SCHEME OF EXAMINATION
RULES & REGULATIONS
AND
SYLLABUS

(for Academic Session 2020-2021)

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

Master of Science (M.Sc.)
Chemistry

Faculty of Science

UNIVERSITY OF KOTA

MBS Marg, KOTA (Rajasthan)-324 005

INDIA

CONTENTS

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					Continuous Assessment (30%)		Semester Assessment (70%)			
					Teaching Th.	Pr.	Credit Points	Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks
1st Year	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
I Semester	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**
1st Year	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
II Semester	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**
2nd Year	Paper-3.1	CHEM-631	*Common Paper:* Chromatography	3	3	-	4	30	12	70	28	100	40
	Paper-3.2	CHEM-632	*Common Paper:* Spectroscopy	3	3	-	4	30	12	70	28	100	40
III Semester	Paper-3.3	CHEM-633	*Specialization Paper-I : Group I / II / III / IV / V*	3	3	-	4	30	12	70	28	100	40
	Paper-3.4	CHEM-634	*Specialization Paper-II : Group I / II / III / IV / V*	3	3	-	4	30	12	70	28	100	40
	Paper-3.5	CHEM-635	*Specialization Paper-III : Group I / II / III / IV / V*	12	-	18	9	--	--	100	50	100	50
			Total (III Semester)	**24**	**34**		**25**	**120**	**48**	**380**	**162**	**500**	**250**
2nd Year	Paper-4.1	CHEM-641	*Common Paper:* Environmental Chemistry	3	3	-	4	30	12	70	28	100	40
	Paper-4.2	CHEM-642	*Common Paper:* Recent Methods of Chemical Synthesis	3	3	-	4	30	12	70	28	100	40
IV Semester	Paper-4.3	CHEM-643	*Specialization Paper-I : Group I / II / III / IV / V*	3	3	-	4	30	12	70	28	100	40
	Paper-4.4	CHEM-644	*Specialization Paper-II : Group I / II / III / IV / V*	3	3	-	4	30	12	70	28	100	40
	Paper-4.5	CHEM-645	*Specialization Paper-III : Group I / II / III / IV / V*	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	*Specialization Paper-I*	CHEM-633	Bio-inorganic Chemistry	Organic Synthesis	Nuclear Chemistry	Advanced Analytical Techniques	Fundamentals of Industrial Process Calculations
	Specialization Paper-II	CHEM-634	Photo-inorganic Chemistry	Heterocyclic Chemistry	Physical Organic Chemistry	Analysis of Commercial Products	Fuel, Petrochemicals and Energy Technology
	Specialization Paper-III	CHEM-635	Inorganic Chemistry Practical	Organic Chemistry Practical	Physical Chemistry Practical	Analytical Chemistry Practical	Industrial Chemistry Practical
2nd Year IV Semester	*Specialization Paper-I*	CHEM-643	Organotransition Metal Chemistry	Chemistry of Natural Products	Electrochemistry	Instrumental Methods of Analysis	Chemical Process Industries
	Specialization Paper-II	CHEM-644	Polymers	Medicinal Chemistry	Chemical Dynamics	Analysis of Consumers Products	Industrial Management, IPR and Regulatory Affairs
	Specialization Paper-III	CHEM-645	Inorganic Chemistry Practical	Organic Chemistry Practical	Physical Chemistry Practical	Analytical Chemistry Practical	Industrial Chemistry Practical

University of Kota
Kota
M.Sc. Chemistry (Physical 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					Continuous Assessment (30%)		Semester Assessment (70%)			
					Teaching Th.	Pr.	Credit Points	Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks
1st Year	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
I Semester	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**
1st Year	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
II Semester	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**
2nd Year	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
III Semester	Paper-3.3	CHEM-633	Nuclear Chemistry	3	3	-	4	30	12	70	28	100	40
	Paper-3.4	CHEM-634	Physical Organic Chemistry	3	3	-	4	30	12	70	28	100	40
	Paper-3.5	CHEM-635	Physical Chemistry Practical	12	-	18	9	--	--	100	50	100	50
			Total (III Semester)	**24**	**34**		**25**	**120**	**48**	**380**	**162**	**500**	**210**
2nd Year	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
IV Semester	Paper-4.3	CHEM-643	Electrochemistry	3	3	-	4	30	12	70	28	100	40
	Paper-4.4	CHEM-644	Chemical Dynamics	3	3	-	4	30	12	70	28	100	40
	Paper-4.5	CHEM-645	Physical 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 + n^{th} number of year of study + n^{th} 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

