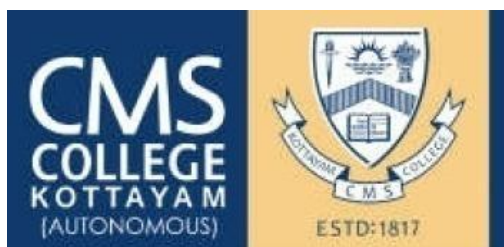


**CMS COLLEGE KOTTAYAM**  
**(AUTONOMOUS)**

**Affiliated to the Mahatma Gandhi University**  
**Kottayam, Kerala**



**CURRICULUM FOR POST GRADUATE PROGRAMME**

**MASTER OF SCIENCE IN ANALYTICAL**  
**CHEMISTRY**

**UNDER CREDIT AND SEMESTER SYSTEM (CSS)**  
(With effect from 2019 Admissions)

Approved by the Board of Studies on 30<sup>th</sup> April 2019

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## ACKNOWLEDGEMENTS

The Board of Studies in Chemistry, CMS College Kottayam (Autonomous), has made serious and sincere attempt to make the curriculum of postgraduate programme in Analytical Chemistry. There are many personalities whose relentless support and guidance made this syllabus a success. We take this opportunity to express our sincere appreciation to all those who were part of this endeavor for structuring the syllabus of PG programme in Chemistry. Our heartfelt gratitude to Dr. N. J. Rao, former Professor, Indian Institute of Science for the 2-day workshop on curriculum designing and to Dr. T. P. Sasikumar, former Professor ISRO for the 2-day curriculum workshop, and to Dr. C. James, Scott Christian College for the workshop on question-bank design.

We express profound gratitude to the Principal, Vice Principal, Members of the Governing Council and Academic Council of CMS College for their sincere cooperation and guidance for completion of this work. We place on record our whole hearted gratitude and appreciation to the members of the Board of Studies for their untiring efforts to prepare the syllabus. We also place on record our gratitude to all professionals, academicians and other stakeholders who gave valuable suggestions in this regard.

Smt.Ajitha Chandy  
Chairman  
Board of Studies

Kottayam  
30.04.2019

## PREFACE

The objective of the M.Sc. Analytical Chemistry programme is to provide the graduates an in-depth knowledge of the scientific basis and the methodology of chemical research. On completing the programme, the students will be able to analyse and solve problems within the broad/specialized field of analytical chemistry. A master's degree in Analytical Chemistry equips the graduates with the necessary skills for embarking a research career or for taking up independent leadership and management of complex work and development situations within the field. The M.Sc. Programme in Analytical Chemistry combines core and elective theory courses as well as practical courses and an independent research guided by an experienced researcher from the department or a national institute. Adhering onto these objectives, M.Sc. Curriculum revision was carried out with utmost vigilance and care. The curriculum revision committee believes that we have taken care of every academic aspect to arrive at comprehensive syllabus for all the courses. While revising the M.Sc. syllabus, the committee has taken into account the emerging trends in various fields of theoretical and experimental chemistry. The thrust was given to inculcate the spirit of hard work and research aptitude in students to pursue higher education in the nationally/internationally reputed institutions and laboratories. Brain-storming discussions in this matter were carried out among the faculty members of Chemistry department of CMS College and experts from various other Colleges, Universities and Institutions. The Board of Studies believes that we have taken care of every aspect to arrive at comprehensive syllabus for all the courses that cater to the advance of the students' knowledge, career and future.

## **REGULATIONS FOR POST GRADUATE PROGRAMMES UNDER CREDIT SEMESTER SYSTEM 2019**

### **Preamble**

**CMS College Kottayam (Autonomous)** was conferred with the Autonomous status as per UGC No.F.22-1/2016(AC) Dtd. 9<sup>th</sup> March 2016 and Mahatma Gandhi U.O.No.2732/VII/2016/Acad. Dtd.12<sup>th</sup> May 2016.

### **REGULATIONS**

CMS College Kottayam (Autonomous) follows Credit Semester System (CSS) for the Post Graduate programmes from the Academic year 2019-20. The Post Graduate programmes of the college are being redesigned and revised in tune with the modifications effected at the UGC Curriculum Framework. This will be reflected in the scheme, course content and mode of examination and Evaluation system. The scheme and syllabus of all the programmes are being revised accordingly. The revisions were effected based on the recommendations made at the Curriculum Revision workshops conducted for the purpose besides several sittings of the Curriculum Revision Committee.

#### **1. TITLE**

- 1.1.** These regulations shall be called “**CMS COLLEGE KOTTAYAM (AUTONOMOUS) REGULATIONS FOR POST GRADUATE PROGRAMMES UNDER CREDIT AND SEMESTER SYSTEM 2019**”

#### **2. SCOPE**

- 2.1** Applicable to all regular Postgraduate Programmes conducted by the CMS College Kottayam (Autonomous) with effect from 2019 admissions.
- 2.2** Medium of instruction is English unless otherwise stated therein.

#### **3. DEFINITIONS**

- 3.1. Academic Week** is a unit of five working days in which the distribution of work is organized from day one to day five, with five contact hours of one hour duration on each day.
- 3.2. Semester** means a term consisting of **90** working days, within **18** five-day academic weeks for teaching, learning and evaluation.
- 3.3. Programme** means a two year programme of study and examinations, spread over four semesters, with a set of courses, the successful completion of which would lead to the award of a degree.
- 3.4. Course** comprises a set of classes or a plan of study on a particular subject which will be taught and evaluated within a semester of a study programme.
- 3.5. Core course** means a course which should compulsorily be studied by a student as requirement in the subject of specialization within a degree programme.

- 3.6. Elective Course** means an elective course chosen from the discipline/ subject, in an advanced area.
- 3.7. Credit** is the numerical value assigned to a course according to the duration of the classes or volume of the syllabus of the course.
- 3.8. Department** means any teaching department in the college.
- 3.9. Dean of Academic Affairs** is a teacher nominated by the Academic Council to coordinate the academic affairs of the college relating to academic planning, curriculum implementation and review.
- 3.10. Dean of Student Affairs** is a teacher nominated by the Academic Council to coordinate the admissions, grievances and other student related services.
- 3.11. Department Council** means the body of all teachers of a department in the college.
- 3.12. Department Coordinator** is a teacher nominated by a Department Council to coordinate the <sup>ln</sup>-Semester examination of the PG programme in that department.
- 3.13. Faculty Advisor** means a teacher from the parent department nominated by the Department Council, who will advise the students of a class on academic matters.
- 3.14. Course Teacher** means a teacher who is in charge of a course. If a course is taught by more than one teacher, one teacher should be assigned as course teacher, nominated by the HOD. The course teacher shall be responsible for the valuation of answer scripts of examinations and other continuous assessments.
- 3.15. In-Semester Assessment (ISA)** means assessment consisting of Attendance, Assignment/Seminar/Viva voce and Examination (theory and practical).
- 3.16. End Semester Assessment (ESA)** means Examination conducted at the end of each semester for all courses (theory and practical).
- 3.17. Internal Examiner** means a teacher working in the college.
- 3.18. External Examiner** means a teacher from outside the college.
- 3.19. Grace Marks** shall be awarded to candidates as per the orders issued by Mahatma Gandhi University.
- 3.20. Grade** means a letter symbol (A, B, C, etc.), which indicates the broad level of performance of a student in a Course/ Semester/Programme.
- 3.21. Grade Point (GP)** is the numerical indicator of the percentage of marks awarded to a student in a course.
- 3.22. College Average (CA)** means average mark secured (ISA+ESA) for a course at the college level.
- 3.23.** Words and expressions used and not defined in this regulation shall have the same meaning assigned to them in the Act and Statutes of the University, UGC Regulations and the Constitution of the CMS College Kottayam (Autonomous).

#### **4. ELIGIBILITY FOR ADMISSION AND RESERVATION OF SEATS**

Eligibility for admission, norms for admission and reservation of seats for various Postgraduate Programmes shall be according to the regulations framed/orders issued by Govt. of Kerala, Mahatma Gandhi University and CMS College Kottayam in this regard.

#### **5. PROGRAMME STRUCTURE**

**5.1** The nomenclature of all PG programmes shall be as per the specifications of University Grants Commission and the Mahatma Gandhi University.

**5.2** Credit Semester System (CSS) will be followed for all PG Programmes from the academic year 2019– 2020.

**5.3** All the PG Programmes will be of two-year duration with four Semesters. A student may be permitted to complete the Programme, on valid reasons, within a period of 8 continuous semesters from the date of commencement of the first semester of the programme.

**5.4** There will be three/four/five courses in each semester and one viva voce and dissertation at the end of the fourth semester.

**5.5** There will be three components for the programme viz. core course, elective course and project spread over four semesters.

**5.6** The total credits required for completing a PG Programme is **80**.

**5.7** The Syllabus for all courses in each semester has been divided into five modules based on certain thematic commonalities.

#### **6. EVALUATION SYSTEM**

- i. The evaluation scheme for each course shall contain two parts:
  - (a) In-Semester Assessment (ISA)
  - (b) End-Semester Assessment (ESA)
- ii. The proportion of ISA to ESA will be 1:3.
- iii. The marks secured for each course shall be converted as grades. The grades for different semesters and overall programme are assigned based on the corresponding semester grade point average and cumulative grade point average respectively.
- iv. A separate minimum of 40% is mandatory for both ISA and ESA to pass for every course.

## 6.1 EVALUATION OF THEORY COURSES

The marks allotted for theory courses in End-Semester Assessment shall be 120 and that for the In-Semester Assessment will be 40.

### A. IN-SEMESTER ASSESSMENT

The In-semester assessment for theory is based on the marks obtained for Attendance, Assignment, Major Seminar and two Test Papers for a particular course.

#### (i) Attendance

Percentage of attendance	Mark
90 and above	6
85 - 89	5
80 - 84	4
76 - 79	3
75	2
Below 75	0

Maximum marks = 6

#### (ii) Assignment (One assignment per course)

Evaluation Component	Mark
Review of related literature	2
Content	3
Reference	2
Punctuality	1

Maximum marks = 8

#### (iii) Major Seminar

A student should present one Major Seminar in a Semester. The faculty advisor should allot students to the respective course teacher in a semester. The seminar topics shall be incorporated in the syllabus for each course/ declared in the beginning of each semester. The student shall prepare the seminar paper with the guidance of the course teacher. The student is expected to make a detailed presentation in a common session in the department, with students and all course teachers. The student shall also make a brief conclusion including the future scope of studying the topic. The teacher in charge of the particular course has to act as the moderator for the seminar.

The course teachers of that semester shall evaluate the seminar and give marks for their course or the average mark of all the evaluators shall be taken as the seminar mark for each course of a semester.

Evaluation Component	Mark
Involvement/punctuality	1
Review of related literature	1
Content	3
Presentation	3
Interactions/ justification	1
Conclusion	1

Maximum marks = 10

**(iv) Test paper**

For each course, two In-Semester examinations of total 16 marks shall be conducted. One of the test paper will be centralized examination of 8 marks and the remaining 8 marks will be awarded with one or more class tests conducted by the course teacher.

**B. END -SEMESTER ASSESSMENT**

End-Semester examinations for each course are conducted at the end of every semester with a maximum marks of 120. The examination for each course will have two components viz., descriptive test and an objective type test. Questions shall be set to evaluate the attainment of course outcomes. The question paper for each course will be generated from the Question Bank which is prepared by due mapping of Course outcomes and Program Specific Outcomes.

**(i) Descriptive Test**

A written examination with a maximum marks of 100 and of three hours duration will be conducted.

**PATTERN OF QUESTIONS**

A question paper shall be a judicious mix of short answer type, short essay/problem solving type and long essay type questions.

No.	Section	Type of questions	Total Questions	Number of questions to be answered	Mark for each question	Total Marks
1	Section A	Short answer type	8	5	4	20
2	Section B (One pair should be from each module)	Short essay/problem solving type	10 (Either/or)	5	8	40
3	Section C	Long essay type	4	2	20	40
	<b>Total</b>		<b>22</b>	<b>12</b>	<b>-</b>	<b>100</b>

**(ii) Objective Test**

A Multiple Choice Objective type Test shall be a component of the End-semester examination which will be conducted in the online mode for each course. The marks obtained shall be converted into 20. The objective type examination for all courses in a semester shall be conducted in a session of one hour. The number of questions in Arts stream will be 50 and that of Science and Mathematics stream will be 40. Questions should be equally distributed among the courses in a semester. There will be four choices for each question. Each question carries 4 marks for correct answer, zero marks for no answer and -1 marks for wrong answer.

## 6.2 EVALUATION OF PRACTICAL COURSES

Practical examination will be conducted at the end of each semester/ end of an academic year. The time of conduct of the practical examination will be decided by the respective BOS.

### A. IN-SEMESTER ASSESSMENT

<b>Evaluation Component</b>	<b>Mark</b>
Attendance	6
Lab Involvement	8
Test	12
Record	8
Viva	6

Maximum Marks = 40

The components and the marks can be modified by the concerned BOS/Expert committee within the limit of maximum marks.

### B. END- SEMESTER ASSESSMENT

<b>Evaluation Component</b>	<b>Mark</b>
Attendance	18
Lab Involvement	24
Test	36
Record	24
Viva	18

Maximum Marks = 120

The components and the marks can be modified by the concerned BOS/Expert committee within the limit of maximum marks.

## 6.3 EVALUATION OF PROJECT

An academic project work shall be done and a dissertation shall be submitted in the final semester of the programme. There will be both In semester and End semester assessment for the project work.

### A. IN- SEMESTER ASSESSMENT

<b>Evaluation Component</b>	<b>Mark</b>
Relevance of the topic	5
Project content and report	15
Presentation	15
Project viva	10
Paper presentation* in Seminar/Conference or publications with ISBN/ISSN (*valid certificate to be submitted)	5

Maximum marks = 50

The components and the marks can be modified by the concerned BOS/Expert committee within the limit of maximum marks.

## B. END -SEMESTER ASSESSMENT

The dissertation at the end of final Semester will be evaluated by a panel of one internal evaluator assigned by HOD and one external evaluator / a panel of two external evaluators, as may be decided by the respective BOS.

<b>Evaluation Component</b>	<b>Mark</b>
Relevance of the topic	15
Project content and report	45
Presentation	45
Project viva	30
Paper presentation* in Seminar/Conference or publications with ISBN/ISSN (*valid certificate to be submitted)	15

Maximum marks = 150

The components and the marks can be modified by the concerned BOS/Expert committee within the limit of maximum marks.

## 6.4 EVALUATION OF COMPREHENSIVE VIVA VOCE

A comprehensive viva voce shall be done at the end of the final semester. There will be both In-semester and End-semester assessment for the viva voce examination.

### A. IN - SEMESTER ASSESSMENT

<b>Evaluation Component</b>	<b>Mark</b>
+2/ UG level questions	4
PG syllabus level questions	10
Subject of interest based questions	8
Advanced level questions	3

Maximum marks = 25

The components and the marks can be modified by the concerned BOS/Expert committee within the limit of maximum marks.

### B. END- SEMESTER ASSESSMENT

The comprehensive Viva Voce Examination at the end of final Semester will be evaluated by a panel of one internal evaluator assigned by HOD and one external evaluator / a panel of two external evaluators, as may be decided by the respective BOS.

<b>Evaluation Component</b>	<b>Mark</b>
+2/ UG level questions	12
PG syllabus level questions	30
Subject of interest based questions	24
Advanced level questions	9

Maximum marks = 75

The components and the marks can be modified by the concerned BOS/Expert committee within the limit of maximum marks.

## **7. Grievance Redressal Mechanism**

In order to address the grievance of students regarding In-Semester assessment, a two-level Grievance Redressal mechanism is established.

**Level 1: Department Level:** The Department cell is chaired by the HOD, Department Coordinator as member secretary and Course teacher in-charge as member. If the grievance is not redressed at the Department level, the student shall report the grievance to the College Level Grievance Redressal Cell.

**Level 2: College level:** College Level Grievance Redressal Cell has the Vice-Principal as the Chairman, Dean of Student Affairs as the Member Secretary and HOD of concerned Department as member.

## **8. Eligibility for End Semester Examination**

A minimum of 75% average attendance for all the courses is mandatory to register for the examination. Condonation of shortage of attendance to a maximum of 10 days in a semester subject to a maximum of 2 times during the whole period of the programme may be granted by the College on valid grounds. Attendance may be granted to students attending University/College union/Co-curricular activities for the days of absence, on production of participation/attendance certificates, within one week, from the teacher in charge of the activity and endorsed by the Dean of Student Affairs. This is limited to a maximum of 10 days per semester. Monthly Attendance report will be published in the college website on or before the 10<sup>th</sup> of every month. Those students who are not eligible even with condonation of shortage of attendance shall repeat the semester along with the next batch after obtaining readmission.

## **9. Promotion to the next Semester**

Those students who possess the required minimum attendance and have registered for the End Semester Examination during an academic semester are promoted to the next semester.

Those students who possess the required minimum attendance and progress during an academic semester and could not register for the semester examination are permitted to apply for Notional Registration to the examinations concerned enabling them to get promoted to the next semester.

## **10. Eligibility for Readmissions**

An additional chance of readmission will be given to those students who could not register for the examination due to shortage of attendance. Readmitted students shall continue their studies with the subsequent batch of students. If an applicant for readmission is found to have indulged in ragging or any other misconduct in the past, readmissions shall be denied.

## **11. MARK CUM GRADE CARD**

The College under its seal shall issue to the student a MARK CUM GRADE CARD on completion of each semester/programme, which shall contain the following information:

- (a) Name of the College
- (b) Title of the Postgraduate Programme
- (c) Name of the Semester
- (d) Name and Register Number of the student

- (e) Date of publication of result
- (f) Code, Title, Credits and Maximum Marks (ISA, ESA & Total) of each course opted in the semester.
- (g) ISA, ESA and Total Marks awarded, Grade, Grade point and Credit point in each course opted in the semester
- (h) College average (CA) of the marks of all courses
- (i) The total credits, total marks (Maximum & Awarded) and total credit points in the semester
- (j) Semester Grade Point Average (SGPA) and corresponding Grade.
- (k) Cumulative Grade Point Average (CGPA) and corresponding Grade.

The final Mark cum Grade Card issued at the end of the final semester shall contain the details of all courses taken during the study programme and the overall mark/grade for the total programme.

There shall be a College Level Monitoring Committee comprising Principal, Vice Principal as member-secretary, Dean of Academic Affairs, Controller of Examinations, IQAC Director and Administrative Assistant as members for the successful conduct of the scheme.

## 12. CREDIT POINT AND CREDIT POINT AVERAGE

**Credit Point (CP)** of a course is calculated using the formula:-

$CP = C \times GP$ , where  $C$  is the Credit and  $GP$  is the Grade point

**Semester Grade Point Average (SGPA)** of a Semester is calculated using the formula:-

$SGPA = TCP/TC$ , where  $TCP$  is the Total Credit Point of that semester, ie,  $\sum_1^n CP_i$ ;  $TC$  is the Total Credit of that semester, ie,  $\sum_1^n C_i$ , where  $n$  is the number of courses in that semester

**Cumulative Grade Point Average (CGPA)** is calculated using the formula:-

$CGPA = TCP/TC$ , where  $TCP$  is the Total Credit Point of that programme, ie,  $\sum_1^n CP_i$ ;  $TC$  is the Total Credit of that programme, ie,  $\sum_1^n C_i$ , where  $n$  is the number of courses in that programme

Grades for the different courses, semesters and overall programme are given based on the corresponding CPA as shown below:

CPA	Grade with Indicator
4.5 to 5.0	A+ Outstanding
4.0 to 4.49	A Excellent
3.5 to 3.99	B+ Very Good
3.0 to 3.49	B Good (Average)
2.5 to 2.99	C+ Fair
2.0 to 2.49	C Marginal
Up to 1.99	D Deficient (Fail)

### **13. TRANSITORY PROVISION**

Notwithstanding anything contained in these regulations, the Principal shall, for a period of six months from the date of coming into force of these regulations, have the power to provide by order that these regulations shall be applied to any programme with such modifications as may be necessary.

The Principal is also authorized to issue orders for the perfect realization of the regulations.

