial molar volume of urea and ethanol in aqueous solution from density measurements. *Adsorption* ● To determine the adsorption isotherms of acetic acid from aqueous solution and I_2 from alcoholic solution by charcoal. ● To investigate the adsorption of oxalic acid from aqueous solution by activated charcoal and to examine the validity of Freundlich & Langmuir's adsorption isotherms. *Acid and Saponification Value* ● To find out the acid value of a given sample. ● To find out the saponification value of given vegetable oil. *Molecular Weight of Polymer* To determine the molecular weight of a given polymeric solution by viscosity and Rast	30

	method.	
II	**BASICS PHYSICAL CHEMISTRY EXPERIMENTS** *Surface Tension/Interfacial Tension* ● To find surface tension/interfacial tension between two immiscible liquids. ● To determine the percentage composition of a given mixture of two liquids say CCl_4 and Toluene by surface tension method. Viscosity ● To find viscosity and coefficient of viscosity of unknown liquids by Ostwald's viscometer method. ● To determine the percentage composition of given unknown mixture by viscosity method. *Distribution Law* ● To study the distribution of benzoic acid, I_2, succinic acid between organic liquid and water at room temperature and show that whether BA, I_2, Succinic acid dimerizes in organic liquid or water. Thermochemistry ● To determine the heat of neutralization of sulphuric acid using Dewar's vacuum flask as the calorimeter. ● To determine the heat of ionization of a weak base i.e. NH_4OH using calorimeter.	30

Suggested Readings:

1. B. Viswanathan and P. S. Raghavan, Practical Physical Chemistry, *M V Learning*, 2017.
2. Shoemaker and Garland, Experiments in Physical Chemistry, *McGraw Hill*, 2015.
3. B. D. Khosla, V. C. Garg and Adarsh Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi, 2014.
4. Saroj Kumar Maity, Naba Kumar Ghosh, Physical Chemistry Practical, *New Central book Agency*, 2012.
5. G. P. Mathews, Experimental Physical Chemistry, 1st Edition. *Oxford University Press*, 1995.
6. A. M. James and F. E. Prichard, Practical Physical Chemistry, *Lomgman*, 1994.
7. B. P. Levitt, Findley's Practical Physical Chemistry, 9th Edition. *Longman Group Ltd.*, 1993.
8. J. B. Yadav, Advanced Practical Physical Chemistry, *Goel Publishing House*, 1991.
9. R. C. Das and B. Behara, Experimental Physical Chemistry, *Tata McGraw Hill*, 1984.

Course No: CH-12	Course Name: Physical Chemistry Practical-II					Course Code: SBS CH 010212 C 0042	
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** II	**L** 0	**T** 0	**P** 4	**Credit** 2	**Contact Hrs. per Week:** 04 **Total Hrs.:** 60
Total Evaluation Marks: 50 **CIE:** **15** Marks **TEE:** **35** Marks	**Examination Duration:** 6 Hrs. **Pre-requisite of course:** Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to UG level.						
Course Objectives	*To provide students exposure of refractometry, chemical kinetics, solution chemistry, turbidity metry, and pH, potentio and conductometry experiments. Advanced experiments such as pH metry, potentiometry and conductometry will be carried out. First-hand experience of turbidity meter studies will be provided. At the end of this course students will be equipped to carry out instrumental analysis at the research level.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of practical physical chemistry. **CO2**: Use of pH meter, potentiometer, conductivity meter in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important practical methods. **CO5**: Development of alternate analytical methods. **CO6**: Use of advanced and recent techniques in experimental chemistry.						

COURSE SYLLABUS

NOTE:
Depending on availability of time and instruments in laboratory, few experiments may be added/deleted.

Unit No.	Contents	Contact Hrs.
I	**CHEMICAL KINETICS AND pH METRY EXPERIMENTS** *Chemical Kinetics* ● Determination of the effect of (a) change in temperature, (b) change in concentration of reactants and catalysts (c) ionic strength of the media on velocity constant of hydrolysis of an ester. ● Determine the velocity constant of hydrolysis of ethyl acetate catalyzed by an acid and NaOH solution. *Solution Chemistry* ● To determine the solubility of an inorganic salt like KCl, NaCl, KNO_3, $NaNO_3$, K_2SO_4 in water at different temperature and hence to obtain the solubility curve. ● To determine the heat of solution of given substance like oxalic acid and benzoic acid by solubility method. *pH metric* ● To determine the strength of strong acid versus strong base, weak acid versus strong base, mixture of strong and weak acids versus strong base, weak acid versus	30

	weak base, strong acid versus weak base using a pH meter. ● To determine the concentration of a reductant or an oxidant i.e. Ferrous ammonium sulphate, $K_2Cr_2O_7$and $KMnO_4$ by a pH metric titration method.	
II	**POTENTIOMETRY AND CONDUCTOMETRY EXPERIMENTS** *Potentiometry* ● To determine the strength of strong acid versus strong base, weak acid versus strong base, mixture of strong and weak acids versus strong base, weak acid versus weak base, strong acid versus weak base using a potentiometer. ● To prepare and test the standard reference electrode i.e., calomel electrode or silver- silver chloride electrode. ● Titrate Mohr's salt against $KMnO_4$potentiometrically and carry out the titration in reverse order. *Turbidimetry* ● To find the turbidity of given solution by using Nephthalo turbidity meter. *Conductometry* ● Study of conductometric titration of NH_4Cl versus NaOH solution, CH_3COONa versus HCl, $MgSO_4$ versus $Ba(OH)_2$, $BaCl_2$ and $K_2SO_4$and comment on the nature of graph. ● To study stepwise neutralization of polybasic acid like oxalic acid, citric acid, phosphoric acid by conductometric titration and explain the variation in the graph.	30

Suggested Readings:

1. B. Viswanathan and P. S. Raghavan, Practical Physical Chemistry, *M V Learning*, 2017.
2. Shoemaker and Garland, Experiments in Physical Chemistry, *McGraw Hill*, 2015.
3. B. D. Khosla, V. C. Garg and Adarsh Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi, 2014.
4. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, *New Central book Agency*, 2012.
5. G. P. Mathews, Experimental Physical Chemistry, 1stEdition. *Oxford University Press*, 1995.
6. A. M. James and F. E. Prichard, Practical Physical Chemistry, *Lomgman*, 1994.
7. B. P. Levitt, Findley's Practical Physical Chemistry, 9thEdition. *Longman Group Ltd.*, 1993.
8. J. B. Yadav, Advanced Practical Physical Chemistry, *Goel Publishing House*, 1991.
9. R. C. Das and B. Behara, Experimental Physical Chemistry, *Tata McGraw Hill*, 1984.

Course No: CH-27	Course Name: Physical Chemistry Practical-III						Course Code: SBS CH 010311 DSE 0063	
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **III**	**L** 0	**T** 0	**P** 6	**Credit** 3	**Contact Hrs. per Week:** **06** **Total Hrs.:** **90**	
Total Evaluation Marks: 75 **CIE:** **22.5** Marks **TEE:** **52.5** Marks		**Examination Duration:** 8 Hrs. **Pre-requisite of course:** Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to UG level.						
Course Objectives	*To provide students exposure of solution chemistry, phase rule, spectrophotometry, polarimetry, ultrasonic interferometry and pH metry, potentiometry and conductometry experiments. Advanced experiments such as ultrasonic interferometer and spectrophotometer will be carried out. First-hand experience of polarimetric studies will be provided. At the end of this course students will be equipped to carry out instrumental analysis at the research level.*							
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of practical physical chemistry. **CO2**: Use of pH meter, potentiometer, conductivity meter in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important practical methods. **CO5**: Development of alternate analytical methods. **CO6**: Use of advanced and recent techniques in experimental chemistry.							

COURSE SYLLABUS

NOTE:
Depending on availability of time and instruments in laboratory, few experiments may be added/deleted.

Unit No.	Contents	Contact Hrs.
I	**CONDUCTOMETRY AND pH METRY** *Conductometry* ● Determination of the equivalent conductance of strong electrolytes such as HCl, KCl, KNO_3, $AgNO_3$ and NaCl and the validity of Onsager equation. ● Determination of the solubility of lead sulfate and silver halides. ● Conductometric titration of Strong acid *vs*. strong base, weak acid *vs*. strong base, Strong acid *vs*. weak base, weak acid *vs*. weak base using conductivity meter. *pH metric* ● Acid base titration of a non-aqueous media using pH meter. ● Determination of dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by titrating it with KOH. ● To determine the strength of strong acid versus weak base (NH_4OH), weak acid versus weak base, strong and weak acid mixture against a weak base	30

	using a pH meter. ● To determine the degree of hydrolysis and hydrolysis constant of aniline, acetic acid by pH metrically.	
II	**SPECTROPHOTOMETRY AND POLARIMETERY** *Spectrophotometry* ● Determine the concentration of Crystal violet and Aurine in mixture of (Crystal violet + Aurine) solution. ● To determine the dissociation constant (K_a)of Methyl red using UV-visible absorption spectrophotometer. ● Verification of Beer law using solutions such as I_2 in CCl_4, and $CuSO_4$ in water, $K_2Cr_2O_7$ and $KMnO_4$ in sulphuric acid medium.	30
III	*Polarimetry* ● To determine the concentration of an optically active substance using polarimeter. ● To determine the percentage of two optically active substances in a given mixture. *Solution Chemistry* ● Determination of Solubility by evaporation and gravimetric method. ● Determination of transition temperature by thermometric method.	30

Suggested Readings:

1. B. Viswanathan, P. S. Raghavan, Practical Physical Chemistry, *M V Learning*, 2017.
2. Shoemaker and Garland, Experiments in Physical Chemistry, *McGraw Hill*, 2015.
3. B. D. Khosla, V. C. Garg and Adarsh Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi, 2014.
4. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, *New Central book Agency*, 2012.
5. G. P. Mathews, Experimental Physical Chemistry, 1stEdition. *Oxford University Press*, 1995.
6. A. M. James and F. E. Prichard, Practical Physical Chemistry, *Lomgman*, 1994.
7. B. P. Levitt, Findley's Practical Physical Chemistry, 9thEdition. *Longman Group Ltd.*, 1993.
8. J. B. Yadav, Advanced Practical Physical Chemistry, *Goel Publishing House*, 1991.
9. R. C. Das and B. Behara, Experimental Physical Chemistry, *Tata McGraw Hill*, 1984.

