

***SCHEME OF EXAMINATION
RULES & REGULATIONS
AND
SYLLABUS***

(for Academic Session 2020-2021)

***M.Sc. Chemistry
Third & Fourth Semester Examination
(Analytical Chemistry Specialization)***

**Master of Science (M.Sc.)
Chemistry**

Faculty of Science



UNIVERSITY OF KOTA

MBS Marg, KOTA (Rajasthan)-324 005

INDIA

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University of Kota, Kota

M.Sc. Chemistry: Semester wise Consolidated Common Scheme of Examinations

Year / Semester	Number, Code or ID and Nomenclature of Paper			Duration of Exam. (in Hrs.)	Teaching Hrs / Week & Credit Points			Distribution of Assessment Marks				Total Marks	
	Number of Paper	Code or ID of Paper	Nomenclature of Paper		Th.	Pr.	Credit Points	Continuous Assessment (30%)		Semester Assessment (70%)			
								Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks
I Semester	Paper-1.1	CHEM-511	Inorganic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-1.2	CHEM-512	Organic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-1.3	CHEM-513	Physical Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-1.4	CHEM-514	Mathematics for Chemists or Biology for Chemists	3	4	-	4	30	12	70	28	100	40
	Paper-1.5	CHEM-515	Practical	12	-	18	9	--	--	100	50	100	50
	Total (I Semester)			24	34		25	120	48	380	162	500	250
II Semester	Paper-2.1	CHEM-521	Inorganic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.2	CHEM-522	Organic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.3	CHEM-523	Physical Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.4	CHEM-524	Computer Applications in Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.5	CHEM-525	Practical	12	-	18	9	--	--	100	50	100	50
	Total (II Semester)			24	34		25	120	48	380	162	500	250
III Semester	Paper-3.1	CHEM-631	<i>Common Paper: Chromatography</i>	3	3	-	4	30	12	70	28	100	40
	Paper-3.2	CHEM-632	<i>Common Paper: Spectroscopy</i>	3	3	-	4	30	12	70	28	100	40
	Paper-3.3	CHEM-633	<i>Specialization Paper-I : Group I / II / III / IV / V</i>	3	3	-	4	30	12	70	28	100	40
	Paper-3.4	CHEM-634	<i>Specialization Paper-II : Group I / II / III / IV / V</i>	3	3	-	4	30	12	70	28	100	40
	Paper-3.5	CHEM-635	<i>Specialization Paper-III : Group I / II / III / IV / V</i>	12	-	18	9	--	--	100	50	100	50
	Total (III Semester)			24	34		25	120	48	380	162	500	250
IV Semester	Paper-4.1	CHEM-641	<i>Common Paper: Environmental Chemistry</i>	3	3	-	4	30	12	70	28	100	40
	Paper-4.2	CHEM-642	<i>Common Paper: Recent Methods of Chemical Synthesis</i>	3	3	-	4	30	12	70	28	100	40
	Paper-4.3	CHEM-643	<i>Specialization Paper-I : Group I / II / III / IV / V</i>	3	3	-	4	30	12	70	28	100	40
	Paper-4.4	CHEM-644	<i>Specialization Paper-II : Group I / II / III / IV / V</i>	3	3	-	4	30	12	70	28	100	40
	Paper-4.5	CHEM-645	<i>Specialization Paper-III : Group I / II / III / IV / V</i>	12	-	18	9	--	--	100	50	100	50
	Total (IV Semester)			24	34		25	120	48	380	162	500	250
Grand Total (I + II + III + IV Semester)				96	136		100	480	192	1520	648	2000	1000

Groups of Specializations in M.Sc. Chemistry

Year / Sem.	Specialization Papers	Code or ID	Group-I: Inorganic Chemistry	Group-II: Organic Chemistry	Group-III: Physical Chemistry	Group-IV: Analytical Chemistry	Group-V: Industrial Chemistry
2nd Year III Semester	<i>Specialization Paper-I</i>	CHEM-633	Bio-inorganic Chemistry	Organic Synthesis	Nuclear Chemistry	Advanced Analytical Techniques	Fundamentals of Industrial Process Calculations
	<i>Specialization Paper-II</i>	CHEM-634	Photo-inorganic Chemistry	Heterocyclic Chemistry	Physical Organic Chemistry	Analysis of Commercial Products	Fuel, Petrochemicals and Energy Technology
	<i>Specialization Paper-III</i>	CHEM-635	Inorganic Chemistry Practical	Organic Chemistry Practical	Physical Chemistry Practical	Analytical Chemistry Practical	Industrial Chemistry Practical
2nd Year IV Semester	<i>Specialization Paper-I</i>	CHEM-643	Organotransition Metal Chemistry	Chemistry of Natural Products	Electrochemistry	Instrumental Methods of Analysis	Chemical Process Industries
	<i>Specialization Paper-II</i>	CHEM-644	Polymers	Medicinal Chemistry	Chemical Dynamics	Analysis of Consumers Products	Industrial Management, IPR and Regulatory Affairs
	<i>Specialization Paper-III</i>	CHEM-645	Inorganic Chemistry Practical	Organic Chemistry Practical	Physical Chemistry Practical	Analytical Chemistry Practical	Industrial Chemistry Practical

University of Kota
Kota
M.Sc. Chemistry (Analytical Chemistry Specialization)

Semester wise Scheme of Examinations

Year / Semester	Number, Code or ID and Nomenclature of Paper			Duration of Exam. (in Hrs.)	Teaching Hrs / Week & Credit Points		Distribution of Assessment Marks				Total Marks		
	Number of Paper	Code or ID of Paper	Nomenclature of Paper		Teaching Th.	Pr.	Credit Points	Continuous Assessment (30%)		Semester Assessment (70%)			
								Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks		
I Semester	Paper-1.1	CHEM-511	Inorganic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-1.2	CHEM-512	Organic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-1.3	CHEM-513	Physical Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-1.4	CHEM-514	Mathematics for Chemists or Biology for Chemists	3	4	-	4	30	12	70	28	100	40
	Paper-1.5	CHEM-515	Practical	12	-	18	9	--	--	100	50	100	50
Total (I Semester)				24	34	25	120	48	380	162	500	210	
II Semester	Paper-2.1	CHEM-521	Inorganic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.2	CHEM-522	Organic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.3	CHEM-523	Physical Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.4	CHEM-524	Computer Applications in Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.5	CHEM-525	Practical	12	-	18	9	--	--	100	50	100	50
Total (II Semester)				24	34	25	120	48	380	162	500	210	
III Semester	Paper-3.1	CHEM-631	Chromatography	3	3	-	4	30	12	70	28	100	40
	Paper-3.2	CHEM-632	Spectroscopy	3	3	-	4	30	12	70	28	100	40
	Paper-3.3	CHEM-633	Advanced Analytical Techniques	3	3	-	4	30	12	70	28	100	40
	Paper-3.4	CHEM-634	Analysis of Commercial Products	3	3	-	4	30	12	70	28	100	40
	Paper-3.5	CHEM-635	Analytical Chemistry Practical	12	-	18	9	--	--	100	50	100	50
Total (III Semester)				24	34	25	120	48	380	162	500	210	
IV Semester	Paper-4.1	CHEM-641	Environmental Chemistry	3	3	-	4	30	12	70	28	100	40
	Paper-4.2	CHEM-642	Recent Methods of Chemical Synthesis	3	3	-	4	30	12	70	28	100	40
	Paper-4.3	CHEM-643	Instrumental Methods of Analysis	3	3	-	4	30	12	70	28	100	40
	Paper-4.4	CHEM-644	Analysis of Consumers Products	3	3	-	4	30	12	70	28	100	40
	Paper-4.5	CHEM-645	Analytical Chemistry Practical	12	-	18	9	--	--	100	50	100	50
Total (IV Semester)				24	34	25	120	48	380	162	500	210	
Grand Total (I + II + III + IV Semester)				96	136	100	480	192	1520	648	2000	840	

Rules & Regulations

Objectives of the Course:

Chemistry is an important part of the current revolutions in Science. No educated person today can understand the modern world without a basic knowledge of chemistry. The existence of a large number of industries including pharmaceutical, agrochemical, petrochemical, heavy & fine chemical, fertilizer, polymer, rubber, cement, glass & ceramic, dye & pigment, pulp & paper, soap & detergent, perfumery, sugar, textile, coal, mine industries as well as power plants necessitate chemistry education. Hence, our goal for introducing the M.Sc. Chemistry programme is to educate the students in an effective manner so that the chemistry professionals can serve the fascinating fields of the chemistry.

M.Sc. Chemistry is a unique kind of course dealing with all aspects of chemistry including fundamental ideas about Inorganic, Organic, Physical, and Analytical Chemistry. This course also includes fundamentals of Mathematics, Biology, Computer, Industrial Techniques, *etc.* which are essential to a chemist to develop his/her overall presentation in the pharmaceutical, chemical, and other related industries. The major objectives of M.Sc. Chemistry course are:

- To impart knowledge in fundamental aspects of all branches of the Chemistry with basic ideas of other subjects such as Mathematics, Biology, Computer Applications in Chemistry.
- To acquire basic knowledge in the specialized areas like Organic Chemistry, Heterocyclic Chemistry, Medicinal Chemistry, Pharmaceutical Chemistry, Industrial Chemistry, Green Chemistry, Organic Synthesis, Polymer Chemistry, Bio-inorganic Chemistry, Physical Chemistry, Environmental Chemistry, Photo-inorganic Chemistry, Solid State Chemistry, Supra-molecular Chemistry, Electrochemistry, *etc.*

Duration of the Course:

The course for the degree of Master of Science in Chemistry shall consist of two academic years divided in to four equal semesters. Each semester consist of minimum 120 working days.

Eligibility for Admission in M.Sc. First Semester:

A candidate who has passed any one of the following examination with Chemistry as a major subject from any University recognized by the UGC shall be permitted to take admission in M.Sc. First Semester Chemistry to award M.Sc. degree in Chemistry with specialization in Inorganic Chemistry / Organic Chemistry / Physical Chemistry / Analytical Chemistry / Industrial Chemistry from this University after completion of a course of study of two academic years divided in the four semester scheme of examination:

- B.Sc. under 10+2+3 pattern with Chemistry as a main subject of study, or
- B.Sc. with specialization in any branch of Chemistry such as Industrial Chemistry, Polymer Chemistry, Applied Chemistry, Pharmaceutical Chemistry, Medicinal Chemistry, *etc.* or
- Three / Four year B.Sc. (Hons.) with Chemistry or any branch of Chemistry such as Industrial Chemistry, Applied Chemistry, Medicinal Chemistry, Pharmaceutical Chemistry, Polymer Chemistry, *etc.* or
- Four year Bachelor of Science and Technology (B.Sc.-Tech.) or Bachelor of Science and Education (B.Sc.-B.Ed.) with Chemistry as a paper.

Minimum Marks required in Qualifying Examination:

- ❖ Qualifying examination passed from any recognised University which is situated in Rajasthan State:
 - General Category = 55%.
 - SC / ST / OBC / SBC or MBC = Min. Pass Marks
- ❖ Qualifying examination passed from any recognised University which is situated at outside the Rajasthan State:
 - All Categories = 60%.

Eligibility for Admission in M.Sc. Third Semester:

A candidate may be promoted in the next academic session (odd semester *i.e.* III semester) if he/she has cleared collectively at least 50% of the papers of both semesters (semester I & II) of previous academic session with 50% of the aggregate marks. The candidate who does not fulfill the above condition will remain as an ex-student and will re-appear in the due papers examinations along with next odd/even semester examinations.

A candidate who has passed B.Ed. examination as a regular course of study after completing first and second semester examinations from this University shall also be eligible to take admission in third semester examination as a regular candidate.

Criteria for Opting Specialization in M.Sc. Third Semester:

In third semester, a student will have an option to choose any specialization (Inorganic Chemistry / Organic Chemistry / Physical Chemistry / Analytical Chemistry / Industrial Chemistry) subject to availability of the specialization and number of seats in a particular specialization in the Department. If number of candidates will be more than seats available in a particular specialization, admission in the specialized course shall be given on the basis of merit (aggregate percentage of first and second semester examination) after receiving option forms with preferences for all available specializations.

Course Structure:

The Master of Science in Chemistry programme will consist of core and advanced courses of theory as well as practical which are compulsory for students. Dissertation(s), project work(s), training(s), field work(s), industrial visit(s), *etc.* (which is/are approved by the concerned Department) may be performed / executed by the students in the government / public / private organization(s), institution(s), industry(ies), firm(s), enterprise(s), *etc.* for advanced learning and more practical exposures.