**Annexure I**  
(Model Mark Cum Grade Card)



**CMS COLLEGE KOTTAYAM (AUTONOMOUS)**  
Affiliated to Mahatma Gandhi University Kottayam  
(Autonomous College as per UGC order no.F.22-1/216(AC)dated 9<sup>th</sup> March  
2016)

**MARK CUM GRADE CARD**

Section :  
Name of the Candidate :  
Unique Permanent Registration Number :  
Degree :  
Programme :  
Stream :  
Name of the Examination :  
Date of Publication of Result :

Course Code	Course Title	Credits (c)	Marks						Grade Awarded (G)	Grade Point (GP)	Credit Point (C x GP)	College Average	Result
			ISA		ESA		TOTAL						
			Awarded	Maximum	Awarded	Maximum	Awarded	Maximum					

ISA - In - Semester Assessment, ESA – End - Semester Assessment

**SGPA:**  
Checked by

**SG:**  
Section Officer

**Controller of Examinations**

Date:

## Annexure II



**CMS COLLEGE KOTTAYAM (AUTONOMOUS)**

Kerala, India – 686 001 Website: [www.cmscollege.ac.in](http://www.cmscollege.ac.in)

e-mail:kottayamcmscollege@gmail.com Tel: 91-481-2566002, Fax: 91-481-2565002

Affiliated to Mahatma Gandhi University Kottayam, Kerala

(Autonomous College as per UGC Order No.F.22-1/216 (AC) dated 9<sup>th</sup> March 2016)

### CONSOLIDATED MARK CUM GRADE CARD

Name of the Candidate:

Unique Permanent Register Number (UPRN):

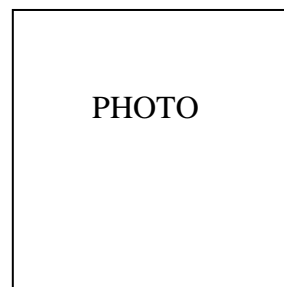
Degree:

Programme:

Stream:

Date of Birth:

Date of Eligibility for the Degree:



**CMS COLLEGE KOTTAYAM (AUTONOMOUS)**

Name:

UPRN:

Course Code	Course Title	Credits (C)	Marks						Grade Awarded (G)	Grade Point	Credit Point (CxGP)	College Average (CA)	Result
			ESA		ISA		Total						
			Awarded	Maximum	Awarded	Maximum	Awarded	Maximum					

**Final Result**

<b>Cumulative Grade Point Average CGPA :</b>
--

**Semester Summary**

Sl.No	Semester	Credit	SGPA	Grade	Month/year	Result
	Semester 1					
	Semester 2					
	Semester 3					
	Semester 4					

Date:

**Controller of Examinations**

## Annexure III



(Reverse side of the Mark cum Grade Card (COMMON TO ALL SEMESTERS) )

### Description of the Evaluation Process

**Table 1**

#### Grade and Grade Point

The Evaluation of each Course comprises of Internal and External Components in the ratio 1:3 for all Courses.

Grades and Grade Points are given based on the percentage of Total Marks (Internal + External) as given in Table 1

(Decimals are to be rounded mathematically to the nearest whole number)

#### Credit point and Credit point average

Grades for the different Semesters and overall Programme are given on a 7-point Scale based on the corresponding CPA, as shown in Table 2.

% Marks	Grade	GP
Equal to 88 and above	A+ Outstanding	5
Equal to 76 and < 88	A Excellent	4
Equal to 64 and < 76	B+ Very Good	3
Equal to 52 and < 64	B Good(Average)	2
Equal to 40 and below 52	C Marginal	1
Below 40	D Deficient (Fail)	0
	Ab Absent	

**Table 2**

Credit point (CP) of a paper is calculated using the formula  $CP = C \times GP$ , where **C is the Credit; GP is the Grade Point**

Semester or Programme (cumulative) Grade Point Average of a Course/Programme is calculated using the formula

$SGPA/CGPA = \frac{TCP}{TC}$ , where **TCP is the Total Credit Point; TC is the Total Credit**

CPA	Grade with Indicator
4.5 to 5.0	A+ Outstanding
4.0 to 4.49	A Excellent
3.5 to 3.99	B+ Very Good
3.0 to 3.49	B Good (Average)
2.5 to 2.99	C+ Fair
2.0 to 2.49	C Marginal
Up to 1.99	D Deficient (Fail)

#### NOTE

A separate minimum of 40% marks each for internal and external (for both theory and practical) are required for a pass for a course. For a pass in a programme, a separate minimum of **Grade C** is required for all the individual courses. If a candidate secures **D Grade** for any one of the course offered in a Semester/Programme **only D grade** will be awarded for that Semester/Programme until he/she improves this to **C GRADE** or above within the permitted period.

## CURRICULUM

### GRADUATE PROGRAMME OUTCOMES (GPO) – POST GRADUATE PROGRAMMES

At the completion of the Post Graduate Programme, the student will be able to accomplish the following programme outcomes.

GPO. No.	Graduate Programme Outcomes (GPOs)
<b>GPO.1</b>	<b>Critical Thinking:</b> Ability to engage in independent and reflective thinking in order to understand logic connections between ideas.
<b>GPO.2</b>	<b>Effective Communication:</b> Development of communication skills for effectively transmitting and receiving information that focuses on acquiring knowledge, problem solving, improving on arguments and theories thereby paving the way for better employability and entrepreneurship.
<b>GPO.3</b>	<b>Social Consciousness:</b> Acquire awareness towards gender, environment, sustainability, human values and professional ethics and understand the difference between acting, responding and reacting to various social issues.
<b>GPO.4</b>	<b>Multidisciplinary Approach:</b> Combining various academic disciplines and professional specializations to cross borders and redefine problems in order to explore solutions based on the new understanding of complex situations.
<b>GPO.5</b>	<b>Subject Knowledge:</b> Acquiring knowledge at a higher level that would help develop the necessary skills, fuel the desire to learn and contribute to the field of expertise thereby providing valuable insights into learning and professional networking with the aim of catering to the local, national and global developmental needs.
<b>GPO.6</b>	<b>Lifelong Learning:</b> Understanding the necessity of being a lifelong learner for personal enrichment, professional advancement and effective participation in social and political life in a rapidly changing world.

### PROGRAMME SPECIFIC OUTCOMES

	<b>Programme Specific Outcomes</b> <i>Upon completion of this programme, the students will be able to;</i>	<b>GPO</b>
<b>PSO1</b>	Demonstrate advanced knowledge of fundamental principles of Chemistry in the core areas of Organic, Inorganic, Physical and Theoretical Chemistry.	1,2,4,5
<b>PSO2</b>	Understand the chemical methods employed for elemental and compound analysis and to provide knowledge in various scientific methods employed in analytical chemistry.	1,2,4,5,6
<b>PSO3</b>	Develop an understanding of the range and uses of analytical methods in chemistry and establish an appreciation of the role of chemistry in quantitative analysis	1,2,4,5
<b>PSO4</b>	Interpret research literature in his/her field of study and Conduct independent research under limited supervision within a research group and Communicate chemistry effectively, by using both oral and written skills.	1,2,3,4,5,6

## PROGRAMME DESIGN

The Post graduate programme in Analytical Chemistry is a two year programme of four semesters. There are five components for the programme namely, the core course, elective course, practical course, viva-voce and a major project. In the first three semesters there are four core courses and three practical courses in each semester. In the fourth semester, there are three elective courses, three practical courses, a major project and a comprehensive viva-voce. The total credits for completing MSc programme in Chemistry are 80.

The Course Design is given below:

<b>Sl No</b>	<b>Course Type</b>	<b>No of courses</b>	<b>Total credits</b>
1.	Core courses	12	45
2.	Elective courses	3	12
3	Practical	6	18
4.	Viva -voce	2	2
5	Project	2	3
	<b>TOTAL</b>	<b>25</b>	<b>80</b>

## PROGRAMME STRUCTURE

	Code	Course	Hours/ Week	Total Hours	Credit
Semester 1	AN1921101	Organometallics and Nuclear chemistry	4	72	4
	AN1921102	Conceptual Organic Chemistry	4	72	4
	AN1921103	Quantum Mechanics and Molecular Spectroscopy	4	72	4
	AN1921104	Statistical Mechanics and Molecular Simulations	3	54	3
	AN1922601	Inorganic Chemistry Practical -I	3	54	<i>Evaluation at the end of second semester</i>
	AN1922602	Organic Chemistry Practical - I	3	54	
	AN1922603	Physical Chemistry Practical	4	72	
	<b>Total</b>			<b>25</b>	
Semester 2	AN1922105	Coordination Compounds, Structure, Reactions & Kinetics	4	72	4
	AN1922106	Reactive Intermediates and Concerted Reactions	4	72	4
	AN1922107	Molecular Quantum Mechanics and computational Chemistry	4	72	4
	AN1922108	Introduction to Molecular Spectroscopy and Applications	3	54	3
	AN1922601	Inorganic Chemistry Practical- I	3	54	3
	AN1922602	Organic Chemistry Practical- I	3	54	3
	AN1922603	Physical Chemistry Practical	4	72	3
<b>Total</b>			<b>25</b>	<b>450</b>	<b>24</b>
Semester 3	AN1923109	Solid State Chemistry and Introduction to Material Science	4	72	4
	AN1923110	Novel Synthetic Strategies and Retro Synthetic Approach	4	72	4
	AN1923111	Selected Topics in Physical Chemistry	4	72	4
	AN1923112	Advanced Spectroscopic Techniques	3	54	3
	AN1924604	Inorganic Chemistry Practical- II	3	54	<i>Evaluation at the end of fourth semester</i>
	AN1924605	Organic Chemistry Practical-II	3	54	
	AN1924606	Instrumental Analysis Practical	4	72	
<b>Total</b>			<b>25</b>	<b>450</b>	<b>15</b>
Semester 4	AN1924301	Analytical Procedures	5	90	4
	AN1924302	Instrumental Methods of Analysis	5	90	4
	AN1924303	Modern Analytical Techniques and Green Chemistry	5	90	4
	AN1924604	Inorganic Chemistry Practical- II	3	54	3
	AN1924605	Organic Chemistry Practical- II	3	54	3
	AN1924606	Instrumental Analysis Practical	4	72	3
	AN1924801	Project			3
	AN1924901	Viva			2
<b>Total</b>			<b>25</b>	<b>450</b>	<b>26</b>
<b>Grand Total</b>					<b>80</b>

## **DETAILED SYLLABUS OF ALL COURSES**

## SEMESTER I

Course	Details				
Code	AN1921101				
Title	<b>ORGANOMETALLICS AND NUCLEAR CHEMISTRY</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/I				
Type	Core Course				
Credits	4	Hrs/Week	4	Total Hours	72

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Demonstrate knowledge of advanced content in the areas of inorganic chemistry such as in organometallic compounds, bioinorganic compounds and nuclear chemistry.	U	1,5
2	Rationalize the synthesis, structure, bonding, properties and reactivity of organometallic compounds.	An	5
3	Recognize the industrially important catalytic processes through the use of an organometallic compound as a catalyst.	An	4,5
4	Analyze the chemical and physical properties of metal ions responsible for their biochemical action as well as the techniques frequently used in bioinorganic chemistry such as oxygen transport, e- transfer, communication, catalysis, transport, storage etc.	An	1,3,5
5	Evaluate the role of nuclear chemistry to find the most suitable measures, administrative methods and industrial solutions to ensure sustainable use of the world's nuclear resources.	An	3,5
6	Integrate knowledge with critical thinking to solve problems.	Ap	2, 6

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember;U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Organometallic Compounds-Synthesis, Structure and Bonding.</b>	<b>18</b>	
1.1	Hapto-nomenclature of organometallic compounds. Organometallic compounds with linear pi donor ligands-olefins, acetylenes, dienes and allyl complexes-synthesis, structure and bonding.	4	1,2
1.2	Synthesis and structure of complexes with cyclic pi donors-metallocenes and cyclic arene complexes. Bonding in ferrocene and dibenzenechromium. Carbene and carbyne complexes.	4	1,2
1.3	Metal carbonyls: CO as a $\pi$ -bonding ligand, synergism, preparation, properties, structure and bonding of simple mono and binuclear metal carbonyls, metal nitrosyls, metal cyanides and dinitrogen complexes. Polynuclear metal carbonyls with and without bridging. Carbonyl clusters-LNCCS and HNCCS, Isoelectronic and isolobal analogy, Wade-Mingos rules, cluster valence electrons. IR spectral studies of bridging and non-bridging CO-ligands.	10	1,2
<b>2.0</b>	<b>Reactions of Organometallic Compounds</b>	<b>9</b>	
2.1	Substitution reactions-nucleophilic ligand substitution, nucleophilic and electrophilic attack on coordinated ligands.	2	1,2
2.2	Addition and elimination reactions-1,2 additions to double bonds, carbonylation and decarbonylation. Oxidative addition- concerted addition, SN2 reactions and radical and ionic mechanisms. Reductive elimination- binuclear reductive elimination and $\sigma$ -bond metathesis. Oxidative coupling and reductive decoupling. Insertion (migration) and elimination reactions – insertions of CO and alkenes, insertion into M-H versus M-R and $\alpha$ , $\beta$ , $\gamma$ and $\delta$ eliminations.	7	1,2
<b>3.0</b>	<b>Catalysis by Organometallic Compounds</b>	<b>18</b>	
3.1	Homogeneous and heterogeneous organometallic catalysis-alkene hydrogenation using Wilkinson catalyst, Tolman catalytic loops.	2	1,3,6
3.2	Reactions of carbon monoxide and hydrogen-the water gas shift reaction, the Fischer-Tropsch reaction(synthesis of gasoline).	2	1,3,6
3.3	Hydroformylation of olefins using cobalt and rhodium catalysts.	1	1,3,6
3.4	Polymerization by organometallic initiators and templates for chain propagation- Ziegler Natta catalysts. Polymerisation by metallocene catalysts.	2	1,3,6

3.5	Carbonylation reactions: Monsanto acetic acid process. Olefin hydroformylation: oxo process. Carbonylation of alkenes and alkynes in the presence of a nucleophile: the Reppe reaction. Carbonylation of aryl halides in the presence of a nucleophile.	2	1,3,6
3.6	Olefin methathesis-synthesis gas based reactions, photodehydrogenation catalyst (“Platinum Pop”).	2	1,3,6
3.7	Oxidation of olefins: Palladium catalysed oxidation of ethylene-the Wacker process. Epoxidation of olefins. Hydroxylation by metal-oxo complexes.	2	1,3,6
3.8	Asymmetric catalysis. Asymmetric hydrogenation, isomerisation and epoxidation.	1	1,3,6
3.9	C-H activation and functionalization of alkanes and arenes: Radical-type oxidation, hydroxylation, dehydrogenation, carbonylation and regioselective borylation of alkanes and cycloalkanes. Radical-type reactions, electrophilic reactions, carbonylation and borylation of arenes. Insertion of alkenes and alkynes in the Ar-H bond.	2	1,3,6
3.10	Application of palladium catalysts in the formation of C-O and C-N bonds. Oxidative coupling reactions of alkynes with other unsaturated fragments for the formation of cyclic and heterocyclic compounds. The Dötz reaction.	2	1,3,6
<b>4.0</b>	<b>Bioinorganic Compounds</b>	<b>18</b>	
4.1	Essential and trace elements in biological systems, Toxic effects of metals (Cd, Hg, Cr and Pb, As), structure and functions of biological membranes, mechanism of ion transport across membranes, sodium pump, ionophores, valinomycin. Phosphate esters in biology, Redox metalloenzymes, cytochromes- cytochrome P450.	5	1,4
4.2	Oxygen carriers and oxygen transport proteins-Structure and functions of haemoglobins and myoglobin. Oxygen transport mechanism, cooperativity, Bohr effect. Structure and functions of haemerythrins, haemocyanin.	3	1,4
4.3	Biochemistry of zinc and copper, structure and functions of carbonic anhydrase, carboxypeptidase A and superoxide dismutase.	3	1,4
4.4	Other important metal containing biomolecules, vitamin B12 and the vitamin B12 coenzymes, Photosynthesis-chlorophyll a, PS I and PS II.	3	1,4
4.5	Role of calcium in muscle contraction, blood clotting mechanism and biological calcification. Metals in medicine-therapeutic applications of cis-platin, radio-isotopes and MRI agents.	4	1,4
<b>5.0</b>	<b>Nuclear Chemistry</b>	<b>9</b>	

5.1	Radioactive decay- $\alpha$ , $\beta$ and $\gamma$ , nuclear isomerism & isomeric transition, internal conversion, Augerelectrons and Auger effect.	1	1,5,6
5.2	Nuclear Reactions- Q value and reaction threshold, reaction cross section, cross section and reaction rate, neutron capture cross section- variation of neutron capture cross section with energy (1/V law). Nuclear fission and fusion reactions- fission fragments and mass distribution, fission yields, fission energy, fission cross section and threshold fission neutrons, nuclear fusion reactions and their applications.	1	1,5,6
5.3	Principles of counting technique such as G.M. counter, proportional, ionization and scintillation counters. Cloud chamber.	2	1,5,6
5.4	Synthesis of transuranic elements such as Neptunium, Plutonium, Curium, Berkelium, Einsteinium, Mendelevium, Nobelium, Lawrencium and elements with atomic numbers 104 to 109.	1	1,5,6
5.5	Analytical applications of radioisotopes-radiometric titrations, kinetics of exchange reactions, measurement of physical constants including diffusion constants, Radioanalysis, Neutron Activation Analysis, Prompt Gama Neutron Activation Analysis and Neutron Absorptiometry.	1	1,5,6
5.6	Applications of radio isotopes in industry, medicine, autoradiography, radiopharmacology, radiation safety precaution, nuclear waste disposal. Isotope dilution analysis, determination of volume of blood in patients.	2	1,5,6
5.7	Radiation chemistry of water and aqueous solutions. Measurement of radiation doses. Relevance of radiation chemistry in biology, organic compounds and radiation polymerization.	1	1,5,6

### References:

1. J.E. Huheey, E.A. Keiter, R.L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, 4<sup>th</sup>Edn., Harper Collins College Publishers, 1993.
2. F.A. Cotton, G Wilkinson, C.A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, 6th edition, Wiley-Interscience, 1999.
3. K.F. Purcell, J.C. Kotz, Inorganic Chemistry, Holt-Saunders, 1977.
4. P. Powell, Principles of Organometallic Chemistry, 2nd Edn., Chapman and Hall, 1988.
5. B.E. Douglas, D.H. McDaniel, J. J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn., Wiley-India, 2007.
6. B.D. Gupta, A.J Elias, Basic Organometallic Chemistry, Universities Press, 2010.
7. R.W. Hay, Bio Inorganic Chemistry, Ellis Horwood, 1984.
8. SumitBhaduri, DobleMukesh, Homogeneous Catalysis: Mechanism and Industrial Applications, Wiley Interscience, 2000.

9. Astruc, D.; *Organometallic Chemistry and Catalysis*, Springer Verlag, 2007.
10. Robert H. Crabtree, *The Organometallic Chemistry of the Transition Metals*, 4th Edn., Wiley Interscience, 2005.
11. H.J. Arnika, *Essentials of Nuclear Chemistry*, Wiley Eastern, 1982.
12. Robert R. Crichton, *Biological Inorganic Chemistry A New Introduction to Molecular Structure and Function*, Elsevier, 2012.

