

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

***(for Academic Session 2021-2022)***

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

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

**Faculty of Science**



**UNIVERSITY OF KOTA**

**MBS Marg, KOTA (Rajasthan)-324 005**

**INDIA**

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**University of Kota, Kota**  
**M.Sc. Chemistry: Semester wise Consolidated Scheme of Examinations**

Year / Semester	Number, Code or ID and Nomenclature of Paper			Duration of Exam. (in Hrs.)	Teaching Hrs. / Week & Credit Points			Distribution of Assessment Marks				Total Marks	
	Number of Paper	Code or ID of Paper	Nomenclature of Paper		Teaching Th.	Pr.	Credit Points	Continuous Assessment (30%)		Semester Assessment (70%)			
								Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks
<b>I Semester</b>	Paper-1.1	CHEM-511	Inorganic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-1.2	CHEM-512	Organic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-1.3	CHEM-513	Physical Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-1.4	CHEM-514	Mathematics for Chemists / Biology for Chemists	3	4	-	4	30	12	70	28	100	40
	Paper-1.5	CHEM-515	Chemistry Practical	12	-	18	9	--	--	225	113	225	113
	<b>Total (I Semester)</b>				<b>24</b>	<b>16</b>	<b>18</b>	<b>25</b>	<b>120</b>	<b>48</b>	<b>505</b>	<b>225</b>	<b>625</b>
<b>II Semester</b>	Paper-2.1	CHEM-521	Inorganic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.2	CHEM-522	Organic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.3	CHEM-523	Physical Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.4	CHEM-524	Computer Applications in Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.5	CHEM-525	Chemistry Practical	12	-	18	9	--	--	225	113	225	113
	<b>Total (II Semester)</b>				<b>24</b>	<b>16</b>	<b>18</b>	<b>25</b>	<b>120</b>	<b>48</b>	<b>505</b>	<b>225</b>	<b>625</b>
<b>III Semester</b>	Paper-3.1	CHEM-631	<i>Common Paper: Chromatography</i>	3	4	-	4	30	12	70	28	100	40
	Paper-3.2	CHEM-632	<i>Common Paper: Spectroscopy</i>	3	4	-	4	30	12	70	28	100	40
	Paper-3.3	CHEM-633	<i>Specialization Paper-I : Group I / II / III / IV / V</i>	3	4	-	4	30	12	70	28	100	40
	Paper-3.4	CHEM-634	<i>Specialization Paper-II : Group I / II / III / IV / V</i>	3	4	-	4	30	12	70	28	100	40
	Paper-3.5	CHEM-635	<i>Specialization Paper-III : Group I / II / III / IV / V</i>	12	-	18	9	--	--	225	113	225	113
	<b>Total (III Semester)</b>				<b>24</b>	<b>16</b>	<b>18</b>	<b>25</b>	<b>120</b>	<b>48</b>	<b>505</b>	<b>225</b>	<b>625</b>
<b>IV Semester</b>	Paper-4.1	CHEM-641	<i>Common Paper: Environmental Chemistry</i>	3	4	-	4	30	12	70	28	100	40
	Paper-4.2	CHEM-642	<i>Common Paper: Recent Methods of Chemical Synthesis</i>	3	4	-	4	30	12	70	28	100	40
	Paper-4.3	CHEM-643	<i>Specialization Paper-I : Group I / II / III / IV / V</i>	3	4	-	4	30	12	70	28	100	40
	Paper-4.4	CHEM-644	<i>Specialization Paper-II : Group I / II / III / IV / V</i>	3	4	-	4	30	12	70	28	100	40
	Paper-4.5	CHEM-645	<i>Specialization Paper-III : Group I / II / III / IV / V</i>	12	-	18	9	--	--	225	113	225	113
	<b>Total (IV Semester)</b>				<b>24</b>	<b>16</b>	<b>18</b>	<b>25</b>	<b>120</b>	<b>48</b>	<b>505</b>	<b>225</b>	<b>625</b>
<b>Grand Total (I + II + III + IV Semester)</b>				<b>96</b>	<b>64</b>	<b>72</b>	<b>100</b>	<b>480</b>	<b>192</b>	<b>2020</b>	<b>900</b>	<b>2500</b>	<b>1092</b>

