SCHEME OF EXAMINATIONS

RULES & REGULATIONS

AND

SYLLABUS

Third & Fourth Semester Examinations
Analytical Chemistry Specialization

(Effective from the Academic Session 2014-2015)

Master of Science (M. Sc.)
Chemistry

Faculty of Science

This syllabus is only for courses running at University Department of Chemistry

UNIVERSITY OF KOTA

MBS Marg, Near Kabir Circle, KOTA (Rajasthan)-324 005

INDIA

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University of Kota
Kota

M. Sc. Chemistry

Scheme of Examinations

(First & Second Semester)

Year / Semester	Number, Code/ID and Nomenclature of Paper			Duration of Exam.	Teaching Hrs/Week & Credit Points		Distribution of Assessment Marks				Total Marks	
							Continuous Assessment (20%)		Semester Assessment (80%)			
	Number of Paper	Code / ID of Paper	Nomenclature of Paper		Teaching Hrs / Week	Credit Points	Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks
I Year I Semester	Paper-1.1	CHEM-511	Inorganic Chemistry	3 Hrs	4	4	20	07	80	29	100	36
	Paper-1.2	CHEM-512	Organic Chemistry	3 Hrs	4	4	20	07	80	29	100	36
	Paper-1.3	CHEM-513	Physical Chemistry	3 Hrs	4	4	20	07	80	29	100	36
	Paper-1.4	CHEM-514	Analytical Chemistry	3 Hrs	4	4	20	07	80	29	100	36
	Paper-1.5	CHEM-515	Mathematics for Chemists / Biology for Chemists	3 Hrs	4	4	20	07	80	29	100	36
	Paper-1.6	CHEM-516	Practical Part-I: Inorganic Chemistry Part-II: Organic Chemistry Part-III: Physical Chemistry Part-IV: Analytical Chemistry	12 Hrs	18	12	60	24	240	96	300	120
			Total (I Semester)	**27 Hrs**	**38**	**32**	**160**	**59**	**640**	**241**	**800**	**320**
I Year II Semester	Paper-2.1	CHEM-521	Inorganic Chemistry	3 Hrs	4	4	20	07	80	29	100	36
	Paper-2.2	CHEM-522	Organic Chemistry	3 Hrs	4	4	20	07	80	29	100	36
	Paper-2.3	CHEM-523	Physical Chemistry	3 Hrs	4	4	20	07	80	29	100	36
	Paper-2.4	CHEM-524	Environmental Chemistry	3 Hrs	4	4	20	07	80	29	100	36
	Paper-2.5	CHEM-525	Computer Applications in Chemistry	3 Hrs	4	4	20	07	80	29	100	36
	Paper-2.6	CHEM-526	Practical Part-I: Inorganic Chemistry Part-II: Organic Chemistry Part-III: Physical Chemistry Part-IV: Environmental Chemistry	12 Hrs	18	12	60	24	240	96	300	120
			Total (II Semester)	**27 Hrs**	**38**	**32**	**160**	**59**	**640**	**241**	**800**	**320**

University of Kota
Kota

M. Sc. Chemistry

Scheme of Examinations

Third & Fourth Semester
(Analytical Chemistry Specialization)