Course No: CH-28	Course Name: Physical Chemistry Practical-IV						Course Code: SBS CH 010312 DSE 0063	
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **III**	**L** 0	**T** 0	**P** 6	**Credit** 3	**Contact Hrs. per Week:** **Total Hrs.:**	**06** **90**
Total Evaluation Marks: 75 **CIE:** **22.5** Marks **TEE:** **52.5** Marks		**Examination Duration:** 8 Hrs. **Pre-requisite of course:** Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to UG level.						
Course Objectives	*To provide students exposure of phase rule, ultrasonic interferometry and pH metry, potentiometry and conductometry experiments. Advanced experiments such as ultrasonic interferometer and spectrophotometer will be carried out. First-hand experience of polarimetric studies will be provided. At the end of this course students will be equipped to carry out instrumental analysis at the research level.*							
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of practical physical chemistry. **CO2**: Use of phase rule, ultrasonic interferometer, conductivity meter in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important practical methods. **CO5**: Development of alternate analytical methods. **CO6**: Use of advanced and recent techniques in experimental chemistry.							

COURSE SYLLABUS

NOTE:
Depending on availability of time and instruments in laboratory, few experiments may be added/deleted.

Unit No.	Contents	Contact Hrs.
I	**PHASE RULE AND ULTRASONIC INTERFEROMETER** *Phase Rule* ● To verify the phase rule for a given two and three component Azeotropic mixtures. ● To determine the transition temperature of given salt hydrate like Sodium sulphate, Strontium sulphate or Sodium thiosulphate. *Ultrasonic Interferometer* ● To find ultrasonic speed of given organic binary liquid mixtures of different composition. ● To study the effect of temperature on ultrasonic speed of given organic mixture.	30
II	**POTENTIOMETRY-I EXPERIMENTS** *Potentiometry* ● To determine the thermodynamic parameters for a reaction from EMF measurement. ● To determine the pH of a series of buffer solutions by potentiometric method. ● To determine the solubility product of AgCl and to determine instability constant of $Ag(NH_3)_2^+$ complex. ● To determine the activity of hydrogen ion in acid medium using hydrogen electrode, hence to determine the ionic product of water and hydrolysis constant of sodium	30

	acetate. ● To determine the degree of hydrolysis and hydrolysis constant of weak acid by potentiometry.	
III	**MAGNETIC MOMENT AND MAGNETIC SUSCEPTIBILITY** ● Determine the magnetic susceptibility of a paramagnetic substance using Gouy's Balance. ● To study the change in weight of a substance after passing magnetic lines of force. **POTENTIOMETRY-II EXPERIMENTS** ● To determine the concentration of a reductant or an oxidant i.e. Ferrous ammonium sulphate and Ceric sulphate by a potentiometric redox titration. ● To determine the amount of KI and KCl present in a mixture by potentiometric titration.	30

Suggested Readings:

1. B. Viswanathan and P. S. Raghavan, Practical Physical Chemistry, *M V Learning*, 2017.
2. Shoemaker and Garland, Experiments in Physical Chemistry, *McGraw Hill*, 2015.
3. B. D. Khosla, V. C. Garg and Adarsh Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi, 2014.
4. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, *New Central book Agency*, 2012.
5. G. P. Mathews, Experimental Physical Chemistry, 1st Edition. *Oxford University Press*, 1995.
6. A. M. James and F. E. Prichard, Practical Physical Chemistry, *Lomgman*, 1994.
7. B. P. Levitt, Findley's Practical Physical Chemistry, 9th Edition. *Longman Group Ltd.*, 1993.
8. J. B. Yadav, Advanced Practical Physical Chemistry, *Goel Publishing House*, 1991.
9. R. C. Das and B. Behara, Experimental Physical Chemistry, *Tata McGraw Hill*, 1984.

Course No: CH-39	Course Name: Physical Chemistry Practical-V					Course Code: SBS CH 010423 DSE 0063	
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **IV**	**L** 0	**T** 0	**P** 6	**Credit** 3	**Contact Hrs. per Week: 06** **Total Hrs.: 90**
Total Evaluation Marks: 75 **CIE: 22.5** Marks **TEE: 52.5** Marks		**Examination Duration:** 8 Hrs.					
		Pre-requisite of course: Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to UG level.					
Course Objectives	*To provide students exposure of Flame photometry, theoretical (computational) techniques, chronopotentiometry, chromatography, and conductometry experiments. Advanced experiments such as chronopotentiometry and computational will be carried out. First-hand experience of chronopotentiometry will be provided. At the end of this course students will be equipped to carry out instrumental analysis at the research level.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of practical physical chemistry. **CO2**: Use of flame photometer, computational techniques, chronopotentiometry in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important practical methods. **CO5**: Development of alternate analytical methods. **CO6**: Use of advanced and recent techniques in experimental chemistry.						

COURSE SYLLABUS

NOTE:
Depending on availability of time and instruments available in laboratory, few experiments may be added/deleted.

Unit No.	Contents	Contact Hrs.
I	**FLAME PHOTOMETRY AND COMPUTATIONAL TECHNIQUES** • Determination of Na^+ and K^+ ions when present together. • Determination of Li/Ca/Ba/Sr ions present in any analyte. *Computational Techniques* • Elementary exercise in computer graphics an illustrative experiment solving the interactive equation. • Plotting a graph in origin. • Drawing a structure of molecules in Avogadro software and molecular modelling.	30
II	**CHROMATOGRAPHY AND CONDUCTOMETRY** • To prepare citric acid from sodium citrate and aniline from aniline hydrochloride using cationic and anionic exchangers. • To differentiate common sugars/amino acids by paper chromatography. *Conductometry* • Titrate a moderately strong acid (Salicylic/Mandelic acid) by the salt line and double alkali method.	30

	• Titrate a mixture of copper sulphate, acetic acid and sulphuric acid with sodium hydroxide. • Titrate magnesium sulphate against $BaCl_2$ and its reverse reaction.	
III	**CHRONOPOTENTIOMETRY TECHNIQUES** • Determine the extent of catalytic activity of Pt and Cu electrode by H_2 evolution reaction (HER). • Determine the extent of catalytic activity of Pt and Cu electrode by O_2 evolution reaction (OER). • Determine the area and roughness factor of the electrode by H-adsorption and H-desorption.	30

Suggested Readings:

1. B. Viswanathan and P. S. Raghavan, Practical Physical Chemistry, *M V Learning*, 2017.
2. Shoemaker and Garland, Experiments in Physical Chemistry, *McGraw Hill*, 2015.
3. B. D. Khosla, V. C. Garg and Adarsh Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi, 2014.
4. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, *New Central book Agency*, 2012.
5. G. P. Mathews, Experimental Physical Chemistry, 1stEdition. *Oxford University Press*, 1995.
6. A. M. James and F. E. Prichard, Practical Physical Chemistry, *Lomgman*, 1994.
7. B. P. Levitt, Findley's Practical Physical Chemistry, 9thEdition. *Longman Group Ltd.*, 1993.
8. J. B. Yadav, Advanced Practical Physical Chemistry, *Goel Publishing House*, 1991.
9. R. C. Das and B. Behara, Experimental Physical Chemistry, *Tata McGraw Hill*, 1984.

Course No: CH-40	Course Name: Physical Chemistry Practical-VI						Course Code: SBS CH 010424 DSE 0063
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **IV**	**L** 0	**T** 0	**P** 6	**Credit** 3	**Contact Hrs. per Week: 06** **Total Hrs.: 90**
Total Evaluation Marks: 75 **CIE: 22.5** Marks **TEE: 52.5** Marks		**Examination Duration:** 8 Hrs.					
		Pre-requisite of course: Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to UG level.					
Course Objectives	*To provide students exposure of nanotechnology experiments. Advanced experiments such as electrochemical methods and sol-gel, co-precipitation method will be carried out. First-hand experience of nanotechnology will be provided. At the end of this course students will be equipped to carry out instrumental analysis at the research level.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of practical physical chemistry. **CO2**: Use of electrochemical, Sol-gel, Coprecipitation methods in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important practical methods. **CO5**: Development of alternate analytical methods. **CO6**: Use of advanced and recent techniques in experimental chemistry.						

COURSE SYLLABUS

NOTE:
Depending on availability of time and instruments available in the laboratory, few experiments may be added/deleted.

Unit No.	Contents	Contact Hrs.
I	**SYNTHESIS OF NANOPARTICLES** ● Synthesize metal nanoparticles by sol-gel method. ● Synthesize metal nanoparticles by co-precipitation method. ● Synthesize metal nanoparticles by reverse micelle technique. ● Extract metal nanoparticles from plants and their products like Mg from chlorophyll.	30
II	**ELECTROCHEMICAL TECHNIQUES** ● Record anodic and cathodic polarization of metal electrode in acidic medium. ● Find corrosion rate from Tafel plots using Stern-Gerry equation. ● Record Nyquist and Bode plots for MS electrode dipped in acidic medium. ● Record cyclic Voltammogram and find anodic and cathodic oxidative peak. ● Verify Cottrell equation using potential step chronoamperometry.	30
III	**CHARACTERIZATION TECHNIQUES** ● Characterization of metal nanoparticles by UV-visible and FTIR spectroscopy techniques. ● Estimate direct and indirect optical energy band gap of metal nanoparticles by UV-visible spectroscopy technique.	30

Suggested Readings:

1. B. Viswanathan and P. S. Raghavan, Practical Physical Chemistry, *M V Learning*, 2017.
2. Shoemaker and Garland, Experiments in Physical Chemistry, *McGraw Hill*, 2015.
3. B. D. Khosla, V. C. Garg and Adarsh Gulati, Senior Practical Physical Chemistry, *R. Chand & Co.*, New Delhi, 2014.
4. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, *New Central book Agency*, 2012.
5. G. P. Mathews, Experimental Physical Chemistry, 1st Edition. *Oxford University Press*, 1995.
6. A. M. James and F. E. Prichard, Practical Physical Chemistry, *Lomgman*, 1994.
7. B. P. Levitt, Findley's Practical Physical Chemistry, 9th Edition. *Longman Group Ltd.*, 1993.
8. J. B. Yadav, Advanced Practical Physical Chemistry, *Goel Publishing House*, 1991.
9. R. C. Das and B. Behara, Experimental Physical Chemistry, *Tata McGraw Hill*, 1984.