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**

Unit-IV

Q. 5. . …… **5 Marks**

or

…… **5 Marks**

Unit-V

Q. 6. …… **5 Marks**

or

…… **5 Marks**

SECTION-C

Unit-I

Q. 7. …… **15 Marks**

Unit-II

Q. 8. …… **10 Marks**

Unit-III

Q. 9. …… **10 Marks**

Unit-IV

Q. 10. …… **10 Marks**

Unit-V

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 sate 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, stationery 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 Stremple, 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 ^{1}H 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 likes 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, Siegmar 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. Maclachalan, 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: Nuclear Chemistry

(Only for Physical 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: Introduction of Radioactivity: 15-18 L

Nuclear models, mass defect, binding energy, mean binding energy of stable nuclei, disintegration theory: Nuclear stability and group displacement law; synthesis of radioisotopes: ^{14}C, ^{3}H, ^{32}P, ^{35}S, ^{36}Cl, ^{82}Br, ^{131}I; contribution of the discovery of artificial radioactivity in the field of heavy element chemistry.

Unit-II: Radioactive Decay Processes: 15-18 L

Alpha decay-penetration of potential barriers, hindered alpha decay, alpha decay energies; beta decay-Fermi theory, Curie plots, comparative half-lives, electron capture, selection rules, forbidden transitions, non-conservation of parity, neutrinos; gamma decay- life-time of excited states, multi-pole radiation and selection rules, isomeric transition, internal conversion and Auger effect.

Unit-III: Detection and Measurement of Radioactivity: 15-18 L

Ionization chamber, Geiger-Muller, proportional, scintillation counters, Wilson cloud chamber, health physics, Instrumentation: Film badges, pocket ion chambers, portable counters and survey meters, accelerators: Van de Graff and cyclotron.

Unit-IV: Isotope Effects and Isotopic Exchange Reactions: 15-18 L

Isotope effect: Definition, physical and chemical isotope effects, generalities of isotope effects; Isotopic exchange: basic concept, characteristics of isotopic exchange, mechanism of isotopic exchange, kinetics of homogenous and heterogeneous isotopic exchange reactions, self-diffusion, and surface measurements.

Tracers:

Selection of radioisotopes as tracer, application of radioisotopes as tracers-analytical, physico-chemical, medical, agriculture and industrial applications, neutron activation analysis, radiometric titrations and isotope dilution techniques, radiopharmaceutical, radio-immunoassay and radiation sterilization.

Unit-V: Nuclear Reactors: 15-18 L

Basic principles of chain reacting systems, characteristics of nuclear reactors and their applications, classification of reactors, breeder reactor, reactor associated problems, nuclear reactors in India, the four factor formula: The reproduction factor, reactor power, life and critical size of reactor, reactor safety, fuel cycle, re-processing of spent fuel, nuclear waste management.

Books:

- *Nuclear Chemistry and its applications – By. Haissionsky – Addison Wesley*
- *Nuclear and Radio Chemistry – By. G. Friedlander, J. W. Kennedy, E. S. Macias and J. M. Miller – A Wiley – Interscince Publication, John Wiley and Sons – III rd Edition.*
- *Radio Chemistry – By An. N. Nesmeyanov, Mir Publishers.*
- *Artificial Radioactivity – By. K. Narayana Rao and H. J. Arnikar – Tata McGraw Hill Publishing Company Ltd. New Delhi*

Paper-3.4: CHEM-634: Physical Organic Chemistry

(Only for Physical 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 Concepts in Molecular Orbital (MO) and Valence Bond (VB) Theory:

Introduction to Huckel molecular orbital (MO) method as a mean to explain modern theoretical methods. Advanced techniques in PMO and FMO theory. Molecular mechanics, semi empirical methods and *ab inito* and density functional methods.