Course Number, Course Code or ID and Nomenclature:

Number of the course has been given in the Arabic number as Paper-1.1, Paper-1.2, and Paper-1.3 and so on. In the Paper-1.2, 1 represents the semester number and 2 represent the paper number.

To give a code to a particular course, following sequence has been adopted:

“Abbreviation of the programme in upper case + nth number of year of study + nth number of semester of the programme + course number in Arabic number”

According to the above sequence, code of paper-IV of the first semester of postgraduate Chemistry shall be as “CHEM-514”. It is noted that the 5 represents here the fifth year of study because it is considered that the student has completed four years of study during his / her undergraduate programme *e.g.* B.Sc. pass course with three or B.Sc. Hons course with three or four years / B.Sc.-B.Ed. / B.Sc.-Tech. / B.Tech. *etc.* with four years. Therefore, the figure 5 represents the fifth year of study.

Nomenclature of the particular course has been given according to the nature or type of contents included in the Unit-I to Unit-V of course of study.

Maximum Marks and Credit Points:

Maximum marks of a theory and practical paper will be decided on the basis of their contact hours per week. One teaching hour per week will carry 25 maximum marks and 1 credit point, therefore, 4 teaching hours per week will carry 100 maximum marks and 4 credit points for each theory paper / course. For practical paper, the maximum marks shall be 100 marks. For calculating of credit points for practical papers, two contact hours per week for laboratory or practical work will be equal to one contact hour per week for theory paper and will carry 1 credit point. Therefore, for 18 contact hours per week for practical work or laboratory work will be equal to 9 contact hours per week for theory paper and will carry 9 credit points.

Attendance:

Every teaching faculty, handling a course, shall be responsible for the maintenance of Attendance Register for candidates who have registered for the course. The teacher of the course must intimate the Head of the Department at least seven calendar days before the last instruction day in the semester about the attendance particulars of all students. Each student should earn 75% attendance in the courses of the particular semester failing which he or she will not be permitted to sit in the End-Semester Examinations. However, it shall be open to the authorities to grant exemption to a candidate who has failed to obtain the prescribed 75% attendance for valid reasons and such exemptions should not under any circumstance be granted for attendance below 65%.

Teaching Methodologies:

The classroom teaching would be through conventional lectures or use of OHP or power point presentations (PPT). The lecture would be such that the student should participate actively in the discussion. Student seminars would be conducted and scientific discussions would be arranged to improve their communicative skill. In the laboratory, instruction would be given for the experiments followed by demonstration and finally the students have to do the experiments individually. For the students of slow learners, special attention would be given.

Assessment Pattern:

The assessment of the student shall be divided into two parts in which first part is continuous assessment / mid-term assessment / internal assessment (30% weightage of the maximum marks) and second part is semester assessment / end-term assessment / external assessment (70% weightage of the maximum marks).

(i) Mid-Term / Internal / Continuous Assessment:

- (a) The continuous / mid-term / internal assessment (30% weightage of the maximum marks) for each theory paper shall be taken by the faculty members in the Department during each semester. Internal assessment part is further divided in two parts of equal weightage of marks as per the details given below:

S. No.	Internal Assessment	Mode of Internal Assessment	Max. Marks
(i)	Mid-Term / Internal / Continuous Assessment-I	Written Examination.	15 Marks

(ii)	Mid-Term / Internal / Continuous Assessment-II	Seminar / Presentation / Assignment / Dissertation / Quiz / Group Discussion / Viva-voce or any other mode of assessment.	15 Marks
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***Note:** In the Mid-Term/Internal/Continuous Assessment-I, written examination shall be of one hour duration for each theory paper and shall be taken according to the academic calendar which will be notified by the Department / University. Time duration for Mid-Term/Internal/Continuous Assessment-II is not allotted. It will be decided by the faculty member which will be taking internal assessment.*

- (b) For practical papers, there will be only one external or semester or end-term assessment (100% weightage of maximum marks) and there will be no continuous or internal or midterm assessment.
- (c) A student who remains absent (defaulter) or fails or wants to improve the marks in the internal assessment may be permitted to appear in the desired paper(s) (only one time) in the same semester with the permission of the concern Head of the Department. A defaulter / improvement fee of Rupees 250/- per paper shall be taken from such candidates. Duly forwarded application of such candidates by the teacher concerned shall be submitted to Head of the Department who may permit the candidate to appear in the internal assessment after production of satisfactory evidence about the reason of his/her absence in the test(s) and deposition of the defaulter / improvement fee. A record of such candidates shall be kept in the Department.
- (d) Regular attendance of the student shall be considered in the internal assessment. Marks (equal to 10% of internal assessment) shall be given to the student(s) for regularity who is/are taken classes regularly. If the attendance / regularity factor is similar for all the students, then weightage marks for regularity may be merged in the weightage of second internal assessment (seminar / presentation / assignment / dissertation / quiz / group discussion / viva-voce, etc.).
- (e) Paper wise consolidated marks for each theory paper and dissertation / seminar (*i.e.* total marks obtained during various modes of internal assessment) obtained by the students (out of the 30% weightage of the maximum marks of the each paper) shall be forwarded by the Head of the Department (in two copies) to the Controller of Examinations of the University within a week from the date of last internal assessment test for incorporation in the tabulation register.
- (f) The consolidated marks obtained by the students be also made known to them before being communicated by the concerned Head of the Department to the University for final incorporation in the tabulation register. If any discrepancies are discovered or pointed out by the students, the same shall be looked into by the concerned faculty member and corrections made wherever necessary. The decision of the Head of the Department before the communication of marks to the University shall be final. No corrections shall be made in the internal assessment marks after the declaration of the result by the University.
- (g) Consolidated marks of internal assessment obtained out of the 30% weightage of maximum marks of each theory paper which will be communicated to the University shall be in whole number and not in fraction. Marks awarded for the

various internal assessments in each paper shall be added up and then round off to the next whole number to avoid any fraction.

- (h) All test copies and other material related to the internal assessment shall also be sent to the Controller of Examinations of the University to keep in record as per the University guidelines.
- (i) The concerned Head of the Department shall be responsible for proper conduct of internal assessment tests and for communication of the consolidated marks to the University within the prescribed time.
- (j) The Head of the Department shall keep a record of the marks and also notify the same to the candidates immediately so that if any candidate is not satisfied with the award in any test or seasonal work, he / she should represent the matter to the higher authority.

(ii) End-Term / External / Semester Assessment:

- (a) The semester or external or end-term assessment (70% weightage of the maximum marks) shall be three hours duration to each theory paper and twelve hours duration (spread over two days with 6 hours per day) for each practical paper and shall be taken by the University at the end of each semester.
- (b) The syllabus for each theory paper is divided into five independent units and question paper for each theory will be divided into three sections as mentioned below:
 - **Section-A** will carry 10 marks with one compulsory question comprising ten short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
 - **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
 - **Section-C** will carry 35 marks with five long answer type questions comprising one compulsory question of 15 marks and four questions of 10 marks each. Students are instructed to attempt total three questions with one compulsory question (answer about in 500 words) and any two more questions (answer about in 400 words) out of remaining four questions. Paper setter shall be advised to design question paper covering from all five units.
- (c) The syllabus of practical paper is divided according to main streams of chemistry including Inorganic Chemistry, Organic Chemistry, Physical Chemistry, Analytical Chemistry, Environmental Chemistry, Heterocyclic Chemistry, Medicinal Chemistry, Organic Synthesis, etc. as well as according to various types of industries. Marks shall be awarded on the basis of major & minor experiments, viva-voce, practical record, regularity factor, lab skills and maintain cleanness of workplace.

Question Paper Pattern:

(A) Mid-Term / Internal / Continuous Assessment:

30% weightage of Maximum Marks (30 Marks out of 100 Maximum Marks).

(i) Mid-Term / Internal / Continuous Assessment-I:

Department of

University / College :

Address

First Internal Assessment Test 20... - 20....
(Written Examination)

Name of Class/Course :	Max. Marks : 15 Marks
Name of Semester :	Duration of Exam. : 1.00 Hr
No. & Name of Paper :	Date of Exam. :

- Q. No. 1.
or
.....
5 Marks
- Q. No. 2.
or
.....
5 Marks
- Q. No. 3.
or
.....
5 Marks

(ii) Mid-Term / Internal / Continuous Assessment-II:

Department of
University / College :
Address

Second Internal Assessment Test 20... - 20....
(Seminar / Presentation / Assignment / Dissertation / Quiz / Group Discussion
/ Viva-voce or any other mode of assessment)

Name of Class/Course :	Max. Marks : 15 Marks
Name of Semester :	Mode of Assessment:
No. & Name of Paper :	Date of Assessment :

Format for
Compilation of Marks/Awards of Internal Assessment-I & II

Department of
University / College :
Address

Name of Class/Course :
Name of Semester :
No. & Name of Paper :
Max. Marks :

S. No.	Name of Student	Father's Name	Marks Obtained			
			Int. Assess.-I	Int. Assess.-II	Total Marks (in Figure)	Total Marks (in Words)

Name & Signature of the Faculty Member

(B) End-Term / External / Semester Assessment:

70% weightage of Max Marks (70 Marks out of 100 Max Marks).

Duration of Examination: 3 Hours

Max. Marks: 70

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.

- **Section-A** will carry 10 marks with one compulsory question comprising ten short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 35 marks with five long answer type questions comprising one compulsory question of 15 marks and four questions of 10 marks each. Students are instructed to attempt total three questions with one compulsory question (answer about in 500 words) and any two more questions (answer about in 400 words) out of remaining four questions. Paper setter shall be advised to design question paper covering from all five units.

SECTION-A

Q. 1.

Unit-I

- | | | |
|------------|--|---------------|
| (i) | | 1 Mark |
| (ii) | | 1 Mark |

Unit-II

- | | | |
|-------------|--|---------------|
| (iii) | | 1 Mark |
| (iv) | | 1 Mark |

Unit-III

- | | | |
|------------|--|---------------|
| (v) | | 1 Mark |
| (vi) | | 1 Mark |

Unit-IV

- | | | |
|--------------|--|---------------|
| (vii) | | 1 Mark |
| (viii) | | 1 Mark |

Unit-V

- | | | |
|------------|--|---------------|
| (ix) | | 1 Mark |
| (x) | | 1 Mark |

SECTION-B

Unit-I

- | | | |
|--------------|-------|----------------|
| Q. 2. | | 5 Marks |
| | or | |
| | | 5 Marks |

Unit-II

- | | | |
|--------------|-------|----------------|
| Q. 3. | | 5 Marks |
| | or | |
| | | 5 Marks |

Unit-III

- | | | |
|--------------|-------|----------------|
| Q. 4. | | 5 Marks |
| | or | |
| | | 5 Marks |

	<u>Unit-IV</u>	
Q. 5.		5 Marks
	or	
.....		5 Marks
	<u>Unit-V</u>	
Q. 6.		5 Marks
	or	
.....		5 Marks
SECTION-C		
	<u>Unit-I</u>	
Q. 7.		15 Marks
	<u>Unit-II</u>	
Q. 8.		10 Marks
	<u>Unit-III</u>	
Q. 9.		10 Marks
	<u>Unit-IV</u>	
Q. 10.		10 Marks
	<u>Unit-V</u>	
Q. 11.		10 Marks

Practical / Project Work* Examinations:

Continuous / Mid-Term / Internal Assessment:

Not applicable in Practical / Project Examinations.

Semester / End-Term / External Assessment:

Duration of Exam: 12 Hours

Maximum Marks: 100

Distribution of Maximum Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1 : Major Experiment	15
2.	Exercise No. 2 : Major Experiment	15
3.	Exercise No. 3 : Major Experiment	15
4.	Exercise No. 4 : Minor Experiment	10
5.	Exercise No. 5 : Minor Experiment	10
6.	Exercise No. 6 : Minor Experiment	10
7.	Practical Record	05
8.	Laboratory Skills, Regularity, etc.	10
9.	Viva-voce	10
Total Marks		100

***Project Work :**

Project work will be undertaken by the students in last semester of M.Sc. Chemistry in place of practical work compulsorily for the on campus programme. The project work shall be experimental based and will be evaluated an external expert. A dissertation of project work has to be submitted by the students in the prescribed format along with plagiarism report. A presentation will be made by the students at the time of evaluation of the project work.