Course	Details				
Code	AN1921102				
Title	<b>CONCEPTUAL ORGANIC CHEMISTRY</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/I				
Type	Core Course				
Credits	4	Hrs/Week	4	Total Hours	72

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	To understand the concept of aromaticity and reactions of carbonyl compounds	Ap	1
2	To describe and analyse the organic reactions by physical methods	An	1 2
3	To understand and analyse photochemical reactions	C	1
4	Understand and analyse reactions based on stereochemical aspects and applications	AP	4
5	To acquaint the student with conformational aspects	Ap	3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Aromaticity</b>	<b>9</b>	
1.1	Concept of aromaticity: Delocalization of electrons - Hückel's rule, criteria for aromaticity, examples of neutral and charged aromatic systems - annulenes. NMR as a tool, carbon nanotubes and graphene	9	1
<b>2.0</b>	<b>Physical Organic Chemistry</b>	<b>9</b>	
2.1	Energy profiles. Kinetic versus thermodynamic control of product formation, Hammond postulate, kinetic isotope effects with examples. Linear free energy relationships-Hammet equation, Taft equation.	3	2
2.2	Hard and soft acids, bases - HSAB principle and its applications. Catalysis by acids, bases and nucleophiles with examples from acetal, cyanohydrin. Ester formation and hydrolysis reactions of esters-AAC2, AAC1, AAL1, BAC2 and BAL1 mechanisms.	6	2
<b>3.0</b>	<b>Reactions of Carbonyl Compounds &amp; Organic Photochemistry</b>	<b>18</b>	
3.1	Reactions of carbonyl compounds: Oxidation, reduction	9	1,3

	(Clemmensen and Wolf-Kishner), addition (addition of cyanide, ammonia, alcohol) reactions, Aldol condensation, Cannizzaro reaction, Addition of Grignard reagent. Structure and reactions of $\alpha$ , $\beta$ - unsaturated carbonyl compounds involving electrophilic and nucleophilic addition - Michael addition, Mannich reaction, Robinson annulation.		
3.2	Photoreactions of carbonyl compounds: Norrish reactions of ketones. Paterno-Buchi reaction. Barton reaction, Di- $\pi$ -methane and Photo Fries rearrangements, photochemistry of conjugated dienes (butadiene only).	9	1,3
<b>4.0</b>	<b>Stereochemistry of Organic Compounds</b>	<b>18</b>	
4.1	Stereoisomerism: Definition based on symmetry and energy criteria, configuration and conformational stereoisomers, introduction to atrop isomerism	3	4
4.2	Center of chirality: Molecules with C, N, S based chiral centers, absolute configuration, enantiomers, racemic modifications, R and S nomenclature using Cahn-Ingold-Prelog rules, molecules with a chiral center and C <sub>n</sub> , molecules with more than one center of chirality, definition of diastereoisomers, constitutionally symmetrical and unsymmetrical chiral molecules, erythro and threo nomenclature.	6	4
4.3	Axial, planar and helical chirality with examples, stereochemistry and absolute configuration of allenes, biphenyls and binaphthyls, ansa and cyclophanic compounds, spiranes, exo-cyclic alkylidene cycloalkanes.	3	4
4.4	Topicity and prostereoisomerism, topicity of ligands and faces as well as their nomenclature, NMR distinction of enantiotopic/diastereotopic ligands.	3	4
4.5	Geometrical isomerism: nomenclature, E-Z notation, methods of determination of geometrical isomers, interconversion of geometrical isomers.	3	4
<b>5.0</b>	<b>Conformational Analysis</b>	<b>18</b>	
5.1	Conformational descriptors : Factors affecting conformational stability of molecules, conformational analysis of substituted ethanes, cyclohexane and its derivatives, decalins, adamantane, norbornane, sucrose and lactose.	3	5
5.2	Conformation and reactivity of elimination (dehalogenation, dehydrohalogenation, semipinacolic deamination and pyrolytic elimination - Saytzeff and Hofmann eliminations), substitution and oxidation of 2o alcohols.	9	5
5.3	Chemical consequence of conformational equilibrium - Curtin Hammett principle.	6	5

## References:

1. R. Bruckner, *Advanced Organic Chemistry: Reaction Mechanisms*, Academic Press, 2002.
2. F.A. Carey, R.A. Sundberg, *Advanced Organic Chemistry, Part A: Structure and Mechanisms*, 5thEdn., Springer, 2007.
3. J. Clayden, N. Greeves, S. Warren, P. Wothers, *Organic Chemistry*, Oxford University Press, 2004.
4. T.H. Lowry, K.S. Richardson, *Mechanism and Theory in Organic Chemistry*, 2ndEdn., Harper & Row, 1981.
5. N.S. Isaacs, *Physical Organic Chemistry*, ELBS/Longman, 1987.
6. D. Nasipuri, *Stereochemistry of Organic Compounds: Principles and Applications*, 3rdEdn., New Age Pub., 2010.
7. D.G. Morris, *Stereochemistry*, RSC, 2001.
8. E.L. Eliel, S.H. Wilen, *Stereochemistry of Organic Compounds*, John Wiley & Sons, 1994.
9. N.J. Turro, V. Ramamurthy, J.C. Scaiano, *Principles of Molecular Photochemistry: An Introduction*, University Science books, 2009.
10. N.J. Turro, *Modern Molecular Photochemistry*, Benjamin Cummings, 1978.
11. K.K.R. Mukherjee, *Fundamentals of Photochemistry*, New Age Pub., 1978.
12. Jerry March, *Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*
13. *Nature Chemistry*, Vol 10, 2018, pp 618 – 624.

Course	Details				
Code	AN1921103				
Title	QUANTUM MECHANICS AND MOLECULAR SPECTROSCOPY				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/I				
Type	Core Course				
Credits	4	Hrs/Week	4	Total Hours	72

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Understand and Familiarize with the main aspects of the historical development of quantum mechanics and understand the central concepts and principles in quantum mechanics	U	1, 3
2	Solve the Schrödinger equation for simple systems in one to three dimensions	Ap	1, 3
3	Understand the concepts of angular momentum and spin, as well as the rules for quantisation and addition of these.	Ap	1,3
4	Evaluate symmetry elements in a molecule and classify molecules into point groups	E	1, 3
5	Apply group theoretical rules to derive group multiplication tables, matrix representations, classes, character tables of point groups	Ap	1, 3
6	Apply group theory to analyze vibration, Raman spectra and electronic spectra of polyatomic molecules.	An	1, 3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
1.0	<b>Foundation of Quantum Mechanics</b>	9	
1.1	Historical background: Blackbody Radiation, Photoelectric effect, Compton effect, Hydrogen atom spectra, Matter waves	2	1
1.2	Operators: Linear operators, eigen functions and eigen values, commutation and non-commutation, construction of operators, normalization concept, Hermitian operators.	3	1
1.3	Postulates of quantum mechanics, time independent and	3	1

	time dependent Schrödinger equation.		
1.4	Evolution of states, Uncertainty principle, Characteristics of wavefunction	1	1
<b>2.0</b>	<b>Application of Schrödinger's Equations to Exactly Solvable Model Problems</b>	<b>22</b>	
2.1	Translational motion: free particle in one-dimension.	2	2
2.2	Penetration into and through barriers: infinitely thick potential well, barrier of finite width	2	2
2.3	Particle in a box: one-dimensional box, particle in a three dimensional box- separation of variables, degeneracy.	4	2
2.4	Vibrational motion: one-dimensional harmonic oscillator (complete treatment), Hermite equation(solving by method of power series), Hermite polynomials, recursion relation, wave functions and energies	4	2
2.5	Rotational motion: Particle on a ring and its solution	2	2
2.6	Non-planar rigid rotor (or particle on a sphere) and their solutions, Legendre and associated Legendre equations, Legendre and associated Legendre polynomials. Spherical harmonics (imaginary and real forms)	4	2
2.7	Hydrogen-like Atoms: Schrodinger equation and its solutions, wave functions and energies of hydrogen-like atoms. Probabilities and radial distribution functions, atomic orbitals, degeneracy.	4	2
<b>3.0</b>	<b>Angular momentum</b>	<b>5</b>	
3.1	Quantization of angular momentum, quantum mechanical operators corresponding to angular momenta ( $L_x$ , $L_y$ , $L_z$ and $L^2$ ),	2	3
3.2	Commutation relations between these operators, shift operators, eigenvalues of angular momentum, Spin: Spin orbitals, construction of spin orbitals from orbitals and spin functions.	3	3
<b>4.0</b>	<b>Molecular symmetry and group theory</b>	<b>27</b>	<b>4,5</b>
4.1	Symmetry elements, symmetry operations, point groups and their symbols, sub groups, classes, abelian and cyclic groups, group multiplication tables-classes in a group and similarity transformation.Herman Mauguin Symbols. Screw axis and glide planes.	5	4,5
4.2	Matrices: addition and multiplication of matrices, inverse and orthogonal matrices, character of a matrix, block diagonalization, matrix representation of symmetry operations, representation of groups by matrices, construction of representation using vectors and atomic orbitals as basis, representation generated by cartesian	10	5

	coordinates positioned on the atoms of a molecule (H <sub>2</sub> O and SO <sub>2</sub> as examples).		
4.3	Reducible and irreducible representations-construction of irreducible representation by standard reduction formula. Statement of Great Orthogonality Theorem (GOT). Properties of irreducible representations. Construction of irreducible representation using GOT-construction of character tables for C <sub>2v</sub> , C <sub>2h</sub> , D <sub>2</sub> , C <sub>3v</sub> and C <sub>4v</sub> . Direct product of representations. Molecular symmetry and Optical activity.	12	5
<b>5.0</b>	<b>Application of Group Theory in Spectroscopy</b>	<b>9</b>	<b>6</b>
5.1	Applications in vibrational spectra: transition moment integral, vanishing of integrals, symmetry aspects of molecular vibrations, vibrations of polyatomic molecules-selection rules for vibrational absorption. Determination of the symmetry of normal modes of H <sub>2</sub> O, Trans-N <sub>2</sub> F <sub>2</sub> and NH <sub>3</sub> using Cartesian coordinates and internal coordinates. Complementary character of IR and Raman spectra-determination of the number of active IR and Raman lines in Td, Oh and Square planar complexes.	4	6
5.2	Application in electronic spectra: types of electronic transitions in organic molecules, transition moment integral, vanishing of integrals, term symbols, selection rules for electronic transition, electronic transitions due to the carbonyl chromophore in formaldehyde .	5	6

**Course texts:**

1. P.W. Atkins, R.S. Friedman, Molecular Quantum Mechanics, 4th Edn., Oxford University Press, 2005.
2. F.A. Cotton, Chemical Applications of Group Theory, 3rd Edn., Wiley Eastern, 1990.
3. A.S. Kunju, G. Krishnan, Group Theory and its Applications in Chemistry, PHI Learning, 2010
4. R. Ameta, Symmetry and Group Theory in Chemistry, New Age International, 2013

**References:**

1. I.N. Levine, Quantum Chemistry, 6th Edn., Pearson Education Inc., 2009.
2. D.A. McQuarrie, Quantum Chemistry, University Science Books, 2008.
3. J.P. Lowe, K Peterson, Quantum Chemistry, 3rd Edn., Academic Press, 2006.
4. T. Engel, Quantum Chemistry and Spectroscopy, Pearson Education, 2006.
5. H. Metiu, Physical Chemistry: Quantum Mechanics, Taylor & Francis, 2006.
6. L. H. Hall, Group Theory and Symmetry in Chemistry, McGraw Hill, 1969
7. V. Ramakrishnan, M.S. Gopinathan, Group Theory in Chemistry, Vishal Publications, 1992.
8. S. Swarnalakshmi, T. Saroja, R.M. Ezhilarasi, A Simple Approach to Group Theory in Chemistry, Universities Press, 2008.
9. S.F.A. Kettle, Symmetry and Structure: Readable Group Theory for Chemists, 3rd Edn., Wiley, 2007.
10. A. Vincent, Molecular Symmetry and Group Theory: A Programmed Introduction to Chemical Applications, 2nd Edn., Wiley, 2000.

Course	Details				
Code	AN1921104				
Title	<b>STATISTICAL MECHANICS AND MOLECULAR SIMULATIONS</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/I				
Type	Core Course				
Credits	3	Hrs/Week	3	Total Hours	54

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Understand the basic concepts of classical and statistical thermodynamics	U	1
2	Analyze the macroscopic properties of matter using classical and statistical thermodynamics	An	1, 3
3	Relate microscopic and macroscopic properties using classical and statistical thermodynamics	An	1, 3
4	Calculate change in thermodynamic properties and absolute values of thermodynamic quantities and equilibrium constants	Ap	1, 3
5	Analyze the phase diagrams of various systems containing three components	An	1, 3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Thermodynamics of ideal systems</b>	<b>9</b>	<b>1,2,3,4</b>
1.1	Brief review on the basic concepts in thermodynamics: First law of thermodynamics (work, heat, energy, internal energy, enthalpy: definition), State and path functions and their significance.	1	1,2,3
1.2	Second law of thermodynamics: Entropy (basic concept, definition) Clausius inequality, variation of entropy with T,P,V	3	1,2,4
1.3	Helmholtz energy, Gibbs energy, Criterion for spontaneity, Maxwell relations and its significance, Fundamental equations, variation of G with T&P ( Gibbs Helmholtz equation, applications of Gibbs Helmholtz equation).	5	1,2,3
<b>2.0</b>	<b>Thermodynamics of non-ideal systems</b>	<b>16</b>	<b>1,2,4</b>
2.1	Partial molar quantities, chemical potential and Gibbs-Duhem equations, determination of partial molar volume and enthalpy.	3	1,2,4
2.2	Fugacity, relation between fugacity and pressure, determination of fugacity of a real gas, variation of fugacity with temperature and pressure. Activity (solute, solvent, ideal dilute solution), dependence of activity on temperature and pressure.	3	1,2,4
2.3	Thermodynamics of mixing (entropy of mixing & free energy	3	1,2,4

	of mixing), Margules relations, excess thermodynamic functions-free energy, enthalpy, entropy and volume. Determination of excess enthalpy and volume.		
2.4	Chemical affinity and thermodynamic functions, equilibrium constant- for ideal gas, general equation, relation connecting K with various TD variables, effect of temperature and pressure on chemical equilibrium- Van Hoff equation.	4	1,2,4
2.5	Third law of thermodynamics, Nernst heat theorem, determination of absolute entropies using third law, entropy changes in chemical reactions.	3	1,2,4
<b>3.0</b>	<b>Three component systems</b>	<b>2</b>	<b>1,2,4,5</b>
3.1	Three component systems-graphical representation. Liquid-liquid equilibria-one pair of partially miscible liquids, two pairs of partially miscible liquids, three pairs of partially miscible liquids.	2	1,2,4,5
<b>4.0</b>	<b>Fundamentals of Statistical Mechanics</b>	<b>23</b>	<b>1,2,3,4</b>
4.1	Mathematical preliminaries: Basic probability theory: fundamental counting principle, permutations, configurations, binomial probabilities, Stirling's approximation	3	1,2,3
4.2	Probability distribution functions, Probability distribution involving discrete and continuous variable, Characterizing distribution functions: Average value, distribution moments, variance.	4	1,2,3,4
4.3	Boltzmann distribution: microstates and configuration, Derivation of Boltzman distribution, Physical meaning of the Boltzman distribution law, Definition of beta.	3	1,2,3
4.4	Ensemble: Canonical ensemble, relating q to Q for an ideal gas, translation partition function, rotational partition function: diatomic and polyatomic, Vibrational partition function, equi-partition theorem, Electronic partition function.	4	1,2,3
4.5	Thermodynamic information in the partition function: Energy, heat capacity, entropy, Helmholtz energy, enthalpy, Gibbs energy	4	1,2,3
4.6	Quantum statistics: Indistinguishable particles and quantum statistics, Bose-Einstein statistics, Fermi-Dirac statistics.	2	1,2,3
4.7	Fundamental concepts and Postulates of statistical mechanics: Phase space and trajectory, Time average equals ensemble average, equal a priori probability, ergodic hypothesis, measure of ergodicity, Liouville theorem and liouville equation, phase space density, Hamilton's equation of motion	3	1,2,3
<b>5.0</b>	<b>Computer simulation methods in statistical mechanics</b>	<b>4</b>	<b>1,2,3</b>
5.1	Monte Carlo simulations: Importance sampling, Metropolis method	2	1,2,3
5.2	Molecular Dynamics simulations: Force calculation, Integrating equations of motion: Verlet algorithm, Velocity Verlet algorithm	2	1,2,3

### **Course Texts:**

1. P.W. Atkins, Physical Chemistry, Oxford University press, 8<sup>th</sup> edition
2. Thomas Engel and Philip Reid, Thermodynamics, Statistical Thermodynamics & Kinetics, Pearson (4<sup>th</sup> Edition), 2018
3. Mark Tuckerman, Statistical Mechanics: Theory and Molecular Simulation, Oxford university Press, 2010.

### **References:**

1. A. M Glazer, J. S Wark, Statistical Mechanics: A survival guide, Oxford University Press (1<sup>st</sup> edition), 2001.
2. J. Rajaram, J.C. Kuriakose, Thermodynamics, S Chand and Co., 1999.
3. K.J. Laidler, J.H. Meiser, B.C. Sanctuary, Physical Chemistry, 4th Edn., Houghton Mifflin, 2003.
4. L.K. Nash, Elements of Classical and Statistical Mechanics, 2nd Edn., Addison Wesley, 1972.
5. D.A. McQuarrie, J.D. Simon, Physical Chemistry: A Molecular Approach, University Science Books, 1997
6. C. Kalidas, M.V. Sangaranarayanan, Non-equilibrium Thermodynamics, Macmillan India, 2002.
7. R.K. Murray, D.K. Granner, P. A. Mayes, V.W. Rodwell, Harper's Biochemistry, Tata McGraw Hill, 1999.
8. Tinoco, K. Sauer, J.C. Wang, J.D. Puglisi, Physical Chemistry: Principles and Applications in Biological Science, Prentice Hall, 2002
9. F.W. Sears, G.L. Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Addison Wesley, 1975.
10. J. Kestin, J.R. Dorfman, A Course in Statistical Thermodynamics, Academic Press, 1971.

Course	Details				
Code	AN1922601				
Title	<b>INORGANIC CHEMISTRY PRACTICAL- I</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/I&II				
Type	Practical				
Credits	3	Hrs/Week	3	Total Hours	54

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Understanding of major concepts, theoretical principles and experimental findings in chemistry	U	1,2
2	Develop advanced laboratory skills used in inorganic synthesis including spectroscopic and analytical techniques for identification and characterization of inorganic molecules	Ap	2
3	Application of safety and chemical hygiene regulations and practices.	Ap	3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO. No.
<b>1.0</b>	<b>Separation and identification of two less familiar metal ions</b>	<b>54</b>	
1.1	Separation and identification of two less familiar metal ions such as Tl, W, Se, Mo, Ce, Th, Ti, Zr, V, U and Li. (Anions which need elimination not to be given. Minimum eight mixtures to be given.)	54	1,2,3
<b>2.0</b>	<b>Colorimetric estimation of metal ions</b>	<b>27</b>	
2.1	Colorimetric estimation of Fe, Cu, Ni, Mn, Cr, NH <sub>4</sub> <sup>+</sup> , nitrate and phosphate ions.	27	1,2,3
<b>3.0</b>	<b>Preparation and characterization of metal complexes</b>	<b>27</b>	
3.1	Preparation and characterization complexes using IR, NMR and electronic spectra. (a) Tris (thiourea)copper(I) complex (b) Potassium tris (oxalate) aluminate (III). (c) Hexammine cobalt (III) chloride. (d) Tetrammine copper (II) sulphate. (e) Schiff base complexes of various divalent metal ions.	27	1,2,3

**References:**

1. A.I. Vogel, G. Svehla, Vogel's Qualitative Inorganic Analysis, 7<sup>th</sup>Edn., Longman,1996.
2. A.I. Vogel, A Text Book of Quantitative Inorganic Analysis, Longman,1966.
3. I.M. Koltoff, E.B. Sandell, Text Book of Quantitative Inorganic Analysis, 3<sup>rd</sup>Edn.,McMillian, 1968.
4. V.V. Ramanujam, InorganicSemimicro Qualitative Analysis, The NationalPub.Co., 1974.

Course	Details				
Code	AN1922602				
Title	<b>ORGANIC CHEMISTRY PRACTICAL - I</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/I&II				
Type	Practical				
Credits	3	Hrs/Week	3	Total Hours	54

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Qualitatively separate the organic components	An	3
2	Provide hands on experience in the preparation of TLC, column chromatography	An	3
3	Develop skills in separating techniques	C	3
4	Acquire advanced knowledge in chemical drawing	C	4

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>PART I</b>	<b>27</b>	
1.1	General methods of separation and purification of organic compounds such as: Solvent extraction Soxhlet extraction Fractional crystallization	7	1,4
1.2	TLC and Paper Chromatography, Column Chromatography, Membrane Dialysis	20	
<b>2.0</b>	<b>PART II</b>	<b>54</b>	
2.1	Separation of Organic binary mixtures by chemical/solvent separation methods	24	3,4
2.2	Separation of organic mixtures by TLC	10	3,4
2.3	Separation/ purification of organic mixtures by column chromatography	10	3,4
2.4	Test for detection of rosin in soaps. Estimation of rosin in soaps	10	3,4
<b>3.0</b>	<b>PART III</b>	<b>27</b>	
3.1	Drawing the structures of organic molecules and reaction	10	1,4

	schemes by ChemDraw, Symyx Draw and Chems sketch.		
3.2	<p>Draw the structures and generate the IR and NMR spectra of the substrates and products in the following reactions:</p> <ol style="list-style-type: none"> <li>1. Cycloaddition of diene and dienophile (Diels-Alder reaction)</li> <li>2. Oxidation of primary alcohol to aldehyde and then to acid</li> <li>3. Benzoin condensation</li> <li>4. Esterification of simple carboxylic acids</li> <li>5. Aldol condensation</li> </ol>	17	1,4

**References:**

1. A.I. Vogel, A Textbook of Practical Organic Chemistry, Longman, 1974.
2. A.I. Vogel, Elementary Practical Organic Chemistry, Longman, 1958.
3. F.G. Mann, B.C Saunders, Practical Organic Chemistry, 4<sup>th</sup> Edn., Pearson Education India, 2009.
4. R. Adams, J.R. Johnson, J.F. Wilcox, Laboratory Experiments in Organic Chemistry, Macmillan, 1979.