DISCIPLINE CENTRIC ELECTIVE COURSES (DCEC)

Course No: CH-43	Course Name: Reaction Mechanism: Structure and Reactivity				Course Code: SBS CH 010101 DCE 2002		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** I	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week: 02** **Total Hrs.: 30**
Total Evaluation Marks: 50 **CIE:** 15 Marks **TEE:** 35 Marks		**Examination Duration:** 2Hrs. **Pre-requisite of course:** Basic and advance knowledge of Physical Organic Chemistry.					
Course Objective	*To provide a basic and advanced knowledge of physical organic chemistry including a better understanding of a reaction mechanism, kinetic and non-kinetic methods, the different types of reactive intermediates involved during a chemical reaction, and kinetic and thermodynamically controlled reactions.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Fundamental understanding of a reaction mechanism. **CO2**: Basic idea of a reactive intermediate involved during a chemical reaction. **CO3**: Basic knowledge of a kinetic and thermodynamic controlled product formation. **CO4**: Basic knowledge of kinetics and non-kinetics method to study a reaction mechanism. **CO5**: Idea about the correlation of stereochemistry and mechanism **CO6**: Advanced knowledge about general physical organic chemistry principles						

COURSE SYLLABUS

NOTE:
i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**FUNDAMENTALS OF REACTION MECHANISMS** Fundamentals of stereoelectronic effects and reactivity, acids and bases, reaction types, intermediates and transition state, effect of temperature and catalysts.	7
II	**REACTIVE INTERMEDIATES** Introduction to structure, formation, stability and reactions of carbocations, carbanions, free radicals, radical anions, radical cations, arynes, carbenes and nitrenes.	8
III	**CHEMICAL EQUILIBRIA AND REACTIVITY** Thermodynamic and kinetic control of reactions, Correlation of reactivity with structure, linear free energy relationships, Hammond's postulate, Curtin-Hammett principle.	7
IV	**KINETICS AND NON-KINETIC METHODS TO STUDY MECHANISM** Kinetic methods: primary and secondary kinetic isotopic effects, isotopic labeling; non-kinetic methods: detection and interception of intermediates, systematic structural variation, stereochemical studies and cross-over experiments.	8

Suggested Readings:

1. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part A, 5th Edition, Springer, 2012.
2. E. V. Anslyn and D. A. Dougherty, Modern Physical Organic Chemistry, University Science Books, 2005.
3. Warren, S.; Greeves, N.; J. Clayden and P. Wothers, Organic Chemistry, 2nd Edition, Oxford University Press, 2001.
4. J. March, Advanced Organic Chemistry, Reactions, Mechanisms and Structure, 4th Edition, John-wiley, 1999.
5. N. S. Isaacs, Physical Organic Chemistry, 2nd Edition, Longman Scientific & Technical, 1995.
6. P. Sykes, A guidebook to Mechanism in Organic Chemistry, 5th Edition, Longman Scientific Technical, 1985.
7. P. Deslongchamps, Stereoelectronic Effects in Organic Chemistry, Pergamon, 1983.

Course No: CH-44	Course Name: Nuclear Chemistry						Course Code: SBS CH 010102 DCE 2002
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** I	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week: 02** **Total Hrs.: 30**
Total Evaluation Marks:50 **CIE: 15** Marks **TEE: 35** Marks		**Examination Duration:** 2 Hrs.					
		Pre-requisite of *course:* To provide the basic knowledge of nuclear structures, radioactivity and applications.					
Course Objectives	*To provide the basics of nuclear structures, radiations, artificial radioactivity and applications of nuclear chemistry, radiopharmacy and chelation therapy.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of nuclear structure **CO2**: To identify and understand various nuclear reactions **CO3**: Measurement of radioactivity **CO4**: Artificial radioactivity **CO5**: To understand chelation therapy **CO6**: Applications of nuclear chemistry						

COURSE SYLLABUS

NOTE:

i) Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**NUCLEAR STRUCTURE** Composition of the nucleus, nuclear size, shape and density, theories of nuclear composition, magnetic and electric properties of nucleus, nuclear spin and parity, nuclear binding forces.	7
II	**NUCLEAR REACTIONS** Penetration potential, nuclear binding energy, nuclear emissions, nuclear transformations, bombardment of nuclei, nuclear fission, nuclear fusion, nuclear explosives, nuclear reactors in India, Szilard–Chalmer's effect, fuel cycle and waste management, reactor power control.	8
III	**RADIOACTIVITY** Radioactive decay and growth, naturally occurring and artificially produced radioactive substances, Measurement of radioactivity, group displacement law, radioactive disintegration series, rate of disintegration, half-life, average life of radioactive elements, unit of radioactivity, nuclear decay, determination of decay constants, decay rates, types of nuclear decay.	7

IV	**ARTIFICIAL RADIOACTIVITY AND APPLICATIONS OF NUCLEAR CHEMISTRY** Discovery of artificial radioactivity, isotopes used in medicines, radiocarbon dating, age determination, effects of radiation on life, applications of tracer element in medical, agriculture and analytical fields, biological effects of radiation, radiation protections, chelation therapy.	8

Suggested Readings:

1. G. Friedlander, J. W. Kennedy, E. S. Macias; Nuclear and Radiochemistry, 3rdEdition.*Willey*, 2013.
2. W. D. Loveland, D. Morrissey and G. T. Seaborg, Modern Nuclear Chemistry, *John Wiley & Sons*, 2006.
3. C. E. Housecroft and A. G. Sharpe; *Inorganic Chemistry*, 2ndEdition.*Pearson*, 2005.
4. H. J. Arnikar, Essentials of Nuclear Chemistry, *Wiley Eastern*, 1988.

Course No: CH-45	Course Name: Green Chemistry					Course Code: SBS CH 010303 DCE 2002	
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** III	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week: 02** **Total Hrs.: 30**
Total Evaluation Marks:50 **CIE: 15** Marks **TEE: 35** Marks		**Examination Duration:** 2Hrs. **Pre-requisite of course:** Basic knowledge of writing balanced chemical reactions. Basic understanding of nature of solvents, catalysts, chromatography and electromagnetic spectrum.					
Course Objectives	*To provide the basic knowledge of Green Chemistry and its applications in the field of chemical sciences.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of green chemistry **CO2**: Use of greener and renewable catalysts and their applications **CO3**: Skills for analyzing and developing new sustainable methods **CO4**: Skills for developing industrially important methods **CO5**: Development of alternate and new eco-friendly synthetic pathways to chemicals **CO6**: Use of advanced and recent green technologies in organic synthesis						

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION TO GREEN CHEMISTRY** Green chemistry history, needs and goals. Limitation/Obstacles in pursuit of the goals of green chemistry. Opportunities for next generation designer materials to create safer future. Twelve principles of Green Chemistry and their illustrations with examples.	7
II	**GREEN CATALYSIS AND RENEWABLE RAW MATERIALS** Heterogeneous catalysis: Use of zeolites, silica, alumina, clay, polymers, cyclodextrin and supported catalyst; Phase-transfer catalysis; Biocatalysis using enzymes; Biomass conversion to fine chemicals.	8
III	**GREENER SOLVENTS** Reactions under aqueous medium: Enhancement of selectivity, efficiency and industrial applicability. Ionic liquids; Supercritical fluids; Solvent free reactions in solid and liquid phase; Alternatives in extraction and chromatography.	7

IV	**GREEN TECHNOLOGY AND FUTURE TRENDS IN GREEN CHEMISTRY** Microwave and Ultrasound assisted reactions; photochemical reactions using sunlight; Flow techniques; combinatorial green chemistry. Green synthesis of ibuprofen and adipic acid (traditional vs green ones).	8

Suggested Readings:

10. G. Brahmachari, Catalyst-free Organic Synthesis. *Royal Society of Chemistry*, 2018.
11. M. Lancaster, Green Chemistry: An Introductory Text,3rd Edition. *Royal Society of Chemistry*, 2016.
12. F. M. Kerton, Alternative Solvents for Green Chemistry. *Royal Society of Chemistry*, 2013.
13. R. A. Sheldon, I. Arends and U. Hanefeld, Green Chemistry and Catalysis, 1stEdition. *Wiley-VCH*, 2007.
14. M. A. Ryan and M. Tinnes, Introduction to Green Chemistry. *American Chemical Society*, 2003.
15. P. T. Anastas and J. C. Warner, Green Chemistry: Theory and Practice. *Oxford University Press*, 1998.