Minimum Pass Marks and Rules regarding Determination of Results:

Each semester shall be regarded as a unit for working out the result of the candidates. The result of each semester examination shall be worked out separately (even if the candidate has appeared at the paper(s) of the lower semester examination along with the papers of higher semester examination) in accordance with the following conditions:

- (i) A candidate, for a semester examination, shall be offered all the papers prescribed for that semester examination and besides he/she also shall be offered paper(s) not cleared by him/her at any of the lower semester examination subject to the limitation that the number of un-cleared papers of the lower semester examinations shall not be exceed the total number of the papers prescribed for any one semester.
- (ii) The candidate shall be declared to have passed the examination, if the candidate secures at least 40% marks in each theory paper separately in continuous or internal or mid-term examination & semester or external or end-term examination and 50% marks in each practical / project / dissertation / seminar with 50% aggregate marks of the maximum marks prescribed for each semester examination. There is no minimum pass marks for the practical record / notebook. However, submission of a practical record / notebook is a mandatory during the practical examination. The candidate should compulsorily attend viva-voce / presentation examination to secure pass in practical / project / dissertation / seminar.
- (iii) A candidate, who has been declared as failed/absent in one or more theory paper(s) at any odd semester examination shall be permitted to join the courses of study for the next higher semester *i.e.* permitted to join the course of second semester after first semester examination, permitted to join the course of fourth semester after third semester examination, permitted to join the course of sixth semester after fifth semester examination and so on and eligible to re-appear in that paper(s) as due paper(s) along with next higher semester (next year) examination provided that he/she must have cleared at least 50% of the papers (including practical / project / dissertation / seminar as one paper) collectively prescribed for the first and second semester examinations taken together for promotion to the third semester examination.
- (iv) A candidate may be promoted in the next semester (odd semester) if he/she has cleared collectively at least 50% of the papers of both semesters of previous academic session with 50% of the aggregate marks. The candidate who does not fulfill the this condition will remain in the same semester as an ex-student and will re-appear in the due papers examination along with next odd/even semester examinations.
- (v) If any student who is provisionally admitted in higher odd semester but could not secure prescribed minimum marks in previous semesters will be treated as ex-student and his/her admission fee will be carry forwarded to the next odd semester of forthcoming academic session.
- (vi) A candidate declared as failed in that particular paper he/she can re-appear for that paper in the next year examination as a due paper. However, the internal marks shall be carried forward for the total marks of the due examination.
- (vii) A candidate may be given only two additional chances for passing the semester thus maximum tenure for completing the two years' postgraduate course will be limited to four years, for three years postgraduate programme up to five years and so on.

- (viii) If the number of papers prescribed at the first and second or third and fourth semester examination is an odd number, it shall be increased by one for the purpose of reckoning 50% of the papers.
- (ix) A candidate who passes in 50% or more papers of the first and second semester examination, and thereby becomes eligible for admission to the third semester examination, but chooses not to do so and desires to appear in the remaining papers of first and second semester examination only or to re-appear in all the prescribed papers and practical/dissertation/seminar of the M.Sc. first and second semester examination will be permitted to do so on the condition that in the latter case his previous performance will be treated as cancelled.
- (x) If a candidate, who has been promoted to the next semester and wishes to improve his / her performance in the theory paper(s) of previous semester, can be permitted to do so in case of the theory papers only, not in practical / project / dissertation / seminar, belonging to the immediately preceding semester only for one time in these papers in next odd/even semester examinations. In such a case, he/she shall have to appear in these papers along with the papers of his/her own semester.
- (xi) A candidate shall be declared as passed after the result of the fourth semester examination, if he/she cleared all papers of the all the four semesters and secure minimum 40% of the aggregate marks of the maximum marks in theory papers and 50% of the aggregate marks of the maximum marks for practical / dissertation / presentation / seminar prescribed for four semesters Master's programme.
- (xii) In the case of an ex-student, the marks secured by him/her at his/her last examination as a regular candidate shall be taken into account except in cases where a candidate is re-appearing at the examination as a regular student and in that event he/she shall have to repeat the internal assessment test which will be finally accounted for working out his result.
- (xiii) A candidate who has failed at the M.Sc. third and fourth semester examination but has passed in at least 50% of the papers prescribed for the examination shall be exempted from re-appearing in a subsequent year in the papers in which he/she has passed.
- (xiv) If a candidate clears any paper(s) prescribed at the first and second semester (previous) and/or third and fourth semester (final) examination after a continuous period of three years, then for the purpose of working out his/her division, only the minimum pass marks shall be taken into account in respect of such paper(s) as are cleared after the aforesaid period provided that in case where a candidate requires more than 40% marks in order to reach the requisite minimum aggregate, as many marks out of those secured by him/her will be taken in to account as would enable him/her to make up the deficiency in the requisite minimum aggregate.
- (xv) In case the candidate is not able to clear his/her due paper(s) in the stipulated period as mentioned above (continuous period of three years), he/she may be given last one mercy attempt to clear due paper(s) subjected to approval of the Vice Chancellor or Board of Management.
- (xvi) The grace marks scheme shall be applicable as per University norms.

Classification of Successful Candidates:

The classification of successful candidates after last semester examination shall be as:

Description of Marks Obtained	Division / Result
• 80% and above in a particular paper	Distinction in that paper.
• A candidate who has secured aggregate 60% and above marks	First Division
• A candidate who has secured aggregate 50% and above but less than 60% marks	Second Division

Candidates who pass all the examinations prescribed for the course in the first instance and within a period two academic years in four semesters from the year / semester of admission to the course only are eligible for University Ranking. A candidate is deemed to have secured first rank provided he/she

- (i) Should have passed all the papers in first attempt itself.
- (ii) Should have secured the highest marks in the whole examination of the programme / course, or should have secured the highest cumulative grade point average (CGPA).

..... **X** **X** **X**

Syllabus

M. Sc. Chemistry Third Semester Examination

Paper-3.1: CHEM-631: Chromatography

(Common Paper for Inorganic Chemistry, Organic Chemistry, Physical Chemistry, Analytical Chemistry and Industrial Chemistry Specializations)

Contact Hours / Week	: 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.

- **Section-A** will carry 10 marks with 01 compulsory question comprising 10 short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 35 marks with five long answer type questions comprising one compulsory question of 15 marks and four questions of 10 marks each. Students are instructed to attempt total three questions with one compulsory question (answer about in 500 words) and any two more questions (answer about in 400 words) out of remaining four questions. Paper setter shall be advised to design question paper covering from all five units..

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

Unit-I: General Introduction of Separation: **15-18 L**
Nature of separation process, classification of separation methods.

Chromatography:

General introduction, principles and types, physical state of mobile phase, mechanism and techniques involved in separation.

Paper Chromatography:

Principle, types, choice of paper and solvent, location of spot, development, visualization, measurement of R_f values, applications.

Supercritical Fluid Chromatography (SFC):

Principle, instrumentation, qualitative and quantitative analysis.

Unit-II: Thin Layer Chromatography (TLC): **15-18 L**
Principle, advantage over paper chromatography, types, preparation of thin layer, choice of sorbent and solvent, development, detection and applications.

High Performance Thin Layer Chromatography (HPTLC):

Principle, advantage over TLC, instrumentation, choice of sorbent and solvent, development, detection and applications.

Unit-III: Column Chromatography: **15-18 L**
Principle, resolution, stationary phase, column efficiency, factors influencing column efficiency, experimental set up and applications; principle and application of flash chromatography.

Gas Chromatography (GC):

Principle, instrumentation, column efficiency, solid supports, liquid phase, column temperature, detectors, chromatographic identification, multi-dimensional GC, fast GC, applications.

Unit-IV: High Performance Liquid Chromatography (HPLC): 15-18 L

Principle, instrumentation, identification of peaks, effect of temperature and packing material, types of HPLC: partition, adsorption, ion-exchange, size-exclusion or gel; derivatization in HPLC: post and pre-columns, applications.

Ion-Exchange or Ion Chromatography (IC):

Principle, types, regeneration, ion-exchange resins and their capacity, retention, selectivity, factors affecting separation, bonded phase chromatography (BPC), high performance ion chromatography (HPIC), applications.

Unit-V: Electrophoresis: 15-18 L

Theory and classification, factors affecting mobility, electrophoresis phenomena: electrolysis, electro-osmosis, temperature and supporting media; instrumentation, methodology, preparation of gel-staining and de-staining, preparative zone electrophoresis, continuous electrophoresis, applications.

Capillary Electrophoresis (CE):

Principle, theory, instrumentation, sample preparation and applications, capillary electro-chromatography and miscellar electro-kinetic capillary chromatography.

Books:

- *Chromatography: Basic Principles, Sample Preparations and Related Methods* by Elsa Lundanes, Leon Reubsaet, Tyge Greibrokk, John Wiley and Sons
- *Introduction to Modern Liquid Chromatography* by Lloyd R. Snyder, Joseph J. Kirkland and John W. Dolan, Wiley
- *Practical HPLC Method Development* by Lloyd R. Snyder, Wiley-Interscience
- *Principles & Practices of Chromatography* by R. P. W. Scott, Library for Science
- *Fundamentals of Analytical Chemistry, VIII Edn., D. A. Skoog, D. M. West, F.J. Holler and S.R. Crouch, Thomson Brooks/Cole Publishers.*
- *Principles of Instrumental Analysis* by D.A. Skoog, F.J. Holler and T.A. Nieman, 5th Edition, Harcourt Brace & Company, Florida.
- *Instrumental Methods of Chemical Analysis, B. K. Sharma, Goel Publishing House, Meerut.*
- *Instrumental Methods of Chemical Analysis, Chatwal and Anand, Himalaya Publishing House, Meerut.*
- *Basic Gas Chromatography 2nd Edition* by Harold M. McNair, James M. Miller, John Wiley and Sons.
- *Comprehensive two dimensional gas chromatography, Volume 55 (Comprehensive Analytical Chemistry)* by Lourdes Ramos, Elsevier
- *Forensic Applications of Gas Chromatography 1st Edition* by Michelle Groves Carlin, John Richard Dean, Taylor & Francis
- *Analytical Gas Chromatography 2nd Edition* by Phillip Strempel, Elsevier
- *Electrophoresis* by Duncan J. Shaw. Academic Press
- *Gel Electrophoresis-Advanced Techniques Edited* by Sameh Magdeldin. InTech.
- *Capillary Electrophoresis Guidebook: Principles, Operation, and Applications* by Kevin D. Altria. Springer Science & Business Media.

Paper-3.2: CHEM-632: Spectroscopy

(Common Paper for Inorganic Chemistry, Organic Chemistry, Physical Chemistry, Analytical Chemistry and Industrial Chemistry Specializations)

Contact Hours / Week	: 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.
▪ **Section-A** will carry 10 marks with 01 compulsory question comprising 10 short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.

- **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 35 marks with five long answer type questions comprising one compulsory question of 15 marks and four questions of 10 marks each. Students are instructed to attempt total three questions with one compulsory question (answer about in 500 words) and any two more questions (answer about in 400 words) out of remaining four questions. Paper setter shall be advised to design question paper covering from all five units.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

Unit-I: Ultraviolet-Visible (UV-VIS) Spectroscopy: 15-18 L

Electromagnetic radiation and spectroscopy, principles of absorption spectroscopy, nature of electronic excitations, chromophores, auxochromes, origin of UV bands, types of absorption bands, factors affecting the position of UV bands, calculation of λ_{\max} of simple organic compounds, visible spectra, qualitative and quantitative applications.

Infrared (IR) Spectroscopy:

IR regions, molecular vibrations, force constant and bond strengths, calculation of vibrational frequencies, Fermi resonance, combination bands, overtones, hot bands, factors affecting the band positions and intensities, sample handling, anharmonicity, group frequencies, applications.

Unit-II: Nuclear Magnetic Resonance (NMR) Spectroscopy: 15-18 L

Nuclear angular momentum, nuclear spin, magnetization & nuclear precession, types of NMR spectrometers, free induction decay, population densities of nuclear spin states, basic theory, equivalent & non-equivalent protons, shielding and de-shielding of nuclei, chemical shift and its measurements, factors affecting chemical shift, spin-spin interactions: theory, types, factors affecting coupling constant "J". typical ^1H NMR absorption signals of various type of compounds. spin systems & classification of spectra, splitting patterns of AX, ABX, AMX, ABC, A_2B_2 , etc. spin systems. simplification of spectra: shift reagents and spin decoupling; proton exchange, nuclear Overhauser effect, basic idea about NMR of nuclei studied other than proton viz. ^{11}B , ^{15}N , ^{19}F & ^{31}P . applications of NMR spectroscopy.

Unit-III: Carbon-13 NMR Spectroscopy: 15-18 L

Carbon-13 nucleus, operating frequency, chemical shifts and their calculation, factors affecting chemical shifts, spin-spin coupling, proton-coupled, proton-decoupled and off-resonance carbon-13 spectra. applications of ^{13}C NMR spectroscopy.

Electron Spin Resonance (ESR) Spectroscopy:

Basic principle, zero field splitting and Kramer's degeneracy, factors affecting the 'g' value, hyperfine splitting, isotropic and anisotropic hyperfine coupling constants, spin-orbit coupling, significance of g-tensor, spin Hamiltonian, spin densities and McConnell relationship, measurement techniques and applications.