Course	Details				
Code	AN1922603				
Title	<b>PHYSICAL CHEMISTRY PRACTICAL</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/I & II				
Type	Practical				
Credits	3	Hrs/Week	4	Total Hours	72

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Interpret data from various experiments, including the construction of appropriate graphs and evaluation of errors.	An	3, 4
2	Quantitatively analyze the extent of adsorption of liquids by solids.	An	1
3	Understand the concept of surface forces in various liquids and the effect of reaction conditions on it.	An	3
4	Apply the terms of phase diagrams in binary and tertiary systems which are used in material science and engineering field.	Ap	1
5	Develop skills in applying the distribution law for various solutes between different appropriate solvent pairs in liquid phase chemical reactions.	C	3
6	Compare and apply theoretical approaches such as HF, MP2, DFT in stimulating various scientific problems and calculating various properties of molecules using Gaussian 09	C	3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Adsorption</b>	<b>12</b>	<b>1,2</b>
1.1	Verification of Freundlich and Langmuir adsorption isotherm: charcoal-acetic acid or charcoal-oxalic acid system.	6	1,2
1.2	Determination of the concentration of the given acid using the isotherms.	6	1,2
<b>2.0</b>	<b>Surface Tension</b>	<b>18</b>	<b>1,3</b>
2.1	Determination of the surface tension of a liquid by a) Capillary rise method	6	1,3

	b) Drop number method c) Drop weight method		
2.2	Determination of parachor values.	6	1,3
2.3	Determination of the composition of two liquids by surface tension measurements	6	1,3
<b>3.0</b>	<b>Phase Diagrams</b>	<b>24</b>	<b>1,4</b>
3.1	Construction of phase diagrams of simple eutectics.	6	1,4
3.2	Construction of phase diagram of compounds with congruent melting point: diphenyl amine-benzophenone system.	6	1,4
3.3	Effect of (KCl/succinic acid) on miscibility temperature.	6	1,4
3.4	Construction of phase diagrams of three component systems with one pair of partially miscible liquids.	6	1,4
<b>4.0</b>	<b>Distribution Law</b>	<b>18</b>	<b>1,5</b>
4.1	Distribution coefficient of iodine between an organic solvent and water.	6	1,5
4.2	Distribution coefficient of benzoic acid between benzene and water	6	1,5
4.3	Determination of the equilibrium constant of the reaction $KI + I_2 \leftrightarrow KI_3$	6	1,5
<b>5.0</b>	<b>Computational Chemistry Experiments</b>	<b>72</b>	<b>1,5</b>
5.1	Single point energy calculations	12	1,5
5.2	Geometry optimization calculations	12	1,5
5.3	3. Frequency calculations	12	1,5
5.4	Basis set effects	12	1,5
5.5	Predicting Ionization energy, electron affinity, proton affinity and atomization energies.	12	1,5
5.6	Studying chemical reactions and reactivity	12	1,5

#### References:

1. J.B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 2001.
2. G.W. Garland, J.W. Nibler, D.P. Shoemaker, Experiments in Physical Chemistry, 8<sup>th</sup>Edn., McGraw Hill, 2009.
3. J.B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 2001.
4. G.W. Garland, J.W. Nibler, D.P. Shoemaker, Experiments in Physical Chemistry, 8th Edn., McGraw Hill, 2009.
5. James B. Foresman and Aeleen Frisch, Exploring Chemistry With Electronic Structure Methods: A Guide to Using Gaussian, Gaussian, second edition, 1996
6. Gaussian 09, Revision A.02, M. J. Frisch*et al.*, 2016

## SEMESTER II

Course	Details				
Code	AN1922105				
Title	<b>COORDINATION COMPOUNDS, STRUCTURE, REACTIONS &amp; KINETICS</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/II				
Type	Core Course				
Credits	4	Hrs/Week	4	Total Hours	72

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Demonstrate knowledge of advanced content in the areas of inorganic chemistry such as in coordination compounds, its key features such as structure, bonding, stereochemistry, mechanism of reactions, kinetics, spectral and magnetic properties etc.	U	1
2	Categorize the structural aspects and bonding of coordination compounds.	An	3
3	Identify the influence of the strength of metal ligand bonds to the spectral and magnetic properties of metal complexes.	An	2
4	Analyze the kinetics and mechanism of reactions in metal complexes.	An	3,
5	Evaluate the stereo chemical aspects of coordination compounds.	E	2
6	Integrate knowledge with different types of coordination compounds of lanthanoids and actinoids.	Ap	3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Structural Aspects and Bonding</b>	<b>18</b>	
1.1	Classification of complexes based on coordination numbers and possible geometries. Sigma and pi bonding ligands such as CO, NO, CN <sup>-</sup> , R <sub>3</sub> P, and Ar <sub>3</sub> P. Stability of complexes, thermodynamic aspects of complex formation-Irving William order of	6	1,2

	stability, chelate effect.		
1.2	Splitting of d orbitals in octahedral, tetrahedral, square planar, square pyramidal and trigonalbipyramidal fields, LFSE, Dq values, Jahn Teller (JT) effect, theoretical failure of crystal field theory, evidence of covalency in the metal-ligand bond, nephelauxetic effect, ligand field theory, molecular orbital theory-M.O energy level diagrams for octahedral and tetrahedral complexes without and with $\pi$ -bonding, experimental evidences for pi-bonding.	12	1,2
<b>2.0</b>	<b>Spectral and Magnetic Properties of Metal Complexes</b>	<b>18</b>	
2.1	Electronic Spectra of complexes-Term symbols of dn system, Racah parameters, splitting of terms in weak and strong octahedral and tetrahedral fields. Correlation diagrams for d1 and d9 ions in octahedral and tetrahedral fields (qualitative approach), d-d transition, selection rules for electronic transition-effect of spin orbit coupling and vibronic coupling.	6	1,3
2.2	Interpretation of electronic spectra of complexes-Orgel diagrams, demerits of Orgel diagrams, Tanabe-Sugano diagrams, calculation of Dq, B and $\beta$ (Nephelauxetic ratio) values, spectra of complexes with lower symmetries, charge transfer spectra, luminescence spectra.	4	1,3
2.3	Magnetic properties of complexes-paramagnetic and diamagnetic complexes, molar susceptibility, Gouy method for the determination of magnetic moment of complexes, spin only magnetic moment. Temperature dependence of magnetism- Curie's law, Curie-Weiss law. Temperature Independent Paramagnetism (TIP), Spin state cross over, Antiferromagnetism-inter and intra molecular interaction. Anomalous magnetic moments.	8	1,3
<b>3.0</b>	<b>Kinetics and Mechanism of Reactions in Metal Complexes</b>	<b>18</b>	
3.1	Thermodynamic and kinetic stability, kinetics and mechanism of nucleophilic substitution reactions in square planar complexes- trans effect-theory and applications, effect of entering ligand, effect of leaving group and effect of ligands already present on reaction rate, effect of solvent and reaction pathways. Substitution in tetrahedral and five-coordinate complexes.	6	1,4

3.2	Kinetics and mechanism of octahedral substitution-water exchange, dissociative and associative mechanisms, base hydrolysis, racemization reactions, solvolytic reactions (acidic and basic). Replacement reactions involving multidentate ligands- The formation of chelates, effect of H <sup>+</sup> on the rates of substitution of chelate complexes, metal ion assisted and ligand assisted dechelation.	6	1,4
3.3	Electron transfer reactions: outer sphere mechanism-Marcus theory, inner sphere mechanism-Taube mechanism. Mixed outer and inner sphere reactions. Two electron transfer and intramolecular electron transfer.	6	1,4
<b>4.0</b>	<b>Stereochemistry of Coordination Compounds</b>	<b>9</b>	
4.1	Geometrical and optical isomerism in octahedral complexes, resolution of optically active complexes, determination of absolute configuration of complexes by ORD and circular dichroism, stereoselectivity and conformation of chelate rings, asymmetric synthesis catalyzed by coordination compounds.	5	1,5
4.2	Linkage isomerism-electronic and steric factors affecting linkage isomerism. Symbiosis-hard and soft ligands, Prussian blue and related structures, Macrocycles-crown ethers.	4	1,5
<b>5.0</b>	<b>Coordination Chemistry of Lanthanoids and Actinoids</b>	<b>9</b>	
5.1	Term symbols for lanthanide ions, Inorganic compounds and coordination complexes of the lanthanoids- halides, oxides and hydroxides, 3, 5, 6, 7, 8 and 9, 10, 11 and 12-coordinate complexes of lanthanoids. Electronic spectra and magnetic properties of lanthanoid complexes. Organometallic complexes of the lanthanoids- $\sigma$ -bonded complexes, cyclopentadienyl complexes, organolanthanoid complexes as catalysts.	5	1,6
5.2	General characteristics of actinoids-difference between 4f and 5f orbitals, coordination complexes of the actinoids- sandwich complexes, coordination complexes and organometallic compounds of thorium and uranium. Comparative account of coordination chemistry of lanthanoids and actinoids with special reference to electronic spectra and magnetic properties.	4	1,6

## References:

1. F.A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry: A Comprehensive Text*, 3rd Edn., Interscience, 1972.
2. J.E. Huheey, E.A. Keiter, R.A. Keiter, *Inorganic Chemistry Principles of Structure and Reactivity*, 4<sup>th</sup> Edn., Pearson Education India, 2006.
3. K.F. Purcell, J.C. Kotz, *Inorganic Chemistry*, Holt-Saunders, 1977.
4. F. Basolo, R.G. Pearson, *Mechanisms of Inorganic Reaction*, John Wiley & Sons, 2006.
5. B.E. Douglas, D.H. McDaniel, J.J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd Edn., Wiley-India, 2007.
6. R.S. Drago, *Physical Methods in Chemistry*, Saunders College, 1992.
7. B.N. Figgis, M.A. Hitchman, *Ligand Field Theory and its Applications*, Wiley-India, 2010.
8. J.D. Lee, *Concise Inorganic Chemistry*, 4th Edn., Wiley-India, 2008
9. R. G. Wilkins, *Kinetics and Mechanisms of Reactions of Transition Metal Complexes*, Wiley VCH, 2002.
10. G. A. Lawrance, *Introduction to Coordination Chemistry*, John Wiley & Sons Ltd, 2010.
11. C. E. Housecroft, A. G. Sharpe, *Inorganic Chemistry*, Pearson, 2012.

Course	Details				
Code	AN1922106				
Title	<b>REACTIVE INTERMEDIATES AND CONCERTED REACTIONS</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/II				
Type	Core Course				
Credits	4	Hrs/Week	4	Total Hours	72

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	To understand organic reaction mechanisms and to analyse reactions	An	1
2	To study about the reactive intermediates and the rearrangements involved	An	3
3	Describe the reaction mechanisms	C	2
4	Learn, Analyse and Apply Concerted Reactions	C	4

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Organic Reaction Mechanisms</b>	<b>18</b>	
1.1	Review of organic reaction mechanisms with special reference to nucleophilic and electrophilic substitution at aliphatic carbon (SN1, SN2, SNi, SE1, SE2), elimination (E1 and E2) and addition reactions (regioselectivity: Markovnikov's addition-carbocation mechanism, anti-Markovnikov's addition-radical mechanism). Elimination vs substitution.	3	1,3
1.2	A comprehensive study on the effect of substrate, reagent, leaving group, solvent and neighbouring group on nucleophilic substitution(SN2 and SN1) and elimination (E1 and E2) reactions.	6	1,3
1.3	Mechanism of electrophilic and nucleophilic aromatic substitution reactions with examples. Arenium ion intermediates. SN1, SNAr, SRN1 and benzyne mechanisms. Arynes: Generation, structure, stability and reactions. Orientation effect	9	1,3
<b>2.0</b>	<b>Chemistry of Carbanions</b>	<b>9</b>	
2.1	Formation, structure and stability of carbanions; Reactions of carbanions: C-X bond (X = C, O, N) formations through the intermediary of carbanions. Chemistry of enolates and	3	2

	enamines. Kinetic and Thermodynamic enolates- lithium and boron enolates in aldol and Michael reactions, alkylation and acylation of enolates.		
2.2	Nucleophilic additions to carbonyls groups: Name reactions under carbanion chemistry-mechanism of Claisen, Dieckmann, Knoevenagel, Stobbe, Darzen and acyloin condensations, Shapiro reaction and Julia elimination. Favorski rearrangement.	4	2
2.3	Ylids: chemistry of phosphorous and sulphurylids - Wittig and related reactions, Peterson olefination.	2	
<b>3.0</b>	<b>Chemistry of Carbocations and Free Radicals</b>	<b>18</b>	
3.1	Formation, structure and stability of carbocations. Classical and non-classical carbocations. C-X bond (X = C, O, N) formations through the intermediary of carbocations. Molecular rearrangements including Wagner-Meerwein, Pinacol-pinacolone, Semi-pinacol, Dienone-phenol and Benzilic acid rearrangements, Noyori annulation, Prins reaction. C-C bond formation involving carbocations: Oxymercuration, Halolactonisation.	9	2
3.2	Generation of radical intermediates and its (a) addition to alkenes, alkynes (inter and intramolecular) for C-C bond formation - Baldwin's rules (b) fragmentation and rearrangements - Hydroperoxide: formation, rearrangement and reactions. Autooxidation. Name reactions involving radical intermediates: Barton deoxygenation and decarboxylation, McMurry coupling	9	2
<b>4.0</b>	<b>Carbenes, Carbenoids and Nitrenes</b>	<b>9</b>	
4.1	Structure of carbenes (singlet and triplet), Generation of carbenes, Addition and Insertion reactions.	2	2
4.2	Reactions of carbenes such as Wolff rearrangement, Reimer-Tiemann reaction, Reactions of ylides by carbenoid decomposition, Bamford-Stevens Reaction (both protic and aprotic solvents)	4	2
4.3	Structure, generation and reactions of nitrene and related electron deficient nitrene intermediates. Hoffmann, Curtius, Lossen, Schmidt and Beckmann rearrangement reactions.	3	2
<b>5.0</b>	<b>Concerted reactions</b>	<b>18</b>	
5.1	Classification - electrocyclic, sigmatropic, cycloaddition, chelotropic, ene and dyotropic reactions. Woodward Hoffmann rules - Frontier orbital and orbital symmetry correlation approaches - PMO method (for electrocyclic and cycloaddition reactions only).	6	4
5.2	Highlighting pericyclic reactions in organic synthesis such as	3	4

	Claisen, Cope, Wittig, Mislow-Evans and Sommelet-Hauser rearrangements. Diels-Alder and Ene reactions (with stereochemical aspects), dipolar cycloaddition (introductory).		
5.3	Unimolecular pyrolytic elimination reactions: Cheletropic elimination, decomposition of cyclic azo compounds, $\beta$ -eliminations involving cyclic transition states such as N-oxides (Cope reaction), Acetates and Xanthates (Chugaev reaction). Problems based on the above topics	9	4

### References:

1. R. Bruckner, *Advanced Organic Chemistry: Reaction Mechanism*, Academic Press, 2002.
2. F.A. Carey, R.A. Sundberg, *Advanced Organic Chemistry, Part B: Reactions and Synthesis*, 5thEdn., Springer, 2007.
3. W. Carruthers, I. Coldham, *Modern Methods of Organic Synthesis*, Cambridge University Press, 2005.
4. J. March, M.B. Smith, *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6thEdn., Wiley, 2007.
5. A. Fleming, *Frontier Orbitals and Organic Chemical Reactions*, Wiley, 1976.
6. S. Sankararaman, *Pericyclic Reactions-A Text Book*, Wiley VCH, 2005.
7. R.T. Morrison, R.N. Boyd, S.K. Bhattacharjee, *Organic Chemistry*, 7thEdn., Pearson, 2011.
8. J. Clayden, N. Greeves, S. Warren, P. Wothers, *Organic Chemistry*, Oxford University Press, 2004

Course	Details				
Code	AN1922107				
Title	MOLECULAR QUANTUM MECHANICS AND COMPUTATIONAL CHEMISTRY				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/II				
Type	Core Course				
Credits	4	Hrs/Week	4	Total Hours	72

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Understand different approximation techniques used in molecular quantum mechanics	Ap	1, 2
2	Identify and explain the main similarities and differences between computational approaches such as HF (Hartree-Fock), semi-empirical, DFT (Density Functional Theory) and force field methods.	Ap	1, 2
3	Describe and identify the various methods' advantages / disadvantages for simulating/modelling various scientific problems.	Ap	1, 2,3
4	Understand Quantum Mechanical and principles of Molecular Orbital theory, Hückel Molecular Orbital Theory, Valence bond theory and hybridization	U	1
5	Understand Group theoretical principles of Molecular Orbital theory, Valence bond theory and hybridization	U	1
6	Apply the concept of linear combination of atomic orbitals to produce Molecular Orbitals, Hückel Molecular Orbitals and hybrid orbitals to understand the molecular structure and geometry.	Ap	1, 2, 3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
1.0	<b>Techniques of Approximation in Quantum Mechanics</b>	10	1
1.1	Many-body problem and the need of approximation methods, independent particle model.	2	1
1.2	Variation method: variation theorem with proof	2	1
1.3	illustration of variation theorem using the trial function $\psi(a-x)$ for particle in a 1D-box and using the trial function $e^{-ar}$ for the hydrogen atom	2	1

1.4	Perturbation method: time-independent perturbation method (non-degenerate case), first order correction to energy, illustration by application to particle in a 1D-box with slanted bottom	3	1
1.5	Perturbation treatment of the ground state of the helium atom.	1	1
<b>2.0</b>	<b>Computational Chemistry</b>	<b>26</b>	<b>2,3</b>
2.1	Introduction to computational chemistry: what you can do with computational chemistry, tools of computational chemistry.	1	2
2.2	Hartree-Fock Self-Consistent Field (HF-SCF) method (Derivation): Pauli's principle, Slater determinants, Coulomb and exchange Operators, Fock operator, Roothan-Hall equation.	5	2
2.3	Basis functions, Slater type orbitals (STO), Gaussian type orbitals (GTO), sketches of STO and GTO, Classification of basis sets - minimal, double zeta, triple zeta, split valence, polarization and diffuse basis sets, contracted basis sets, Pople style basis sets and their nomenclature, Hartree-Fock limit.	4	2,3
2.4	Electron correlation, Post Hartree-Fock methods: Qualitative ideas on Configuration Interaction(CI) and Møller Plesset approaches to electron correlation.	5	2,3
2.5	Semi-empirical methods: General introduction to semi-empirical methods: basic principles and terminology.	3	2,3
2.6	Introduction to Density Functional Theory (DFT) methods: Hohenberg-Kohn theorems. Kohn-Sham orbitals. Exchange correlation functional. Local density approximation.	4	2,3
2.7	Molecular mechanics methods: Basic principle, Force fields, potential energy functions, inter and intramolecular interactions, empirical parameters, basic idea of QM/MM methods	4	2,3
<b>3.0</b>	<b>Computational Chemistry Calculations</b>	<b>9</b>	<b>3</b>
3.1	Potential energy surface: stationary point, transition state or saddle point, local and global minima, geometry optimisation.	3	3
3.2	Molecular geometry input: cartesian coordinates and Z-matrix. Z-matrix of diatomic molecules, non-linear triatomic molecule, linear triatomic molecule, polyatomic molecules like ammonia.	3	3
3.3	Comparison and applications of Ab initio, DFT, Semi-empirical and Molecular mechanics methods.	3	3
<b>4.0</b>	<b>Chemical Bonding</b>	<b>18</b>	<b>4,6</b>

4.1	Brief review of Schrödinger equation for molecules and Born-Oppenheimer approximation. Valence Bond (VB) theory, VB theory of H <sub>2</sub> molecule, singlet and triplet state functions (spin orbitals) of H <sub>2</sub> .	4	4,6
4.2	Molecular Orbital (MO) theory, MO theory of H <sub>2</sub> <sup>+</sup> ion, MO theory of H <sub>2</sub> molecule, MO treatment of homonuclear diatomic molecules and hetero nuclear diatomic molecules. Comparison of MO and VB theories – ionic terms and configuration interaction. Bond order. Correlation diagrams, non-crossing rule. MOs of diatomic molecules – H <sub>2</sub> , Li <sub>2</sub> , B <sub>2</sub> , C <sub>2</sub> , N <sub>2</sub> , O <sub>2</sub> and F <sub>2</sub> , paramagnetism of O <sub>2</sub> .	7	4,6
4.3	Quantum mechanical treatment of sp, sp <sup>2</sup> and sp <sup>3</sup> hybridization. Hückel Molecular Orbital (HMO) theory of ethene, allyl systems, butadiene and benzene. Calculation of charge distributions, bond orders and free valency.	7	4,6
<b>5.0</b>	<b>Applications of Group Theory in Chemical Bonding</b>	<b>9</b>	<b>5,6</b>
5.1	Projection operator, generation of SALCs, transformation properties of atomic orbitals, construction of hybrid orbitals with BF <sub>3</sub> , CH <sub>4</sub> , PCl <sub>5</sub> as examples. Symmetry adapted linear combinations (SALC) of C <sub>2v</sub> , C <sub>2h</sub> , C <sub>3</sub> , C <sub>3v</sub> and D <sub>3h</sub> point groups. MO diagram for water and ammonia.	9	5,6

**Course Texts:**

1. Molecular Quantum Mechanics, Peter Atkins and Ronald Friedman, Oxford University Press, 2005
2. Errol Lewar, Computational Chemistry: Introduction to theory and application of Molecular Quantum Mechanics, Second edition, Springer
3. Attila Szabo and Neil S. Ostlund, Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory, Dover Books in Chemistry, 1996
4. D.A. McQuarrie, Quantum Chemistry, University Science Books, 2008.
5. A.S. Kunju, G. Krishnan, Group Theory and its Applications in Chemistry

**References:**

1. I.N. Levine, Quantum Chemistry, 6th Edn., Pearson Education, 2009.
2. R.K. Prasad, Quantum Chemistry, 3rd Edn., New Age International, 2006.
3. F.A. Cotton, Chemical Applications of Group Theory, 3rd Edn., Wiley Eastern, 1990.
4. V. Ramakrishnan, M.S. Gopinathan, Group Theory in Chemistry, Vishal Publications, 1992.
5. J.H. Jensen, Molecular Modeling Basics, CRC Press, 2010.
6. F. Jensen, Introduction to computational chemistry, 2nd Edn., John Wiley & Sons, 2007.
7. A. Leach, Molecular Modelling: Principles and Applications, 2nd Edn., Longman, 2001.
8. J.P. Fackler Jr., L.R. Falvello (Eds.), Techniques in Inorganic Chemistry: Chapter 4, CRC Press, 2011.
9. C.J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2nd Edn., John Wiley & Sons, 2004.