**Groups of Specializations in M.Sc. Chemistry**

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

## University of Kota Kota

### M.Sc. Chemistry (Inorganic Chemistry Specialization)

#### Semester wise Scheme of Examinations

Year / Semester	Number, Code or ID and Nomenclature of Paper			Duration of Exam. (in Hrs.)	Teaching Hrs. / Week & Credit Points			Distribution of Assessment Marks				Total Marks	
	Number of Paper	Code or ID of Paper	Nomenclature of Paper		Teaching		Credit Points	Continuous Assessment (30%)		Semester Assessment (70%)			
					Th.	Pr.		Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks
<b>1st Year</b> <b>I Semester</b>	Paper-1.1	CHEM-511	Inorganic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-1.2	CHEM-512	Organic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-1.3	CHEM-513	Physical Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-1.4	CHEM-514	Mathematics for Chemists / Biology for Chemists	3	4	-	4	30	12	70	28	100	40
	Paper-1.5	CHEM-515	Chemistry Practical	12	-	18	9	--	--	225	113	225	113
<b>Total (I Semester)</b>				<b>24</b>	<b>16</b>	<b>18</b>	<b>25</b>	<b>120</b>	<b>48</b>	<b>505</b>	<b>225</b>	<b>625</b>	<b>273</b>
<b>1st Year</b> <b>II Semester</b>	Paper-2.1	CHEM-521	Inorganic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.2	CHEM-522	Organic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.3	CHEM-523	Physical Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.4	CHEM-524	Computer Applications in Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-2.5	CHEM-525	Chemistry Practical	12	-	18	9	--	--	225	113	225	113
<b>Total (II Semester)</b>				<b>24</b>	<b>16</b>	<b>18</b>	<b>25</b>	<b>120</b>	<b>48</b>	<b>505</b>	<b>225</b>	<b>625</b>	<b>273</b>
<b>2nd Year</b> <b>III Semester</b>	Paper-3.1	CHEM-631	Chromatography	3	4	-	4	30	12	70	28	100	40
	Paper-3.2	CHEM-632	Spectroscopy	3	4	-	4	30	12	70	28	100	40
	Paper-3.3	CHEM-633	Bio-inorganic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-3.4	CHEM-634	Photo-inorganic Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-3.5	CHEM-635	Inorganic Chemistry Practical	12	-	18	9	--	--	225	113	225	113
<b>Total (III Semester)</b>				<b>24</b>	<b>16</b>	<b>18</b>	<b>25</b>	<b>120</b>	<b>48</b>	<b>505</b>	<b>225</b>	<b>625</b>	<b>273</b>
<b>2nd Year</b> <b>IV Semester</b>	Paper-4.1	CHEM-641	Environmental Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-4.2	CHEM-642	Recent Methods of Chemical Synthesis	3	4	-	4	30	12	70	28	100	40
	Paper-4.3	CHEM-643	Organotransition Metal Chemistry	3	4	-	4	30	12	70	28	100	40
	Paper-4.4	CHEM-644	Polymers	3	4	-	4	30	12	70	28	100	40
	Paper-4.5	CHEM-645	Inorganic Chemistry Practical	12	-	18	9	--	--	225	113	225	113
<b>Total (IV Semester)</b>				<b>24</b>	<b>16</b>	<b>18</b>	<b>25</b>	<b>120</b>	<b>48</b>	<b>505</b>	<b>225</b>	<b>625</b>	<b>273</b>
<b>Grand Total (I + II + III + IV Semester)</b>				<b>96</b>	<b>64</b>	<b>72</b>	<b>100</b>	<b>480</b>	<b>192</b>	<b>2020</b>	<b>900</b>	<b>2500</b>	<b>1092</b>

## **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 consists of minimum 120 working days.

### **Eligibility for Admission in M.Sc. First Semester:**

A candidate who has passed any one of the following examinations 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. 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 as well as the required infrastructure and faculty members of that specialization in the Department. If number of candidates will be more than available seats in a particular specialization, the admission in the specialized course shall be given on the basis of merit (aggregate percentage of first and second semester examinations) after receiving the option forms from the students 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 +  $n^{\text{th}}$  number of years of study +  $n^{\text{th}}$  number of semesters 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 Credits:**

Maximum marks of a theory and practical paper will be decided on the basis of their teaching hours per week. One hour per week teaching of theory/tutorial classes will be equal to one credit while two hours per week teaching of laboratory/practical classes will be equal to one credit also. One credit will carry 25 marks, therefore, theory paper having 4 credits will carry 100 maximum marks and practical paper having 4, 8 and 9 credits will carry 100, 200 and 225 maximum marks respectively.

### **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) or any modern ICT tools. The lecture would be such that the student should participate actively in the discussion. Student seminars would be conducted and scientific discussions would also 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. A special attention would be given to the slow learner students.

### **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 by which internal assessment will be taken.*

- (b) For practical papers, there will be no continuous or internal or midterm assessment and therefore, there will be only one external or semester or end-term assessment having 100% weightage of maximum marks.
- (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

3 Marks

Q. No. 2. ....  
or

3 Marks

Q. No. 3. ....  
or

3 Marks

Q. No. 4. ....  
or

3 Marks

Q. No. 5. ....  
or

3 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 First & Second Internal Assessments**

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			
			First Internal Assessment	Second Internal Assessment	Total Marks of I & II Int. Assess (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: 225**

**Distribution of Maximum Marks:**

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Major Experiment	30
2.	Exercise No. 2: Major Experiment	30
3.	Exercise No. 3: Major Experiment	30
4.	Exercise No. 4: Minor Experiment	15
5.	Exercise No. 5: Minor Experiment	15
6.	Exercise No. 6: Minor Experiment	15
7.	Practical Record	15
8.	Laboratory Skills, Regularity, etc.	25
9.	Comprehensive Viva-voce	50
<b>Total Marks</b>		<b>225</b>

**Project Work:**

The project work may also be undertaken in place of the practical work in the last semester of the M.Sc. Chemistry programme, if necessary infrastructural facilities as well as faculty members are available in the University Teaching Department / Departments of affiliated colleges. The project work shall be based on experiments, hands-on-trainings on instruments, etc. For this purpose, the students will be allotted to the faculty members to carry out the experiments, hands-on-trainings, etc. during the last semester of the M.Sc. Chemistry programme. A dissertation / project completion report has to be submitted by each student in the prescribed format along with plagiarism report. The dissertation / project completion report will be evaluated and a comprehensive viva-voce will also be taken by the panel of examiners provided by the University. A presentation will also be made by the student to present the project work briefly at the time of evaluation and comprehensive viva-voce of the project work. Marks/grade will be given to the student by the panel of examiners.

**Format for dissertation / project completion report**

Title Page

Bonafide Certificate

Dissertation Work	Page No
1. Introduction	...
2. Review of Literature	...
3. Materials and Methods	...
4. Results and Discussion	...
5. Summary	...
6. Conclusion	...
7. References	...
8. Publication, if any	...