Unit-IV: Mass Spectrometry: 15-18 L

Basic principle, production of ions by electron impact, chemical ionization and field desorption techniques, separation and detection of ions. mass spectrum: molecular ion peak, base peak, isotopic peak, metastable peak; fragmentation patterns of organic molecules with examples of various classes of compounds, McLafferty rearrangement, factors affecting the fragmentation pattern and governing the reaction

pathways, identification of molecular ion peaks, determination of molecular weight and molecular formula of compounds, hydrogen deficiency index, nitrogen rule, negative ion mass spectrometry, brief introduction to high resolution mass spectrometry (HRMS) and combined or hyphenated techniques like GC-MS, LC-MS, IC-MS, CE-MS, ICP-MS; applications mass spectrometry.

Unit-V: Structure Elucidation:

15-18 L

An integrated problem solving approach based on analytical data including CHNS/O percentage, spectral data (UV, IR, NMR, MS, etc.) and hyphenated technique data (GC-MS, LC-MS, ICP-MS, LC-NMR, etc.) including reaction sequences for structure elucidation of organic compounds.

Books:

- *Encyclopedia of Spectroscopy and Spectrometry, Three-Volume Set: Encyclopedia of Spectroscopy and Spectrometry, Second Edition: 3 volume set*
- *NMR Spectroscopy: Basic Principles, Concepts, and Applications in Chemistry, Harald Günther, Wiley; 2 edition, 1995.*
- *Carbon-13 NMR spectroscopy, Hans-Otto Kalinowski, Stefan Berger, Siegmur Braun, Wiley, 1988.*
- *Introduction to Spectroscopy, Donald L. Pavia, Cengage Learning, 2009*
- *Pulse methods in 1D and 2D liquid-phase NMR Wallace S. Brey, Academic Press, 1988.*
- *Organic Structure Determination Using 2-D NMR Spectroscopy: A Problem-Based Approach, Jeffrey H. Simpson, Academic Press, 2008.*
- *High-Resolution NMR Techniques in Organic Chemistry, Timothy D. W. Claridge, Elsevier, 1999*
- *Identification of Organic Compounds, R. M. Silverstien, G. C. Hassler and T. C. Morill, John Wiley.*
- *Organic Spectroscopy, Jag Mohan, Narosa Publication.*
- *Spectroscopy of Organic Compounds, P. S. Kalsi, New Age International.*
- *NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R. V. Parish, Ellis Harwood.*
- *Physical Methods in Chemistry, R. S. Drago, Saunders College.*
- *Introduction to Photoelectron Spectroscopy, P. K. Ghosh, John Wiley.*
- *Introduction to Magnetic Resonance, A. Carrington and A. D. MacLachlan, Harper & Row.*
- *LC/MS: A Practical User's Guide by Marvin McMaster, Wiley-Interscience*
- *Gas Chromatography and Mass Spectrometry: A Practical Guide, Second Edition by O. David Sparkman, Academic Press.*
- *Instrumental Methods of Chemical Analysis, Gurdeep Raj Chatwal and Shaym Anand, Himalaya Publications..*

Paper-3.3: CHEM-633: Advanced Analytical Techniques

(Only for Analytical Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.

- **Section-A** will carry 10 marks with 01 compulsory question comprising 10 short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 35 marks with five long answer type questions comprising one compulsory question of 15 marks and four questions of 10 marks each. Students are instructed to attempt total three questions with one compulsory question (answer about in 500 words) and any two more questions (answer about in 400 words) out of remaining four questions. Paper setter shall be advised to design question paper covering from all five units.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

Unit-I: Extraction Methods: 15-18 L

Basic principles, classification of extraction systems, factors affecting extraction process, mechanism of extraction, extraction of liquids, extraction by chelation, extraction by solvation, extraction by ion-pair formation, extraction by sonication, extraction equilibria for chelates, extraction equilibria for solvation, separation of metals by extraction, solid-phase extraction (SPE), supercritical fluid extraction (SFE), supramolecular extraction, centrifugation and ultra-centrifugation, membrane separation.

Unit-II: Isolation and Purification Techniques: 15-18 L

Filtration (simple, micro, *etc.*), recrystallization (in aqueous & non-aqueous solutions, at low temperature, in inert atmosphere, semi-micro, micro, *etc.*), use of decolourising carbon, difficulties in recrystallization, drying of liquids, freezing, sublimation, distillation (simple, steam, fractional, vacuum, high vacuum or molecular, *etc.*), nucleation and crystal growth, crystal hydrates and solvates, chemical methods for separation, determination of physical constants (mp, mixed mp, bp, m. wt., density, optical rotator power, RI, *etc.*).

Unit-III: High Frequency Titrations: 15-18 L

Principle, instrumentation-cells, oscillator circuit and high frequency titrimeters, theory, correlation of high frequency titration curves with low frequency titration curves. Applications- acid base, complexometric, measurement of dielectric constant and analysis of mixture of organic compounds. Advantages and disadvantages of high frequency methods.

Unit-IV: Polarography: 15-18 L

Principles, classification of polarographic techniques, types of polarographic currents, instrumentation, factors affecting polarographic wave, pulse polarography, and differential pulse polarograph.

Potentiometry:

Metal electrodes for measuring the metal's cation, metal-metal salt electrodes, redox electrodes, calomel electrode, measurement of potential, determination of concentrations, residual liquid-junction potential, accuracy on direct potentiometric, glass pH electrode, ion-selective electrodes.

Unit-IV: Voltammetry: 15-18 L

Voltammetric principles, hydrodynamic voltammetry, stripping voltammetry, cyclic voltammetry, criteria of reversibility of electrochemical reactions, quasi-reversible and irreversible processes, qualitative and quantitative analysis.

Amperometry:

Principles and amperometric titration techniques: Dropping mercury electrode, rotating platinum microelectrode and dead stop.

Books:

- *Introduction to Instrumental Analysis, R. D. Braun, McGraw-Hill Book Company, New Delhi*
- *Vogel's Textbook of Quantitative Chemical Analysis, 6th Edn. Pearson Education Asia*
- *Analytical Chemistry, An Introduction, D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, 7th Edn., Saunders College publishing, N. Y.*
- *Principles of Instrumental Analysis, D. A. Skoog and J. J. Leary, 4th Edn., N. Y.*

- *The Principles of Electrochemistry*, A. Duncan, Mac Innes Dover Publication Inc. N. Y.F. Scholz, Electroanalytical methods, Springer, 2002.
- *P. Monk, Fundamentals of electroanalytical chemistry*, Wiley, 2001.
- *A.P.F. Turner I. Karube, I. G. Wilson, Biosensors- Fundamentals and applications*. Oxford University Press, New York, 1987.
- *Organic electro chemistry by Henning Lund & Ole Hammerich*, 4th edition, Publisher: Marcel Dekker, Inc, New York.

Paper-3.4: CHEM-634: Analysis of Commercial Products

(Only for Analytical Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.

- **Section-A** will carry 10 marks with 01 compulsory question comprising 10 short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 35 marks with five long answer type questions comprising one compulsory question of 15 marks and four questions of 10 marks each. Students are instructed to attempt total three questions with one compulsory question (answer about in 500 words) and any two more questions (answer about in 400 words) out of remaining four questions. Paper setter shall be advised to design question paper covering from all five units.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

Unit-I: Analysis of Petrochemicals: 15-18 L

Constituents, petroleum fractionation, analysis of petroleum products: specific gravity, viscosity, doctor test, sulphuric acid absorption, aniline point, vapour pressure and colour determination, cloud point, pour point; determination of water, neutralization value (acid and base numbers), ash content, sulphur and mercaptan sulphur, determination of lead in petroleum.

Analysis of Fuels: Proximate and ultimate analysis of fuel, calorific value by Bomb calorimetry, analysis of fuel gases (coal gas, producer gas, water gas).

Unit-II: Analysis of Agrochemicals: 15-18 L

Analysis of Fertilizers: Analysis nitrogen: urea nitrogen, total Kjeldahl nitrogen method, ammonia nitrogen; analysis of phosphorous: total phosphorous, available and non-available, alkalimetric ammonium molybdophosphate method; analysis of potassium: potassium by sodium tetraphenyl borate method.

Analysis of herbicides: atrazine, alachlor; Analysis of Fungicides: nimbin, carbendazim; Analysis of bactericides: chloramine, triclosan, chlorhexidine; Analysis of insecticides: DDT, BHC, aldrin, endosulfan, malathion, monochrotophos; Analysis of nematicides: aldicarb; Analysis of rodenticides: warfarin, bromadiolone.

Unit-III: Analysis of Polymers: 15-18 L

Chemical Methods of Analysis: Introduction, preparation of the sample, determination of purity, physical tests, preliminary examination, burning

characteristics, transition points, molecular weight, density, refractive index, pyrolytic behaviour, qualitative and quantitative elementary analysis, solubility and acid numbers, acetyl number, iodine number end group analysis, colour tests.

Analysis of Plastics:

Basics of plastic analysis, fundamental conditions for plastic analysis, water test, copper wire test, acetone test, heat test, isopropyl alcohol test, oil test.

Unit-IV: Analysis of Glass and Ceramics: 15-18 L

Introduction, composition, method of analysis-sampling and sampling preparation, composition analysis-preliminary testing, decomposition, chemical method for the individual constituents-Si, B, Pb, Zn, Al, Cl, Ca, Mg, Ti.

Analysis of Cement:

Loss on ignition, insoluble residue, total silica, sesquioxides, lime, magnesia, ferric oxide, sulphuric anhydride, air and dust pollution from cement plants, atmospheric dispersion of pollutants in cement industry.

Unit-V: Analysis of Minerals and Ores: 15-18 L

Hematite, pyrolusite, gypsum, dolomite, chromate, bauxite, limestone and uranium ores.

Analysis of Metal and Alloys: Steel, Cu-Ni alloy, solder, bronze, brass, aluminium alloy, ferroalloys of silicon, chromium, titanium and vanadium.

Books:

- *Standard Methods of Chemical Analysis, F. J. Welcher.*
- *Instrumental Methods of Analysis (6th Edition) – H. H. Willard & L. L. Merritt.*
- *A Text Book of Quantitative Inorganic Analysis (3rd Edition) – A. I. Vogel.*
- *Treatise on Analytical Chemistry (Series of Volumes) – I. M. Kolthoff & P. J. Elwing.*
- *Introduction to Instrumental Analysis – R. D. Braun.*
- *Handbook of Industrial Chemistry – Davis Burner*
- *Association of Official Analytical Chemistry (AOAC) – 13th Edition 1980.*
- *Pharmacopoeia of India, British & United States.*
- *Hand Book of Food Analysis – S. N. Mahindru.*
- *Analytical Biochemistry – Holme Peck*
- *Post Graduate Chemistry Practical Part – I – Patel, Gadre & Turkhia.*
- *Agricultural Analysis. By Kanwar.*
- *Soil Analysis. By Jackson.*
- *Encyclopedia of Industrial Methods of Chemical Analysis. By F D Snell (All senus)*
- *Principle and practice of Analytical chemistry by F.U.Fifield and D.Keuley 3rd, Blackie and sons Ltd.*
- *Cosmetics by W D Poucher (Three volumes)*
- *Perfumery Technology (JCI) by B. Bilal and B.V.Well*
- *Laboratory Techniques in Food Analysis by I.M.Kolthof, D.Pearson*
- *Handbook of Analysis and Quality, Control for Fruits and Vegetable Products 2nd by S.Ranganna*
- *Aids to the Analysis of Food and Drug by Nicholls*
- *Analysis of Food Products (Swan Publishers) by S.N.Mahendur*
- *Textbook of Forensic Pharmacy by B M Mithal 9th edition 1993, National Centre Kolcutta.*
- *Forensic Pharmacy by B.S Kuchekar, and A.M Khadatore Nirali Prakshan)*

Paper-3.5: CHEM-635: Analytical Chemistry Practical

(Only for Analytical Chemistry Specialization)

Contact Hours / Week : 18 Hours

Duration of Examination: 12 Hours

Maximum Marks : 100 Marks

Distribution of Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1 : Major Experiment	15
2.	Exercise No. 2 : Major Experiment	15
3.	Exercise No. 3 : Major Experiment	15
4.	Exercise No. 4 : Minor Experiment	10
5.	Exercise No. 5 : Minor Experiment	10
6.	Exercise No. 6 : Minor Experiment	10
7.	Practical Record	05
8.	Laboratory Skills, Regularity, etc.	10
9.	Viva-voce	10
Total Marks		100

Spectrophotometry:

- Determination of equilibrium constant of reaction $KI + I_2 = KI_3$ spectrophotometrically
- Determination of stoichiometry and stability constant of Ferric isothiocyanate complex ion in solution.
- Determination of rate constant of alkaline bleaching of Malachite green and effect of ionic strength on the rate of reaction.
- Determination of the amount of each copper and bismuth or copper and iron (III) from the given mixture at 745 nm by spectrophotometric titration using solution of EDTA.
- Determination of Al^{3+} , Ti^{3+} , Fe^{3+} using 8-Hydroxyquinoline.
- Determination of Fe^{2+} using 1,10-phenanthroline method.
- Determination of Cr^{3+} diphenylcarbazide method.
- Determination of Ni^{2+} by DMG method.
- Estimation of purity of a given azo dye by colorometry.
- Determination of fluoride/nitrite/phosphate spectrophotometrically.