Course	Details				
Code	AN1922108				
Title	<b>INTRODUCTION TO MOLECULAR SPECTROSCOPY AND APPLICATIONS</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/II				
Type	Core Course				
Credits	3	Hrs/Week	3	Total Hours	54

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Understand the concepts of spectroscopy	U	1
2	Analyze the relationship between rotational, vibrational and electronic spectroscopy	An	1, 3
3	Understand and relate the concepts of NMR, EPR and Mossbauer spectroscopy	An	1, 3
4	Comprehend the relationship between quantum mechanics, group theory and spectroscopy	An	1
5	Solve problems based on the theory of various spectroscopic techniques	An	1, 3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Basics of Spectroscopic Techniques</b>	<b>9</b>	<b>1,4,5</b>
1.1	Brief review of Electromagnetic spectrum: nature of radiation, Maxwell's equations in free space and in isotropic nonmagnetic media, wave amplitude, angular frequency, phase, period, wavelength, wave number, wave vector, velocity of propagation, Black-body radiation, quantum theory of electromagnetic radiation, wave-particle duality, nature of photon – energy, rest mass, momentum, charge, spin, radiant energy, radiant energy density, radiant flux (power), radiant flux density, radiant intensity and radiance.	3	1,4,5
1.2	Radiation-matter interaction: basic concepts of absorption, emission, transmission, reflection, refraction, dispersion, polarization and scattering, absorption cross section, Einstein's coefficients, signal to noise ratio, natural line width, line broadening factors, Doppler broadening, time-	6	1,4,5

	dependent perturbation theory (no proof required) and its consequences in spectroscopy, transition moment integral, symmetry and selection rules, intensity of spectral lines, Born-Oppenheimer approximation, rotational, vibrational and electronic energy levels, radiative and non-radiative transitions, relaxation time.		
<b>2.0</b>	<b>Microwave Spectroscopy</b>	<b>9</b>	<b>1,2,4,5</b>
2.1	Microwave spectroscopy: classical description of molecular rotation, the rigid diatomic rotor – energy Eigen values and Eigen states, principal moments of inertia and classification (linear, symmetric tops, spherical tops and asymmetric tops), rotational transitions, selection rules, intensity of rotational lines, relative population of energy levels, derivation of $J_{\max}$ , effect of isotopic substitution, calculation of intermolecular distance, general layout and working principle of a microwave spectrometer, spectrum of non-rigid rotors, rotational spectra of polyatomic molecules, Stark effect and its application, nuclear spin and electron spin interaction.	9	1,2,4,5
<b>3.0</b>	<b>Infrared Spectroscopy</b>	<b>9</b>	<b>1,2,4,5</b>
3.1	Infrared spectroscopy: Morse potential energy diagram, anharmonicity – electrical and mechanical, vibrational term values, fundamentals, overtones and hot bands, determination of force constants, diatomic vibrating rotator, break down of the Born-Oppenheimer approximation, effect of nuclear spin, general layout and working principle of an infrared spectrometer, vibrational spectra of polyatomic molecules, potential energy surfaces, normal modes of vibrations, local modes of vibrations, potential energy functions with more than one minimum, combination and difference bands, Fermi resonance, finger print region and group vibrations, principles of FTIR spectroscopy.	9	1,2,4,5
<b>4.0</b>	<b>Raman and Electronic Spectroscopy</b>	<b>18</b>	<b>1,2,4,5</b>
4.1	Raman spectroscopy: scattering of light, classical theory of Raman spectrum, quantum theory of Raman spectrum, general layout and working principle of a Raman spectrometer, rotational and vibrational Raman spectrum, complementary nature of Raman and IR spectra, group theory and mutual exclusion principle, polarized and depolarized Raman lines, basic principles of resonance Raman spectroscopy.	6	1,2,4,5

4.2	Electronic spectroscopy: classical theory of electronic spectroscopy, quantum theory of electronic spectroscopy, general layouts and working principles of an absorption spectrometer and an emission spectrometer, term symbols, selection rules, oscillator strength of transitions, vibronic transitions, Franck-Condon principle, electronic spectra of polyatomic molecules, $n-\pi^*$ and $\pi-\pi^*$ transitions, Jablonski diagram, fluorescence and phosphorescence, free electron model of conjugated systems, bathochromic shift and hypsochromic shifts, theory of solvation and spectral shifts, fluorescence quenching, Förster-resonance energy transfer (FRET) – dipole-dipole approximation, Fermi-Golden rule, rate equation of energy transfer, orientation factor, Dexter energy transfer, electron transfer – Marcus classical and semiclassical theory.	8	1,2,4,5
4.3	Lasers – different types of lasers: solid state lasers – Ti:Sapphire, Nd:YAG and semiconductor lasers, gas lasers – helium-neon, argon ion and N <sub>2</sub> lasers. Cavity modes, continuous wave and pulsed lasers, Q-switching, mode locking, harmonic generation  Applications of lasers in spectroscopy: two photon and multiphoton absorption, time domain spectroscopy – Flash photolysis, femtosecond spectroscopy	4	
<b>5.0</b>	<b>Resonance Spectroscopy</b>	<b>9</b>	<b>1,3,4,5</b>
5.1	NMR spectroscopy: interaction between nuclear spin and applied magnetic field, nuclear energy levels (Hamiltonian and energy), population of energy levels, Larmor precession, Bloch equations and its solutions, Master equation and its implications, rotating frame of reference, relaxation methods, correlation function, spectral density function, magic angle spinning, chemical shift, theory of spin coupling	5	1,3,4,5
5.2	EPR spectroscopy: electron spin in molecules, interaction with magnetic field, g factor, factors affecting g values, fine structure and hyperfine structure, Kramers' degeneracy, McConnell equation.	3	1,3,4,5
5.3	Mossbauer spectroscopy: working principle, chemical shift, factors determining chemical shift	1	1,3,4,5

## References:

1. C.N. Banwell, E.M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edn., Tata McGraw Hill, 1994.
2. J. M. Hollas, Modern spectroscopy, Wiley, 2014.
3. D. C. Harris, M. D. Bertolucci, Symmetry and Spectroscopy: An Introduction to Vibrational and Electronic Spectroscopy, Dover Books, 1989.
4. Principles of fluorescence spectroscopy, J. R. Lakowicz, Springer, 2006.
5. W. Kemp, NMR in chemistry-A Multinuclear Introduction, McMillan, 1986.
6. H. Friebolin, Basic One- and Two-Dimensional NMR-Spectroscopy, Wiley, 1993.
7. H. Gunther, NMR Spectroscopy, Wiley, 1995.
8. C. H. Mayne, Fundamentals of High Resolution Pulse and Fourier Transform NMR Spectroscopy, Web book, University of Utah, [https://chem.utah.edu/\\_documents/facilities/nmr/Basic%20NMR%20Frame%20Book.pdf](https://chem.utah.edu/_documents/facilities/nmr/Basic%20NMR%20Frame%20Book.pdf)
9. D. N. Sathyanarayana, Introduction to Magnetic Resonance Spectroscopy ESR, NMR, NQR, IK International, 2009.
10. S. K. Dogra, H. S. Randhawa, Atomic and Molecular Spectroscopy, Pearson, 2014.
11. P.W. Atkins, Physical Chemistry, ELBS, 1994.
12. D. A. McQuarrie, J. D. Simon, Physical Chemistry: A Molecular Approach, University Science Books, 1997.
13. O. Svelto, Principles of Lasers, Springer, 2010

Course	Details				
Code	AN 1922601				
Title	<b>INORGANIC CHEMISTRY PRACTICAL-I</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/I&II				
Type	Practical				
Credits	3	Hrs/Week	3	Total Hours	54

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Understanding of major concepts, theoretical principles and experimental findings in chemistry	U	1,3
2	Develop advanced laboratory skills used in inorganic synthesis including spectroscopic and analytical techniques for identification and characterization of inorganic molecules	Ap	2
3	Application of safety and chemical hygiene regulations and practices.	Ap	3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Separation and identification of two less familiar metal ions</b>	<b>54</b>	
1.1	Separation and identification of two less familiar metal ions such as Tl, W, Se, Mo, Ce, Th, Ti, Zr, V, U and Li. (Anions which need elimination not to be given. Minimum eight mixtures to be given.)	54	1,2,3
<b>2.0</b>	<b>Colorimetric estimation of metal ions</b>	<b>27</b>	
2.1	Colorimetric estimation of Fe, Cu, Ni, Mn, Cr, NH <sub>4</sub> <sup>+</sup> , nitrate and phosphate ions.	27	1,2,3
<b>3.0</b>	<b>Preparation and characterization of metal complexes</b>	<b>27</b>	
3.1	Preparation and characterization complexes using IR, NMR and electronic spectra. (a) Tris (thiourea)copper(I) complex (b) Potassium tris (oxalate) aluminate (III). (c) Hexammine cobalt (III) chloride. (d) Tetrammine copper (II) sulphate. (e) Schiff base complexes of various divalent metal ions.	27	1,2,3

**References:**

1. A.I. Vogel, G. Svehla, Vogel's Qualitative Inorganic Analysis, 7<sup>th</sup>Edn., Longman,1996.
2. A.I. Vogel, A Text Book of Quantitative Inorganic Analysis, Longman,1966.
3. I.M. Koltoff, E.B. Sandell, Text Book of Quantitative Inorganic Analysis, 3<sup>rd</sup>Edn.,McMillian, 1968.
4. V.V. Ramanujam, InorganicSemimicro Qualitative Analysis, The NationalPub.Co., 1974.

Course	Details				
Code	AN1922602				
Title	<b>ORGANIC CHEMISTRY PRACTICAL- I</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/I&II				
Type	Practical				
Credits	3	Hrs/Week	3	Total Hours	54

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Qualitatively separate the organic components	An	3
2	Provide hands on experience in the preparation of TLC, column chromatography	An, Ap	3
3	Develop skills in separating techniques	An,C	3
4	Acquire advanced knowledge in chemical drawing	Ap, C	4

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>PART I</b>	<b>27</b>	
1.1	General methods of separation and purification of organic compounds such as: Solvent extraction, Soxhlet extraction, Fractional crystallization	7	1,4
1.2	TLC and Paper Chromatography, Column Chromatography Membrane Dialysis	20	1,2
<b>2.0</b>	<b>PART II</b>	<b>54</b>	
2.1	Separation of Organic binary mixtures by chemical/solvent separation methods	24	3,4
2.2	Separation of organic mixtures by TLC	10	3,4
2.3	Separation/ purification of organic mixtures by column	10	3,4

	chromatography		
2.4	Test for detection of rosin in soaps. Estimation of rosin in soaps	10	3,4
<b>3.0</b>	<b>PART III</b>	<b>27</b>	
3.1	Drawing the structures of organic molecules and reaction schemes by ChemDraw, Symyx Draw and Chems sketch	10	1,4
3.2	Draw the structures and generate the IR and NMR spectra of the substrates and products in the following reactions: 1. Cycloaddition of diene and dienophile (Diels-Alder reaction) 2. Oxidation of primary alcohol to aldehyde and then to acid 3. Benzoin condensation 4. Esterification of simple carboxylic acids 5. Aldol condensation	17	1,4

#### References:

1. A.I. Vogel, A Textbook of Practical Organic Chemistry, Longman, 1974.
2. A.I. Vogel, Elementary Practical Organic Chemistry, Longman, 1958.
3. F.G. Mann, B.C Saunders, Practical Organic Chemistry, 4<sup>th</sup> Edn., Pearson Education India, 2009.
4. R. Adams, J.R. Johnson, J.F. Wilcox, Laboratory Experiments in Organic Chemistry, Macmillan, 1979.

Course	Details				
Code	AN1922603				
Title	<b>PHYSICAL CHEMISTRY PRACTICAL</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/I & II				
Type	Practical				
Credits	3	Hrs/Week	4	Total Hours	72

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Interpret data from various experiments, including the construction of appropriate graphs and evaluation of errors.	An	3, 4
2	Quantitatively analyze the extent of adsorption of liquids by solids.	An	1
3	Understand the concept of surface forces in various liquids and the effect of reaction conditions on it.	An	3
4	Apply the terms of phase diagrams in binary and tertiary systems which are used in material science and engineering field.	Ap	1
5	Develop skills in applying the distribution law for various solutes between different appropriate solvent pairs in liquid phase chemical reactions.	C	3
6	Compare and apply theoretical approaches such as HF, MP2, DFT in stimulating various scientific problems and calculating various properties of molecules	C	3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Adsorption</b>	<b>12</b>	<b>1,2</b>
1.1	Verification of Freundlich and Langmuir adsorption isotherm: charcoal-acetic acid or charcoal-oxalic acid system.	6	1,2
1.2	Determination of the concentration of the given acid using the isotherms.	6	1,2
<b>2.0</b>	<b>Surface Tension</b>	<b>18</b>	<b>1,3</b>
2.1	Determination of the surface tension of a liquid by a) Capillary rise method b) Drop number method	6	1,3

	c) Drop weight method		
2.2	Determination of parachor values.	6	1,3
2.3	Determination of the composition of two liquids by surface tension measurements	6	1,3
<b>3.0</b>	<b>Phase Diagrams</b>	<b>24</b>	<b>1,4</b>
3.1	Construction of phase diagrams of simple eutectics.	6	1,4
3.2	Construction of phase diagram of compounds with congruent melting point: diphenyl amine-benzophenone system.	6	1,4
3.3	Effect of (KCl/succinic acid) on miscibility temperature.	6	1,4
3.4	Construction of phase diagrams of three component systems with one pair of partially miscible liquids.	6	1,4
<b>4.0</b>	<b>Distribution Law</b>	<b>18</b>	<b>1,5</b>
4.1	Distribution coefficient of iodine between an organic solvent and water.	6	1,5
4.2	Distribution coefficient of benzoic acid between benzene and water	6	1,5
4.3	Determination of the equilibrium constant of the reaction $KI + I_2 \leftrightarrow KI_3$	6	1,5
<b>5.0</b>	<b>Computational Chemistry Experiments</b>	<b>72</b>	<b>1,5</b>
5.1	Single point energy calculations	12	1,5
5.2	Geometry optimization calculations	12	1,5
5.3	3. Frequency calculations	12	1,5
5.4	Basis set effects	12	1,5
5.5	Predicting Ionization energy, electron affinity, proton affinity and atomization energies.	12	1,5
5.6	Studying chemical reactions and reactivity	12	1,5

#### References:

1. J.B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 2001.
2. G.W. Garland, J.W. Nibler, D.P. Shoemaker, Experiments in Physical Chemistry, 8<sup>th</sup>Edn., McGraw Hill, 2009.
3. J.B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 2001.
4. G.W. Garland, J.W. Nibler, D.P. Shoemaker, Experiments in Physical Chemistry, 8th Edn., McGraw Hill, 2009.
5. James B. Foresman and Aeleen Frisch, Exploring Chemistry With Electronic Structure Methods: A Guide to Using Gaussian, Gaussian, second edition, 1996
6. Gaussian 09, Revision A.02, M. J. Frisch*et al.*,

## SEMESTER III

Course	Details				
Code	AN1923109				
Title	<b>SOLID STATE CHEMISTRY AND INTRODUCTION TO MATERIAL SCIENCE</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	2/III				
Type	Core Course				
Credits	4	Hrs/Week	4	Total Hours	72

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Recapitulate and summarize Crystal structure and crystal defects.	U	1,3
2	Correlate Crystal structure to the electrical, magnetic and optical properties of inorganic compounds and Superconductivity.	Ap	2,4
3	Understand Inorganic Chains, Rings, Cage and Cluster compounds their synthesis, structure and bonding.	An	1,3
4	Distinguish between different types of Organometallic polymers-their synthesis and importance.	U	1,2
5	Identify the different methods of synthesis for various Solid materials	U	1,2
6	Explain the properties of magnetic nanoparticles and their important applications.	U	2,3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO. No.
<b>1.0</b>	<b>Solid State Chemistry</b>	<b>18</b>	
1.1	Different crystal structures with special emphasis on the structures of Zinc blende, Wurtzite, Rutile, fluorite, antiferite, Nickel Arsenide, Perovskite and Ilmenite. Spinels. Crystal defects – Stoichiometric and non-stoichiometric Line defects, point defects and plane defects.	6	1
1.2	Solid state reactions-Mechanism of diffusion, Diffusion	6	1

	coefficient, vacancy diffusion, Thermal decomposition of solid-Type I reactions, Type II reactions.		
1.3	Phase transition in solids: classification of phase transitions-first and second order phase transitions, Martensitic transformations, order-disorder transitions and spinodal decomposition. Kinetics of phase transitions, sintering. Growing single crystals-crystal growth from solution, growth from melts and vapor deposition technique.	6	1
<b>2.0</b>	<b>Electrical, Magnetic and Optical Properties of Solids</b>	<b>18</b>	
2.1	Kronig-Penney model, Free electron theory, Zone theory and MO theory of solids Band theory of solids- Applications to Transition metal compounds and compounds like NaCl, MgO and fullerenes. Energy bands-conductors and non-conductors, Mechanism of intrinsic and extrinsic semiconductors. Mobility of charge carriers- Hall Effect (derivation required). Piezo-electricity, pyroelectricity and ferro electricity- hysteresis. Conductivity of pure metals.	5	2
2.2	Magnetic properties of transition metal oxides, garnets, spinels, ilmenites and perovskites, magnetoplumbites.	4	2
2.3	Optical properties-photoconductivity, photovoltaic effects, luminescence. Applications of optical properties-phosphors, solid state lasers and solar cells.	4	2
2.4	Super conductivity-Type I and Type II superconductors, Meisner effect, BCS theory of superconductivity (derivation not required)-Cooper pairs. High temperature superconductors, super conducting cuprates - YBaCu oxide system. Josephson's Junction, conventional superconductors, organic superconductors, fullerenes, carbon nanotubes and graphenes.	5	2,3
<b>3.0</b>	<b>Inorganic Chains, Rings, Cage, Clusters</b>	<b>18</b>	
3.1	Chains - catenation, heterocatenation. Silicones. Zeolites-synthesis, structure and applications. Isopoly acids of vanadium, molybdenum and tungsten. Heteropoly acids of Mo and W. Polythiazil-one dimensional conductors. Infinite metal chains.	5	1,3
3.2	Rings-topological approach to boron hydrides, Styx numbers. Heterocyclic inorganic ring systems- structure and bonding in phosphorous-sulphur and sulphur-nitrogen compounds. Homocyclic inorganic ring systems-structure and bonding in sulphur, selenium and phosphorous compounds.	5	1
3.3	Synthesis, structure and bonding of cage like structures of phosphorous. Boron cage compounds-Wade MingosLauher rules, MNO rule, boranes, carboranes, metallocarboranes.	8	1,3

	Aluminium, indium and gallium clusters, Cages and clusters of germanium, tin and lead, Cages and clusters of tellurium, Mercuride clusters in amalgams. Medical applications of boron clusters- nucleic acid precursors, DNA binders, application of C2B10 for Drug Design, Nuclear Receptor Ligands Bearing C2B10 Cages.		
<b>4.0</b>	<b>Organometallic Polymers</b>	<b>9</b>	
4.1	Polymers with organometallic moieties as pendant groups, polymers with organometallic moieties in the main chain, condensation polymers based on ferrocene and on rigid rod polyynes, poly(ferrocenylsilane)s, applications of Poly(ferrocenylsilane)s and related Polymers, applications of Rigid-Rod Polyynes, Polygermanes and Polystannanes polymers prepared by ring opening polymerization, organometallic dendrimers.	9	2,4
<b>5.0</b>	<b>Magnetic Nanoparticles and Synthesis of Solids</b>	<b>9</b>	
5.1	Synthesis of Solids: Nucleation, Growth, epitaxy and topotaxy. Methods for the synthesis of MgAl <sub>2</sub> O <sub>4</sub> , silica glass, indium tin oxide and their coatings, zeolites and alumina based abrasives, hydrothermal synthesis, intercalation and deintercalation. Preparation of thin films, electrochemical methods, chemical vapour deposition. Synthesis of amorphous silica and diamond films- sputtering and laser ablation.	5	2,4
5.2	Magnetic nanoparticles, superparamagnetism and thin films, applications of magnetic nanoparticles- data storage, Magnetic Resonance Imaging (MRI) and Contrast Enhancement using magnetic nanoparticles, biomedical applications of magnetic nanoparticles.	4	2,4

## References:

1. L.V. Azaroff, Introduction to Solids, McGraw Hill, 1984.
2. A.R. West, Solid State Chemistry and its Applications, Wiley-India, 2007.
3. D.K. Chakrabarty, Solid State Chemistry, New Age Pub., 2010.
4. D.M. Adams, Inorganic Solids: An Introduction to Concepts in Solid State Structural Chemistry, Wiley, 1974.
5. C.N.R. Rao, K.J. Rao, Phase Transitions in Solids, McGraw Hill, 2010.
6. B.E. Douglas, D.H. McDaniel, J.J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn., John Wiley & sons, 2006.
7. Earnshaw, Introduction to Magnetochemistry, Academic Press, 1968.
8. J.E. Huheey, E.A. Keiter, R.L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, 4<sup>th</sup>Edn., Harper Collins College Pub., 1993.
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10. K.F. Purcell, J.C. Kotz, Inorganic Chemistry, Holt-Saunders, 1977.