Acknowledgement

**Format of the Cover Page and Title Page**

-----**TITLE OF THE DISSERTATION / PROJECT REPORT**-----

A Dissertation / Project Report

Submitted in part fulfilment of the requirement for the award of the Degree of

Master of Science in .....

with specialization in .....

of the  
University of Kota

Submitted by  
(Name of Student)  
(Enrolment Number)

Submitted to  
(Name of Supervisor / Mentor)  
(Designation)

Department of .....

(Name of College, if any)  
University of Kota  
Kota

(Month, Year)

**Format of the Bonafide Certificate**

**CERTIFICATE**

This is to certify that the dissertation / project report entitled "-----  
-----" submitted in part fulfilment of  
the requirement of the degree of Master of Science in Chemistry with specialization  
in ----- to the University of Kota is a record of  
bonafide research work carried out by -----  
under my supervision and guidance and that no part of the dissertation has been  
submitted for the award of any degree, diploma, fellowship or other similar titles or  
prizes and that the work has not been published in part or full in any scientific or  
popular journals or magazines in India or abroad.

Date:  
Place:

Signature  
(Student)

Signature  
(Supervisor / Mentor)



**Distribution of Maximum Marks:**

S. No.	Name of Exercise	Marks
1.	Dissertation / Project Report	100
2.	Presentation of the Dissertation / Project Report	50
3.	Laboratory Skills, Regularity, etc.	25
4.	Comprehensive Viva-voce	50
<b>Total Marks</b>		<b>225</b>

**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 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 are 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 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:

<b>Description of Marks Obtained</b>	<b>Division / Result</b>
• 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 12-15 lectures or contact hours which also include revisions, seminars, internal assessments, etc.*

#### **Unit-I: General Introduction of Separation: 12-15 L**

Nature of separation process, classification of separation methods.

##### **Chromatography:**

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

##### **Paper Chromatography:**

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

##### **Supercritical Fluid Chromatography (SFC):**

Principle, instrumentation, qualitative and quantitative analysis.

#### **Unit-II: Thin Layer Chromatography (TLC): 12-15 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: 12-15 L**

Principle, resolution, stationary phase, column efficiency, factors influencing column efficiency, experimental set up and applications; principle and application of flash chromatography.

##### **Gas Chromatography (GC):**

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

**Unit-IV: High Performance Liquid Chromatography (HPLC):** **12-15 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:** **12-15 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 micellar 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 12-15 lectures or contact hours which also include revisions, seminars, internal assessments, etc.*

**Unit-I: Ultraviolet-Visible (UV-VIS) Spectroscopy: 12-15 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  $\lambda_{\max}$  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: 12-15 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  $^1\text{H}$  NMR absorption signals of various type of compounds. spin systems & classification of spectra, splitting patterns of AX, ABX, AMX, ABC,  $\text{A}_2\text{B}_2$ , 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.  $^{15}\text{N}$ ,  $^{19}\text{F}$  &  $^{31}\text{P}$ . applications of NMR spectroscopy.

**Unit-III: Carbon-13 NMR Spectroscopy: 12-15 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  $^{13}\text{C}$  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: 12-15 L**

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



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

**Unit-V: Structure Elucidation:**

**12-15 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; 2e, 1995.*
- *Carbon-13 NMR spectroscopy, Hans-Otto Kalinowski, Stefan Berger, Siegmara 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. Silverstein, G. C. Hassler and T. C. Morill, John Wiley.*
- *Organic Spectroscopy, Jag Mohan, Narosa Publication.*
- *Spectroscopy of Organic Compounds, P. S. Kalsi, New Age International.*
- *NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R. V. Parish, Ellis Harwood.*
- *Physical Methods in Chemistry, R. S. Drago, Saunders College.*
- *Introduction to Photoelectron Spectroscopy, P. K. Ghosh, John Wiley.*
- *Introduction to Magnetic Resonance, A. Carrington and A. D. MacLachlan, Harper & Row.*
- *LC/MS: A Practical User's Guide by Marvin McMaster, Wiley-Interscience*
- *Gas Chromatography and Mass Spectrometry: A Practical Guide, Second Edition by O. David Sparkman, Academic Press.*
- *Instrumental Methods of Chemical Analysis, Gurdeep Raj Chatwal and Shyam Anand, Himalaya Publications.*

**Paper-3.3: CHEM-633: Bio-inorganic Chemistry**

(Only for Inorganic 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 12-15 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

**Unit-I: Metal Ions in Biological Systems: 12-15 L**

Bulk and trace metals with special reference to Na, K, Mg, Ca, Fe, Cu, Zn and Co.

**K<sup>+</sup>/Na<sup>+</sup> pump:** role of metal ions in biological processes.

**Bioenergetics and ATP Cycle:** DNA polymerization, glucose storage, metal complexes in transmission of energy; chlorophylls, photosystem-I and photosystem-II in cleavage of water.

**Nitrogen fixation:** Biological nitrogen fixation, and its mechanism, nitrogenase, Chemical nitrogen fixation.

**Unit-II: Transport and Storage of Dioxygen: 12-15 L**

Haem proteins and oxygen uptake structure and function of haemoglobin, myoglobin, haemocyanin and hemerythrin, model synthetic complexes of iron, cobalt and copper.

**Electron Transfer in Biology:** Structure and function of metal of proteins in electron transport, processes cytochromes and iron-sulphur proteins, synthetic models.

**Unit-III: Metal Storage and Transport and Biomineralization: 12-15 L**

Ferritin, transferrin and siderophores.

**Calcium in Biology:** Calcium in living cells, transport and regulation, molecular aspects of intra-molecular processes, extracellular binding proteins.