Electroanalytical Methods of Analysis:

(i) **Oxidation-Reduction Titrations**

- Standardization with sodium oxalate of $KMnO_4$ and determination of Ca^{2+} ion.
- Standardization of ceric sulphate with Mohr's salt and determination of Cu^{2+} , NO_3^{-1} and $C_2O_4^{-2}$ ions.
- Standardization of $K_2Cr_2O_7$ with Fe^{2+} and determination of Fe^{3+} (Ferric alum)
- Standardization of hypo solution with potassium iodate / $K_2Cr_2O_7$ and determination of available Cl_2 in bleaching powder, Sb^{3+} and Cu^{2+} .
- Determination of hydrazine with KIO_3 titration.

(ii) **Precipitation Titrations**

- $AgNO_3$ standardization by Mohr's method by using adsorption indicator.
- Volhard's method for Cl^- determination.
- Determination of ammonium / potassium thiocyanate.
- Estimation of magnesium or cadmium as oxinate by titration with standard bromate solution.

- Estimation of KBr in the given solution by titrating against std. AgNO_3 solution using eosine as indicator.
- (iii) **Complexometric Titrations:**
 - Determination of Cu^{2+} and Ni^{2+} by using masking reagent by EDTA titration.
 - Determination of Ni^{2+} (back titration).
 - Determination of Ca^{2+} (by substitution method).
 - Estimation of the purity of oxalic acid employing standard Ce(IV) solution.
 - Estimation of various transition elements like Zn/Ni/Co/Cd/Al from various commercial samples by complexometric titrations on potentiometer by using mercury electrode.
- (iv) **Voltametric Titrations:**
 - Determination of trace metal impurities present in a polluted water sample by anodic stripping voltammetric procedure.
- (v) **Electrogravimetric Titrations:**
 - Electrogravimetric estimation of barium, copper, chromium, lead, nickel present in the solution at ppm level.
- (vi) **Amperometric Titrations:**
 - Amperometric determination of Zinc with standard EDTA solution.
 - Amperometric titration of lead with standard potassium dichromate solution.
 - Amperometric determination of magnesium (or cadmium) by precipitating it as oxinate and titrating against standard KBrO_3 solution.
 - Estimation of the mercapto group in thioglycolic acid by titrating with standard AgNO_3 solution amperometrically.
 - Amperometric titration of (i) thiourea v/s silver nitrate (ii) vitamin C v/s ferric nitrate
 - Amperometric titration of (a) Pb v/s SO_4^{2-} (b) Pb v/s $\text{K}_2\text{Cr}_2\text{O}_7$ (c) Ni v/s DMG.
 - Estimation of sulphadizine in sulpha tablet by amperometric titration method

Analysis of Alloys & Ores:

- Analysis of Nichrome alloy:
 - Cr by colorimetry
 - Ni by gravimetry
- Analysis of Zinc blend ore
 - Zn by complexometry
 - Fe by volumetry
- Analysis of Calcite ore
 - Ca by complexometry
 - Fe by colorimetry
- Analysis of felspar ore
- Analysis of steel and ferrous alloy:
Carbon, silicon, manganese, phosphorous, sulphur, selenium, copper, nickel, chromium, vanadium, tungsten, molybdenum, cobalt, aluminium, titanium, nitrogen, lead, niobium, iron

Analysis of Ferrous Slugs:

- Determination of iron, calcium and magnesium, total oxides

Analysis of Cement and building materials:

- Analysis of cement and building materials: Silicon dioxide, aluminium oxide, ferric oxide, calcium oxide, magnesium oxide, sulphurtrioxide, sulphide- sulphur, loss on ignition, insoluble residue, sodium and potassium oxide.

Analysis of Quartzes:

- Volatile residue, zirconium dioxide, aluminium oxide, calcium and magnesium oxides, sodium and potassium oxide.

Analysis of Clays and Feldspars:

- Determination of moisture, silicon dioxide, total oxides, ferric oxide, titanium dioxide, aluminium oxide, calcium oxide, magnesium oxide.

Analysis of Glasses:

- Determination of various parameters of glass
- Determination of lead and lead glass.

Analysis of Ceramics:

- Determination of titanium dioxides and aluminium oxide from oxide ceramics.

Analysis of Fuel / Petroleum / Petroleum Products:

- Determination of calorific value of fuel and coal
- Estimation of moisture in given coal sample.
- Estimation of ash content in given coal sample.
- Estimation of proximate value of given coal sample.
- Determination of the strong acid number or inorganic acidity of oil
- Determination of viscosity and surface tension of oil / liquid.
- Determination of saponification value of oil
- Determination of bromine / hydroxyl / iodine value of oil.
- Determination of aniline point of oil.
- Determination of cloud point and pour point of oil.
- Determination of flash point & fire point of oil.
- Determination of aniline point of liquid fuel
- Determination of carbon residue of liquid fuel
- Determination of octane & cetane number
- Determination of sulphur / lead / other elements in petroleum products
- Determination of alkalinity / salinity / rancidity / water content / diesel index of oil / petroleum sample.
- Determination of organic and inorganic chloride in oil / petroleum sample.
- The ultimate analysis of given sample of soft coke.
- Determine the viscosity of a given sample of oil in centistokes at room temperature and at 40°, 50°, 60° 65°, 70°C. Plot a graph between kinematic viscosity and temperature in degree centigrade.

Analysis of Agrochemicals:

- Analysis of soil sample, soil micronutrients for Ca, Fe and P content
- Analysis of pigments with respect to Zn and Cr.
- Analysis of pesticide residue and toxicological effects.
- Analysis of malathion by colorometry.
- Determination of organic carbon in soil by Walk Ley and Black method.
- Determination of available chlorine in bleaching powder by Bunsen method.
- Determination of total chlorine in pesticide formulation.
- Determination of copper in fungicide.
- Estimation of nitrogen from given fertilizer by Kjeldahl method.
- Estimation of phosphorus from given fertilizer by volumetry / colourimetry.
- Estimation of potassium from given fertilizer by gravimetry / Flame photometry.

- Determination of K_2O content in given sample of potash fertilizer.
- Determination of P_2O_5 content in given sample of phosphatic fertilizers.
- Determination of moisture content in given sample of urea
- Analysis of insecticides: DDT, BHC, aldrin, endosulfon, malathion, parathion.
- Analysis of herbicides: 2,4-Dichlorophenoxyacetic acid, dalapon, paraquat, Banalin, Butacarb.
- Analysis of fungicides: Boardeaux mixture, copper oxychloride, zineb, benomyl.

Analysis of Polymers:

- Determination of acid, saponification, iodine, hydroxyl and carboxyl values of a plastic material.
- Determination of molecular weight of a polymer.

Chromatographic Analysis:

Separation and identification of compounds (*e.g.* amino acids, carbohydrates, ions, inorganic or organic compounds, *etc.*) by following chromatographic techniques:

- Paper Chromatography
- Thin Layer Chromatography
- Column Chromatography
- Flash Chromatography
- Ion-Chromatography
- Electrophoresis

Ion Chromatography

(i) Chemical Applications

- Determination of anions in toothpaste by Ion Chromatography.
- Determination of anions and cations in high purity water by Ion Chromatography.
- Determination of metals and polyphosphates in given sample by Ion Chromatography.
- Determination of azide in aqueous samples by Ion Chromatography.
- Determination of dissolved hexavalent chromium in drinking water, groundwater and industrial waste.
- Determination of diethanolamine and triethanolamine in surface finishing, wastewater and scrubber solutions water effluents by Ion Chromatography
- Determination of fluoride in acidulated phosphate topical solution.
- Determination of oxalate and other anions in Bayer liquor using Ion Chromatography
- Determination of amino acids, carbohydrates, alcohols, and glycols in fermentation Broths
- Determination of calcium, magnesium, manganese and iodine in Brine
- Determination of trace anions and cations in concentrated bases using auto-neutralization pre-treatment/Ion Chromatography
- Determination of trace anions in organic solvents and concentrated hydrofluoric acid.
- Determination of trace transition metals in reagent grade acids, bases, salts, and organic solvents using chelation Ion Chromatography
- Determination of polyphenols
- Determination of N,N-dimethyl-o-toluidine and N,N-diethyl-o-toluidine in ethylene gas samples.

- Determination of transition metals at ppt levels in High-Purity Water and SC2 (D-clean) Baths.
- (ii) Petroleum Refining**
 - Extraction of total petroleum hydrocarbon contaminants (diesel and waste oil) in soils
 - Extraction of hydrocarbon contaminants (BTEX, Diesel, and TPH) in soils
 - Extraction of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans
 - Extraction of PAHs from environmental samples by accelerated solvent extraction (ASE)
 - Determination of thiosulfate in refinery and other wastewaters
 - Automated solid phase extraction (SPE) of total petroleum hydrocarbons using Dionex AutoTrace® Instrument
 - Determination of biofuel sugars by Ion Chromatography
 - Determination of cations in biodiesel using a Reagent-Free Ion Chromatography.
 - Determination of 32 low molecular mass organic acids in biomass by Ion Chromatography Mass Spectrometry
- (iii) Safety and Security Applications**
 - Extraction of explosives from soils by accelerated solvent extraction (ASE)
 - Determination of monovalent cations in explosives
- (iv) Cosmetics**
 - Rapid Determination of benzalkonium chloride in cosmetics
- (v) Polymers**
 - Polysialic acid analysis: Separating polymers with high degrees of polymerization

Note: Any other relevant experiments may be added / performed.

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Syllabus

M. Sc. Chemistry Fourth Semester Examination

Paper-4.1: CHEM-641: Environmental Chemistry

(Common Paper for Inorganic Chemistry, Organic Chemistry, Physical Chemistry, Analytical Chemistry and Industrial Chemistry Specializations)

Contact Hours / Week	: 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.

- **Section-A** will carry 10 marks with 01 compulsory question comprising 10 short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 35 marks with five long answer type questions comprising one compulsory question of 15 marks and four questions of 10 marks each. Students are instructed to attempt total three questions with one compulsory question (answer about in 500 words) and any two more questions (answer about in 400 words) out of remaining four questions. Paper setter shall be advised to design question paper covering from all five units.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

Unit-I: Air Pollution: 15-18 L

Concept of environment chemistry, composition of atmosphere, major sources of air pollution, chemical reactions, smog formation, acid rain, classification and effect of air pollutants, NO_x, SO_x, CO_x particulates and ozone; Greenhouse effect and global warming, ozone depletion, automobile emissions, prevention and control of vehicular pollution, alternative fuels: Biodiesel, ethanol, CNG, ultra low sulphur diesel (ULSD).

Monitoring of Air Pollution:

Principles of environment monitoring, methods for monitoring of air pollutants including NO_x, SO_x, CO_x, SPM.

Prevention and Control of Air Pollution:

Control of pollution by fuel selection and utilization, process or equipment modification, devices, site selection, stacks, planting trees and growing vegetation, general methods of air pollution control.

Unit-II: Water Pollution: 15-18 L

Types of water pollution, sources of water pollution, water pollutants, their classification and effects, water pollution laws and standards.

Analysis of Water:

Chemical and physical examination of water, preservation and pre-concentration, hydrogen ion concentration, acidity, alkalinity, hardness, pH, free CO₂, Cl₂, metals, ions, dissolved chlorine and oxygen, BOD, COD, chlorine dosage, *E. coli* index, general methods of water pollution control.

Unit-III: Soil Pollution: 15-18 L

Composition and types of soil, mineral and organic matter in soil, soil pollution by industrial wastes, urban wastes, radioactive pollution and agriculture practices.

Soil Analysis:

Analysis of nitrates, nitrites, ammonical nitrogen, total nitrogen, phosphates, organic carbon, potassium, calcium, sodium, magnesium, iron, zinc, etc.