11. WaiKee Li, Gong-Du Zhou, Thomas Chung WaiMak, *Advanced Structural Inorganic Chemistry*, International Union of Crystallography, 2008.
12. Matthias Driess, Heinrich Nöth, *Molecular Clusters of the Main Group Elements*, Wiley-VCH, 2004.
13. Richard J.D. Tilley, *Understanding Solids*, 2nd edition, Wiley, 2013.
14. G.L. Hornyak, J.J. Moore, H.F. Tibbals, J. Dutta, *Fundamentals of Nanotechnology*, CRC Press, 2009.
15. Chris Binns, *Introduction to nanoscience and nanotechnology*, Wiley, 2010.
16. Vadapalli Chandrasekhar, *Inorganic and organometallic polymers*, Springer, 2005.
17. Anthony R. West, *Basic Solid State Chemistry*, John Wiley and Sons, 1988.

Course	Details				
Code	AN1923110				
Title	NOVEL SYNTHETIC STRATEGIES AND RETROSYNTHETIC APPROACHES				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	2/III				
Type	Core Course				
Credits	4	Hrs/Week	4	Total Hours	72

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	To learn the various synthetic strategies	Ap	1
2	Employment of the methods in carbocycle and heterocycle synthesis	An	2
3	To understand the retrosynthetic approach	C	1
4	To apply the synthetic strategies in the mimicking of biological systems.	Ap	1,3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Organic Synthesis via Oxidation and Reduction</b>	<b>18</b>	
1.1	Survey of organic reagents and reactions in organic chemistry with special reference to oxidation and reduction. Metal based and non-metal based oxidations of (a) alcohols to carbonyls (Chromium, Manganese, aluminium and DMSO based reagents) (b) alkenes to epoxides (peroxides/per acids based)-Sharpless asymmetric epoxidation, Jacobsen epoxidation, Shi epoxidation (c) alkenes to diols (Manganese and Osmium based)-Prevost reaction and Woodward modification (d) alkenes to carbonyls with bond cleavage (Manganese and lead based, ozonolysis) (e) alkenes to alcohols/carbonyls without bond cleavage hydroboration-oxidation, Wacker oxidation, selenium/chromium based allylic oxidation (f) ketones to ester/lactones- Baeyer-Villiger oxidation.	9	1
1.2	(a) Catalytic hydrogenation (Heterogeneous: Palladium/Platinum/Rhodium and Nickel. Homogeneous: Wilkinson). (b) Metal based reductions- Birch	9	1

	reduction, pinacol formation, acyloin formation (c) Hydride transfer reagents from Group III and Group IV in reductions - LiAlH <sub>4</sub> , DIBAL-H, Red-Al, NaBH <sub>4</sub> and NaCNBH <sub>3</sub> , selectrides, trialkylsilanes and trialkylstannane. Meerwein-Ponndorf-Verley reduction. Baker's yeast.		
<b>2.0</b>	<b>Modern Synthetic Methods and Reagents</b>	<b>18</b>	
2.1	Baylis-Hillman reaction, Henry reaction, Nef reaction, Kulinkovich reaction, Ritter reaction, Sakurai reaction, Tishchenko reaction, Ugi reaction, Noyori reaction. Brook rearrangement. Tebbe olefination. Metal mediated C-C and C-X coupling reactions: Heck, Stille, Suzuki, Suzuki-Miyaura, Negishi-Sonogashira, Nozaki-Hiyama, Buchwald-Hartwig, Ullmann and Glaser coupling reactions. Wohl-Ziegler reaction. Reagents such as NBS, DDQ and DCC. Gilman reagent.	15	1
2.2	Introduction to multicomponent reactions-Click reactions.	3	1
<b>3.0</b>	<b>Construction of Carbocyclic and Heterocyclic Ring Systems &amp; Protecting Group Chemistry</b>	<b>18</b>	
3.1	Different approaches towards the synthesis of three, four, five and six-membered rings. Photochemical approaches for the synthesis of four membered rings, oxetanes, and cyclobutanes, ketene cycloaddition (inter and intra molecular), Pauson-Khand reaction, Volhardt reaction, Bergman cyclization, Nazarov cyclization, Mitsunobu reaction, cation-olefin cyclization and radical-olefin cyclization.	3	2
3.2	Inter-conversion of ring systems (contraction and expansion)-Demjenov reaction, Reformatsky reaction. Construction of macrocyclic rings-ring closing metathesis.	3	2
3.3	Formation of heterocyclic rings: 5-membered ring heterocyclic compounds with one or more than one hetero atom like N, S or O - pyrrole, furan, thiophene, imidazole, thiazole and oxazole.	3	2
3.4	Protection and deprotection of hydroxy, carboxyl, carbonyl, and amino groups. Chemo and regio selective protection and deprotection. Illustration of protection and deprotection in synthesis.	3	2
3.5	Protection and deprotection in peptide synthesis: common protecting groups used in peptide synthesis, protecting groups used in solution phase and solid	3	2

	phaseptide synthesis (SPPS).		
3.6	Functional equivalence and reactivity Umpolung. Role of trimethyl silyl group inorganic synthesis.	3	2
<b>4.0</b>	<b>Reterosynthetic Analysis</b>	<b>9</b>	
4.1	Basic principles and terminology of reterosynthesis: synthesis of aromatic compounds, one group and two group C-X disconnections, one group C-C and two group C-C disconnections.	3	3
4.2	Amine and alkene synthesis: important strategies of retrosynthesis, functional group transposition, important functional group interconversions. Enantioselective synthesis of Corey lactone, longifolene and luciferin. Umpolung equivalent - Peterson olefination, enolate formation, Ireland method.	6	3
<b>5.0</b>	<b>Biosynthesis and Bio-mimetic Synthesis.</b>	<b>9</b>	
5.1	Basic principles of the biosynthesis of terpenes, steroids, alkaloids, carbohydrates, proteins and nucleic acids.	2	4
5.2	Biosynthesis of cholesterol, $\alpha$ -terpineol, morphine, glucose and phenyl alanine	4	4
5.3	Biogenesis of isoprenoids and alkaloids. Biomimetic synthesis of progesterone and sparteine.	3	4

## References:

01. M.B. Smith, Organic Synthesis, 3rd Edn., Wavefunction Inc., 2010.
02. F.A. Carey, R. I. Sundberg, Advanced Organic Chemistry, Part A and B, 5th Edn., Springer, 2007.
03. S. Warren, P. Wyatt, Organic Synthesis: The disconnection Approach, 2nd Edn., Wiley, 2008.
04. V.K. Ahluwalia, Oxidation in Organic Synthesis, CRC Press, 2012.
05. I. Ojima, Catalytic Asymmetric Synthesis, 3rd Edn., John Wiley & Sons, 2010. 36
06. W. Carruthers, I. Coldham, Modern Methods of Organic Synthesis, 4th Edn., Cambridge University Press, 2004.
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08. R. Noyori, Asymmetric Catalysis in Organic Synthesis, John Wiley & Sons, 1994.
09. L. Kuerti, B. Czako, Strategic Applications of Named Reactions in Organic Synthesis, Elsevier Academic Press, 2005.
10. R.O.C. Norman, J.M. Coxon, Principles of Organic Synthesis, 3rd Edn., Chapman and Hall, 1993.
11. V.K. Ahluwalia, L.S. Kumar, S. Kumar, Chemistry of Natural Products, CRS Press, 2007.

Course	Details				
Code	AN1923111				
Title	<b>SELECTED TOPICS IN PHYSICAL CHEMISTRY</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	1/III				
Type	Core Course				
Credits	4	Hrs/Week	4	Total Hours	72

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Apply elementary laws of chemical kinetics and analyze reaction mechanisms.	Ap	1
2	Evaluate and plot equations and functions representing the kinetic behavior of a chemical system	An	1
3	Identify the type of crystal structure in solids and the behavior of liquid crystals	U	1
4	Solve problems on electrochemical cell parameters, electrochemical active surface area, current and overpotential under given condition	Ap	1 2
5	Impart advanced knowledge of adsorption processes and catalysis at solid surfaces, and to apply this to describe the kinetics of catalysed reactions.	U	2
6	Describe various colloidal systems and their structural properties	R	1
7	Explain theory and practices of photochemical and photophysical methods, and apply these methods in quantitative calculations	E	1 3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Chemical Kinetics and Catalysis</b>	<b>27</b>	
1.1	Theories of reaction rates: collision theory-steric factor, potential energy surfaces. Conventional transition state theory-Eyring equation. Comparison of the two theories. Thermodynamic formulation of the two theories. Thermodynamic formulation of the	5	1

	reaction rates. Significance of $\Delta G^\ddagger$ , $\Delta H^\ddagger$ and $\Delta S^\ddagger$ . Volume of activation. Effect of pressure and volume on velocity of gas reactions.		
1.2	Various theories of unimolecular reactions (Lindemann-Hinshelwood mechanism, RRK, RRKM theories), chain reactions: free radical and chain reactions, steady state treatment, kinetics of $H_2-Cl_2$ and $H_2-Br_2$ thermal and photochemical reactions, Rice-Herzfeld mechanism, branching chains $H_2-O_2$ , Semenov-Hinshelwood mechanism of explosive reactions, mechanisms of step growth, ionic and addition polymerization, kinetics of anionic and cationic polymerization	7	1,2
1.3	Fast reactions: relaxation, flow and shock methods, flash photolysis, NMR and ESR methods of studying fast reactions.	2	1,2
1.4	Reactions in solution: factors determining reaction rates in solutions, effect of dielectric constant and ionic strength, cage effect, Bronsted-Bjerrum equation, primary and secondary kinetic salt effect, influence of solvent on reaction rates, significance of volume of activation, linear free energy relationship, kinetic isotope effect.	4	1
1.5	Acid-base catalysis: specific and general catalysis, Skrabal diagram, Bronsted catalysis law, prototropic and protolytic mechanism with examples, acidity function.	3	1,2
1.6	Enzyme catalysis and its mechanism, Michelis-Menten equation, effect of pH and temperature on enzyme catalysis	3	1,2
1.7	Mechanisms of heterogeneous catalysis: unimolecular and bimolecular surface reactions	3	1,2
<b>2.0</b>	<b>Electrochemistry and Electromotive Force</b>	<b>9</b>	
2.1	Theories of ions in solution, Drude and Nernst's electrostriction model and Born's model, Debye-Huckel theory, Derivation of Debye-Huckel-Onsager equation, validity of DHO equation for aqueous and non aqueous solutions, Debye-Falkenhagen effect, conductance with high potential gradients, activity and activity coefficients in electrolytic solutions, ionic strength, Debye-Huckel limiting law and its various forms, qualitative and quantitative tests of Debye-Huckel limiting equation, deviations from the DHLL.	5	4

2.2	Polarization - electrolytic polarization, dissolution and decomposition potential, concentration polarization, overvoltage, hydrogen and oxygen overvoltage, mechanism of anodic and cathodic processes (theories of overvoltage), Butler- Volmer equation for simple electron transfer reactions, transfer coefficient, exchange current density, rate constants, Tafel equation and its significance.	4	4
<b>3.0</b>	<b>Crystallography</b>	<b>9</b>	
3.1	Methods of characterizing crystal structure, rotating crystal method, powder Xray diffraction method, determination of structure of sodium chloride by powder method, comparison of the structures of NaCl and KCl, brief outline of single crystal X-ray diffraction and crystal growth techniques.	5	3
3.2	Structure factor: atomic scattering factor, coordinate expression for structure factor, structure by Fourier synthesis	2	3
3.3	Liquid crystals: mesomorphic state, types, examples and applications of liquid crystals. Theories of liquid crystals. Photoconductivity of liquid crystals.	2	3
<b>4.0</b>	<b>Surface Chemistry</b>	<b>9</b>	
4.1	Different types of surfaces, thermodynamics of surfaces, Gibbs adsorption equation and its verification, surfactants and micelles, general properties of emulsions, foam structure, aerosols, surface films, surface pressure and surface potential and their measurements and interpretation. Application of low energy electron diffraction and photoelectron spectroscopy, ESCA and Auger electron spectroscopy, scanning probe microscopy, ion scattering, SEM and TEM in the study of surfaces.	5	5
4.2	Adsorption: Langmuir theory, kinetic and statistical derivation, multilayer adsorption-BET theory, Use of Langmuir and BET isotherms for surface area determination. Application of Langmuir adsorption isotherm in surface catalysed reactions, the Eley-Rideal mechanism and the Langmuir-Hinshelwood mechanism, flash desorption.	2	5
4.3	Colloids: Zeta potential, electrokinetic phenomena, sedimentation potential and streaming potential, Donnan membrane equilibrium.	2	6
<b>5.0</b>	<b>Photochemistry</b>	<b>18</b>	

5.1	Quantum yield, chemical actinometry, excimers and exciplexes, photosensitization, chemiluminescence, bioluminescence, thermoluminescence, pulse radiolysis, hydrated electrons, photostationary state, dimerization of anthracene, ozone layer in the atmosphere.	8	7
5.2	Principle of utilization of solar energy, solar cells and their working.	2	7
5.3	Quenching of fluorescence and its kinetics, Stern-Volmer equation, concentration quenching, fluorescence and structure, delayed fluorescence, E-type and P-type, effect of temperature on emissions, photochemistry of environment, green house effect, two photon absorption spectroscopy, lasers in photochemical kinetics.	8	7

#### References:

01. J. Rajaram, J.C. Kuriakose, Kinetics and Mechanisms of Chemical Transformations, Macmillan India, 2000.
02. K.J. Laidler, Chemical kinetics, 3rd Edn., Harper&Row, 1987.
03. C. Kalidas , Chemical Kinetic Methods: Principles of Fast Reaction Techniques and Applications, New Age International, 2005.
04. J.W. Moore, R. G. Pearson, Kinetics and Mechanisms, John Wiley & Sons, 1981.
05. P.W. Atkins, Physical Chemistry, ELBS, 1994.
06. D.A. McQuarrie, J.D. Simon, Physical chemistry: A Molecular Approach, University Science Books, 1997
07. S. Glasstone, Introduction to Electrochemistry, Biblio Bazar, 2011.
08. D. R. Crow, Principles and Applications of Electrochemistry, 4th Edn., S. Thornes, 1994.
09. B.K. Sharma, Electrochemistry, Krisna Prakashan, 1985.
10. L.V. Azaroff, Introduction to Solids, Mc Graw Hill, 1984.
11. D.K. Chakrabarty, Solid State Chemistry, New Age Pub., 2010.
12. A.R. West, Basic Solid State Chemistry, John Wiley & Sons, 1999.
13. A.W. Adamson, A.P. Gast, Physical Chemistry of Surfaces, 6th Edn., John Wiley & sons, 1997.
14. K.K. Rohatgi-Mukherjee, Fundamentals of photochemistry, 2nd Edn., New Age International, 1986.
15. G. Aruldhas, Molecular structure and Spectroscopy, PHI Learning, 2007

Course	Details				
Code	AN1923112				
Title	ADVANCED SPECTROSCOPIC TECHNIQUES				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	2/III				
Type	Core Course				
Credits	3	Hrs/Week	3	Total Hours	54

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Learn the basic principles of interpret uv-visible, chiroptical, vibrational, 1-D and 2-D NMR and Mass spectroscopy for the structure identification of organic compounds	U	1, 2, 3
2	Analyze and interpret uv-visible, chiroptical, vibrational, 1-D and 2-D NMR and Mass spectral data of organic compounds	An	1, 2, 3
3	Evaluate various structural possibilities and arrive at the most logical structure of organic compounds by analysis and interpretation of uv-visible, chiroptical, vibrational, 1-D and 2-D NMR and Mass spectral data.	E	1, 2, 3
4	Identify the structure of organic compounds by analysis and interpretation of uv-visible, chiroptical, vibrational, 1-D and 2-D NMR and Mass spectral data.	An	1, 2, 3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Ultraviolet-Visible and Chiroptical Spectroscopy</b>	<b>9</b>	<b>1,2</b>
1.1	Energy levels and selection rules, Woodward-Fieser and Fieser-Kuhn rules.	1	1
1.2	Influence of substituent, ring size and strain on spectral characteristics. Solvent effect, Stereochemical effect, non-conjugated interactions.	3	1
1.3	Chiroptical properties - ORD, CD, plane curves, Cotton effect, octant rule, axial haloketone rule, assignment of configuration of chiral molecules.	3	1

	Problems based on the above topics.	2	2
<b>2.0</b>	<b>Infrared Spectroscopy</b>	<b>9</b>	<b>1,2,3</b>
2.1	Fundamental vibrations, characteristic regions of the spectrum (fingerprint and functional group regions), influence of substituent, ring size, hydrogen bonding, vibrational coupling and field effect on frequency, determination of stereochemistry by IR technique.	7	1
2.2	IR spectra of C=C bonds (olefins and arenes) and C=O bonds.	1	1
2.3	Problems on spectral interpretation with examples.	1	2,3
<b>3.0</b>	<b>Nuclear Magnetic Resonance Spectroscopy</b>	<b>18</b>	<b>1,2,3</b>
3.1	NMR phenomenon, <sup>1</sup> H nucleus, Zeeman splitting, RF absorption, Larmor precession, relaxation processes, Chemical shift and shielding/deshielding, factors affecting chemical shift, chemical and magnetic non-equivalence, local diamagnetic shielding and magnetic anisotropy.	4	1
3.2	Spin coupling: Spin coupling and peak splitting pattern, Pascal's triangle, Pople notation - AX, AX <sub>2</sub> , AX <sub>3</sub> , A <sub>2</sub> X <sub>3</sub> , AB, ABC, AMX type coupling, first order and non-first order spectra, coupling constant, mechanism of coupling, geminal, vicinal and long range coupling, Dirac model, Karplus curve, quadrupole broadening and decoupling, homoallylic coupling, propargylic coupling, deceptive simplicity, virtual coupling, diastereomeric protons.	6	1
3.3	<sup>13</sup> C NMR: <sup>13</sup> C nucleus, natural abundance, sensitivity, <sup>13</sup> C chemical shift and structure correlation, proton coupled <sup>13</sup> C spectra, proton decoupled <sup>13</sup> C spectra, broad band decoupling, rotating frame of reference, mechanism of heteronuclear decoupling, cross polarization, NOE.	3	1
3.4	Simplification non-first order spectra to first order spectra: shift reagents, spin decoupling and double resonance, off resonance decoupling.	1	1
3.5	2D NMR and COSY, HOMOCOSY and HETEROCOSY – HETCOR and HMQC.	1	1
3.6	Polarization transfer, DEPT, selective Population Inversion, INEPT, MRI.	2	1
3.7	Problems on spectral interpretation with examples.	1	2,3
<b>4.0</b>	<b>Mass Spectrometry</b>	<b>9</b>	<b>1,2,3</b>
4.1	Molecular ion: basic principles, ion production methods (EI). Soft ionization methods: SIMS, FAB, CA, MALDI, PD, Field Desorption, Electrospray	8	1