**Metal-Nucleic Acid Complexes:** Metal ions and metal complex interactions. Metal complex nucleic acids.

**Unit-IV: Metalloenzymes: 12-15 L**

Zinc enzymes: carboxypeptidase and carbonic anhydrase. Iron enzymes-catalase, peroxidase and cytochrome P-450. Copper enzymes-superoxide dismutase. Molybdenum oxatransferase enzymes-xanthine oxidase. Coenzyme vitamin B<sub>12</sub>.

**Unit-V: Metals in Medicine: 12-15 L**

Metal deficiency and disease, toxic effects of metals, metals used for diagnosis and chemotherapy with particular reference to anticancer drugs.

**Books:**

- *Principles of Bioinorganic Chemistry. S.J. Lippard and J.M. Berg University Science Books.*
- *Bioinorganic Chemistry, I Bertini, H.B. Gray. S.J. Lippard and J.S. Valentine, University Sci. Books.*
- *Inorganic Biochemistry Vols I and II Ed. G.L. Eichhorn, Elsevier.*
- *Progress in Inorganic Chemistry Vols. 18 G.L. Eichhorn, Elsevier and 38 Ed J.J. Lippard Wiley.*

**Paper-3.4: CHEM-634: Photo-inorganic Chemistry**

(Only for Inorganic 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 12-15 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

**Unit-I: Basic of Photochemistry:** **12-15 L**  
Absorption, excitation, photochemical laws, quantum yield, electronically excited states-life times, measurements of the times. Flash photolysis stopped flow techniques. Energy dissipation by radiative and non-radiative processes, absorption spectra, Frank-Condon principle, photochemical stages-primary and secondary processes.

**Unit-II: Properties of Excited States:** **12-15 L**  
Structure, dipole moment, acid-base strengths, reactivity. Photochemical kinetics-calculation of rates of radiative processes. Bimolecular deactivation-quenching.

**Unit-III: Excited States of Metal Complexes:** **12-15 L**  
Comparison with organic compounds, electronically excited states of metal complexes, charge transfer spectra, charge transfer excitations, methods for obtaining charge-transfer spectra.

**Metal Complex Sensitizers:**

Metal complex sensitizers, electron relay, metal colloid systems, semiconductor supported metal or oxide systems, water photolysis, nitrogen fixation and carbon dioxide reduction.

**Unit-IV: Ligand Field Photochemistry:** **12-15 L**  
Photo-substitution, photo-oxidation and photo-reduction, lability and selectivity, zero vibrational levels of ground state and excited state, energy content of excited state, zero-zero spectroscopic energy, development of the equations for redox potentials of the excited states.

**Unit-V: Redox Reactions by Excited Metal Complexes:** **12-15 L**  
Energy transfer under conditions of weak interaction and strong interaction-exciple complex formation; condition of the excited states to be useful as redox reactants, excited electron transfer, metal complexes as attractive candidates, (2,2-bipyridine and 1,10-phenanthroline complexes), illustration of reducing and oxidizing character of Ru<sup>+2</sup>(bipyridal complex, comparison with Fe(bipy)<sub>3</sub>; role of spin-orbit coupling-life time of these complexes. Application of redox processes of electronically excited states for catalytic purposes, transformation of low energy reactants into high energy products, chemical energy into light.

**Books:**

- *Concepts of Inorganic Photochemistry, A.W. Adamson and P.D. Fleischauer, Wiley.*
- *Inorganic Photochemistry, J. Chem. Educ. vol. 60 No. 10, 1983.*
- *Progress in Inorganic Chemistry, Vol. 30ed. S.J. Lippard. Wiley.*
- *Coordination Chem. Revs. 1981, vol. 39, 121, 131; 1975, 15, 321; 1990 97, 313.*
- *Photochemistry of Coordination Compounds, V. Balzari and V. Carassiti, Academic Press.*
- *Elements in Inorganic Photochemistry, G.J. Ferraudi, Wiley.*

### **Paper-3.5: CHEM-635: Inorganic Chemistry Practical**

(Only for Inorganic Chemistry Specialization)

**Contact Hours / Week** : 18 Hours

**Duration of Examination:** 12 Hours

**Maximum Marks:** 225 Marks

**Distribution of Marks:**

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Major Experiment	30
2.	Exercise No. 2: Major Experiment	30
3.	Exercise No. 3: Major Experiment	30
4.	Exercise No. 4: Minor Experiment	15
5.	Exercise No. 5: Minor Experiment	15
6.	Exercise No. 6: Minor Experiment	15
7.	Practical Record	15
8.	Laboratory Skills, Regularity, etc.	25
9.	Comprehensive Viva-voce	50
<b>Total Marks</b>		<b>225</b>

**Quantitative Analysis:**

Analysis of a three-component mixture of metal ions by gravimetrically and volumetrically:

- $\text{Cu}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Zn}^{2+}$
- $\text{Cu}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Ag}^+$
- $\text{Cu}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Mg}^{2+}$
- $\text{Cu}^{2+}$ ,  $\text{Ag}^+$ ,  $\text{Fe}^{2+}$
- $\text{Ni}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Fe}^{2+}$

**Inorganic Preparations:**

Preparation of selected inorganic compounds and their study by IR, electronic, Mossbauer, ESR and magnetic susceptibility measurements. Handling of air and moisture sensitive compounds involving vacuum lines. Selection can be made from the following:

- $\text{Na}_3[\text{Co}(\text{ONO})_6]$
- $[\text{CoCl}(\text{NH}_3)_5]\text{Cl}_3$
- $\text{TiO}(\text{C}_9\text{H}_8\text{NO})_2 \cdot 2\text{H}_2\text{O}$
- $\text{Na}[\text{Cr}(\text{NH}_3)_2(\text{SCN})_4]$
- $[\text{Co}(\text{NH}_3)_6][\text{Co}(\text{NO}_2)_6]$
- cis- $[\text{Co}(\text{trien})(\text{NO}_2)_2] \cdot \text{Cl} \cdot \text{H}_2\text{O}$
- $\text{Hg}[\text{Co}(\text{SCN})_4]$
- $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$
- Sodium tetrathionate  $\text{Na}_2\text{S}_4\text{O}_6$ .
- Sodium amide. *Inorg. Synth.*, 1946, 2, 128.
- PhBce Dichlorophenylborane - Synthesis in vacuum line.
- Hexa-bis(4-nitrophenoxy)cyclotriphosphazene.
- Preparation of Tin (IV) iodide, Tin (IV) chloride and Tin (II) iodide, *Inorge, Synth.*, 1953, 4, 119.