Control of Soil Pollution:

Control of domestic and industrial wastes, soil remediation, environmental friendly technologies for agriculture

Unit-IV: Industrial Pollution: 15-18 L

Environmental pollution from various industries and control of industrial pollution.

Industrial Wastes and their Treatment:

Characteristics and types of industrial wastes, principles of industrial waste treatment, protection of biosphere and surface water from pollution with industrial sewage, sampling and chemical analysis of industrial waste water, waste water treatment, solid waste management, hazardous waste management.

Unit-V: Radioactive Pollution: 15-18 L

Radioactive substances, state of radioactive isotopes in solution, gases and solids; units of radiation, analysis of radionuclides, sources of radioactive pollution, radioactive fallout, nuclear reactors, nuclear installations, radioactive ore processing, nuclear accidents, effects of radioactive pollution on power plants and polymers, control of radioactive pollution.

Books:

- *Environmental Chemistry. B. K. Sharma. 12th Edition, 2011, Goel Publishing House, Meerut.*
- *Environmental Chemistry, Colin Baird, W.H. Freeman Co. New York, 1998.*
- *Environmental Pollution: Principles, Analysis and Control. P. Narayanan. 1st Edition, 2007, CBS Publishers & Distributors, New Delhi.*
- *Environmental Pollution Control Engineering. C. S. Rao. 2nd Edition, 2006, New Age International Publishers, New Delhi.*
- *Environmental Pollution analysis, S.M. Khopkar, Wiley Eastern, New Delhi, 1994.*
- *Pollution Control in Process Industries. S. P. Mahajan. 20th Ed, 2006, TataMcGraw-Hill, New Delhi.*
- *Industrial Pollution. V. P. Kudesia. 5th Edition, 2007, Pragati Prakashan, Meerut.*
- *Water Supply and Sanitary Engineering. G. S. Birdie & J. S. Birdie. 8th Edition, 2008, Dhanpat Rai Publishing Company, New Delhi.*
- *Environmental Toxicology, J.Rose Gordon and Breach (Ed.), Science Publication, New York, 1993.*
- *Introduction to Atmospheric Chemistry, P.V. Hobbs, Cambridge.*

Paper-4.2: CHEM-642: Recent Methods of Chemical Synthesis

(Common Paper for Inorganic Chemistry, Organic Chemistry, Physical Chemistry, Analytical Chemistry and Industrial Chemistry Specializations)

Contact Hours / Week	: 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.

- **Section-A** will carry 10 marks with 01 compulsory question comprising 10 short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 35 marks with five long answer type questions comprising one compulsory question of 15 marks and four questions of 10 marks each. Students are instructed to attempt total three questions with one compulsory question (answer about in 500 words) and any two more

questions (answer about in 400 words) out of remaining four questions. Paper setter shall be advised to design question paper covering from all five units.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

Unit-I: Modern Approaches of Organic Synthesis: 15-18 L

Principles and concepts of green chemistry, atom economy, waste minimization techniques, different approaches to green synthesis.

Reagents: Dimethyl carbonate; polymer supported reagents: chromic acid and per-acids.

Catalysts: Introduction to catalysts, homogeneous and heterogeneous catalysts, solid acid-base catalysts, metal oxide supported catalysts, oxidation catalysts, basic catalysts, polymer supported catalysts, phase transfer catalysts, bio-catalysts.

Unit-II: Solvents for Organic Synthesis: 15-18 L

Introduction, characteristics properties, types and examples of green solvents.

Water: Reasons for using water as green solvent, biphasic systems, synthesis in water (asymmetric aldol reaction, synthesis of quinoxalines, carbon dioxide fixation, preparation of nanoparticles), near critical water.

Supercritical Liquids:

The phase diagram of CO₂, supercritical CO₂, its properties and applications in dry cleaning, decaffeination of coffee and synthesis.

Ionic Liquids: Basic concept, types, physicochemical properties, preparation of ionic liquids: dialkylimidazolium and alkylpyridinium cation based ionic liquids, ionic liquids with fluorine containing anions and chiral ionic liquids; synthetic applications of ionic liquids (alkylation, allylation, oxidation and hydrogenation), concept of supported ionic liquids and their applications.

Unit-III: Microwave Assisted Organic Synthesis: 15-18 L

Introduction of microwave assisted organic syntheses, fundamentals of microwave technology, microwave activation, equipment, time and energy benefits, limitations; applications, reactions in organic solvents: Esterification, Diels-Alder reaction; solvent free reactions (solid state reactions): saponification, alkylation of reactive methylene compounds.

Unit-IV: Ultrasound Assisted Organic Synthesis: 15-18 L

Basics of sono-chemistry, ultrasound cavitation, sonocemical effect, experimental parameters, transducers, reactors, homogeneous and heterogeneous sono-chemistry, Kornblum-Russell reaction, Hetero-Michael reaction, preparation of Grignard's reagent.

Electrochemical Organic Synthesis:

Basic principle, anodic oxidations, cathodic reductions, elimination reactions, Kolbe reaction, synthesis of sebacic acid.

Unit-V: Organic Synthesis Using Reactors: 15-18 L

General introduction and types of reactors, chemical reactor design, simulation and optimization; mass and energy balance, mass and energy transfer. *Batch reactors:* Basic concepts, types and reactions; concepts of laboratory and pilot scale organic syntheses. *Vapour phase reactors:* Types and design. Raw materials, process flow diagrams, product syntheses, separations, purifications and waste compositions at

industrial scale productions of pharmaceuticals, agrochemicals, organic fertilizers and dyes.

Books:

- *Green Chemistry: Theory and Practice*, Paul T. Anastas and John C. Warner
- *Green Chemistry: An Introductory Text* by Mike Lancaster, Royal Society of Chemistry
- *Green Chemistry and Catalysis* by Sheldon, Arends and Hanefeld, WILEY-VCH, Germany
- *Green Solvents, Vol. 5: Reactions in Water*. edited by Paul T. Anastas, WILEY-VCH
- *Green Solvents, Vol. 6: Ionic Liquids*. edited by Paul T. Anastas, WILEY-VCH
- *Ionic Liquids in Synthesis* by Wasserscheid and Welton. WILEY-VCH
- *Microwaves in Organic Synthesis*, Antonio de la Hoz (Ed), André Loupy (Ed), Wiley-VCH
- *Organic Synthesis in Water*, Paul A Grieco Blackie.
- *Organic Synthesis: Special Techniques*, V. K. Ahluwalia and Renu Aggrawal
- *Chemical Reviews 2007, 107, 2167-2820* (Special issue on Green Chemistry)
- *Fundamentals and Applications of Organic Electrochemistry: Synthesis, Materials, Devices* by Toshio Fuchigami, Mahito Atobe, Shinsuke Inagi.

Paper-4.3: CHEM-643: Instrumental Methods of Analysis

(Only for Analytical Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.

- **Section-A** will carry 10 marks with 01 compulsory question comprising 10 short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 35 marks with five long answer type questions comprising one compulsory question of 15 marks and four questions of 10 marks each. Students are instructed to attempt total three questions with one compulsory question (answer about in 500 words) and any two more questions (answer about in 400 words) out of remaining four questions. Paper setter shall be advised to design question paper covering from all five units.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

Unit-I: X-rays Diffraction:

15-18 L

Production of X-rays, X-rays spectra, monochromatic X-rays sources, X-rays detectors, X-rays absorption, X-ray fluorescence and X-rays diffraction methods, Bragg's law, determination of crystal structure by Bragg's law, XRD apparatus, applications of XRD in crystalite size determination by using Sherrer formula, determination of cis-trans isomerism, polymer crystallization

X-ray photoelectron spectroscopy (XPS), X-ray fluorescence spectroscopy (XRF), Auger electron spectroscopy (AES), Energy-dispersive X-ray spectroscopy (EDX).

Unit-II: Electron Diffraction:

15-18 L

Scattering intensity v/s scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules, low energy electron diffraction and structure of surfaces

Neutron Diffraction:

Scattering of neutrons by solids and liquids, magnetic scattering, measurement techniques, elucidation of structure of magnetically ordered unit cell.

Microscopic Methods: General introduction to SEM and TEM.

Unit-III: Thermo-analytical Methods: 15-18 L

Introduction and classification of thermoanalytical methods; thermogravimetric analysis (TGA): definition, types, instrumentation, TGA curve, factors affecting TGA curves, calculation of percent decomposition and composition of compounds, limitation and advantages of TGA, application of TGA to the thermal behavior including crystalline copper sulphate, calcium oxalate monohydrate, zinc hexafluorosilicate; differential thermal analysis (DTA): definition, theoretical basis, instrumentation, factors affecting the DTA curve, application of DTA, advantages and disadvantages of DTA; differential scanning calorimetry (DSC): Definition, comparison of DTA and DSC techniques, instrumentation, factors affecting DSC curves.

Unit-IV: Radio-analytical Methods: 15-18 L

Determination of nuclear radiation and counting devices, radioactivity tracers-principal and applications, isotopic analysis-direct and inverse, special analytical application-radiometric titrations, neutron activation analysis principle, instrumentation, applications and limitations, radio-chromatography and radio-immunoassay.

Nephelometry and Turbidometry:

Introduction, theory, comparison of spectrophotometry, turbidimetry and nephelometry, instrumentation and applications

Unit-V: Polarimetry: 15-18 L

Polarisation of light, optical activity, theories of optical activity, factors affecting angle of rotation, specific rotation, optical rotator dispersion and circular dichroism-Cotton effect, ORD and CD curves, instrumentation, measurement of rotatory power, applications of polarimetry, optical activity and chemical constitution, representation of optical isomerism, deciding between two structures for a molecule, distinguish between a pair of enantiomorphs, saccharimetry, difference between saccharimetry and polarimetry, saccharimeters, kinetic polarimetry, spectropolarimetry.

Refractometry:

Principle, parameters influencing refraction, significance of critical angle during measurements, refractometers, qualitative and quantitative analysis and analytical applications

Books:

- D. A. Skoog and D. M. West, *Fundamentals of Analytical Chemistry*, Holt Rinehart and Winston Publications, IV Edn, 1982.
- D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, *Fundamentals of Analytical Chemistry*, Thomson Asia Pte Ltd., Singapore, Viiiith Edn., 2004.
- D.A. Skoog, *Principles of Instrumental Analysis*, Saunders College Pub.Co, III Edn., 1985.
- J.G. Dick, *Analytical Chemistry*, McGraw Hill Publishers, 1974.
- Willard, Merit, Dean and Settle, *Instrumental Methods of Analysis*, CBS Publishers and Distributors, IV Edn., 1989
- G. D. Christian and J.E.O Reilly, *Instrumental Analysis*, Allyn and Bacon Inc, II Edn., 1986.
- G.W. Ewing, *Instrumental Methods of Chemical Analysis*, McGraw Hill Pub, 1975.

Paper-4.4: CHEM-644: Analysis of Consumers Products

(Only for Analytical Chemistry Specialization)

Contact Hours / Week	: 4 Hours	Maximum Marks	: 100 Marks
Duration of Examination	: 3 Hours	Continuous Assessment	: 30 Marks
		Semester Assessment	: 70 Marks

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.

- **Section-A** will carry 10 marks with 01 compulsory question comprising 10 short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 35 marks with five long answer type questions comprising one compulsory question of 15 marks and four questions of 10 marks each. Students are instructed to attempt total three questions with one compulsory question (answer about in 500 words) and any two more questions (answer about in 400 words) out of remaining four questions. Paper setter shall be advised to design question paper covering from all five units.

Note: Contents of each unit may be completed into 15-18 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

Unit-I: Drug Analysis: **15-18 L**

Introduction to drugs, their classification, sources of impurities in pharmaceutical raw materials (chemical, atmospheric and microbial contaminants etc.); impurity profile, limit test, solubility tests, disintegration test, stability test, narcotic and dangerous drugs, analysis of some drugs (paracetamol, diclofenac, losartan, inidazole, alprazolam).

Unit-II: Clinical Analysis : **15-18 L**

Sampling and selective analysis of biological fluids (using routine and automatic instruments): glucose, bilirubins & biluverdins, total cholesterol, haemoglobin, creatinine, total proteins, albumin, urea-nitrogen, corticosteroids and barbiturates; vitamins and antibiotics; immunological methods of analysis: ELISA and RIA.

Unit-III: Food Analysis: **15-18 L**

Sampling and selective analysis of food flavours, food colour, food preservatives, milk and milk products, floor starches, tea, coffee, sugar content analysis of honey, jam & jelly; alcohol content in beverages; analysis of oils and fats: softening point, congent point, titre point, cloud point, iodine value, saponification value, acid value and Polenske value, Elaiden test; pesticide residue analysis.