	Ionization, isotope abundance, Fragmentation patterns-nitrogen and ring rules. McLafferty rearrangement and its applications. HRMS, MS-MS, LC-MS, GC-MS.		
4.2	Problems on spectral interpretation with examples.	1	2,3
<b>5.0</b>	<b>Structural Elucidation Using Spectroscopic Techniques</b>	<b>9</b>	<b>1,2,3,4</b>
5.1	Index of hydrogen deficiency, rule of thirteen	1	1
5.2	Identification of structures of unknown organic compounds based on the data from UV-Vis, IR, <sup>1</sup> H NMR and <sup>13</sup> C NMR spectroscopy (HRMS data or Molar mass or molecular formula may be given).	6	2,3,4
5.3	Interpretation of the given UV-Vis, IR and NMR spectra.	2	2

### References:

1. D.L. Pavia, G.M. Lampman, G.S. Kriz, Introduction to Spectroscopy, 3rd Edn., Brooks Cole, 2000.
2. A.U. Rahman, M.I. Choudhary, Solving Problems with NMR Spectroscopy, Academic Press, 1996.
3. L. D. Field, S. Sternhell, J. R. Kalman, Organic Structures from Spectra, 4th Edn., John Wiley & sons, 2007.
4. C.N. Banwell, E.M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edn., Tata McGraw Hill, 1994.
5. D.F. Taber, Organic Spectroscopic Structure Determination: A Problem Based Learning Approach, Oxford University Press, 2007.
6. H. Gunther, NMR Spectroscopy, 2nd Edn., Wiley, 1995.
7. R.M. Silverstein, G.C. Bassler, T.C. Morrill, Spectroscopic Identification of Organic Compounds, 5th Edn., Wiley, 1991.
8. D.H. Williams, I. Fleming, Spectroscopic Methods in Organic Chemistry, 6th Edn., McGraw-Hill, 2008.
9. W. Kemp, Organic Spectroscopy, 2nd Edn., Macmillan, 1987.
10. F. Bernath, Spectra of Atoms and Molecules, 2nd Edn., Oxford University Press, 2005.
11. E.B. Wilson Jr., J.C. Decius, P.C. Cross, Molecular Vibrations: The Theory of Infrared and Raman Vibrational Spectra, Dover Pub., 1980.
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Course	Details				
Code	AN1924604				
Title	INORGANIC CHEMISTRY PRACTICAL- II				
Degree	M.Sc.				
Branch(s)	Analytical chemistry				
Year/Semester	2/III&IV				
Type	Practical				
Credits	3	Hrs/Week	3	Total Hours	54

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	To know the various methods used to estimate binary mixtures.	U	1,3
2	Develop laboratory skills in analyzing samples of different alloys like Brass, Bronze, Coin alloy etc and find its composition.	Ap	3
3	Identify different minerals and estimate the percentage of the parent element present in it by suitable analytical methods.	Ap	3
3	Application of safety and chemical hygiene regulations and practices.	Ap	2,3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Separation and estimation of two different metal ions</b>	<b>54</b>	
1.1	Estimation of simple binary mixtures (like Cu-Ni, Cu-Zn, Fe-Cr, Fe-Cu, Fe-Ni, Pb-Ca) of metallic ions in solution by volumetric and gravimetric methods	54	1,2,3
<b>2.0</b>	<b>Determination of the composition of Alloy</b>	<b>27</b>	
2.1	Analysis of one of the alloys of brass, bronze and solder and estimate the percentage composition.	27	1,2,3
<b>3.0</b>	<b>Analysis of Ore</b>	<b>27</b>	
3.1	Analysis of one of the ores from hematite, chromite, dolomite, monazite, ilmenite.	27	1,2,3

**Course Text:**

Vogel's text book of quantitative chemical analysis; 5<sup>th</sup> edition

**References:**

01. I.M. Kolthoff, E.B. Sandell, Text Book of Quantitative Inorganic Analysis, 3rd Edn., Mc Millian, 1968.
02. G. Pass, H. Sutcliffe, Practical Inorganic Chemistry, Chapman & Hall, 1974.
03. N.H. Furman, Standard Methods of Chemical Analysis: Volume 1, Van Nostrand, 1966.
04. F.J. Welcher, Standard Methods of Chemical Analysis: Vol. 2, R.E. Kreiger Pub., 2006

Course	Details				
Code	AN1924605				
Title	<b>ORGANIC CHEMISTRY PRACTICAL-II</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	2/III&IV				
Type	Practical				
Credits	3	Hrs/Week	3	Total Hours	54

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Quantitatively analyze the mass and various parameters of substrates present in many organic compounds.	Ap	1
2	Synthesise organic compounds in atom economy level with less time	An	3
3	Analyze various unknown spectrums	C	2
4	Prepare organic compounds in an environmental friendly way	C	1

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Standard Quantitative Analysis</b>	<b>40</b>	
1.1	Standard quantitative analysis of milk, butter, oils, fats, starch, glucose, vitamins and medicinal preparations.	20	1
1.2	Estimation of the number of acetyl, methoxyl, phenolic, amino, nitro, carboxyl, ester, ether and carbonyl groups in organic compounds	20	1
<b>2.0</b>	<b>Designing of multistep Synthetic Sequences with mechanism</b>	<b>10</b>	1
<b>3.0</b>	<b>Prediction of the structure of unknown compounds using IR, <math>^1\text{H}</math> NMR, <math>\text{C}^{13}</math> NMR spectrum</b>	<b>10</b>	
3.1	About 50 compounds have to be practiced	10	3
<b>4.0</b>	<b>Microwave assisted organic Synthesis</b>	<b>30</b>	2
<b>5.0</b>	<b>Multi Step preparations by the Green Alternatives of Chemical Method</b>	<b>18</b>	4

## References:

01. A.I. Vogel, a Textbook of Practical Organic Chemistry, Longman, 1974.
02. A.I. Vogel, Elementary Practical Organic Chemistry, Longman, 1958.
03. F.G. Mann and B.C Saunders, Practical Organic Chemistry, 4th Edn. Pearson Education India, 2009.
04. J.R. Adams, J.R. Johnson, J.F. Wilcox, Laboratory Experiments in Organic Chemistry, Macmillan, 1979.
05. V.K ahluwalia, Green Chemistry: Environmentally Benign Reactions, Ane Books, 2009
06. Monograph on green Chemistry Laboratory Experiments, Green chemistry Task Force Committee, DST, 2009

Course	Details				
Code	AN1924606				
Title	<b>INSTRUMENTAL ANALYSIS PRACTICAL</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	2/ III & IV				
Type	Practical				
Credits	3	Hrs/Week	4	Total Hours	72

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Determine the concentration of sulphate and halides using Nephelometry.	E	3
2	Determine the rate constant of first and second order reactions.	E	3
3	Examine the influence of ionic strength on rate constant.	Ap	3
4	Determine the concentrations of acid, sugar solutions, and to determine rate constant of inversion of cane sugar in the presence of HCl by polarimetry	E	3
5	Determine the concentrations and molar refractions using refractive index measurements.	E	3
6	Show the complex formation between mercuric iodide and KI by refractometry.	Ap	3
7	Determine the half wave potential, organic compounds and to determine Cd by Polarography	E	3
8	Determine the concentration of acid, mixture of acids, degree of ionization etc using conductivity experiments and to verify Onsager Equation.	E	3
9	Determine the concentration of acid, mixture of acids, and mixture of halides by potentiometric measurements.	E	3
10	Estimate the amount of Cu, Ni and Pb by electrogravimetry	An	3
11	Determine the concentration of Na <sup>+</sup> , K <sup>+</sup> , Li <sup>+</sup> and Ca <sup>2+</sup> ions by flame photometry.	E	3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO. No.
<b>1.0</b>	<b>Nephelometry</b>	<b>2</b>	
1.1	Determination of sulphate	1	1
1.2	Determination of halides	1	1
<b>2.0</b>	<b>Chemical Kinetics</b>	<b>36</b>	
2.1	Determination of the rate constant of the hydrolysis of ester by NaOH.	8	2
2.2	Determination of Arrhenius parameters.	8	2
2.3	Kinetics of reaction between $K_2S_2O_8$ and KI.	8	2
2.4	Influence of ionic strength on the rate constant of the reaction between $K_2S_2O_8$ and KI.	8	3
2.5	Iodination of acetone in acid medium.	4	2
<b>3.0</b>	<b>Polarimetry</b>	<b>24</b>	
3.1	Kinetics of the inversion of sucrose in presence of HCl.	8	4
3.2	Determination of concentration of sugar solution.	4	4
3.3	Determination of the concentration of HCl.	8	4
3.4	Determination of the relative strength of acids.	4	4
<b>4.0</b>	<b>Refractometry</b>	<b>18</b>	
4.1	Identification of pure organic liquids and oils.	2	5
4.2	Determination of molar refraction of pure liquids.	4	5
4.3	Determination of concentration of solutions(KCl-Water,Glycerol-Water)	4	5
4.4	Determination of molar refraction of solids.	4	5
4.5	Study of complex formation between KI and $HgI_2$ system.	4	6
<b>5.0</b>	<b>Polarography And Related Experiments</b>	<b>6</b>	
5.1	Determination of half wave potential.	2	7
5.2	Determination of Cd by (a) standard series (b) standard addition (c) pilot ion method.	2	7
5.3	Determination of organic compounds.	2	7
<b>6.0</b>	<b>Conductivity Measurements</b>	<b>26</b>	
6.1	Verification of Onsager equation.	4	8
6.2	Determination of degree of ionization of weak electrolytes.	4	8
6.3	Determination of Pka value of organic acids.	2	8
6.4	Determination of solubility of sparingly soluble salts.	4	8
6.5	Titration of a mixture of acids against a strong base.	8	8
6.6	Titration of a dibasic acid against a strong base.	4	8
<b>7.0</b>	<b>Potentiometry</b>	<b>18</b>	
7.1	Determination of single electrode potentials (Cu and Zn).	2	9
7.2	Application of Henderson Equation.	4	9
7.3	Titration of a mixture of acids against a strong base.	4	9
7.4	Determination of the concentrations of a mixture of $Cl^-$ and $I^-$ ions.	8	9

<b>8.0</b>	<b>Electrogravimetric Estimations</b>	<b>6</b>	
8.1	Electro gravimetric estimation of Cu	2	10
8.2	Electro gravimetric estimation of Ni	2	10
8.3	Electro gravimetric estimation of Pb	2	10
<b>9.0</b>	<b>Flame Photometry</b>	<b>8</b>	
9.1	Determination of Na <sup>+</sup> , K <sup>+</sup> , Li <sup>+</sup> and Ca <sup>2+</sup>	8	11

**References:**

1. J.B Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 2001
2. B. Viswanadhan, Practical Physical Chemistry, Viva Pub, 2005.
3. G.W Garland, J.W Nibler, D.P Shoemaker, Experiments in Physical Chemistry, 8<sup>th</sup>Edn, Mc. Graw Hill, 2009.

## SEMESTER IV

Course	Details				
Code	AN1924301				
Title	ANALYTICAL PROCEDURES				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	2/IV				
Type	Elective				
Credits	4	Hrs/Week	5	Total Hours	90

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	To understand the methods of data treatment and to apply the methods to solve the problems in sampling	Ap	3
2	Evaluate analytical data	E	3
3	To describe the different analytical procedures	U	2
4	To study about the applications of forensic science in chemistry	Ap	2
5	To understand the chemistry of food.	U	2
6	Describe about the methodology of science in general and chemistry in particular	U	1

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
1.0	<b>Data Analysis and Sampling.</b>	27	
1.1	Systematic and random errors, distribution of experimental results, statistical treatment- standard deviation, variance, confidence limits, application of statistics to data treatment and evaluation, student-t and f tests, detection of gross errors, rejection of a result-Q test, estimation of detection limits.	5	1
1.2	Least square method, correlation coefficient and its determination.	2	1
1.3	Hypothesis testing using statistical analysis.	1	1
1.4	Use of spread sheets for plotting calibration curves, quality assurance and control charts.	1	1
1.5	Basis and procedure of sampling, sampling statistics, sampling and physical state, crushing and grinding, gross sampling, size of the gross sample, sampling liquids, gas and	5	1

	solids (metals and alloys),		
1.6	Preparation of a laboratory sample, moisture in samples-essential and non-essential water, absorbed and occluded water, determination of water (direct and indirect methods).	4	1
1.7	Decomposition and dissolution, source of error, reagents for decomposition and dissolution like HCl, H <sub>2</sub> SO <sub>4</sub> , HNO <sub>3</sub> , HClO <sub>4</sub> , HF.	2	1
1.8	Microwave decompositions, combustion methods, use of fluxes like Na <sub>2</sub> CO <sub>3</sub> , Na <sub>2</sub> O <sub>2</sub> , KNO <sub>3</sub> , NaOH, K <sub>2</sub> S <sub>2</sub> O <sub>7</sub> , B <sub>2</sub> O <sub>3</sub> and lithium metaborate.	3	1
1.9	Elimination of interference from samples-separation by precipitation, electrolytic precipitation, extraction and ion exchange	3	1
1.10	Distribution ratio and completeness of multiple extractions, types of extraction procedures.	1	1
<b>2.0</b>	<b>Conventional Analytical Procedures</b>	<b>18</b>	
2.1	Gravimetry: Principle and procedure, inorganic and organic precipitating agents - examples.	2	2
2.2	Titrimetric analysis: Acid-base titration- theory, titration curves.	2	2
2.3	Titrations in non-aqueous media, different solvents and their selection for a titration, indicators for non-aqueous titrations.	3	2
2.4	Redox titration: Titrations involving typical titrants like KMnO <sub>4</sub> , K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> , Ce(IV), Mn(III), I <sup>-</sup> , Cl <sup>-</sup> and S <sub>2</sub> O <sub>3</sub> <sup>2-</sup> , redox indicators.	3	2
2.5	Precipitation titration: Titration curves, determination of end points (coloured precipitates, coloured soluble compounds), adsorption indicators.	3	2
2.6	Complexometric titration: Titration curves, types of EDTA titrations (direct, back, replacement, alkalimetric and exchange reactions), masking and demasking agents, metal ion indicators, murexide, eriochrome black T, Patton and Reeder's indicators, calcon, calmagite, xylenol orange.	5	2
<b>3.0</b>	<b>Environmental Analysis</b>	<b>18</b>	
3.1	Analytical procedures involved in environmental monitoring. Water quality- BOD, COD, DO, nitrite, nitrate, iron, fluoride.	4	3
3.2	Soil/Sediment analysis: Brief idea of chemistry of soil, trace element analysis in soil - B, Cd, Cu, Fe, Mn, Mo, Zn, Pb. Pesticides and pollution- classification and degradation of pesticides, methods of pesticide analysis. Sampling of soil, aquatic sediments, pH, electrical conductivity, redox potential, alkalinity, inorganic and organic contents.	4	3

3.3	Air pollution monitoring sampling, collection of air pollutants-SO <sub>2</sub> , NO <sub>2</sub> , NH <sub>3</sub> , O <sub>3</sub> and SPM.	2	3
3.4	Analysis of metals, alloys and minerals: Analysis of brass, steel and limestone. Corrosion analysis.	2	3
3.5	Toxicology of Cd, Pb, Hg, As, Se, Pu, oxides of nitrogen and sulphur, benzene, halogenated hydrocarbons, aromatic amino compounds, benzopyrene and related compounds, treatment of hazardous waste and their disposal.	6	3
<b>4.0</b>	<b>Food Chemistry and Forensic Science</b>	<b>18</b>	
4.1	Food adulteration and analysis: Common adulterants, detection of adulterated food by simple analytical techniques- flame photometry, atomic absorption, enzymatic methods, DSC, rapid methods of microbial analysis, immunoassays.	5	5
4.2	Food additives and flavours, food colours-permitted and non-permitted, beverages, soft drinks. Food poisons – natural poison, chemical poisons, first aid for poison consumed victims.	4	5
4.3	Forensic-basic principles and significance, finger printing-classification, conventional methods of development of finger prints-fluorescent and chemical methods, application of laser and other radiations for the development of latent finger print.	4	4
4.4	Documents- different types of forged signatures- inherent signs of forgery.	2	4
4.5	Counterfeiting -AAS analysis, Detection of gold purity in 22 carat-authenticity of diamond.	1	4
4.6	Forensic toxicology: Classification of poisons, estimation of poisons. Treatment in case of poisoning- use of antidotes for common poison.	2	4
<b>5.0</b>	<b>Research Methodology of Chemistry</b>	<b>9</b>	
5.1	The search of knowledge, purpose of research, scientific methods, role of theory, characteristics of research.	1	6
5.2	Types of research: Fundamental research, applied research, historical and experimental research.	1	6
5.3	Chemical literature: Primary, secondary and tertiary sources of literature. Classical and comprehensive reference. Literature databases: ScienceDirect, SciFinder, Chemical Abstract.	3	6
5.4	Scientific writing: Presentation of scientific data, research reports, thesis, journal articles, books. Types of publications: articles, communications, reviews.	3	6
5.5	Important scientific and chemistry journals, Impact factor.	1	6

## References:

1. J.M. Mermet, M. Otto, R. Kellner, Analytical chemistry, Wiley-VCH, 2004.
2. D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Fundamentals of Analytical Chemistry, 8<sup>th</sup>Edn., Saunders College Pub., 2007.
3. J.H. Kennedy, Analytical Chemistry: Principles, Saunders College Pub., 1990.
4. J.G. Dick, Analytical Chemistry, R.E. Krieger Pub., 1978.
5. G.H. Jeffery, J. Bassett, J. Mendham, R.C. Denney, Vogel's Text Book of Quantitative Chemical Analysis, 5<sup>th</sup>Edn., John Wiley & sons, 1989.
6. S.E. Manahan, Environmental chemistry, 9<sup>th</sup>Edn., CRC Press, 2010.
7. C.L. Wilson, D.W. Wilson, Comprehensive Analytical Chemistry, Elsevier, 1982.
8. G.D. Christian, J.E. O'Reilly, Instrumental Analysis, Allyn & Bacon, 1986.
9. R.A. Day, A.L. Underwood, Quantitative Analysis, 6<sup>th</sup>Edn., Prentice Hall, 1991.
10. A.I. Vogel, A Textbook of Practical Organic Chemistry, Longman, 1974.
11. D.C. Harris, Quantitative Chemical Analysis, 7<sup>th</sup>Edn., W.H. Freeman & Co., 2011.
12. K.W. Kolasinski, Surface Science: Foundations of Catalysis and Nanoscience, 2<sup>nd</sup>Edn., Wiley, 2009.
13. F.W. Fifield, D. Kealey, Principles and Practice of Analytical Chemistry, Blackwell Science, 2000.
14. W. Horwitz (Editor), Official Method of Analysis of AOAC International, 18<sup>th</sup>Edn., AOAC, 2010
15. British Pharmacopeia, TSO, 2012.
16. B.B. Nanda, R.K. Tewari, Forensic Science in India: A Vision for the Twenty-first Century, Select Pub., 2001.
17. A.S. Osborn, Questioned Documents, 2<sup>nd</sup>Edn., Rawman & Littlefield Pub., 1974.
18. M.K. Mehta, Identification of Thumb Impression and Cross Examination of Finger Print Experts, N.M. Tripathi Pub., 1963.
19. M. Johari, Identification of Firearms, Ammunition and Firearm Injuries, BPR & D, 1980.
20. J.D. DeHaan, Kirk's Fire Investigation, 5<sup>th</sup>Edn., Prentice Hall, 2002.
21. M. Prakash, C.K. Arora, Methods in Toxicology, Anmol Pub., 1998.
22. P. Fellows, Food Processing Technology: Principles and Practice, CRC Press, 2000.
23. Quantitative Analysis 6<sup>th</sup> Edn. R. A. Day Jr. & A. L. Underwood PHI Learning (Pvt) Ltd New Delhi 2001.
24. Analytical Chemistry: Principles John H Kennedy, Cengage Learning 2011.
25. Analytical Chemistry: Gary D Christian. 6<sup>th</sup> Edn. 2004, Wiley India (Pvt) Ltd.