**Spectrophotometry:**

- Determination of equilibrium constant of reaction  $\text{KI} + \text{I}_2 = \text{KI}_3$  spectrophotometrically

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

#### **(v) Electrogravimetric Titrations:**

- Electrogravimetric estimation of barium, copper, chromium, lead, nickel present in the solution at ppm level.

#### **(vi) Amperometric Titrations:**

- Amperometric determination of Zinc with standard EDTA solution.

- Amperometric titration of lead with standard potassium dichromate solution.
- Amperometric determination of magnesium (or cadmium) by precipitating it as oxinate and titrating against standard  $\text{KBrO}_3$  solution.
- Estimation of the mercapto group in thioglycolic acid by titrating with standard  $\text{AgNO}_3$  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  $\text{SO}_4^{2-}$  (b) Pb v/s  $\text{K}_2\text{Cr}_2\text{O}_7$  (c) Ni v/s DMG.
- Estimation of sulphadiazine in sulpha tablet by amperometric titration method.

**Flame Photometric Determinations:**

- Sodium and potassium when present together.
- Lithium/Calcium/barium/strontium.
- Cadmium and magnesium in tap water.

*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 12-15 lectures or contact hours which also include revisions, seminars, internal assessments, etc.*

#### **Unit-I: Air Pollution: 12-15 L**

Concept of environment chemistry, composition of atmosphere, major sources of air pollution, chemical reactions, smog formation, acid rain, classification and effect of air pollutants, NO<sub>x</sub>, SO<sub>x</sub>, CO<sub>x</sub> particulates and ozone; Greenhouse effect and global warming, ozone depletion, automobile emissions, prevention and control of vehicular pollution, alternative fuels: Biodiesel, ethanol, CNG, ultra low sulphur diesel (ULSD).

##### **Monitoring of Air Pollution:**

Principles of environment monitoring, methods for monitoring of air pollutants including NO<sub>x</sub>, SO<sub>x</sub>, CO<sub>x</sub>, 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: 12-15 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<sub>2</sub>, Cl<sub>2</sub>, metals, ions, dissolved chlorine and oxygen, BOD, COD, chlorine dosage, *E. coli* index, general methods of water pollution control.

#### **Unit-III: Soil Pollution: 12-15 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, environment friendly technologies for agriculture

**Unit-IV: Industrial Pollution:**

**12-15 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 wastewater, wastewater treatment, solid waste management, hazardous waste management.

**Unit-V: Radioactive Pollution:**

**12-15 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. 12<sup>th</sup> 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. 1<sup>st</sup> Edition, 2007, CBS Publishers & Distributors, New Delhi.
- *Environmental Pollution Control Engineering*. C. S. Rao. 2<sup>nd</sup> 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. 20<sup>th</sup> Ed, 2006, TataMcGraw-Hill, New Delhi.
- *Industrial Pollution*. V. P. Kudesia. 5<sup>th</sup> Edition, 2007, Pragati Prakashan, Meerut.
- *Water Supply and Sanitary Engineering*. G. S. Birdie & J. S. Birdie. 8<sup>th</sup> 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: 12-15 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 peracids.

**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, biocatalysts.

**Unit-II: Solvents for Organic Synthesis: 12-15 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<sub>2</sub>, supercritical CO<sub>2</sub>, 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 alkyipyridinium 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: 12-15 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: 12-15 L**

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

**Electrochemical Organic Synthesis:**

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

**Unit-V: Organic Synthesis Using Reactors: 12-15 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. Anastos 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. Anastos, WILEY-VCH
- *Green Solvents, Vol. 6: Ionic Liquids*. edited by Paul T. Anastos, 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: Organotransition Metal Chemistry**

(Only for Inorganic 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 12-15 lectures or contact hours which also include revisions, seminars, internal assessments, etc.

#### **Unit-I Alkyls and Aryls of Transition Metals: 12-15 L**

Types, routes of synthesis, stability and decomposition pathways organo-copper in organic synthesis. Transition metal compounds with bonds to hydrogen.

#### **Unit-II Compounds of Transition Metal-Carbon Multiple Bonds: 12-15 L**

Alkylidenes, alkylidyne, low valent carbenes and carbynes-synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligands, role in organic synthesis.

#### **Unit-III Transition Metal $\pi$ -Complexes: 12-15 L**

Transition metal  $\pi$ -Complexes with unsaturated organic molecules, alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes, preparation, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligands and to organic synthesis.

**Unit-IV Homogeneous Catalysis: 12-15 L**

Stoichiometric reactions for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction), oxo palladation reactions, activation of C-H bond.

**Unit-V Fluxional Organometallic Compounds: 12-15 L**

Fluxionality and dynamic equilibrium in compounds such as  $\eta^2$ -olefine,  $\eta^3$ -allyl and dienyl complexes.