Course No: CH-46	Course Name: Carbohydrate Chemistry and its Applications						Course Code: SBS CH 010304 DCE 2002
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** III	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week: 02** **Total Hrs.: 30**
Total Evaluation Marks: 50 **CIE: 15** Marks **TEE: 35** Marks		**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Basic knowledge of writing chemical formulae, their interconversion and stereochemistry of substituted cyclohexane. Understanding of common reactions of aldehydic and ketonic functional groups.					
Course Objectives	*To provide the knowledge of chemistry of carbohydrates, their reactions and applications*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of carbohydrates **CO2**: In-depth understanding of carbohydrates and their reactions **CO3:** Important aspects of carbohydrates associated with human health **CO4**: Skills to design and create products and solutions to real life problems **CO5**: Understanding the role of carbohydrates in other allied fields **CO6**: Ability to analyse, design and solve problems based on carbohydrates						

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**CARBOHYDRATES-I** Introduction and biomedical Importance, Classification: Monosaccharides, oligosachharides and polysaccharides, Sugars and non-sugars, Reducing and non-reducing sugars. Monosaccharides: Nomenclature, Structural representation, Isomerism. Physical and chemical properties of some important monosaccharides including stereochemical aspects wherever needed.	7
II	**CARBOHYDRATES-II** Synthesis of glucose and fructose. Oligosaccharides: Nomenclature and important terminology, Structural representation, Isomerism, physical and chemical properties of some important disaccharides (lactose, maltose and sucrose).	8
III	**CARBOHYDRATES-III** Polysaccharides: Nomenclature and important terminology, Homo and heteroploysaccharides, Structural representation. Physical and chemical properties of some important polysaccharides (Cellulose, Starch, Chitin). Glycolysis: Metabolism of Glucose.	7

IV	**CARBOHYDRATES-IV** Applications: Importance of monosaccharides and their derivatives like deoxy sugars, glycosides, myoinositol, amino sugars, *N*-acetylmuramic acid, sialic acid in different fields. Importance of oligosaccharides and polysaccharides in different sectors. Artificial sweeteners: Synthesis and importance.	8

Suggested Readings:

1. P. Y. Bruice, Organic Chemistry, 5th Edition. *Pearson Education*, 2014.
2. M. Sinnott, Carbohydrate Chemistry and Biochemistry: Structure and Mechanism, 2nd Edition. *Royal Society of Chemistry*, 2013.
3. P. Y. Bruce and K. J. R. Prasad, Essential Organic Chemistry, *Pearson Education*, New Delhi, 2008.
4. T. K. Lindhorst, Essentials of Carbohydrate Chemistry and Biochemistry, 3rd Edition, *Wiley*, 2007.
5. A. L. Lehninger, D. L. Nelson and M. M. Cox, Lehninger Principles of Biochemistry, 4th Edition. *W. H. Freeman*, 2004.
6. M. Loudon, Organic Chemistry, *Oxford University Press*, New Delhi, 2002.

Course No: CH-47	Course Name: Asymmetric Catalysis: Fundamentals to Frontiers						Course Code: SBS CH 010305 DCE 2002	
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** III	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week:**	**02**
							Total Hrs.:	**30**
Total Evaluation Marks: 50 **CIE:** **15** Marks **TEE:** **35** Marks		**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Basic knowledge of writing chemical formulae, their interconversion and stereochemistry. Basic understanding of homogenous and heterogeneous catalysis.						
Course Objectives	*To provide the advanced knowledge of asymmetric catalysis in organic synthesis.*							
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic and in-depth understanding of asymmetric synthesis **CO2**: Use of catalysts and their applications in the field of asymmetric synthesis **CO3**: Understanding of advanced stereochemical synthetic methods **CO4**: Skills for developing pharmaceutically important methods for chiral compounds **CO5**: Understanding of new eco-friendly synthetic pathways to chiral chemical compounds **CO6**: Ability to analyse, design and solve problems based on asymmetric induction							

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**ASYMMETRIC INDUCTION AND CATALYSIS** Asymmetric induction, modes of asymmetric induction, asymmetric catalysis and basics of asymmetric catalysis including energetic of reactions, Important factors affecting asymmetric catalysis.	7
II	**LEWIS ACID -BASE CATALYSIS AND CHIRAL AUXILLIARIES** Lewis acid and Lewis base catalysis including examples. Chiral auxiliary: Basic requirements of chiral auxiliary; Chiral pool sources: selected examples of few most common chiral auxiliaries (Oppolzer, Evans oxazolidones, Myers amides, 8-phenylmenthol).	8
III	**KINETIC RESOLUTION, DESYMMETRIZATION AND MECHANISTIC STUDIES** Kinetic, dynamic kinetic and parallel kinetic resolution; Desymmetrization reactions. Mechanistic studies of asymmetric reactions	7
IV	**MULTIFUNCTIONAL AND MODERN ASPECTS OF ASYMMETRIC CATALYSIS** Non-liner effects and Chiral amplifications. Bifunctional, dual and multifunctional catalyst Modern aspects of asymmetric catalysis: Counteranion directed catalysis, cooperative catalysis, dual and merged catalysis, asymmetric photocatalysis.	8

Suggested Readings:

1. E. M. Carreira, L. Kvaerno, Classics in Stereoselective Synthesis, *Wiley-VCH: Weinheim*, Germany, 2009.
2. M. Nogrady, Stereoselective Synthesis: A Practical Approach, *Wiley*, 2008.
3. P. J. Walsh, M. C. Kozlowski, Fundamentals of Asymmetric Catalysis, *University Science Book*, 2009.
4. A. Berkessel, H. Groger, Asymmetric Organocatalysis: From Biomimetic Concepts to Applications in Asymmetric Synthesis, *Wiley-VCH*, 2005.
5. I. Ojima, Catalysis in Asymmetric Synthesis, *Wiley-VCH*, 2004.
6. Recent review and research articles relevant to above topics (reprints to be handed over to students).

Course No: CH-48	Course Name: Supramolecular Chemistry				Course Code: SBS CH 010306 DCE 2002		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** III	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week: 02** **Total Hrs.: 30**
Total Evaluation Marks: 50 **CIE: 15** Marks **TEE: 35** Marks	**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Basic knowledge of non-covalent interactions, lock and key analogy and host-guest systems.						
Course Objectives	*To provide the basic knowledge of Supramolecular Chemistry, the terminologies, design and concepts and applications.*						
Course Outcomes:	After completing this course, studentsare expected to learn the following: **CO1**: Basic knowledge of supramolecular chemistry **CO2**: The concepts and various terminologies in supramolecular chemistry **CO3**: Nature of supramolecular interactions **CO4**: Understanding of supramolecular concepts and design **CO5**: Knowledge of various binding hosts such as crown ethers, cryptands, spherands **CO6**: Develop skills for designing new super/supramolecules						

COURSE SYLLABUS

NOTE:
i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.
ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION TO SUPRAMOLECULAR CHEMISTRY** Definition and Development of Supramolecular Chemistry; What is Supramolecular Chemistry? Host–Guest Chemistry; Development; Classification of Supramolecular Host-Guest Compounds.	7
II	**TERMINOLOGIES AND CONCEPTS** Receptors, Coordination and the Lock and Key Analogy, Binding Constants; Definition and Use; Measurement of Binding Constants; Cooperativity and the Chelate Effect; Preorganisation and Complementarity; Thermodynamic and Kinetic Selectivity, and Discrimination.	8
III	**NATURE OF SUPRAMOLECULAR INTERACTIONS WITH EXAMPLES** Ion–ion Interactions; Ion–Dipole Interactions; Dipole–Dipole Interactions; Hydrogen Bonding; Cation–π Interactions; Anion-π Interactions; *π–π* Interactions; Van der Waals Forces and Crystal Close Packing; Closed Shell Interactions. Hydrophobic Effects, Solvation.	7
IV	**SUPRAMOLECULAR CONCEPTS AND DESIGN** Host Design; Informed and Emergent Complex Matter; Nanochemistry. Supramolecular Cation Coordination Chemistry; Concepts in Coordination Chemistry; EDTA – a Classical Supramolecular Host; Crown ethers; Cryptands; Spherands.	8

Suggested Readings:

1. J. W. Steed, J. L. Atwood, Supramolecular Chemistry, 2nd Edition. *Wiley*, 2009.
2. J. W. Steed, Supramolecular Chemistry: From Molecules to Nanomaterials, 8 Volume 7th Edition. *John Wiley & Sons*, 2012.
3. J.-M. Lehn, Supramolecular Chemistry: Concepts and Perspectives. *Wiley*, 2006.

Course No:	Course Name:						Course Code:
CH-49	Introduction to Nanomaterials						SBS CH 010307 DCE 2002
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 02**
2021 Onwards	M.Sc. Chemistry	I	2	0	0	2	**Total Hrs.: 30**

Total Evaluation Marks:50 **CIE: 15** Marks **TEE: 35** Marks	**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Basic understanding of materials, characterization techniques, surface area and dimensionality.
Course Objectives	*This course is designed to give exposure of nanomaterials and chemistry of it to the fresh postgraduate students. Many important nanomaterials such as graphene, carbon nanotubes, nanorods etc., their classification, synthesis, characterization and applications would be introduced to the students.*
Course Outcomes:	After completing this course, students are expected to learn the following: **CO1**: Basic knowledge of nanomaterials **CO2**: Classification of nanomaterials in terms of dimensionality **CO3**: Various synthetic process of nanomaterials with emphasis on gas phase synthesis **CO4**: Characterization methods of nanomaterials **CO5**: Preliminary knowledge of nanotubes, nanorods and nanoplates **CO6**: Exposure of wonder materials such as graphene and carbon nanotubes

COURSE SYLLABUS

NOTE:
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ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION** An Introduction to Nanomaterials with Historical Perspectives. Nanomaterials and Nanocomposites. Elementary Consequences of Small Particle Size - Surface of Nanoparticles. Classification of nanomaterials - zero dimensional (0D), one dimensional (1D) and two dimensional (2D) nanomaterials.	6
II	**SYNTHESIS OF NANOMATERIALS** Top-Down and Bottom-Up Approach of Synthesis of Nanomaterials. Gas-Phase Synthesis of Nanoparticles - Physical and Chemical Vapor Synthesis Processes. Radio- and Microwave Plasma Processes. Flame Aerosol Process. Synthesis of Coated Particles.	8
III	**CHARACTERIZATION OF NANOMATERIALS** Characterization of Nanomaterials: Global Methods for Characterization, X-Ray and Electron Diffraction, Electron Microscopy, Scanning Transmission Electron Microscopy.	8
IV	**NANOTUBES, NANORODS, AND NANOPLATES** Introduction of Nanotubes, Nanorods, and Nanoplates, One-Dimensional Crystals, Carbon Nanotubes and Graphene, Nanotubes and Nanorods from Materials other than Carbon, Synthesis of Nanotubes and Nanorods.	8

Suggested Readings:

1. D. Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd Edition. *Wiley-VCH*, 2013.
2. D. C. Agarwal, Introduction to Nanoscience and Nanomaterials. *World Scientific*, 2013.