Quantitative MO Theory:

Hűckel molecular orbital (HMO) method as applied to ethene, ally and butadiene. Qualitative MO theory ionisation potential. Electron affinities. MO energy levels. Orbital symmetry. Orbital interaction diagrams. Valence bond (VB) configuration mixing diagrams. Relationship between VB configuration mixing and resonance theory.

Unit-II Principles of Reactivity:

Mechanistic significance of entropy, enthalphy and Gibb's free energy. Arrhenius equation. Transition state theory. Uses of activation parameters, Hammond's postulate, Bell-Evans-Polanyi Principle. Potential energy surface model. Marcus theory of electron transfer. Reactivity and selectivity principles.

Solvation and Solvent Effects:

Qualitative understanding of solvent-solute effects on reactivity. Thermodynamic measure of solvation. Effects of solvation on reaction rates and equilibria. Various empirical indexes of solvation based on physical properties, solvent-sensitive reaction rates, spectroscopic properties and scales for specific solvation. Use of solvation scales in mechanistic studies. Solvent effects from the curve-crossing model.

Unit-III Structural Effects on Reactivity:

Linear free energy relationships (LFER). The Hammett equation, substituent constants, theories of substituent effects. Interpretation of values. Reaction constant. Deviations from Hammett equation. Dual parameter correlation, inductive substituent constant. The Taft model, σ_i and σ_R scales.

Acids, Bases, Electrophiles, Nucleophiles and Catalysis:

Acid-base dissociation, Electronic and structural effects, acidity and basicity. Acidity functions and their application. Hard and soft acids and bases. Nucleophilicity scales.

Nucleofugacity. The α-effect. Ambivalent nucleophiles. Acid-base catalysis-specific and general catalysis. Brőnsted catalysis, Nucleophilic and electrophilic catalysis. Catalysis by noncovalent binding-micellar catalysis.

Steric and Conformation Properties:

Various type of steric strain and their influence on reactivity. Steric acceleration. Rotation around partial double bonds. Winstein-Holness and Curtin-Hammett principle.

Unit-IV Nucleophilic and Electrophilic Reactivity:

Structural and electronic effects on S_N^1 and S_N^2 reactivity. Solvent effect. Kinetic isotope effects. Intra-molecular assistance. Electron transfer nature of S_N^2 reaction. Nucleophilicity and S_N^2 reactivity based on curve crossing mode. Relationship between polar and electron transfer reactions S_{RN}^1 mechanism. Electrophilic reactivity, general mechanism. Kinetic of S_E^2 Ar reaction. Structural effects on rates and selectivity. Curve-crossing approach to electrophilic reactivity.

Radical Reactivity: Radical stability, polar influences, solvent and steric effects. A curve crossing approach to radical addition, factors affecting barrier heights in addition, regioselectivity in radical reactions.

Unit-V Supramolecular Chemistry:

Properties of covalent bonds-bond length, inter-bond angles, force constant, bond and molecular dipole moments. Molecular and bond polarizability, bond dissociation enthalpy, entropy. Intermolecular forces, hydrophobic effects. Electrostatic, induction, dispersion and resonance energy, magnetic interactions, magnitude of interaction energy, forces between macroscopic bodies, medium effects. Hydrogen bond. Principles of molecular association and organization as exemplified in biological macromolecules like enzymes, nucleic acids, membranes and model system like micelles and vesicles. Molecular receptors and design principles. Supramolecular reactivity and catalysis. Molecular channels and transport processes.