Course	Details				
Code	AN1924302				
Title	<b>INSTRUMENTAL METHODS OF ANALYSIS</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	2/IV				
Type	Elective				
Credits	4	Hrs/Week	5	Total Hours	90

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Design and carry out scientific experiments	Ap	3
2	Understand the theories of instrumental methods available in analytical chemistry	An	3
3	Design and use spectroscopic methods for qualitative and quantitative analysis.	C	3
4	Explain the principles and practices of surface study techniques	U	2
5	Develop skills in the scientific method of planning, developing, conducting, reviewing and reporting experiments	C	4

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Introduction to Instrumental Methods</b>	<b>18</b>	
1.1	Electrical and nonelectrical data domains-transducers and sensors, detectors, examples for piezoelectric, pyroelectric, photoelectric, pneumatic and thermal transducers. Criteria for selecting instrumental methods - precision, sensitivity, selectivity, and detection limits.	6	1
1.2	Signals and noise: sources of noise, S/N ratio, methods of enhancing S/N ratio– hardware and software methods.	6	1
1.3	Electronics: transistors, FET, MOSFET, ICs, OPAMs. Application of OPAM in amplification and measurement of transducer signals.	6	1
<b>2.0</b>	<b>Molecular Spectral Measurements</b>	<b>27</b>	
2.1	UV-Vis spectroscopic instrumentation: types of optical instruments, components of optical instruments-sources, monochromators, detectors. Sample preparations. Instrumental noises. Applications in qualitative and	4	2

	quantitative analysis.		
2.2	Molecular fluorescence and fluorometers: photoluminescence and concentration, electron transition in photoluminescence, factors affecting fluorescence, instrumentation details. Fluorometric standards and reagents. Introduction to photoacoustic spectroscopy.	4	2
2.3	IR spectrometry: instrumentation designs-various types of sources, monochromators, sample cell considerations, different methods of sample preparations, detectors of IR-NDIR instruments. FTIR instruments. MidIR absorption spectrometry. Determination of path length. Application in qualitative and quantitative analysis.	4	2
2.4	Raman Spectrometric Instrumentation: sources, sample illumination systems. Application of Raman spectroscopy in inorganic, organic, biological and quantitative analysis.	3	2
2.5	NMR spectrometry-magnets, shim coils, sample spinning, sample probes ( <sup>1</sup> H, <sup>13</sup> C, <sup>31</sup> P). Principle of MRI.	3	2
2.6	Mass Spectrometry- Ion sources - EI, CI, FI, MALDI, Electrospray and FAB, Instrumental components- mass analyzers, magnetic sector, double focussing, quadrupole, TOF, Ion trap, FT instruments. Applications in identification of pure compounds, molecular formula, compound identification from comparison spectra, analysis of mixtures by hyphenated methods, quantitative applications. Application of MS with GC, HPLC.	9	2
<b>3.0</b>	<b>Atomic Spectral Measurements</b>	<b>27</b>	
3.1	Atomic emission and atomic absorption phenomena: comparison of relative merits and drawbacks. Instrumentation details of AAS. Atomisation methods flame, electrothermal and plasma techniques, glow discharge and laser ablation, sources: HCl, EDL-TGL, wavelength choice detectors, use in qualitative and quantitative analysis, interferences in measurements-chemical, spectral, and instrumental background correction techniques.	10	3
3.2	Atomic emission spectroscopy flame, arc, spark, plasma emissions (ICP and DCP), details of wave selection detection systems, applications.	8	3
3.3	Atomic X-ray spectrometry: emission of X-ray, absorption process, fluorescence, instrumentation: X-ray tube, radio isotope filters and monochromators, X-ray detectors and transducers, photon counting, gas filled transducers, Geiger tube, counters, signal processors. Application in quantitative and qualitative analysis. Diffraction methods.	9	3
<b>4.0</b>	<b>Surface Study Techniques - Instrumentation and Applications</b>	<b>9</b>	

4.1	Spectroscopic methods: ISS, SIMS, ESCA, AES, AAS.	5	4
4.2	Microscopic methods: SEM, STM, AFM.	4	4
<b>5.0</b>	<b>Research Methodology of Chemistry</b>	<b>9</b>	
5.1	The search of knowledge, purpose of research, scientific methods, role of theory, characteristics of research.	1	5
5.2	Types of research: fundamental research, applied research, historical and experimental research.	2	5
5.3	Chemical literature: primary, secondary and tertiary sources of literature. Classical and comprehensive reference. Literature databases: ScienceDirect, SciFinder. Chemical Abstract.	3	5
5.4	Scientific writing: research reports, thesis, journal articles, books. Types of publications: articles, communications, reviews.	2	5
5.5	Important scientific and chemistry journals. Impact factor.	1	5

### References:

01. D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Fundamentals of Analytical Chemistry, 8th Edn., Saunders College Pub., 2007.
02. H.H. Willard, L.L. Merritt, J.A. Dean, Instrumental Methods of Analysis, 5th Edn., Van Nostrand, 1974.
03. G.D. Christian, J.E. O'Reilly, Instrumental Analysis, Allyn&Bacon, 1986.
04. W.W. Wendladt, Thermal Methods of Analysis, Interscience, 1964.
05. T. Hatakeyama, F.X. Quinn, Thermal Analysis, John Wiley&Sons, 1999.
06. H.F. Ebel, C. Bliefert and W.E. Russey, The Art of Scientific Writing, Wiley-VCH, 2004.
07. F.A. Settle, Handbook of Instrumental Techniques for Analytical Chemistry, Prentice Hall PTR, 1997.
08. R. Wiesendanger, Scanning Probe Microscopy and Spectroscopy, Cambridge University Press, 1994.
09. R.L. Dominoswki, Research Methods, Prentice Hall, 1981.
10. W.Best, J.V. Kahn, Research in Education, 10th Edn., Pearson/Allyn&Bacon, 2006.
11. B.E. Cain, The Basis of Technical Communication, ACS, 1988.

Course	Details				
Code	AN1924303				
Title	<b>MODERN ANALYTICAL TECHNIQUES AND GREEN CHEMISTRY</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	2/IV				
Type	Elective				
Credits	4	Hrs/Week	5	Total Hours	90

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Understand the theory, principle and applications of electroanalytical techniques like potentiometry, voltammetry, amperometry and coulometry	U	2
2	Discuss the theory and applications of chromatography and apply this methods as analytical tool for the effective separation of various analyte species	An	2, 3
3	Explain various analytical techniques based on thermal and radiochemical analysis	An	2, 3
4	Illustrate the fundamental aspects of process instrumentation	Ap	2, 3,
5	Understand the basic principles of green chemistry	Ap	2, 3 4

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
1.0	<b>Electroanalytical techniques</b>	27	1
1.1	Potentiometry: techniques based on potential measurements, different types of indicator electrodes, glass electrodes, principle, theory applications, limitations of glass electrode, applications in pH measurements, modern modifications, other types of ion selective electrodes, solid, liquid, gas sensing and specific types of electrodes, biomembrane, biological and biocatalytic electrodes as biosensors, importance of selectivity coefficients. Systems for ion selective electrode systems. Potentiometric titrations-types and applications	10	1
1.2	Polarography and voltametric techniques: micro electrode and their specialities, potential and current variations at	10	1

	the micro electrode systems, conventional techniques for concentration determination, limitations of detection at lower concentrations, techniques of improving detection limit-rapid scan, ac, pulse, differential pulse square wave polarographic techniques. Applications of polarography.		
1.3	Amperometry: biamperometry, amperometric titrations. Coulometry-primary and secondary coulometry, advantages of coulometric titrations, applications. Principle of chronopotentiometry. Anodic stripping voltammetry-different types of electrodes and improvements of lower detection limits. Voltammetric sensors. Organic polarography.	7	1
<b>2.0</b>	<b>Chromatography And Capillary electrophoresis</b>	<b>36</b>	
2.1	Chromatography: Classification, migration rates of solutes, important relationships, Gas, chromatography, GSC and GLC Instrumentation-preparation of column and column materials, temperature, effects, different types of detectors, capillary columns-bonded and cross linked phases, chiral stationary phases, selectivity factors, applications.	10	2
2.2	Liquid Chromatography: column efficiency, band broadening and the factors affecting it, particle size. HPLC-its instrumentation pumps, sample injection, columns, solvent selection and detectors. Partition chromatography, bonded phase chromatography	8	2
2.3	Ion exchange chromatography-ion exchange equilibria, packings, detectors, Applications, Size Exclusion Chromatography- columns and limits of permeation and exclusion, applications. Planar Chromatography: methodology, materials for stationary phases, applications. Paper chromatography.	5	2
2.4	Supercritical fluid chromatography: properties of supercritical fluids, operating variables in instrumentation, stationary and mobile phases, comparison with the techniques, applications, supercritical fluid extraction, advantages, applications.	4	2
2.5	Capillary electrophoresis-migration rates and plate heights, instrumentation, sample introduction, detection methods, applications. Capillary gel electrophoresis. Capillary isotachopheresis. Isoelectric focusing. Capillary electro chromatography-packed columns. Micellar electro kinetic chromatography.	9	2

<b>3.0</b>	<b>Thermal and Radiochemical Methods</b>	<b>9</b>	
3.1	Thermogravimetry (TG), Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC) and their instrumentation. Thermometric Titrations.	6	3
3.2	Measurement of alpha, beta, and gamma radiations, neutron activation analysis and its applications. Principle and applications of isotope dilution methods.	3	3
<b>4.0</b>	<b>Process Instrumentation</b>	<b>9</b>	<b>4</b>
4.1	Automatic and automated systems, flow injection systems, special requirements of process instruments, sampling problems, typical examples of C, H and N analysers.	9	4
<b>5.0</b>	<b>Green Chemistry</b>	<b>9</b>	<b>5</b>
5.1	Principles of green chemistry, atom economy, principles of green organic synthesis, green alternatives of organic synthesis-coenzyme catalysed reactions, green alternatives of molecular rearrangements, electrophilic aromatic substitution, reactions, oxidation-reduction reactions, clay catalysed synthesis, condensation reactions. Green photochemical reactions.	5	5
5.2	Green Solvents: ionic liquids, supercritical CO <sub>2</sub> , fluorosolvent chemistry, General principles of microwave assisted organic synthesis.	4	5

#### Course Texts:

Instrumental analysis; Skoog, Holler, Crouch  
 Instrumental methods of analysis; Willard, Merritt, Dean, Settle

#### References:

- 01 J.M. Mermet, M. Otto, R. Kellner, Analytical Chemistry, Wiley-VCH, 2004.
02. D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Fundamentals of Analytical Chemistry, 8th Edn., Saunders College Pub., 2007.
03. J.G. Dick, Analytical Chemistry, R.E. Krieger Pub., 1978.
04. J.H. Kennedy, Analytical Chemistry: Principles, Saunders College Pub., 1990.
05. G.H. Jeffery, J. Bassett, J. Mendham, R.C. Denney, Vogel's Text Book of Quantitative Chemical Analysis, 5th Edn., John Wiley & sons, 1989.
06. S.E. Manahan, Environmental Chemistry, 9th Edn., CRC Press, 2010.
07. C.L. Wilson, D.W. Wilson, Comprehensive Analytical Chemistry, Elsevier, 1982.
08. G.D. Christian, J.E. O'Reilly, Instrumental Analysis, Allyn & Bacon, 1986.
09. R.A. Day, A.L. Underwood, Quantitative Analysis, Prentice Hall, 1967.
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13. F.W. Fifield, D. Kealey, Principles and Practice of Analytical Chemistry, Blackwell Science, 2000.
14. W. Horwitz (Editor), Official Method of Analysis of AOAC International, 18th Edn., AOAC, 2010
15. British Pharmacopeia, TSO, 2012.

Course	Details				
Code	AN1924604				
Title	<b>INORGANIC CHEMISTRY PRACTICAL- II</b>				
Degree	M.Sc.				
Branch(s)	Analytical chemistry				
Year/Semester	2/III&IV				
Type	Practical				
Credits	3	Hrs/Week	3	Total Hours	54

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	To know the various methods used to estimate binary mixtures.	U	1,3
2	Develop laboratory skills in analyzing samples of different alloys like Brass, Bronze, Coin alloy etc and find its composition.	Ap	3
3	Identify different minerals and estimate the percentage of the parent element present in it by suitable analytical methods.	Ap	3
3	Application of safety and chemical hygiene regulations and practices.	Ap	2,3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Separation and estimation of two different metal ions</b>	<b>54</b>	
1.1	Estimation of simple binary mixtures (like Cu-Ni, Cu-Zn, Fe-Cr, Fe-Cu, Fe-Ni, Pb-Ca) of metallic ions in solution by volumetric and gravimetric methods	54	1,2,3
<b>2.0</b>	<b>Determination of the composition of Alloy</b>	<b>27</b>	
2.1	Analysis of one of the alloys of brass, bronze and solder and estimate the percentage composition.	27	1,2,3
<b>3.0</b>	<b>Analysis of Ore</b>	<b>27</b>	
3.1	Analysis of one of the ores from hematite, chromite, dolomite, monazite, ilmenite.	27	1,2,3

**Course Text:**

Vogel's text book of quantitative chemical analysis; 5<sup>th</sup> edition

**References:**

01. I.M. Kolthoff, E.B. Sandell, Text Book of Quantitative Inorganic Analysis, 3rd Edn., Mc Millian, 1968.
02. G. Pass, H. Sutcliffe, Practical Inorganic Chemistry, Chapman & Hall, 1974.
03. N.H. Furman, Standard Methods of Chemical Analysis: Volume 1, Van Nostrand, 1966.
04. F.J. Welcher, Standard Methods of Chemical Analysis: Vol. 2, R.E. Kreiger Pub., 2006

Course	Details				
Code	AN1924605				
Title	<b>ORGANIC CHEMISTRY PRACTICAL- II</b>				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	2/III&IV				
Type	Practical				
Credits	3	Hrs/Week	3	Total Hours	54

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Quantitatively analyze the mass and various parameters of substrates present in many organic compounds.	Ap	1
2	Synthesise organic compounds in atom economy level with less time	An	3
3	Analyze various unknown spectrums	An,C	2
4	Prepare organic compounds in an environmental friendly way	C	1

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Standard quantitative analysis</b>	<b>40</b>	
1.1	Standard quantitative analysis of milk, butter, oils, fats, starch, glucose, vitamins and medicinal preparations.	20	1
1.2	Estimation of the number of acetyl, methoxyl, phenolic, amino, nitro, carboxyl, ester, ether and carbonyl groups in organic compounds	20	1
<b>2.0</b>	<b>Designing of multistep Synthetic Sequences with mechanism</b>	<b>10</b>	1
<b>3.0</b>	<b>Prediction of the structure of unknown compounds using IR, <math>^1\text{H}</math> NMR, <math>\text{C}^{13}</math> NMR spectrum</b>	<b>10</b>	
3.1	About 50 compounds have to be practiced	10	3
<b>4.0</b>	<b>Microwave assisted organic Synthesis</b>	<b>30</b>	2
<b>5.0</b>	<b>Multi Step preparations by the Green Alternatives of Chemical Method</b>	<b>18</b>	4

**References:**

01. A.I. Vogel, a Textbook of Practical Organic Chemistry, Longman, 1974.
02. A.I. Vogel, Elementary Practical Organic Chemistry, Longman, 1958.
03. F.G. Mann and B.C Saunders, Practical Organic Chemistry, 4th Edn. Pearson Education India, 2009.
04. J.R. Adams, J.R. Johnson, J.F. Wilcox, Laboratory Experiments in Organic Chemistry, Macmillan, 1979.
05. V.K ahluwalia, Green Chemistry: Environmentally Benign Reactions, Ane Books, 2009
06. Monograph on green Chemistry Laboratory Experiments, Green chemistry Task Force Committee, DST, 2009

Course	Details				
Code	AN1924606				
Title	INSTRUMENTAL ANALYSIS- PRACTICAL				
Degree	M.Sc.				
Branch(s)	Analytical Chemistry				
Year/Semester	2/ III & IV				
Type	Practical				
Credits	3	Hrs/Week	4	Total Hours	72

CO No.	Expected Course Outcomes <i>Upon completion of this course, the students will be able to:</i>	Cognitive Level	PSO No.
1	Determine the concentration of sulphate and halides using Nephelometry.	E	3
2	Determine the rate constant of first and second order reactions.	E	3
3	Examine the influence of ionic strength on rate constant.	Ap	3
4	Determine the concentrations of acid, sugar solutions, and to determine rate constant of inversion of cane sugar in the presence of HCl by polarimetry	E	3
5	Determine the concentrations and molar refractions using refractive index measurements.	E	3
6	Show the complex formation between mercuric iodide and KI by refractometry.	Ap	3
7	Determine the half wave potential, organic compounds and to determine Cd by Polarography	E	3
8	Determine the concentration of acid, mixture of acids, degree of ionization etc using conductivity experiments and to verify Onsager Equation.	E	3
9	Determine the concentration of acid, mixture of acids, and mixture of halides by potentiometric measurements.	E	3
10	Estimate the amount of Cu, Ni and Pb by electrogravimetry	An	3
11	Determine the concentration of Na <sup>+</sup> , K <sup>+</sup> , Li <sup>+</sup> and Ca <sup>2+</sup> ions by flame photometry.	E	3

PSO – Programme Specific Outcome; CO-Course Outcome; Cognitive Level: R-Remember; U-Understanding; Ap-Apply; An-Analyze; E-Evaluate; C-Create.

Module	Course Description	Hrs	CO No.
<b>1.0</b>	<b>Nephelometry</b>	<b>2</b>	
1.1	Determination of sulphate	1	1
1.2	Determination of halides	1	1
<b>2.0</b>	<b>Chemical Kinetics</b>	<b>36</b>	
2.1	Determination of the rate constant of the hydrolysis of ester by NaOH.	8	2
2.2	Determination of Arrhenius parameters.	8	2
2.3	Kinetics of reaction between $K_2S_2O_8$ and KI.	8	2
2.4	Influence of ionic strength on the rate constant of the reaction between $K_2S_2O_8$ and KI.	8	3
2.5	Iodination of acetone in acid medium.	4	2
<b>3.0</b>	<b>Polarimetry</b>	<b>24</b>	
3.1	Kinetics of the inversion of sucrose in presence of HCl.	8	4
3.2	Determination of concentration of sugar solution.	4	4
3.3	Determination of the concentration of HCl.	8	4
3.4	Determination of the relative strength of acids.	4	4
<b>4.0</b>	<b>Refractometry</b>	<b>18</b>	
4.1	Identification of pure organic liquids and oils.	2	5
4.2	Determination of molar refraction of pure liquids.	4	5
4.3	Determination of concentration of solutions(KCl-Water, Glycerol-Water)	4	5
4.4	Determination of molar refraction of solids.	4	5
4.5	Study of complex formation between KI and $HgI_2$ system.	4	6
<b>5.0</b>	<b>Polarography And Related Experiments</b>	<b>6</b>	
5.1	Determination of half wave potential.	2	7
5.2	Determination of Cd by (a) standard series (b) standard addition (c) pilot ion method.	2	7
5.3	Determination of organic compounds.	2	7
<b>6.0</b>	<b>Conductivity Measurements</b>	<b>26</b>	
6.1	Verification of Onsager equation.	4	8
6.2	Determination of degree of ionization of weak electrolytes.	4	8
6.3	Determination of Pka value of organic acids.	2	8
6.4	Determination of solubility of sparingly soluble salts.	4	8
6.5	Titration of a mixture of acids against a strong base.	8	8
6.6	Titration of a dibasic acid against a strong base.	4	8
<b>7.0</b>	<b>Potentiometry</b>	<b>18</b>	
7.1	Determination of single electrode potentials (Cu and Zn).	2	9
7.2	Application of Henderson Equation.	4	9
7.3	Titration of a mixture of acids against a strong base.	4	9
7.4	Determination of the concentrations of a mixture of $Cl^-$ and $I^-$ ions.	8	9
<b>8.0</b>	<b>Electrogravimetric Estimations</b>	<b>6</b>	

8.1	Electro gravimetric estimation of Cu	2	10
8.2	Electro gravimetric estimation of Ni	2	10
8.3	Electro gravimetric estimation of Pb	2	10
<b>9.0</b>	<b>Flame Photometry</b>	<b>8</b>	
9.1	Determination of Na <sup>+</sup> , K <sup>+</sup> , Li <sup>+</sup> and Ca <sup>2+</sup>	8	11

**References:**

1. J.B Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 2001
2. B. Viswanadhan, Practical Physical Chemistry, Viva Pub, 2005.
3. G.W Garland, J.W Nibler, D.P Shoemaker, Experiments in Physical Chemistry, 8<sup>th</sup> Edn, Mc. Graw Hill, 2009.

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