Course No:	Course Name:				Course Code:		
CH-50	Molecular Magnetism				SBS CH 010308 DCE 2002		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credit**	**Contact Hrs. per Week: 02**
2021 Onwards	M.Sc. Chemistry	III	2	0	0	2	**Total Hrs.: 30**

Total Evaluation Marks:50 **CIE: 15** Marks **TEE: 35** Marks	**Examination Duration:** 2 Hrs. **Pre-requisite of course:** To provide the basic knowledge of *molecular magnetism*.
Course Objectives	*To provide the basic knowledge of origin of magnetism and molecular magnetism. At the end of this course, students will learn about the basic concept of magnetism, magnetic interaction, spin transition and magnetic exchange.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Origin of magnetism **CO2**: Scope of molecular magnetism **CO3**: Effective magnetic moment **CO4**: Spin transition **CO5**: Quantum tunneling **CO6**: Single molecule magnets

COURSE SYLLABUS

NOTE:
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ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**BASIC CONCEPTS OF MAGNETISATION** Origin of magnetism, magnetic susceptibility, measurement of magnetic susceptibility: Gouy method, induction method, superconducting quantum interference device magnetometer, Evans method, zero-field cooled measurements, field scan, reduced magnetization, hysteresis, AC susceptibility, classification of magnetic behaviour: diamagnetic, paramagnetic, ferromagnetic, ferromagnetic, antiferromagnetic compounds.	7
II	**MAGNETIC INTERACTION** Classical *vs*. quantum model, Curie Law, Curie-Weiss Law, spin-orbit coupling, magnetically non-equivalent sites in the unit cell, solute-solvent interaction, solute-solute interaction configurational equilibrium.	8
III	**SPIN TRANSITION** Van Vleck equation, magnetic anisotropy, low spin high spin transition, mechanism of spin transition, spin cooperativity, molecular electronics, intermediate spin and spin-admixed states.	7

IV	**MAGNETIC EXCHANGE** Magnetic exchange, Bleany-Bowers equation, mechanism of exchange coupling, spin hamiltonian, magnetic interaction in oligonuclear complexes, magneto-structural correlations, quantum tunneling of magnetization, single molecule magnets.	8

Suggested Readings:

1. J. M. D. Corey, Magnetism and Magnetic Materials. *Cambridge University Press*, UK, 2010.
2. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4thEdition. *Pearson Education*, 2006.
3. D. Gatteschi, R. Sessoli and J. Villain, Molecular Nanomagnets. *Oxford University Press*, *Oxford,* 2006.
4. O. Kahn, Molecular Magnetism*, VCH Publishers, Inc*., *Orsay, France*, 1993.

DISCIPLINE CENTRIC SKILL-BASED COURSES (DCSC)

Course No: CH-51	Course Name: Computational Chemistry				Course Code: SBS CH 010201 DCS 2002		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** II	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week: 02** **Total Hrs.: 30**
Total Evaluation Marks: 50 **CIE: 15** Marks **TEE: 35** Marks		**Examination Duration:** 2 Hrs. **Pre-requisite of course:** To provide the basic knowledge of computational Chemistry. Basic understanding of ab-initio methods, DFT, basis sets and potential energy map.					
Course Objectives	*To provide the basic knowledge of various parameters and software involved in computational Chemistry and its application towards understanding the stability of molecules and proposing its reaction mechanism.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of computational chemistry **CO2**: Scope of computational chemistry **CO3**: Computational methods **CO4**: Use of computational software and of polyatomic molecules **CO5**: Skills for analyzing stability of molecules and visualization of transition states **CO6**: Skills for proposing new molecules						

COURSE SYLLABUS

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ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION TO COMPUTATIONAL CHEMISTRY** Computational chemistry map, scope of computational chemistry, Born-Oppenheimer approximation, idea of self-consistency, Hartree-Fock theory, restricted HF calculations; open shell systems, ROHF and UHF calculations, HF limit and electron correlation, semi empirical methods.	7
II	**DENSITY FUNCTIONAL THEORY** Electron density, exchange-correlation functional, local Density approximation, generalized gradient approximation, hybrid density functional methods, self-Interaction corrections.	8
III	**BASIS SETS** Definition of basis sets, Slater and Gaussian type orbitals, minimal, double-zeta, split-valence, core-valence, Pople style basis Sets, polarization and diffuse functions, calculation of basis functions, pseudopotentials or effective core potentials, choice of basis bets.	7
IV	**BASIC CONCEPTS OF POTENTIAL ENERGY SURFACES** Z-matrix construction, Stationary Points, geometry optimization, local and global minima, and transition state theory. Computations of single point energy, optimizations and transition states of polyatomic molecules, intrinsic reaction coordinate analysis.	8

Suggested Readings:

1. J. B. Foresman and A. Frisch, Exploring Chemistry with Electronic Structure Methods, 2nd Edition. *Gaussian Inc.*, 2015.
2. F. Jensen, Introduction to Computational Chemistry, *John Wiley & Sons*, 2007
3. C. J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2nd Edition. *John Wiley & Sons Ltd*, 2004.
4. C. J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2nd Edition. *John Wiley & Sons Ltd*, 2002.
5. D. A. McQuarrie, Physical Chemistry: A molecular Approach, 1st Edition. *University Science Books*, 1997.

Course No: CH-52	Course Name: Analytical Techniques in Chemistry				Course Code: SBS CH 010202 DCS 2002		
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** II	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week: 02** **Total Hrs.: 30**
Total Evaluation Marks: 50 **CIE: 15** Marks **TEE: 35** Marks		**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Knowledge of solution preparation, safety measure in chemistry practical laboratory and basic practical knowledge up to UG level.					
Course Objectives	*To provide students with a basic understanding of analytical chemistry, classical and modern analytical techniques. This course will strengthen the fundamentals of analytical chemistry, especially thermogravimetric, imaging and impedance spectroscopy techniques.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of analytical chemistry. **CO2**: Use of thermogravimetric, imaging and polarization techniques in daily life. **CO3**: Skills for analyzing and developing new sustainable methods. **CO4**: Skills for developing industrially important analytical methods. **CO5**: Development of alternate analytical methods. **CO6**: Use of advanced and recent techniques in analytical chemistry.						

COURSE SYLLABUS

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ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**THERMOGRAVIMETRIC ANALYSIS (TGA/DTA/DSC)** Principle, instrumentation of TGA, DTA, and DSC. Effect of heat on Materials, Chemical decomposition and T. G. Curves, Analysis of T.G. curve to show nature decomposition reactions, the product and qualities of compounds expelled, T.G. in controlled atmosphere, applications.	8
II	**ELECTROCHEMICAL ANALYSIS** Analysis of Metal, Alloys, Soil and Fertilizers by using electrochemical techniques like cyclic voltammetry, chronoamperometry, Pulse voltammetry. Theory, principle, working and application of cyclic voltammetry, chronoamperometry, Pulse voltammetry. Use of chemical and biosensors in environmental pollutant detection.	7
III	**IMAGING TECHNIQUES** An introduction to microscopy, the transmission and scanning electron microscope, electron optics, TEM specimen preparation and imaging system, dynamics of scattering, operating principle of SEM, penetration of electron in solids, SEM operating conditions and specimen preparation, electron beam lithography.	8
IV	**ELECTROCHEMICAL POLARIZATION AND IMPEDANCE SPECTROSCOPY** Anodic and cathodic polarization, Tafel plots, anodic and cathodic Tafel slopes, Corrosion rate from	7

	corrosion current density, Open circuit potential, Impedance spectroscopy, Nyquesi plots, Bode plots.	

Suggested Readings:

1. S. L. Chopra and J. S. Kanwar, Analytical Agriculture Chemistry, *Kalyani publishers,* 2008.
2. S. M. Khopkar, Concepts in Analytical Chemistry, 2nd Edition. New Age International Pub.2004.
3. H. H. Willard, L. L. Merritt, J. A. Dean and F. A. Settle, Instrumental methods of analysis, 7th Edition. *United States*, 1988.
4. D. A. Skoog and D. M. West, Principles of instrumental analysis, 2nd Edition. *Saunders College*, Philadelphia, 1980.
5. F. D. Snell and F. M. Biffen, Commercial Methods of Analysis, Tata McGraw Hill Book Company, New York, 1944.

Course No: CH-53	Course Name: Process Development of Active Pharmaceutical Ingredients						Course Code: SBS CH 010403 DCS 2002
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **IV**	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week: 02** **Total Hrs.: 30**
Total Evaluation Marks:50 **CIE: 15** Marks **TEE: 35** Marks		**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Understanding of general principles of chemistry and spectroscopic techniques.					
Course Objectives	*To provide the knowledge of Process Development of Active Pharmaceutical Ingredients to the students*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of active pharmaceutical ingredients **CO2**: Understand the process flow diagram and various process parameters **CO3:** Important features associated with process development of APIs **CO4**: Skills to develop technology for APIs and intermediates from lab scale to commercial batch **CO5**: understanding of GLP, GMP and safety in API industry **CO6**: Ability to understand various issues related to regulatory affairs						

COURSE SYLLABUS

NOTE:

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ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**PHARMACEUTICAL INDUSTRY AND ACTIVE PHARMACEUTICAL INGREDIENTS(APIS)** Pharmaceutical industries: Past and present; Introduction and Importance of active pharmaceutical ingredients, bulk drugs and their intermediates, Import and Export of APIs Scale-up approach of APIs: process research and development, optimization, maximization of percentage yield of the product, in-process control techniques.	8
II	**CHEMICAL TECHNOLOGY OF SELECTED APIS** Case studies with special emphasis on various factors for selection of routes: availability of raw materials and intermediates, process control parameters, pollution control procedures, polymorphs, safety issues, productivity etc.	7
III	**PROCESS TECHNOLOGY and REGULATORY PROFILE** Overview of plant layout, plant design, utilities and process flow sheets, Raw material consumption and costing, Overview of GLP, GMP and safety in API industry, Overview of Quality Assurance and Regulatory Affairs	8
IV	**STABILITY OF PRODUCTS** Drug substance – criteria, storage conditions, long term testing accelerated testing, frequency, evaluation, labeling; Drug product- selection of batches criteria, specification, conditions of storage and testing.	7

Suggested Readings:

1. N. G. Anderson, Practical Process Research and Development, 2nd Edition. *Academic Press, Elsevier*, 2012.
2. P. J. Harrington, Pharmaceutical Process Chemistry for Synthesis: Rethinking the Routes to Scale-Up, *Wiley*, 2011.
3. D. Lednicer, Strategies for Organic Drug Synthesis and Design, 2nd Edition, *Wiley*, 2008.
4. D. J. Pisano, D. S. Mantus, FDA Regulatory Affairs: A Guide for Prescription Drugs, Medical Devices, and Biologics 2nd Edition. *CRC Press*, 2008
5. K. Gadamasetti, Process Chemistry in Pharmaceutical Industry, Volume-I & II, *Taylor and Francis*, 1999.