Books:

- *Molecular Mechanics, U. Burkrt and N.L. Allinger, ACS Monograph 177, 1982.*
- *Orgaic Chemists, Book of Orbitals : L. Salem and W.L. Jorgensen, Academic Press.*
- *Mechanism and Theory in Organic Chemistry, T.H. Lowry and K.C. Richardson, Harper and Row.*
- *Introduction to Theoretical Organic Chemistry and Molecular Modeling.*
- *Physical Organic Chemistry : N.S. Isaacs, ELBS/Longman.*
- *Supramolecular Chemistry : Concepts and Perspective, J.M. Lehn, VCH.*
- *The Physical Basis of Organic Chemistry : H. Maskill, Oxford University Press.*

Paper-3.5: CHEM-635: Physical Chemistry Practical

(Only for Physical 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**

Thermodynamics:

- Determination of partial molar volume of solute (e.g. KCl) and solvent in a binary mixture.
- Determination of the temperature dependence of the solubility of a compound in two solvents having similar intromolecular in interactions (benzoic acid in water and in DMSO-Water mixture and calculate the partial molar heat of solution.

Spectroscophotometry:

- 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 $A1^{3+}$, 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 Titartions:

- 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 thioglycollic 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 $K_2Cr_2O_7$ (c) Ni v/s DMG.
- Estimation of sulphadizine in sulpha tablet by amperometric titration method.

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

..... x ..... x ..... x .....

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, NOx, SOx, COx 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 NOx, SOx, COx, 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 CO_2, Cl_2, 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 sewages, 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 CO_2, supercritical CO_2, 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-Micahel 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: Electrochemistry

(Only for Physical 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 Conversion and Storage of Electrochemical Energy: 15-18 L

Present status of energy consumption: Direct energy conversion by electrochemical means. Maximum intrinsic efficiency of an electrochemical converter. Physical interpretation of the Carnot efficiency factor in Electrochemical energy converters. Power outputs. Electrochemical generators (Fuel Cells): History of fuel cells, Hydrogen oxygen cells, Hydrogen Air cell, Hydrocarbon air cell, Alkaline fuel cell, Phosphoric and fuel cell, direct NaOH fuel cells, applications of fuel cells.

Electrochemical Energy Storage : Properties of Electrochemical energy stores : Measure of battery performance, Charging and discharging of a battery, Storage Density, Energy Density.

Unit-II Classical Batteries: **15-18 L**

(i) Lead Acid (ii) Nickel-Cadmium, (iii) Zinc-Manganese dioxide.

Modern Batteries:

(i) Zinc-Air (ii) Nickel-Metal Hydride, (iii) Lithium Battery, Future

Electricity Storers:

Storage in (i) Hydrogen, (ii) Alkali Metals, (iii) Non aqueous solutions.

Bio-electrochemistry:

Bioelectrodics, Membrane Potentials, Simplistic theory, Modern theory, Electrical conductance in biological organism: Electronic, Protonic electrochemical mechanism of nervous systems, enzymes as electrodes.

Unit-III Corrosion and Stability of Metals: **15-18 L**

Civilization and surface mechanism of the corrosion of the metals; Thermodynamics and the stability of metals, Potential-pH (or Pourbaix) Diagrams; Corrosion current and corrosion potential-Evans diagrams. Measurement of corrosion rate : (i) Weight Loss method, (ii) Electrochemical Method.

Inhibiting Corrosion:

Cathodic and Anodic Protection. Inhibition (i) by addition of substrates to the electrolyte environment (ii) by charging the corroding metal from external source, anodic protection. Organic inhibitors. The fuller Story. Green inhibitors.

Unit-IV Kinetics of Electrode Processes: **15-18 L**

Essentials of Electrode reaction. Current Density, Over potential, Tafel Equation, Butler-Volmer equation. Standard rate constant (K^o) and Transfer coefficient, Exchange Current.

Irreversible Electrode Processes:

Criteria of irreversibility, information from irreversible wave.

Methods of determining kinetic parameters for quasi-reversible and irreversible waves : Koutecky's methods, Meites Israel method, Gelling's method.