**Books:**

- *Principles and Application of Organotransition Metal Chemistry*, J.P. Collman, L.S. Hegsdus, J.R. Norton and R.G. Finke, University Science Books.
- *The Organometallic Chemistry of the Transition Metals*, R.H. Crabtree. John Wiley.
- *Metallo-organic Chemistry*, A.J. Pearson, Wiley.
- *Organometallic Chemistry*, R.C. Mehrotra and A. Singh New Age International.

**Paper-4.4: CHEM-644: Polymers**

(Only for Inorganic 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 12-15 lectures or contact hours which also include revisions, seminars, internal assessments, etc.*

**Unit-I Polymers: 12-15 L**

Importance of polymers. Basic concepts: Monomers, repeat units, degree of polymerization Linear, branched and network polymers. Classification of polymers. Polymerization: condensation, addition/radical chain-ionic and co-ordination and copolymerization. Polymerization conditions and polymer reactions. Polymerization in homogeneous and heterogeneous systems.

**Unit-II Structure and Properties: 12-15 L**

Morphology and order in crystalline polymers-configurations of polymers chains. crystal structure of polymers. Morphology of crystalline polymers, strain-induced morphology, crystallization and melting. Polymer structure and physical properties-crystalline melting point ( $T_m$ ), melting point of homogenous series, effect of chain flexibility and other steric factors, entropy and heat of fusion. The glass transition



temperature (T<sub>g</sub>), relationship between T<sub>m</sub> and T<sub>g</sub>, effect of molecular weight, diluents, chemical structure, chain topology, branching and cross linking.

**Unit-III Polymer Characterization: 12-15 L**

Polydispersion-average molecular weight concept. Number, weight and viscosity average molecular weights. Polydispersity and molecular weight distribution. The practical significance of molecular weight. Measurement of molecular-weights, end-group, viscosity, light scattering, osmotic and ultracentrifugation methods. Analysis and testing of polymers-Chemical analysis of polymers, spectroscopic methods, X-ray diffraction study. Microscopy. Thermal analysis and physical testing tensile strength. Fatigue, impact. Tear resistance, hardness and abrasion resistance.

**Unit-IV Polymer Processing: 12-15 L**

Plastics, elastomers and fibers. Compounding. Processing techniques: Calendaring, die casting, rotational casting, film casting, injection molding, blow molding, extrusion molding, thermoforming, foaming, reinforcing and fiber spinning.

**Unit-V Inorganic Polymers: 12-15 L**

Structure, Properties and Applications of

- Polymers based on Boron-borazines, boranes and carboranes.
- Polymers based on Silicon-silicones, polymetalloxanes, polymetallosiloxanes, silazanes.

Structure, Properties and Applications of

- Polymers based on Phosphorous-Phosphazenes, Polyphosphates
- Polymers based on Sulphur-Tetra Sulphur tetranitride and related compounds.

**Books:**

- *Inorganic Chemistry, J.E. Huheey, Harper Row.*
- *Developments in Inorganic polymer Chemistry, M.F. Lappert and G.J. Leigh.*
- *Inorganic polymers- N.H. Ray.*
- *Inorganic polymers, Graham and Stone.*
- *Inorganic Rings and Cages: D.A. Armitage.*
- *Textbook of Polymers Science, F.W. Billmeyer Jr. Wiley.*
- *Contemporary Polymer Chemistry, H.R. Alcock and F.W. Lambe, Prentice Hall.*
- *Polymer science, V.R. Gowariker, N.V. Viswanthan and J. Shreedhar Wiley-Eastern.*

**Paper-4.5: CHEM-645: Inorganic Chemistry Practical**

(Only for Inorganic Chemistry Specialization)

**Contact Hours / Week : 18 Hours**

**Duration of Examination : 12 Hours**

**Maximum Marks: 225 Marks**

**Distribution of Marks:**

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Major Experiment	30
2.	Exercise No. 2: Major Experiment	30
3.	Exercise No. 3: Major Experiment	30
4.	Exercise No. 4: Minor Experiment	15
5.	Exercise No. 5: Minor Experiment	15
6.	Exercise No. 6: Minor Experiment	15
7.	Practical Record	15



8.	Laboratory Skills, Regularity, etc.	25
9.	Comprehensive Viva-voce	50
<b>Total Marks</b>		<b>225</b>

### Inorganic Preparations:

Preparation of selected inorganic compounds and their study by IR, electronic, Mossbauer, ESR and magnetic susceptibility measurements. Handling of air and moisture sensitive compounds involving vacuum lines. Selection can be made from the following:

- Synthesis and thermal analysis of group II metal oxalate hydrate. *J. Chem. Ed.*, 1988, 65, 1024.
- Atomic absorption analysis of Mg and Ca.
- Trialkoxyboranes-IR and NMR spectra.
- Relative Stability of Tin (IV) and Pb (IV).
- Preparation of ammonium hexachlorostannate  $(\text{NH}_4)_2 \text{SnCl}_6$  ammonium hexachloroplumbate  $(\text{NH}_4)_2 \text{PbCl}_6$ .
- Metal complexes of dimethyl sulfoxide (IR):  $\text{CuCl}_2 \cdot 2\text{DMSO}$ ,  $\text{PdCl}_2 \cdot 2\text{DMSO}$ ,  $\text{RuCl}_2 \cdot 4\text{DMSO}$ . *J. Chem. Edu.*, 1982, 59, 57.
- Magnetic moment of  $\text{Cu}(\text{acac})_2 \cdot \text{H}_2\text{O}$ .
- Separation of optical isomer of  $\text{cis}[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$ . *J. Chem. Soc.*, 1960, 4369.
- Determination of Cr(III) complexes.  $[\text{Cr}(\text{H}_2\text{O})_6]\text{NO}_3 \cdot 3\text{H}_2\text{O}$ ,  $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl} \cdot 2\text{H}_2\text{O}$ ,  $[\text{Cr}(\text{en})_3]\text{Cl}_3$ ,  $\text{Cr}(\text{acac})_3$ . *Inorg. Synths.*, 1972, 13, 184.
- Preparation and use of Ferrocene. *J. Chem. Edu.* 1966, 43, 73; 1976, 53, 730.
- Preparation of phosphine  $\text{Ph}_3\text{P}$  and its transition metal complexes.
- Preparation of  $[\text{Co}(\text{phenanthroline-5,6 quinone})]$ .
- Any other experiment such as conversion of p-xylene to terephthalic acid catalyzed by  $\text{CoBr}_2$  (homogeneous catalysis).
- Synthesis of trichlorodiphenylantimony (V) hydrate. *Inorg. Synths.*, 1985, 23, 194
- Synthesis of metal acetylacetonate: Magnetic moment, IR, NMR, *Inorg. Synths*, 1957, 5, 130, 1963, 1, 183.
- Bromination of  $\text{Cr}(\text{acac})_3$ . *J. Chem. Edu.*, 1986, 63, 90.
- Ion exchange separation of oxidation state of vanadium. *J. Chem. Edu.*, 1980, 57, 316; 1978, 55, 55.
- Preparation of N,N bis (salicylaldehyde) ethylenediamine, silane  $\text{H}_2$ .  $\text{Co}(\text{Silane})$  *J. Chem. Edu.*, 1977, 54, 443; 1973, 50, 670.
- Preparation of Fe(II) chloride (use it as Friedel-Craft chlorination source) *J. Org. Chem.*, 1978, 43, 2423; *J. Chem. Edu.*, 1984, 61, 645; 1986, 63, 361.
- Reaction of Cr(III) with a multidentate ligand: a kinetics experiment (visible spectra Cr-EDTA complex) *J. Am. Chem. Soc.*, 1953, 75, 6570.
- Preparation of copper glycine complex-cis and trans bis (glycinato Copper (II)). *J. Chem. Soc. Dalton*, 1979, 1901, *J. Chem. Edu.*, 1982, 59, 1052.

### Conductometry:

- Determination of relative strength of acetic acid, chloroacetic acid and trichloroacetic acid through measuring their  $K_a$ -value by conductivity measurement method.
- Conductometric titration of (i) strong acid, monobasic weak acid or polybasic weak acid with strong base (ii) zinc with EDTA and (iii)  $\text{KCl}$  v/s  $\text{AgNO}_3$ .

- Determination of the strength of HCl+CH<sub>3</sub>COOH mixture against standard NaOH solution.
- Conductometric titration of triple mixture (HCl+NH<sub>4</sub>Cl+KCl) with (i) NaOH and (ii) AgNO<sub>3</sub>.
- 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<sub>3</sub>/acetic acid and to determine the degree of dissociation and equilibrium constant in different solvents and in their mixtures (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Hückel-Onsager theory.
- Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Hückel's limiting law.
- Titration of ZnSO<sub>4</sub> / MgSO<sub>4</sub> against BaCl<sub>2</sub> and Ba(CH<sub>3</sub>COO)<sub>2</sub> and calculation of amount of sulphate present.
- Determination of solubility and solubility product of sparingly soluble salts (e.g. PbSO<sub>4</sub>, BaSO<sub>4</sub>) conductometrically.

#### **Potentiometry / pH metry:**

- Determination of EMF of Daniel cell.
- Determination of standard electrode potential (E<sub>o</sub>) value of the ferrous-ferric system by titrating ferrous ammonium sulphate against potassium dichromate potentiometrically.
- Determination of pK<sub>a</sub> of dibasic acid (oxalic acid, succinic acid, etc).
- Determination of the formation constant of Ag-ammonia complex and stoichiometry of the complex potentiometrically.
- Determination of hydrolysis constant and degree of hydrolysis of aniline hydrochloride pH metrically
- Determination of thermodynamic parameters for electrochemical reactions (To determine ΔG<sub>o</sub>, ΔH<sub>o</sub> and ΔS<sub>o</sub> for the formation of 1 mole cadmium in 1 wt.% amalgam at 25°C and activity coefficient of solution)
- Estimate the number of halides present in the given mixture by titrating with AgNO<sub>3</sub> solution.
- Determination of strength of acetic acid from the commercial vinegar sample by potentiometric titration and its confirmation by conductometric / pH metric titration using standard solution of NaOH.
- Micro-determination of glucose using potassium ferrocyanide as internal reagent and Ce (IV) solution as standard titrant.
- Determination of the dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by titrating it with KOH.
- Estimation of various transition elements like Zn/Ni/Co/Cd/Al from various commercial samples by complexometric titrations on potentiometer by using mercury electrode.
- Determine the amount of HCl by using weak base (NH<sub>4</sub>OH) 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 Voltammetry of the  $[\text{Fe}(\text{CN})_6]^{3-}/[\text{Fe}(\text{CN})_6]^{4-}$  system.

**Chromatographic Separations:**

- Cadmium and zinc
- Zinc and magnesium.
- Thin-layer chromatography-separation of nickel, manganese, cobalt and zinc. Determination of  $R_f$  values.
- Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of  $R_f$  values.