Course No: CH-54	Course Name: Chemistry of Industrially Important Products						Course Code: SBS CH 010404 DCS 2002
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **IV**	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week: 02** **Total Hrs.: 30**
Total Evaluation Marks: 50 **CIE: 15** Marks **TEE: 35** Marks		**Examination Duration:** 2 Hrs. **Pre-requisite of course:** Understanding of general principles of chemistry and spectroscopic techniques in addition to synthetic aspects.					
Course Objectives	*To provide the knowledge of Chemistry of Industrially Important Products to the students*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Overview of industrially important products **CO2**: Various process parameters associated with dyes, pigments, petrochemicals, blends, additives and polymers **CO3:** Important features associated with process development of industrially important compounds **CO4**: Skills to develop technology for of industrially important compounds **CO5**: Understanding of agrochemicals and polymers used in textile industries **CO6**: Ability to understand various issues related to petrochemicals and dyes						

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**DYES AND PIGMENTS** Introduction and classification of dyes, color & constitution, different types of chromophores. Fluorescence and phosphorescence, dye intermediates, Developments of acid and basic dyes. Applications of different dyes and challenges associated with them. Chemistry and applications of optical brightening agents and pigments.	8
II	**PETROCHEMICALS** Crude oil and natural gas, refinery operations, energy consumption, lower olefins and acetylenes, cracking processes, synthesis gas, ammonia and methanol production, acetic acid and acetic anhydride production, C_1 products: Formic acid, hydrogen cyanide, chloromethanes, C_2 products: ethanol, acetaldehyde, ethylene oxide	7
III	**PROCESS TECHNOLOGY OF POLYMERS/FABRICS** Chemistry and Technology of chemical processing of polyester, nylon and acrylics. Dyeing machines for dyeing fiber, yarn and fabric. Mass coloration. Coloration of polypropylene	8

IV	**BLENDS, ADDITIVES AND AGROCHEMICALS** Blends, antioxidants, UV stabilizers, antistatic agents, peroxides, lubricants, fire retardants, heat stabilizers, plasticizers. Agricultural Chemicals: Fertilizers, insecticides, herbicides, fungicides.	7

Suggested Readings:

1. A. Heaton, An introduction to Industrial Chemistry, 3rdEdition, *Springer Science,* 2013.
2. K. Venkataraman, The Chemistry of Synthetic Dyes, *CBS*, 2010.
3. J. A. Tyrell, Fundamental of Industrial Chemistry, *Wiley*, 2005.
4. K. Hunger, Industrial Dyes: Chemistry, Properties, Applications, *Wiley*, 2002.
5. K. V. Datye and A. A. Vaidya, Chemical Processing of Synthetic Fibers and Blends, *Wiley*, 1984.

DISSERTATION
(Research Project)

Course No: CH-55A		**Course Name:** Dissertation-I				**Course Code:** SBS CH 010327 DCS 001408	
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **III**	**L** 0	**T** 0	**P** 14	**Credit** 8	**Contact Hrs. per Week: 14** **Total Hrs.: 220**
Total Evaluation Marks: 200 **CIE: 66** Marks **TEE: 134** Marks		**Examination Duration:** External Viva-Voce **Pre-requisite of course:** None					
Course Objectives	The aim of the dissertation project work is to familiarize the students with advanced research.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Overview of handling research projects **CO2**: Develop skills in planning and setting-up experiments **CO3:** Handling of various instruments **CO4**: Research presentation skills **CO5**: Ability to understand various issues related to research **CO6**: Skills in writing research reports						

COURSE SYLLABUS

Unit No.	**Contents**	**Contact Hrs.**
I-IV	This course applies to students who opt to carry out their dissertation work in Central University of Haryana. The topic for the project work is to be decided by the supervisor/guide concerned. The project report is to be evaluated by a committee constituted by the Head, Department of Chemistry, School of Basic Sciences having at least one external member.	220

Course No: CH-55B		**Course Name:** Dissertation-II				**Course Code:** SBS CH 010428 DCS 001408	
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** **IV**	**L** 0	**T** 0	**P** 14	**Credit** 8	**Contact Hrs. per Week: 14** **Total Hrs.: 220**
Total Evaluation Marks: 200 **CIE: 66** Marks **TEE: 134** Marks		**Examination Duration:** External Viva-Voce **Pre-requisite of course:** None					
Course Objectives	The aim of the dissertation project work is to familiarize the students with advanced research.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Overview of handling research projects **CO2**: Develop skills in planning and setting-up experiments **CO3:** Handling of various instruments **CO4**: Research presentation skills **CO5**: Ability to understand various issues related to research **CO6**: Skills in writing research reports						

COURSE SYLLABUS

Unit No.	Contents	Contact Hrs.
I-IV	This course applies to students who opt to carry out their dissertation work in Central University of Haryana. The topic for the project work is to be decided by the supervisor/guide concerned. The project report is to be evaluated by a committee constituted by the Head, Department of Chemistry, School of Basic Sciences having at least one external member.	220

GENERIC ELECTIVE COURSES

ELECTIVE COURSE OFFERED BY THE DEPARTMENT TO STUDENTS OF OTHER DEPARTMENTS

Course No: CH-58	Course Name: Chemistry for Biologists						Course Code: SBS CH 010101 GE 4004
Batch: 2021 Onwards	**Programme:** P.G. (Generic Elective Course)	**Semester:** I	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks:100 **CIE: 30** Marks **TEE: 70** Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course:** None					
Course Objectives	*To provide an opportunity to learn some basic concepts of chemistry important for biologists.* *To provide the knowledge of UV-vis., IR and ^{1}H-NMR spectroscopy*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of some important concepts of chemistry **CO2**: Understanding of formulae writing and stereochemistry of organic compounds **CO3:** Important aspects associated with other branches of science **CO4**: Skills to interpret data of organic compounds using advanced spectral techniques **CO5**: Ability to communicate about chemical sciences across the fields **CO6**: Ability to analyse, design and solve problems						

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

iii) P.G. Students from other departments may opt this course.

Unit No.	Contents	Contact Hrs.
I	**SOME BASIC TERMS AND CONCEPTS** Mole concept and Stoichiometry. Solution and different methods of expressing the concentration of a solution. Chemical bonds: Ionic, covalent, coordinate and metallic bonds. Shapes of the molecules, Polarized chemical bonds and polarity in the molecules. Intermolecular forces: Dispersion, dipole-dipole, hydrogen bonds, ion-dipole forces and their effect on the properties of the compounds. Biological implications of hydrogen bonding. Problems based on given topics.	15
II	**STEREOCHEMISTRY** Isomerism: Introduction, Formula writing, Structural and stereo isomerism, Conformations: analysis of ethane, *n*-butane, cyclohexane and its derivatives, Configurational isomerism, Geometrical and optical isomerism. Symmetry and chirality in the molecules having one or more than one chiral center, R & S, D & L, threo and erythro nomenclature, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective reactions. Problems based on given topics.	15

III	**CONCEPTS OF PHYSICAL CHEMISTRY** Thermodynamics: Change in Internal energy, enthalpy, free energy and entropy; Endothermic and exothermic processes, Exergonic and endergonic processes, Coupled biological processes, Chemical Kinetics: Reaction rate and rate constant, Catalysts and catalysis, Enzymes as catalysts, Enzyme inhibition. Chemical equilibrium: Equilibrium, equilibrium constant, Le Châtelier's principle and factors affecting the principle, Aqueous Equilibria: Introduction, importance in biology, pH and pH control, Buffers and their importance.	15
IV	**SPECTROSCOPIC TECHNIQUES** Ultraviolet and visible (UV-vis) spectroscopy: Introduction, Principle and selection rules of UV phenomenon, Various electronic transitions, Beer-Lambert law, presentation of spectrum, effect of solvents on electronic transitions, ultraviolet bands for carbonyl compounds and unsaturated carbonyl compounds. Fieser-Woodward rules for conjugated dienes. Infrared Spectroscopy: Introduction, Principle and selection rules of IR spectroscopy, Hookes law, Characteristic vibrational frequencies of organic compounds. Overtones, combination bands and Fermi resonance. Factors affecting the vibrational frequencies. ^{1}H NMR: Principle, nuclear spin states, nuclear magnetic moments, mechanism of resonance, chemical shifts, diamagnetic shielding, magnetic anisotropy, spin-spin splitting, coupling constant, ^{1}H NMR spectra of various simple organic compounds.	15

Suggested Readings:

1. B. R. Puri, L. R. Sharma and M. S. Pathania, Principles of Physical Chemistry,47th Edition. *Vishal Publishing Co.,* 2017.
2. B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, 33rd Edition. *Vishal Publishing Co.,* 2017.
3. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Spectroscopy, 5th Edition. *Cengage Learning India Private Limited,* 2015.
4. P. S. Kalsi, Stereochemistry: Conformation and Mechanism, *New Age International Private Limited*, 2015.
5. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Revised Edition. (Revised by S. P. Singh and Om Prakash). *TRINITY Press, An Imprint of Laxmi Publications Pvt. Ltd*., 2015.
6. P. Atkins and J. Paula, Atkins' Physical Chemistry, 10th Edition. *Oxford University Press*, 2014.
7. J. Clayden, N. Geeves and S. Warren, Organic Chemistry, *Oxford University Press*, 2012.
8. Morrison, Boyd and Bhattcharjee, Organic Chemistry, 7th Edition, *Pearson*, 2010.
9. F. A. Carey and R. J. Sundburg, Advanced Organic Chemistry PART A., *Springer*, 2007.
10. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd Edition, *New Age International*, 2005.
11. K. J. Laidler, Chemical Kinetics, 3rd Edition. *Pearson Education*, 1997.