Unit-V Potential Sweep Method: **15-18 L**

Linear sweep Voltammetry, Cyclic Voltammetry, theory and applications. Diagnostic criteria of cyclic voltammetry. Controlled current microelectrode techniques: comparison with controlled potential methods, chronopotentiometry, theory and applications.

Bulk Electrolysis Method: Controlled potential coulometry, controlled coulometry. Electro-organic synthesis and its important applications.

Books:

- *Modern Electrochemistry Vol. I, IIA, Vol. IIB J'OM Bockris and A.K.N. Reddy, Plenum Pub. NY.*
- *Polarographic Techniques by L. Meites, Interscience.*
- *"Fuel Cells : Their electrochemistry". McGraw Hill Book Company, New York.*
- *Modern Polarographic Methods by A.M. Bond, Marcell Dekker.*
- *Polarography and Allied techniques by K. Zutshi, New age International publicatin. New Delhi.*
- *Electroanalytical Chemistry by Basil H. Vessor & Galen W. ; Wiley Interscience.*
- *Topics in Pure and Applied Chemistry, Ed. S. K. Rangrajan, SAEST Publication, Karaikudi (India)*

Paper-4.4: CHEM-644: Chemical Dynamics

(Only for Physical 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 Atmospheric Reactions: **15-18 L**

Physical structure of the atmosphere, chemical composition of the atmosphere, Kinetics and mechanism of NO_x, ClO_x cycles and $H_2 + O_2$ reaction. Mechanism of general methane oxidation. Kinetics and mechanism of low temperature oxidation of methane. Concept of global warming.

Unit-II Transition State: **15-18 L**

A brief aspect of statistical mechanics and transition state theory. Application in calculation of second order rate constant for reactions involving collision of (1) atom + atom (2) atom + molecule (3) molecule + molecule reactions. Static solvent effects and thermodynamics formulations. Adiabatic electron transfer reactions, energy surfaces.

Kinetics of Enzymes:

Kinetics of one enzymes-Two substrate systems and their experimental characteristics. Enzyme inhibitors and their experimental characteristics. Kinetics of enzyme inhibited reactions.

Unit-III Radiation Chemistry: **15-18 L**

Radiation chemistry and photochemistry. Radiation chemistry of water and aqueous solutions. Hydrogen atom and hydroxyl radical-oxidizing and reducing conditions. Kinetics and mechanism of photochemical and photosensitized reactions (One example in each case). Stern-Volmer equation and its application. Hole-concept in the presence of semiconductor type photocatalysts.

Dynamics of Gas-surface Reactions:

Adsorption/desorption kinetics and transition state theory. Dissociative adsorption and precursor state. Mechanism of Langmuir's adsorption of the oxidation of carbon monoxide to carbon dioxide. True and apparent activation energies.

Unit-IV Substitution Reactions: **15-18 L**

Classification of ligand substitution mechanism. Anation and base catalyzed kinetics of anation reactions. Aquation and acid catalyzed kinetics of aquation reactions (octahedral complexes). Inner-sphere electron transfer reactions and mechanism.

Various types of inner sphere bridges, adjustment and remote attack. Linkage isomerism. Chemical and resonance mechanism. Marcus-Cross relation in outer sphere reactions (no mathematical derivation). Its application in reactions

$$Ce(IV) + Mo(CN)_5^{4-} \rightarrow Ce(III) + Mo(CN)_6^{3-};$$
$$Fe(CN)_6^{3-} + Fe(CN)_6^{4-} \rightarrow Fe(CN)_6^{4-} + Fe(CN)_6^{3-}$$

Bridged outer-sphere electron transfer mechanism. Kinetics of reactions in the presence of cyclodextrines.

Unit-V Metal ion Catalysis and Induced Phenomena: 15-18 L

Metal ion catalyzed reactions, their kinetics and reaction mechanism in solutions. Induced reactions, their characteristics. Mechanism of (i) Fe(II) induced oxidation of iodine by Cr(VI) (ii) As(III) induced oxidation of Mn(II) by chromate in acid solutions. Kinetics and mechanism of induced reactions in metal complexes (octahedral complexes of Cobalt (III) only).