Unit-IV: Cream & Lotion Analysis: **15-18 L**

Composition of creams and lotions, determination of water, propylene glycol, non-volatile matter and ash content, determination of borates, carbonates, sulphates, phosphates, chlorides, titanium and zinc oxides.

Face Powder, Deodorant & Antiperspirant Analysis:

Composition, analysis of fats and fatty acids, boric acid, Mg, Ca, Zn, Fe, Ti, Al, phenol, hexachlorophenone, methanamine, sulphonates and urea.

Unit-V: Soap Analysis: **15-18 L**

Method of analysis: sampling, separation, identification; determination of fatty acids, total anhydrous soap and combined alkali, potassium, water, determination of inorganic fillers and soap builders; determination of constituents and other additives.

Detergent Analysis:

Types, method of analysis: sampling, separation, identification of components, determination of surfactants and other constituents.

Books:

- *Standard Methods of Chemical Analysis, F. J. Welcher*
- *Instrumental Methods of Analysis (6th Edition) – H. H. Willard & L. L. Merritt.*
- *A Text Book of Quantitative Inorganic Analysis (3rd Edition) – A. I. Vogel.*
- *Treatise on Analytical Chemistry (Series of Volumes) – I. M. Kolthoff & P. J. Elwing.*
- *Introduction to Instrumental Analysis – R. D. Braun.*
- *Handbook of Industrial Chemistry – Davis Burner*
- *Association of Official Analytical Chemistry (AOAC) – 13th Edition 1980.*
- *Pharmacopoeia of India, British & United States.*
- *Hand Book of Food Analysis – S. N. Mahindru.*
- *Analytical Biochemistry – Holme Peck*
- *Post Graduate Chemistry Practical Part – I – Patel, Gadre & Turkhia.*
- *Agricultural Analysis. By Kanwar.*
- *Encyclopedia of Industrial Methods of Chemical Analysis. By F D Snell (All senus)*
- *Cosmetics by W D Poucher (Three volumes)*
- *Perfumery Technology (JCI) by B. Bilal and B.V.Well*
- *Laboratory Techniques in Food Analysis by I.M.Kolthof, D.Pearson*
- *Handbook of Analysis and Quality, Control for Fruits and Vegetable Products 2nd Ed by S.Ranganna*
- *Aids to the Analysis of Food and Drug by Nicholls*
- *Analysis of Food Products (Swan Publishers) by S.N.Mahendur*
- *Textbook of Forensic Pharmacy by B M Mithal 9th edition 1993, National Centre Kolcutta.*
- *Forensic Pharmacy by B.S Kuchekar, and A.M Khadatare Nirali Prakshan)*

Paper-4.5: CHEM-645: Analytical Chemistry Practical

(Only for Analytical Chemistry Specialization)

Contact Hours / Week : 18 Hours

Duration of Examination : 12 Hours

Maximum Marks : 100 Marks

Distribution of Marks:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1 : Major Experiment	15
2.	Exercise No. 2 : Major Experiment	15
3.	Exercise No. 3 : Major Experiment	15
4.	Exercise No. 4 : Minor Experiment	10
5.	Exercise No. 5 : Minor Experiment	10
6.	Exercise No. 6 : Minor Experiment	10
7.	Practical Record	05
8.	Laboratory Skills, Regularity, etc.	10
9.	Viva-voce	10
Total Marks		100

Conductometry:

- Determination of relative strength of acetic acid, chloroacetic acid and trichloroacetic acid through measuring their K_a -value by conductivity measurement method.
- Conductometric titration of (i) strong acid, monobasic weak acid or polybasic weak acid with strong base (ii) zinc with EDTA and (iii) KCl v/s $AgNO_3$.
- Determination of the strength of HCl+ CH_3COOH mixture against standard NaOH solution.

- Conductometric titration of triple mixture ($\text{HCl} + \text{NH}_4\text{Cl} + \text{KCl}$) with (i) NaOH and (ii) AgNO_3 .
- Determination of thermodynamic ionization constant of a monobasic acid by (i) conductometry and (ii) potentiometry.
- To study the effect of solvent on the conductance of AgNO_3 /acetic acid and to determine the degree of dissociation and equilibrium constant in different solvents and in their mixtures (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Hückel-Onsager theory.
- Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Hückel's limiting law.
- Titration of ZnSO_4 / MgSO_4 against BaCl_2 and $\text{Ba}(\text{CH}_3\text{COO})_2$ and calculation of amount of sulphate present.
- Determination of solubility and solubility product of sparingly soluble salts (e.g. PbSO_4 , BaSO_4) conductometrically.

Potentiometry / pH metry:

- Determination of EMF of Daniel cell.
- Determination of standard electrode potential (E_o) value of the ferrous-ferric system by titrating ferrous ammonium sulphate against potassium dichromate potentiometrically.
- Determination of pK_a of dibasic acid (oxalic acid, succinic acid, *etc.*).
- Determination of the formation constant of Ag-ammonia complex and stoichiometry of the complex potentiometrically.
- Determination of hydrolysis constant and degree of hydrolysis of aniline hydrochloride pH metrically
- Determination of thermodynamic parameters for electrochemical reactions (To determine ΔG_o , ΔH_o and ΔS_o for the formation of 1 mole cadmium in 1 wt.% amalgam at 25°C and activity coefficient of solution)
- Estimate the amount of halides present in the given mixture by titrating with AgNO_3 solution.
- Determination of strength of acetic acid from the commercial vinegar sample by potentiometric titration and its confirmation by conductometric / pH-metric titration using standard solution of NaOH .
- Micro-determination of glucose using potassium ferrocyanide as internal reagent and Ce (IV) solution as standard titrant.
- Determination of the dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by titrating it with KOH .
- Estimation of various transition elements like Zn/Ni/Co/Cd/Al from various commercial samples by complexometric titrations on potentiometer by using mercury electrode
- Determine the amount of HCl by using weak base (NH_4OH) potentiometrically.
- Fabrication of ion-selective electrodes for Co , Ni , Cu , Zn , Pd , Cd , *etc.* ions and record the electrode response and sensitivity.
- Titrate a phosphoric acid solution against alkali using glass electrode potentiometrically and calculate the first and second ionization constants of the acid
- Estimation of heavy metal toxicity using ion-selective electrodes: Pb , Cd , Hg , *etc.*
- Electrochemical Impedance study of metal/solution interface.
- Cyclic Voltametry of the $[\text{Fe}(\text{CN})_6]^{3-}/[\text{Fe}(\text{CN})_6]^{4-}$ system.

Drug Analysis:

- Preparation and characterization of active pharmaceutical ingredients with purity assay.
- Complete assay of aspirin / ibuprofen / paracetamol / sulpha drugs
- Limit test for impurities like Pb, As, Fe, moisture, chloride, sulfate, boron, free halogen, selenium, *etc.*
- Determination of water in drug sample by Karl-Fischer titration.
- Estimation of mixture of benzoic acid / salicylic acid / iron in pharmaceutical preparation.
- Estimation of ascorbic acid
- Estimation of Benzoic acid in ointment by titrimetry
- Non-aqueous titration method for estimation of isoniazide and sodium benzoate.
- Estimation of sulphadiazine in sulpha tablets
- Determination of aspirin in drug tablet by pH metry titration with NaOH.
- Determination of viscosity of ointment / syrup / liquid, *etc.*
- Analysis of the aminoglycoside antibiotics kanamycin and amikacin matches USP requirements
- Determination of viscosity of ointment/syrup/oils using Brookfield viscometer.

Clinical Analysis:

- Analysis of assay of enzymes (pepsin, monoamine, oxidase, tyrosinase), vitamins (thiamine, ascorbic acid, Vit. A) and hormones (progesterone, oxytocin, insulin) chemical, instrumental and biological assay wherever applicable.
- Separation and identification of plasma proteins.
- Estimation of Cholesterol in egg yolk or blood serum.
- Estimation of Cholesterol in egg yolk or blood serum.
- Estimation of amino acid in protein hydrolysate by Sorenson formal titration method.
- Estimation of blood glucose, protein, chloride, sodium, potassium, urea, uric acid
- Determination of cortisol from blood and urine samples; determination of oestrogens from urine samples.

Analysis of Food & Food Products:

- Analysis of moisture content, ash, fibre, nutrients, anti-nutrients, toxicants, microorganism-spoilage, preservatives.
- Analysis of amino acids, proteins, carbohydrates, lipids and fat.
- Analysis of edible oils, dairy products, pickles *etc.*, fruit and vegetable products
- Analysis of food additives.
- Analysis of food adulteration.
- Estimation of vitamin A in food product by Carr-price method.
- Estimation of vitamin C in fruit juice by iodometry.
- Determination of Vitamin B₂ (Riboflavin) by flurometry.
- Estimation of proteins, sugars, vitamins, amino acids, crude fibre, total minerals, metals, crude fat and water in foods.
- Estimation of ascorbic acid by ceric ammonium sulphate method.
- Estimation of Glucose and fructose in honey by Lane and Eynone method.
- Determination of Hydroxymethylfurfural in Honey and Biomass
- Estimation of lactose in milk by iodometry.
- Quantitative analysis of iron, calcium and phosphorus in milk powder. (Fe-Colorimetrically, Ca-Complexometrically, P-Colorimetrically)
- Casein isolation from milk by isoelectric precipitation (Yield expected).

- Analysis of lipids: saponification value, acid value and iodine value.
- Determination of tannins, chemical residues and aflatoxins,
- Estimation of preservative and antioxidants.
- Determination of saccharin in beverages.
- Determination of strength of acetic acid from the commercial vinegar sample by potentiometric titration and its confirmation by conductometric / pH-metric titration using standard solution of NaOH
- Determination of commercial washing soda by potentiometric titration method.
- Estimation of amino acid in protein hydrolysate by Sorenson formal titration method.
- Estimation of pectin as Ca-Pectate colorimetrically
- Determination of Ca in egg shell by flame photometry method.
- Determination of fluoride in tooth paste colorimetrically with alizarins.
- Estimation of sodium benzoate / sodium metabisulphite, boric acid and salicylic acid in food.
- Estimation of tannin from tea.
- Isolation of caffeine from tea.
- Analysis of iodized table salt.
- Determination of Sialic Acids
- Determination of carbohydrates in coffee.
- Determination of Na/K/Li/Ca in given sample by flame photometry method.
- Chemical analysis of chilli-powder

Forensic Chemistry:

- Determination of lethal dose, LD-50 and LC-50.
- Determination of cyanide, organophosphate and snake venom.
- Estimation of poisonous materials such as lead, mercury and arsenic in biological samples.

Analysis of Soap, Detergent, Shampoo and Cosmetics:

- Preparation of soaps and detergents.
- Estimation of EDTA in detergent and shampoo.
- Assay of soaps and detergent
- Determination of Na/K/Li/Ca in given sample by flame photometry method.
- Determination of washing strength of detergents by surface tension method.
- Determination of CMC of detergents.
- Determination of composition of perfume by GC/MS
- Estimation of fragrance in the perfumes by GC/MS.
- Estimation of Zinc in face powder by gravimetry
- Analysis of suspected allergens in perfumes by GC/MS.
- Estimation of benzoic acid in ointment.

Analysis of Heavy & Fine Chemicals:

- Preparation and characterization of copper sulphate.
- Preparation and characterization of methyl orange and methyl red.
- Estimation of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ in washing soda.
- Determination of thiosulphate content of a commercial hypo solution.
- Estimation of available chlorine in the sample of bleaching powder

Atomic Absorption Spectroscopy:

- Determination of metals in given samples by AAS technique.
- Preparation of standard calibration graphs of Pb, Cd, Zn and Fe by AAS.

Flame Photometric Determinations:

- Estimation of sodium / potassium / lithium / calcium / magnesium / barium / strontium in a given sample flame photometrically.