Course No: CH-59	Course Name: Chemistry of Materials						Course Code: SBS CH 010102 GE 4004
Batch: 2021 Onwards	**Programme:** P.G. (Generic Elective Course)	**Semester:** I	**L** 3	**T** 1	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks:100 **CIE: 30** Marks **TEE: 70** Marks		**Examination Duration:** 3 Hrs.					
		Pre-requisite of course: To provide basic nanomaterials and photophysical phenomena					
Course Objectives	*To give a very basic understanding of Chemistry of nanomaterials, porous materials and some photophysical phenomena with focus on energy and environment.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic understanding of nanomaterials **CO2**: To understand the dramatic changes in properties that occurs by reducing the size **CO3**: Characterization of nanomaterials **CO4**: To impart knowledge on how to perform the synthesis of such small sizes and shapes of materials **CO5**: Knowledge of fundamental of photophysical phenomena **CO6**: Application of nanomaterials and photophysical phenomenon						

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

Unit No.	Contents	Contact Hrs.
I	**NANOMATERIALS** An Introduction, Elementary Consequences of Small Particle Size - Surface of Nanoparticles. Classification of nanomaterials-zero dimensional (0D)-one dimensional (1D)-two dimensional (2D) nanomaterials. Gas-Phase Synthesis of Nanoparticles - Physical and Chemical Vapor Synthesis Processes. Radio- and Microwave Plasma Processes. Flame Aerosol Process. Synthesis of Coated Particles.	15
II	**CHARACTERIZATION OF NANOMATERIALS** Global Methods for Characterization, X-Ray and Electron Diffraction, Electron Microscopy, Scanning Transmission Electron Microscopy. Nanotubes, Nanorods, and Nanoplates, One-Dimensional Crystals, Graphene and Carbon Nanotubes. Nanotubes and Nanorods from Materials other than Carbon, Synthesis of Nanotubes and Nanorods.	15
III	**HYBRID MATERIALS** Coordination Polymers, Introduction, Classification of Coordination Polymers, Design Strategies of Coordination Polymers-Metal Nodes and Linkers, Secondary Building Unit Concept, Topology and Interpenetration, Synthesis of Coordination Polymers-Solvothermal/Hydrothermal, Sonochemical, Microwave, Mechanochemical. Charaterization: X-ray diffraction and Spectroscopic Methods.	15

	Applications of Coordination Polymers in Gas Storage, Gas Separation, Catalysis and Drug Delivery.	
IV	**PHOTOPHYSICAL PHENOMENA** Interaction of electromagnetic radiation with matter, Grotthus-Draper law, Stark-Einstein law of photochemical equivalence, quantum yield, electronically excited singlet states, life time of electronically excited state, construction of Jablonski diagram, electronic transitions and intensity of absorption bands, types of photophysical pathways, radiationless transitions, fluorescence emission, phosphorescence emission, Fluorescence quenching, chemiluminescence, photochemical reactions.	15

Suggested Readings:

1. D. Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd Edition. *Wiley-VCH*, 2013.
2. D. C. Agarwal, Introduction to Nanoscience and Nanomaterials. *World Scientific*, 2013.
3. S. R. Batten, S. M. Neville and D. R. Turner, Coordination Polymers: Design, Analysis and Application. *RSC Publishing*, 2009.
4. M.-C. Hong and L. Chen, design and Construction of Coordination Polymers. *Wiley*, 2009.
5. S. Kaskel, The Chemistry of Metal-Organic Frameworks, Vol. 1, *Wiley-VCH*, 2016.
6. L. R. Macgillivray, Metal-Organic Frameworks: Design and Applications, *Wiley*, 2010.
7. W. D. Jr. Callister and D. G. Rethwisch, Fundamentals of Materials Science and Engineering: An Integrated Approach, *John Wiley and Sons*, 2012.
8. K. K. Rohatgi and K. K. Mukherjee; Fundamentals of Photochemistry, 3rdEdition. *New Age International (P) Ltd.*, 2014.

Course No: CH-60	Course Name: Medicinal Chemistry						Course Code: SBS CH 010203 GE 4004
Batch: 2021 Onwards	**Programme:** P.G. (Generic Elective Course)	**Semester:** **II**	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks:100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3Hrs.					
		Pre-requisite of course: To provide basics of medicinal chemistry					
Course Objective	*This course will provide a basic understanding and fundamentals of Medicinal Chemistry, drug-target actions, process of development of new drugs and regulatory processes of drug approval, intellectual property and drug abuse and misuse.*						
Course Outcomes:	After completing this course, student is expected to learn the following. **CO1**: General overview about drugs and their function **CO2**: Idea of the various steps in drug discovery and development **CO3**: Fundamental understanding of how drug-target interactions happen **CO4**: Basic understanding of chemical principles involved in pharmacodynamics **CO5**: Classification and uses of various drugs **CO6**: A broad idea of drug manufacture, administration and drug abuse						

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

iii) P.G. Students from other departments may opt this course.

Unit No.	Contents	Contact Hrs.
I	**FUNDAMENTALS** Historical development of systems of medicine, Basic chemical and biochemical principles, Key definitions, drug, target, receptors, enzymes, common drugs and their classification, anti-inflammatory drugs, antihistamines, antacids, antibiotics, narcotics, antivirals, and antineoplastics.	15
II	**DRUG ACTION** Chemistry of drug-target interactions, bioavailability, drug absorption, distribution, metabolism, excretion (ADME), pharmacokinetics and pharmacodynamics, toxicity, side effects, lipophilicity and hydrophilicity, blood-brain barrier and its significance, routes of drug administration	15

III	**DRUG DESIGN AND SYNTHESIS** Development of new drugs, concept of lead compounds and lead modifications, structure-activity relationship (SAR), isosterism, bio-isosterism, important chemical principles behind design of drugs, natural products and their uses, chemical synthesis of drugs, drug formulation, drug delivery, photodynamic therapy.	15
IV	**DRUGS AND SOCIETY** Regulatory processes for drug approval, regulatory agencies, intellectual property, patents, drug misuse, drug abuse, abuse of antibiotics, fraud practices in treatment, historically important drugs and vaccines.	15

Suggested Readings:

1. R. B. Silverman, The Organic Chemistry of Drug Design and Drug Action, 3rdEdition. *Academic Press*, 2014.
2. G. L. Patrick, An Introduction to Medicinal Chemistry, 5th Edition. *Oxford University Press*, 2013.
3. D. Sriram and P. Yogeshwari, Medicinal Chemistry, 2ndEdition. *Pearson*, 2012.
4. Ed. Robert F. Dorge, Wilson and Gisvold'sTextBook of Organic Medicinal and Pharmaceutical Chemistry, 12thEdition, 2010.
5. Ed. M. E. Wolff, Burger's Medicinal Chemistry and Drug Discovery, Vol. 1, 7th Edition. *John Wiley*, 2010.
6. S. S. Pandeya and J. R. Dmmock, An Introduction to Drug Design, 1st Edition. *New Age International*, 1999.

Course No: CH-61	Course Name: Drug, Design and Discovery					Course Code: SBS CH 010304 GE 4004	
Batch: 2021 Onwards	**Programme:** P.G. (Generic Elective Course)	**Semester:** **III**	**L** 4	**T** 0	**P** 0	**Credit** 4	**Contact Hrs. per Week: 04** **Total Hrs.: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hrs. **Pre-requisite of course:** None					
Course Objective	This course will provide a basic understanding and fundamentals towards drug discovery and development process.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: General idea about modern medicine and medicinal chemistry **CO2**: The process of drug discovery and development **CO3**: Fundamental understanding of how drug-target interactions happen **CO4**: Basic understanding of chemical principles involved in pharmacodynamics **CO5**: Classification and uses of various drugs **CO6**: A broad idea of drug manufacture, administration and drug abuse						

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have seven sub-parts and students need to answer any four. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries seven marks.

iii) P.G. Students from other departments may opt this course.

Unit No.	Contents	Contact Hrs.
I	**INTRODUCTION** ***History of drug discovery and targets*:** Introduction, Stages of drug discovery, lead discovery, Recent trends in drug discovery. Validation and diversity of drug targets ***Biological drug targets*:** Drug target identification, Receptors, types, binding and activation, theories of drug receptor interaction, drug receptor interactions, agonists vs antagonists, artificial enzymes, Biopharmaceutical therapies, , Hit to lead, Clinical biomarkers.	15
II	**DRUG DESIGN** ***Prodrug design:*** Basic concept, Carrier linked prodrugs/Bioprecursors, prodrugs of functional group, prodrugs to improve patient acceptability, Drug solubility, drug absorption and distribution, site specific drug delivery and sustained drug action. Rationale of prodrug design and practical consideration of prodrug design. ***Combating drug resistance*:** Causes for drug resistance, strategies to combat drug resistance in antibiotics and anticancer therapy, genetic principles of drug resistance. ***Analog Design***: Introduction, classical & non-classical, bioisosteric replacement strategies, rigid analogs, alteration of chain branching, changes in ring size, ring position isomers, design of stereo isomers and geometric isomers, fragments of a lead molecule, variation in inter atomic distance	15

III	**ANTIBIOTICS AND CARDIOVASCULAR DRUGS** Cell wall biosynthesis, inhibitors, β-lactam rings, antibiotics inhibiting protein synthesis, Synthesis of penicillin G, amoxycillin, cephalosporin, ciprofloxacin. Introductory idea of tetracycline and streptomycin. Introduction and general mode of action. Synthesis of ditiazem, verapamil, methyldopa and atenolol.	15
IV	**LOCAL ANTIINFECTIVE DRUGS AND PSYCHOACTIVE DRUGS** Introduction and general mode of action. Synthesis of furazolidone, naldixic acid, dapsone, isoniazid, ethambutol, gluconazole, chloroquin and primaquin. Introduction, neurotransmitters, CNS depressants, general anaesthgetics, mode of action of hypnotics,sedatives, anti-anxiety drugs, benzodiazopines, buspirone. Antipsychotic drugs–theneuroleptics, antidepressants, butyrophenones. Synthesis of diazepam, alprazolam,phenyltoin and glutethimide.	15