Oscillatory Reactions:

Autocatlysis and oscillatory reactions, Kinetics and mechanism of Belousov-Zhabotinski (B-Z) reactions.

Books Suggested :

- *Progress in Inorganic Chemistry, Vol. 30.*
- *R. Lumry and R.W. Raymond, Electron Transfer Reactions, Interscience.*
- *N.L. Bender, Mechanism of Homogeneous Catalysis from protein to protein, Wiley.*
- *A.G. Sykes, Kinetics of Inorganic reactions, Pergamon.*
- *S.W. Benson, Mechanism of Inorganic Reactions, Academic Press.*
- *Physical Chemistry Vol. 2, Ed. Prof Ya Grasimov, Mir publisher.*
- *Inorganic Reaction Mechanism, Basolo and Pearson, J.Wiley .*
- *Electron Transfer Reactions, H. Taube, Oxford Press.*

Paper-4.5: CHEM-645: Physical Chemistry Practical

(Only for Physical 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**

Chemical Kinetics:

- Determination of order of reaction with respect to Ag(I) in oxidation of Mn(II) by $S_2O_8^{2-}$ and rate constant for un-catalyzed reaction.
- Determination of the primary salt effect on the kinetics of ionic reaction and testing of the Bronsted relationship (iodide ion is oxidised by persulphate ion).
- Determination of energy and enthalpy of activation in the reaction of KMnO4 and benzyl alcohol in acid medium.
- Determination of energy of activation of and entropy of activation from a single kinetic run
- Determination of rate constant and formation constant of an intermediate complex in the reaction of Ce(IV) and Hypophosphorous acid at ambient temperature.
- Kinetics of decomposition of benzene diazonium chloride.
- Kinetics of decomposition of acidified hydrogen peroxide with potassium iodide and determination of activation energy.
- Kinetics of an enzyme catalyzed reaction.
- Flowing clock reactions.
- Oscillatory reactions.

Conductometry:

- Determination of relative strength of acetic acid, chloroacetic acid and trichloroacetic acid through measuring their Ka-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 ($HCl+NH_4Cl+KCl$) 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-Hűckel-Onsager theory.
- Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Hűckel's limiting law.
- Titration of $ZnSO_4$ / $MgSO_4$ against $BaCl_2$ and $Ba(CH_3COO)_2$ 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 (Eo) value of the ferrous-ferric system by titrating ferrous ammonium sulphate against potassium dichromate potentiometrically.
- Determination of pKa 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 ΔGo, ΔHo and ΔSo for the formation of 1 mole cadmium in 1 wt.% amalgam at 25^{o}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 conducltmetric / 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 $[Fe(CN)6]^{3-}$/$[Fe(CN)6]^{4-}$ system.

Electronics

This lab course will have theory as well as practical and the lectures shall be delivered during lab hours.

Basic Electronics

Notations used in the electronic circuit, study of electronic compounds and colour codes. Conversion of chemical quantities into electronic quantities. transducer, illustration with electrodes, thermocouples and thermistors. Passive components : Resistors, capacitors and inductors with some emphasis on solid state properties of materials. Net works of resistors. Thevenin's theorem, superposition theorem, loop analysis, RC circuits, LR Circuits, LCR circuits. Illustration of the use of circuits in NQR spectroscopy, Mőssbauer spectroscopy cyclic voltammetry and in power supplied as filter circuits.

Active components

Introduction to ordinary diodes and Zener diode with some emphasis on p-n junction as a solid state property. Use of diode as rectifiers, clipping and clamping circuits. Power supplies. Transistors : An extension of p-n-p and n-p-n transistors. Characteristics of transistors, hybrid parameters; transistor circuits as amplifiers, high impedance (preamplifier) circuits. Darlinction pairs, differential amplifiers.