Fluorimetry & Phosphorimetry:

- Estimation of quinine as quinine sulfate from medicinal tablets
- Determination of amount of vit-B2 in the medicinal tablet fluorometrically.
- Any other experiments related to Spectrofluorimeter / phosphorimeter

Nephelometry & Turbidimetry:

- Determination of chloride by turbidimetry.
- Determination of amount of zinc from given sample solution by nephelometric / turbidimetric titration using standard solution of $K_4(Fe(CN)_6)$ in 0.4 M HCl
- Determination of amount of sulphate from the given sample solution by nephelometric / turbidimetric titration using standard solution of $Ba(NO_3)_2$ or $Pb(NO_3)_2$

Thermal Analysis:

Study of temperature effect on organic and inorganic compounds, calculate of percent decomposition and composition studies of given samples including following compounds as examples:

- Copper sulphate pentahydrate
- Calcium oxalate monohydrate
- Zinc hexafluorosilicate

X-Rays Diffraction:

- Determination of structure / packing pattern of solids.
- Any other experiments related to XRD

Ion Chromatography:

(i) **Medical Science Applications**

- Determination of sulfate counter ion and anionic impurities in aminoglycoside drug substances by IC with Suppressed Conductivity Detection
- Determination of tobramycin, neomycin B, streptomycin and impurities Using HPAE-PAD
- Determination of galactosamine containing organic impurities in heparin by HPAE-PAD Using the Dionex CarboPac PA20 Column
- Determination of hemoglobin variants by cation-exchange chromatography
- Determination of transition metals in serum and whole blood by Ion Chromatography
- Analysis of ions in physiological fluids
- Analysis of choline and acetylcholine
- Analysis of fatty acids.
- Determination of oxalate and carbohydrate in urine by Ion Chromatography
- Determination of protein concentrations using AAA-Direct
- Monitoring protein deamidation by cation-exchange Chromatography
- Analysis of mannose-6-phosphate
- Determination of nucleotides by Ion Chromatography with UV absorbance detection

- Determination of residual trifluoroacetate in protein purification buffers and peptide preparations by Reagent-Free Ion Chromatography
- Determination of tryptophan using AAA-Direct
- Identification of a hydroxylysine-containing peptide using AAA-Direct
- High-resolution analysis and purification of oligonucleotides with the DNAPac PA100 Column
- High-resolution cation-exchange alternative to peptide mapping for protein ID and QA/QC
- (ii) **Food and Beverage Applications**
 - Determination of mercury contamination in herbal medicines
 - Rapid separation of anthocyanins in Cranberry and Bilberry extracts using a Core-Shell Particle Column
 - Determination of trace sodium in cranberry powder
 - Determination of sudan dyes I–IV in curry paste
 - Determination of mono-, di-, and triphosphates and citrate in Shrimp by Ion Chromatography
 - Determination of phytic acid in soybeans and black Sesame seeds
 - Determination of nitrate and nitrite Ion Chromatography determination in milk samples
 - Separation of organic acids and common inorganic anions in wine
 - Determination of hydroxymethylfurfural in honey and biomass
 - Fast determination of anthocyanins in pomegranate juice
 - Determination of lactose in lactose-free milk products by high-performance anion-exchange Chromatography with Pulsed Amperometric Detection
 - Fast HPLC Analysis of dyes in foods and beverages
- (iii) **Electronics Applications**
 - Determination of trace anion contamination in the extracts of electronic components
 - Determination of sodium at the ppt level in the presence of high concentrations of ethanolamine in power plant waters
 - Determination of inorganic anions and organic acids in fermentation broths
 - Determination of phosphite in electroless nickel plating bath
 - Determination of chloride, suppressors, additives and byproducts in acid copper plating baths
 - Determination of saccharin in electrolytic nickel sulfate baths
 - Determination of an anionic fluorochemical surfactant (FC-95) in a steel bath
 - Determination of an anionic fluorochemical surfactant in a semiconductor Etch Bath
 - Monitor trace anion contamination in the extracts of electronic components
 - Determination of cations and amines in hydrogen peroxide by Ion Chromatography Using a RFIC™ (Reagent-Free) System
 - Determination of dissolved silica and common Anions Using Dual Detection
- (iv) **Agrochemicals**
 - Determination of perchlorate in high ionic strength fertilizer extracts by Ion Chromatography

Any other relevant experiments may be added / performed.

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Sample Question Paper

Paper-1.2: CHEM-512: Organic Chemistry

Duration of Exam: 3 Hours

Maximum Marks: 70

Note: The syllabus is divided into five independent units and question paper will be divided into three sections.

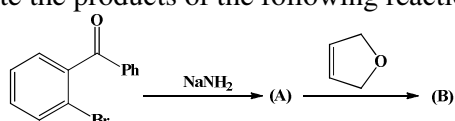
- **Section-A** will carry 10 marks with 01 compulsory question comprising 10 short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer about in 250 words). Paper setter shall be advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.
- **Section-C** will carry 35 marks with five long answer type questions comprising one compulsory question of 15 marks and four questions of 10 marks each. Students are instructed to attempt total three questions with one compulsory question (answer about in 500 words) and any two more questions (answer about in 400 words) out of remaining four questions. Paper setter shall be advised to design question paper covering from all five units.

SECTION-A

Q. 1.

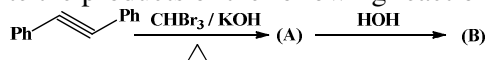
Unit-I

(i) Write the products of the following reaction:



$\frac{1}{2} + \frac{1}{2} = 1$

(ii) Write the products of the following reaction:



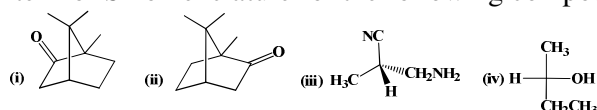
$\frac{1}{2} + \frac{1}{2} = 1$

Unit-II

(iii) Write Fischer projection of D-glucose followed by Howarth formula.

$\frac{1}{2} + \frac{1}{2} = 1$

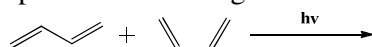
(iv) Write R or S nomenclature for the following compounds:



$\frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4} = 1$

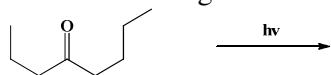
Unit-III

(v) Complete the following reaction:



1

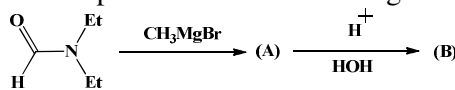
(vi) Complete the following reaction:



1

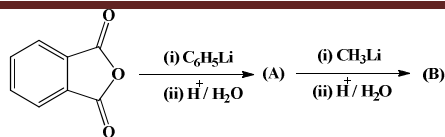
Unit-IV

(vii) Write the products of the following reaction:



$\frac{1}{2} + \frac{1}{2} = 1$

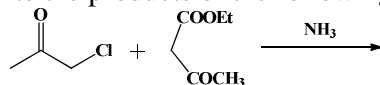
(viii) Write the products of the following reaction:



$$\frac{1}{2} + \frac{1}{2} = 1$$

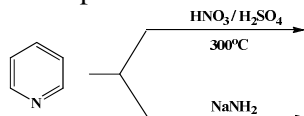
Unit-V

(ix) Write the products of the following reaction:



1

(x) Write the products of the following reaction:



$$\frac{1}{2} + \frac{1}{2} = 1$$

SECTION-B

Unit-I

Q. 2. Write note on the following (any two):

- (i) Resonance
- (ii) Tautomerism
- (iii) Conjugation
- (iv) Aromaticity

$$2\frac{1}{2} + 2\frac{1}{2} = 5$$

OR

Give an account on formation, stability and chemical reactions of the following:

- (i) Carbocations
- (ii) Carbenes

$$2\frac{1}{2} + 2\frac{1}{2} = 5$$

Unit-II

Q. 3. Draw the conformational structures of n-butane and mono- & di-substituted cyclohexane.

$$2 + 3 = 5$$

OR

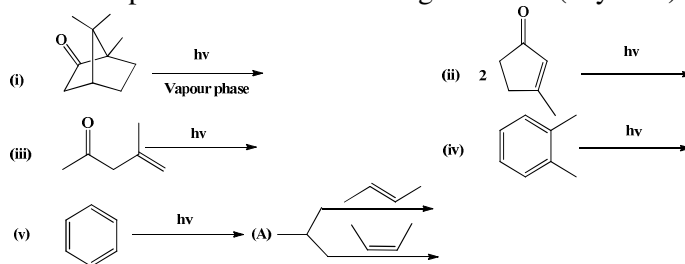
Write note on the following (any two):

- (i) Symmetry elements
- (ii) Chirality
- (iii) Threo & Erythro isomers
- (iv) Enantiomers & Diastereomers

$$2\frac{1}{2} + 2\frac{1}{2} = 5$$

Unit-III

Q. 4. Write the products of the following reactions (any four):



$$1\frac{1}{4} + 1\frac{1}{4} + 1\frac{1}{4} + 1\frac{1}{4} = 5$$

OR

Discuss in detail:

- (i) Paterno-Büchi reaction
- (ii) Photochemistry of 1,5-dienes

$2\frac{1}{2} + 2\frac{1}{2} = 5$

Unit-IV

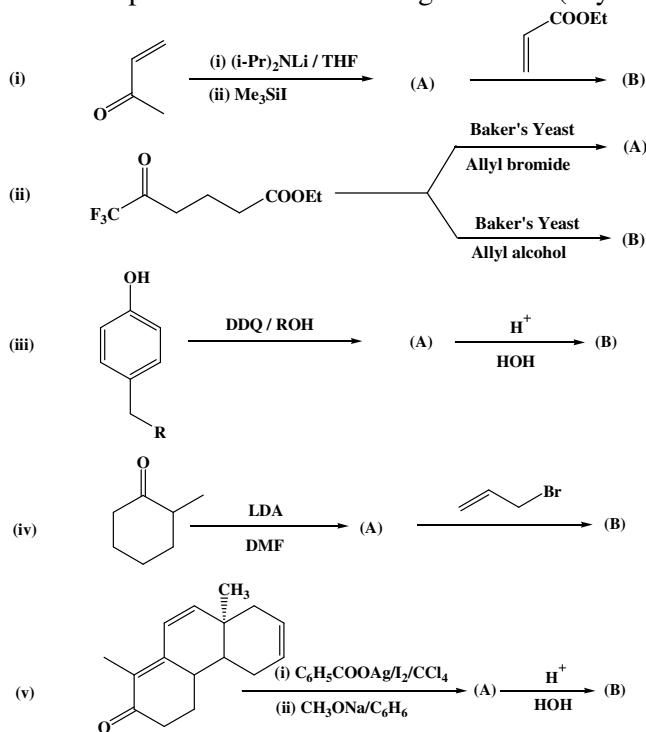
Q. 5. Write note on the following:

- (i) Metal hydrides in organic synthesis
- (ii) Phase transfer catalysts

$2\frac{1}{2} + 2\frac{1}{2} = 5$

OR

Write the products of the following reactions (any four):



$1\frac{1}{4} + 1\frac{1}{4} + 1\frac{1}{4} + 1\frac{1}{4} = 5$

Unit-V

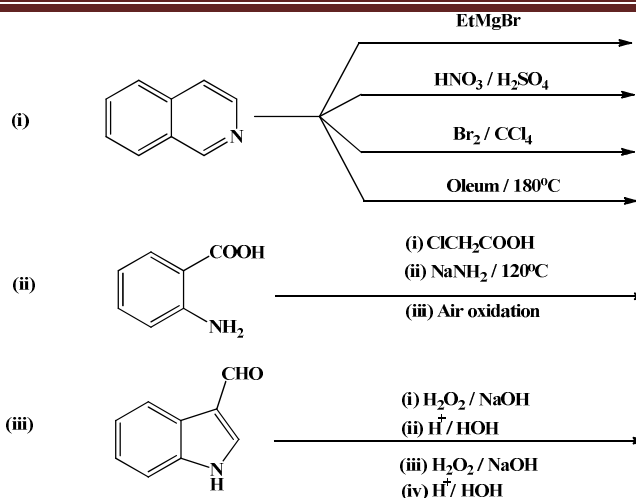
Q. 6. Give the plausible mechanisms of the following name reactions:

- (i) Fischer-indole synthesis
- (ii) Doebner-Miller synthesis
- (iii) Bischler-Napieralski synthesis
- (iv) Skraup synthesis

$1\frac{1}{4} + 1\frac{1}{4} + 1\frac{1}{4} + 1\frac{1}{4} = 5$

OR

Write the products of the following reactions (any two):



$2\frac{1}{2} + 2\frac{1}{2} = 5$

SECTION-C

Unit-I

- Q. 7.** Classify the types of organic reactions. How will you identify the mechanism of a particular type of organic reaction? Explain in detail.

2+13 = 15

Unit-II

- Q.8.** Describe the nomenclature of organic molecules according to R / S & E / Z systems.

5+5 = 10

Unit-III

- Q. 9.** Give an account on the following:
- (i) Photochemistry of β,γ -unsaturated carbonyl compounds.
 - (ii) Photo-Fries rearrangement
 - (iii) Barton reaction

5+3+2 = 10

Unit-IV

- Q. 10.** Discuss the synthesis and chemical reactions of the following:
- (i) Pyrimidines
 - (ii) Pyrones

5+5 = 10

Unit-V

- Q. 11.** Discuss in detail the use of following reagents in organic synthesis (any two):
- (i) Grignard's Reagent
 - (ii) Wilkinson's Catalyst
 - (iii) Metal Hydrides

5+5 = 10

..... **X** **X** **X**