*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.*

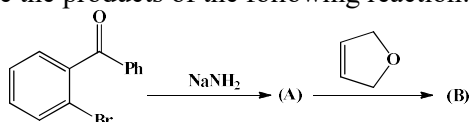
- **Section-A** will carry 10 marks with 01 compulsory question comprising 10 short answer type questions (maximum 20 words answer) taking two questions from each unit. Each question shall be of one mark.
- **Section-B** will carry 25 marks with equally divided into five long answer type questions (answer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

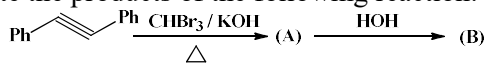
**Q. 1.**

##### Unit-I

(i) Write the products of the following reaction:



(ii) Write the products of the following reaction:

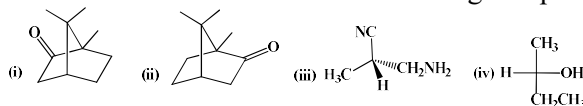


##### Unit-II

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

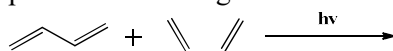
$\frac{1}{2} + \frac{1}{2} = 1$

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

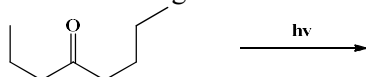


##### Unit-III

(v) Complete the following reaction:

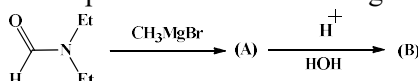


(vi) Complete the following reaction:

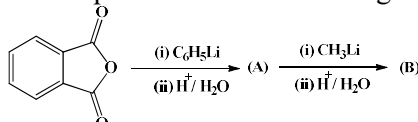


##### Unit-IV

(vii) Write the products of the following reaction:

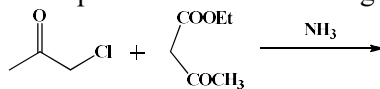


(viii) Write the products of the following reaction:



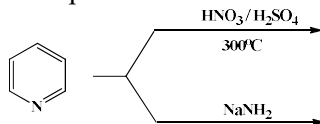
**Unit-V**

(ix) Write the products of the following reaction:



1

(x) Write the products of the following reaction:



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

**SECTION-B**

**Unit-I**

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

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

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

OR

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

- (i) Carbocations
- (ii) Carbenes

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

**Unit-II**

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

$2 + 3 = 5$

OR

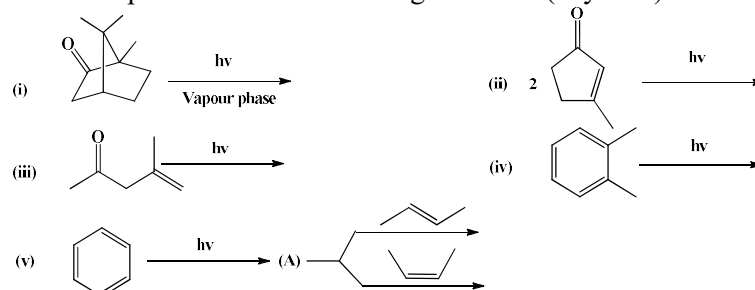
Write note on the following (any two):

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

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

**Unit-III**

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



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

OR

Discuss in detail:

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

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

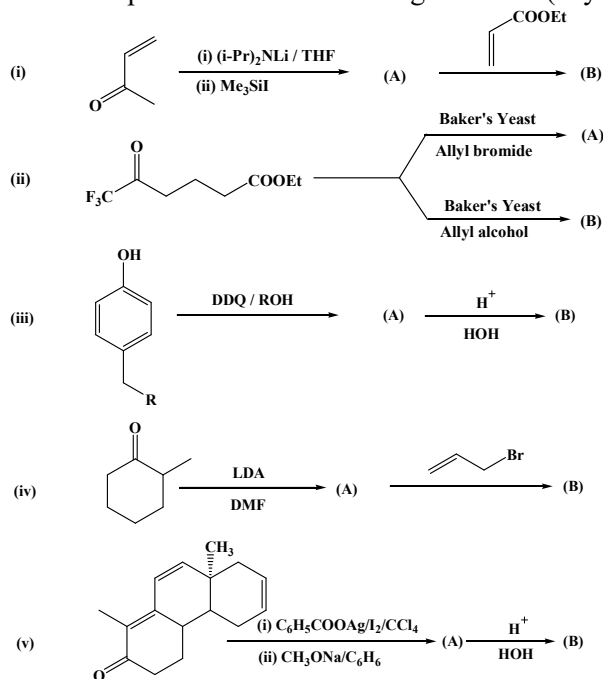
### Unit-IV

- Q. 5.** Write note on the following:  
 (i) Metal hydrides in organic synthesis  
 (ii) Phase transfer catalysts

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

OR

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



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

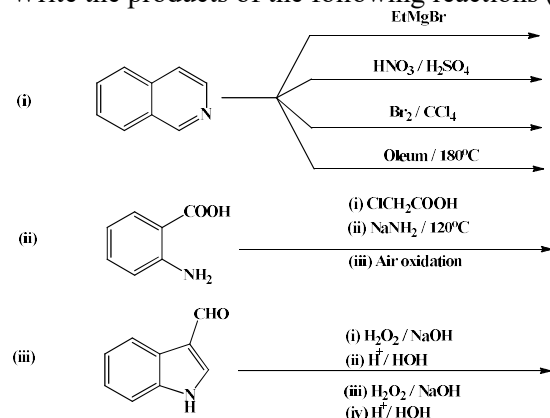
### Unit-V

- Q. 6.** Give the plausible mechanisms of the following name reactions:  
 (i) Fischer-indole synthesis  
 (ii) Doebner-Miller synthesis  
 (iii) Bischler-Napieralski synthesis  
 (iv) Skrapu synthesis

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

OR

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



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

**SECTION-C**

**Unit-I**

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

2+13 = 15

**Unit-II**

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

5+5 = 10

**Unit-III**

- Q. 9.** Give an account on the following:  
(i) Photochemistry of  $\beta,\gamma$ -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** .....