Operational Amplifiers

Ideal characteristics; inverter, summer, integrator, differentiator, voltage follower, illustrative use of operational amplifiers. Introduction to Fourier transformation in

instrumentation. List of Experiments in electronics (Do at least five experiments from this section):

1. (a) To plot the diode characteristics and find its dynamic resistance and cut in voltage.
   (b) To plot the characteristics of transistor used as a diode and compare the results with those of (a)
2. (a) To plot the diode characteristics and find its dynamic resistance and cut in voltage.(b) To plot the characteristics of transistor used as a diode and compare the results with those of (a)wave form.
3. To implement a diode damper circuit which damps the positive peak of the input voltage to (a) Zero voltage and (b) a given voltage. Verify the performance.
4. (a) To plot the characteristics of an NPN transistor in CE configuration. (b) To find the h-parameter of the transistor from the characteristics.
5. (a) To plot the characteristics of an NPN transistor in CB configuration. (b) To find the h-parameter of the transistor from the characteristics and compare it with the results of experiment No. 6.
6. (a) To plot the drain and transfer characteristics of a JEET in CS configuration. (b) To find out the pinch off voltage, maximum drain to source saturation current and the transconductance.
7. To obtain the frequency response of an RC coupled amplifier and estimate the bandwidth.
8. (a) To plot the characteristics of Zener diode and find its dynamic resistance under reverse biased condition. To use zener diode for a voltage regulation. (i) Plot the line regulation curve. (ii) Plot the load Regulation curve.
9. (a) To wire a Half wave Rectifier circuit using diode and measure the rms voltage, de voltage and to find Ripple factor.
   (b) To study the performance of half way and full wave doubler circuits.
10. To plot the characteristics of UJT and find the peak voltage, peak current and valley voltage and use as a relaxation oscillator.

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

..... x ..... x ..... x .....

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.*

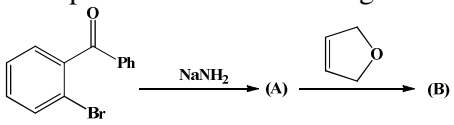
- ***Section-A*** *will carry 10 marks with 01 compulsory question comprising 10 short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.*
- ***Section-B*** *will carry 25 marks with equally divided into five long answer type questions (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.

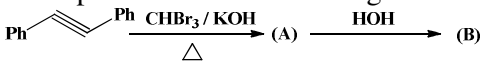
Unit-I

(i) Write the products of the following reaction:



½ + ½ = 1

(ii) Write the products of the following reaction:



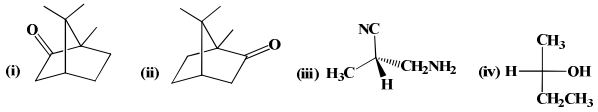
½ + ½ = 1

Unit-II

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

½ + ½ = 1

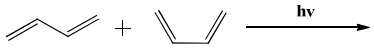
(iv) Write R or S nomenclature for the following compounds:



¼ +¼+¼+¼ = 1

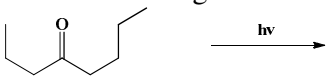
Unit-III

(v) Complete the following reaction:



1

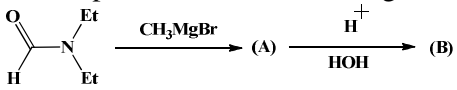
(vi) Complete the following reaction:



1

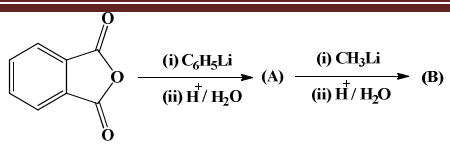
Unit-IV

(vii) Write the products of the following reaction:



½ + ½ = 1

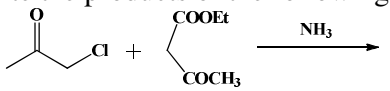
(viii) Write the products of the following reaction:



½ + ½ = 1

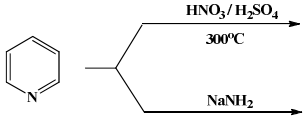
Unit-V

(ix) Write the products of the following reaction:



1

(x) Write the products of the following reaction:



½ + ½ = 1

SECTION-B

Unit-I

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

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

2½ + 2½ = 5

OR

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

(i) Carbocations
(ii) Carbenes

2½ + 2½ = 5

Unit-II

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

2 + 3 = 5

OR

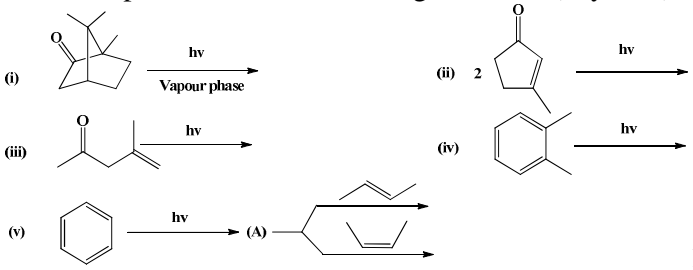
Write note on the following (any two):

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

2½ + 2½ = 5

Unit-III

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



1¼+1¼+1¼+1¼ = 5

OR

Discuss in detail:

(i) Paterno-Büchi reaction

(ii) Photochemistry of 1,5-dienes

2½ + 2½ = 5

Unit-IV

Q. 5. Write note on the following:

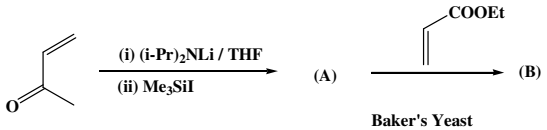
(i) Metal hydrides in organic synthesis

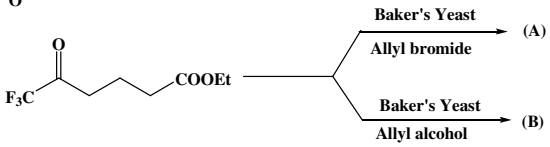
(ii) Phase transfer catalysts

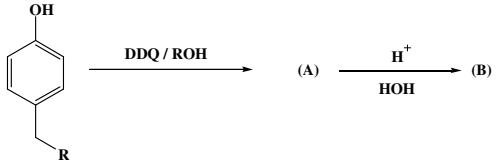
2½ + 2½ = 5

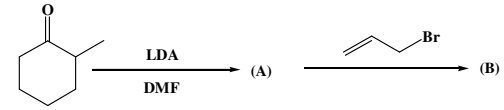
OR

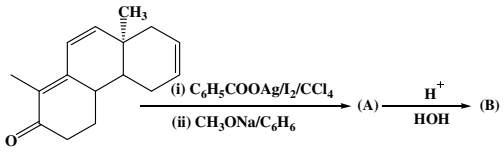
Write the products of the following reactions (any four):

(i) 

(ii) 

(iii) 

(iv) 

(v) 

1¼+1¼+1¼+1¼ = 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

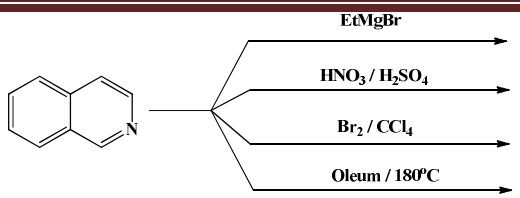
(iv) Skraup synthesis

1¼+1¼+1¼+1¼ = 5

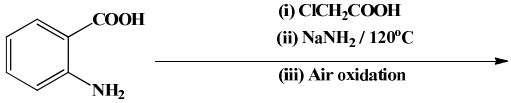
OR

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

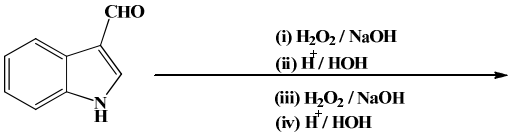
(i)



(ii)



(iii)



2½ + 2½ = 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 .....