Suggested Readings:

1. R. B. Silverman, The Organic Chemistry of Drug Design and Drug Action, 3rd Edition. *Academic Press*, 2014.
2. D. M. Brahmankar and S. B. Jaiswal, Biopharmaceutics and Pharmacokinetics, 2ndEdition. *Vallabh Prakashan,* New Delhi, 2014.
3. G. L. Patrick, An Introduction to Medicinal Chemistry, 5th Edition. *Oxford University Press*, 2013.
4. D. Sriram and P. Yogeshwari, Medicinal Chemistry, 2ndEdition. *Pearson*, 2012.
5. Ed. Robert F. Dorge, Wilson and Gisvold's Text Book of Organic Medicinal and Pharmaceutical Chemistry, 12th Edition, 2010.
6. Ed. M. E. Wolff, Burger's Medicinal Chemistry and Drug Discovery, Volume 1, 7th Edition. *John Wiley*, 2010.
7. S. S. Pandeya and J. R. Dmmock, An Introduction to Drug Design, 1st Edition. *New Age International*, 1999.

Course No: CH-62	Course Name: Magneto Nuclear Chemistry						Course Code: SBS CH 010405 GE 4004
Batch: 2021 Onwards	**Programme:** P.G. (Generic Elective Course)	**Semester:** **IV**	**L** 2	**T** 0	**P** 0	**Credit** 2	**Contact Hrs. per Week: 02** **Total Hrs.: 30**
Total Evaluation Marks:50 **CIE: 15** Marks **TEE: 35** Marks		**Examination Duration:** 2 Hrs.					
		Pre-requisite of course: To provide the basic knowledge of magnetism and nuclear chemistry.					
Course Objectives	*To provide the basic knowledge of origin of magnetism and* nuclear chemistry. *At the end of this course, students will learn about the basic concept of magnetism, magnetic interaction, spin transition and magnetic exchange.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Basic theory of magnetism **CO2**: Knowledge of exchange interaction **CO3**: To understand orbital contribution **CO4**: Basic understanding of nuclear structure **CO5**: To understand artificial radioactivity and chelation therapy **CO6**: Scope of magnetism and nuclear chemistry						

COURSE SYLLABUS

NOTE:

i)Question no. 1 is compulsory and to be set from the entire syllabus. It will have four sub-parts and students need to answer any two. Each part carries three and half marks.

ii) Question nos. 2 to 5 are to be set from all four units one from each. Every question will have three sub-parts and students need to answer any two sub-parts of each question. Each part carries three and half marks.

Unit No.	Contents	Contact Hrs.
I	**BASIC CONCEPTS OF MAGNETISM** Definition, Origin of magnetism, classification of magnetic behaviour; diamagnetic, paramagnetic, ferromagnetic, ferromagnetic, antiferromagnetic compounds, magnetic interactions, spin crossover, spin-orbit coupling, Curie law, Curie-Weiss law	7
II	**MAGNETIC INTERACTION** Mechanism of exchange interaction, reduced magnetization, magnetic hysteresis, calculation of magnetic moment, orbital contribution to the magnetic moment, anomalous magnetic moments, magnetic susceptibility.	8
III	**RADIOACTIVITY** Radioactive decay and growth, naturally occurring and artificially produced radioactive substances, Measurement of radioactivity, group displacement law, radioactive disintegration series, rate of disintegration, half-life, average life of radioactive elements, unit of radioactivity, nuclear decay, determination of decay constants, decay rates, types of nuclear decay.	7

IV	**ARTIFICIAL RADIOACTIVITY AND APPLICATIONS OF NUCLEAR CHEMISTRY** Discovery of artificial radioactivity, isotopes used in medicines, radiocarbon dating, age determination, effects of radiation on life, applications of tracer element in medical, agriculture and analytical fields, biological effects of radiation, radiation protections, chelation therapy.	8

Suggested Readings:

1. G. Friedlander, J. W. Kennedy, E. S. Macias; Nuclear and Radiochemistry, 3rdEdition.*Willey*, 2013.
2. J. M. D. Coey, Magnetism and Magnetic Materials, *Cambridge University Press*, UK, 2010.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity, 4thEdition.*Pearson Education*, 2006.
4. W. D. Loveland, D. Morrissey and G. T. Seaborg, Modern Nuclear Chemistry, *John Wiley & Sons*, 2006.
5. D. Gatteschi, R. Sessoli and J. Villain, Molecular Nanomagnets, *Oxford University Press*, Oxford, 2006.
6. C. E. Housecroft and A. G. Sharpe; *Inorganic Chemistry*, 2ndEdition.*Pearson*, 2005.
7. O. Kahn, Molecular Magnetism, *VCH Publishers, Inc*., Orsay, France, 1993.
8. H. J. Arnikar, Essentials of Nuclear Chemistry, *Wiley Eastern*, 1988.

SWACHH BHARAT INTERNSHIP PROGRAMME

Course No:	Course Name:					Course Code:	
CH-56	Activities at Department and University Level					SBS CH 010105 DCS 0042	
Batch: 2021 Onwards	**Programme:** M.Sc. Chemistry	**Semester:** I to IV	**L** 0	**T** 0	**A** 6	**Credit** 2	**Contact Hrs. per Week: 6** **Total Hrs.: 100**
Total Evaluation Marks:		**Examination Duration:** NA					
		Pre-requisite of course: None					

Course Objectives	*The main objective of this course is to make the students aware about the importance of cleanliness for social development.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1**: Learn about the importance of cleanliness **CO2**: Develop skills in finding and solving sanitation related problems **CO3:** Motivating others not to litter **CO4**: Motivating others not to use plastic bags **CO5**: To manage and implement campaigns and demonstrate sanitation advice in nearby villages. **CO6**: Skill to train others

COURSE SYLLABUS

Unit No.	Contents	Contact Hrs.
I-IV	This course is applicable to all students to carry out various activities associated with cleanliness and recycling of the waste materials at departmental and university level in line with Swachh Bharat Abhiyan that may include: • To conduct outreach programs for creating awareness on Swachh Bharat in association with NCC or NSS or women cell etc. • To produce energy and manure using bio-wastes. • Plantation drives to increase the green cover and conservation of old trees. • Self-sustainable units through energy production using solar panels. • Plastic free environment. • Development of Green Buildings concept in the society. • Effective Waste management and recycling. • Rain water harvesting. • Proper disposal of chemical waste. • Creating awareness in the community through short films. • Use of social media for broader community outreach. **Note**: Students will submit a brief report on the activities carried out to the department for the record purpose.	100

A = Activity

9. TEACHING-LEARNING PROCESS

- Lectures
- Discussions
- Simulations
- Role Playing
- Participative Learning
- Interactive Sessions
- Seminars
- Research-based Learning/Dissertation or Project Work
- Technology-embedded Learning
- Hands on training
- Self study analysis
- Report writing

10. IMPLEMENTATION OF BLENDED LEARNING

Blended Learning is a pedagogical approach that combines face to-face classroom methods with computer-mediated activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and engaging. It focuses on integration of traditional classroom activities and innovative ICT-enabled strategies. It emphasizes student-centric learning environment where the teacher is the facilitator for productive and measurable learning outcomes. It optimizes and compliments the face to face learning, giving ample freedom and flexibility to the students and teachers to access and explore the wide range of open-access sources such as video lectures, podcasts, recordings and articles through digital platforms. It gives freedom and autonomy to the teachers in selection of appropriate digital platforms, resources and time-slots to complement and supplement face to face learning. The Blended Learning doesn't undermine the role of the teacher, rather it gives him/her an opportunity to explore the unexplored in accordance with the requirements of the curriculum.

Key features of Blended Learning

- **Student-Centric Pedagogical Approach** focusing on flexibility in timing, quality content, needs and interests of students and freedom to study through the mode of his/her choice;
- Freedom to Select variety of mediums and techniques;
- Increased student engagement in learning;
- Enhanced teacher and student interaction;

- Improved student learning outcomes;
- More flexible teaching and learning environment;
- More responsive for self and continuous learning;
- Better opportunities for experiential learning;
- Increased learning skills;
- Greater access to information, improved satisfaction and learning outcomes.

Note: It was resolved that Blended Learning with 40% component of online teaching and 60% face to face classes for each programme, may be adopted

11. ASSESSMENT AND EVALUATION

Overall assessment will be made as per CUH PG ordinances

- Continuous Comprehensive Evaluation at regular after achievement of each Course-level learning outcome
- Formative Assessment on the basis of activities of a learner throughout the programme instead of one-time assessment
- Oral Examinations to test presentation and communication skills
- Open Book Examination for better understanding and application of the knowledge acquired if required
- Group Examinations on Problem solving exercises
- Seminar Presentations
- Review of Literature
- Collaborative Assignments

12. KEYWORDS

- LOCF
- NEP-2020
- Blended Learning
- Face to face (F to F) Learning
- Programme Outcomes
- Programme Specific Outcomes
- Course-level Learning Outcomes

- Postgraduate Attributes
- Learning Outcome Index
- Formative Assessment and Evaluation
- Comprehensive and Continuous Evaluation

13. REFERENCES

- National Education Policy-2020. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf
- The draft subject specific LOCF templates available on UGC website. https://www.ugc.ac.in/ugc_notices.aspx?id=MjY5OQ==
- Draft Blended Mode of Teaching and Learning: Concept Note available on UGC website. https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf

14. APPENDICES

Curricular Reforms — Extracts from National Education Policy-2020

8118809_UGC-Letter-reg-Swachcha-Bharat-Abhiyan-.pdf

3258851_swach-bharat-swashth-bharat--guidelines-2014.pdf