Year / Semester	Number, Code/ID and Nomenclature of Paper			Duration of Exam.	Teaching Hrs/Week & Credit Points		Distribution of Assessment Marks				Total Marks	
							Continuous Assessment (20%)		Semester Assessment (80%)			
	Number of Paper	Code / ID of Paper	Nomenclature of Paper		Teaching Hrs /	Credit Points	Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks	Max. Marks	Min. Pass Marks
II Year III Semester	Paper-3.1	CHEM-631	Spectroscopy	3 Hrs	4	4	20	07	80	29	100	36
	Paper-3.2	CHEM-632	Chromatography	3 Hrs	4	4	20	07	80	29	100	36
	Paper-3.3	CHEM-633	Elective-I: IPR, QA & QC and Regulatory Affairs	3 Hrs	4	4	20	07	80	29	100	36
	Paper-3.4	CHEM-634	Elective-II : Electro-analytical Chemistry	3 Hrs	4	4	20	07	80	29	100	36
	Paper-3.5	CHEM-635	Elective-III: Applied Analytical Chemistry	3 Hrs	4	4	20	07	80	29	100	36
	Paper-3.6	CHEM-636	Practical: Paper-3.1 & 3.2 with electives as Part-I : Elective-I Part-II : Elective-II Part-III : Elective-III	12 Hrs	18	12	60	24	240	96	300	120
	Total (III Semester)			**27 Hrs**	**38**	**32**	**160**	**59**	**640**	**241**	**800**	**320**
II Year IV Semester	Paper-4.1	CHEM-641	Spectroscopy	3 Hrs	4	4	20	07	80	29	100	36
	Paper-4.2	CHEM-642	Recent Advances in Chemistry	3 Hrs	4	4	20	07	80	29	100	36
	Paper-4.3	CHEM-643	Elective-I: Instrumental Methods of Analysis	3 Hrs	4	4	20	07	80	29	100	36
	Paper-4.4	CHEM-644	Elective-II: Pharmaceutical Analysis	3 Hrs	4	4	20	07	80	29	100	36
	Paper-4.5	CHEM-645	Elective-III: Applied Analytical Chemistry	3 Hrs	4	4	20	07	80	29	100	36
	Paper-4.6	CHEM-646	Practical: Paper-4.1 & 4.2 with electives as Part-I : Elective-I Part-II : Elective-II Part-III : Elective-III	12 Hrs	18	12	60	24	240	96	300	120
	Total (IV Semester)			**27 Hrs**	**38**	**32**	**160**	**59**	**640**	**241**	**800**	**320**
Grand Total (Semester I + II + III + IV)				**108 Hrs**	**152**	**128**	**640**	**236**	**2560**	**964**	**3200**	**1280**

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 pharmaceutical, agrochemical and chemical factories, coals, mines and related industries necessitates chemistry education. Hence our goal in introducing the M. Sc programme in Chemistry to educate the students in the fascinating fields of chemistry in an effective manner.

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 about Mathematics, Biology, Computer applications in Chemistry.
- To acquire basic knowledge in the specialized areas like Organic Synthesis, Heterocyclic Chemistry, Medicinal Chemistry, Pharmaceutical Chemistry, Green Chemistry, Polymer Chemistry, Bio-inorganic / Organic / Physical Chemistry, Environmental Chemistry, Photo-inorganic / Organic Chemistry, Solid State Chemistry, Supra-molecular Chemistry, Electrochemistry, *etc*.

Duration of the Course:

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

Eligibility for Admission in M Sc First Semester:

A candidate who has passed any one of the following degrees 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 from this University after completion of a course of study of two academic years divided in the four semester scheme of examination:

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

Eligibility for Admission in M Sc Third Semester:

A candidate who has cleared at least 50% of the papers (including practical / project / dissertation / seminar *etc.* as one paper) prescribed for the first and second semester examinations taken together as a regular course of study from this University shall be promoted to the third semester examination as a regular candidate.

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 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) subject to availability of the specialization in the Department. Admission for the specialization course shall be given on the merit basis (aggregate percentage of first and second semester examination) after receiving option forms with preferences for all available specializations, if number of candidates will be more than seats available in a particular specialization.

Structure of the Programme:

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.

Course Number, Course Code/ID and Nomenclature:

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

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

"Abbreviation of the programme in upper case + n^{th} number of year of study + n^{th} number of semester of the programme + course number in Arabic number"

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

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:

Maximum marks of a theory and practical paper will be decided on the basis of their contact hours per week. One teaching hour per week will carry 25 maximum marks and therefore, four teaching hours per week will carry 100 maximum marks for each theory paper / course. Each three contact hours per week for laboratory or practical work will be equal to two contact hours per week for theory paper, therefore, for 18 contact hours per week for practical work or laboratory work will be equal to 12 contact hours per week for theory paper and hence will carry 300 maximum marks.

Attendance:

Every teaching faculty, handling a course, shall be responsible for the maintenance of Attendance Register for candidates who have registered for the course. The teacher of the course must intimate the Head of the Department at least seven calendar days before the last instruction day in the semester about the attendance particulars of all students. Each student

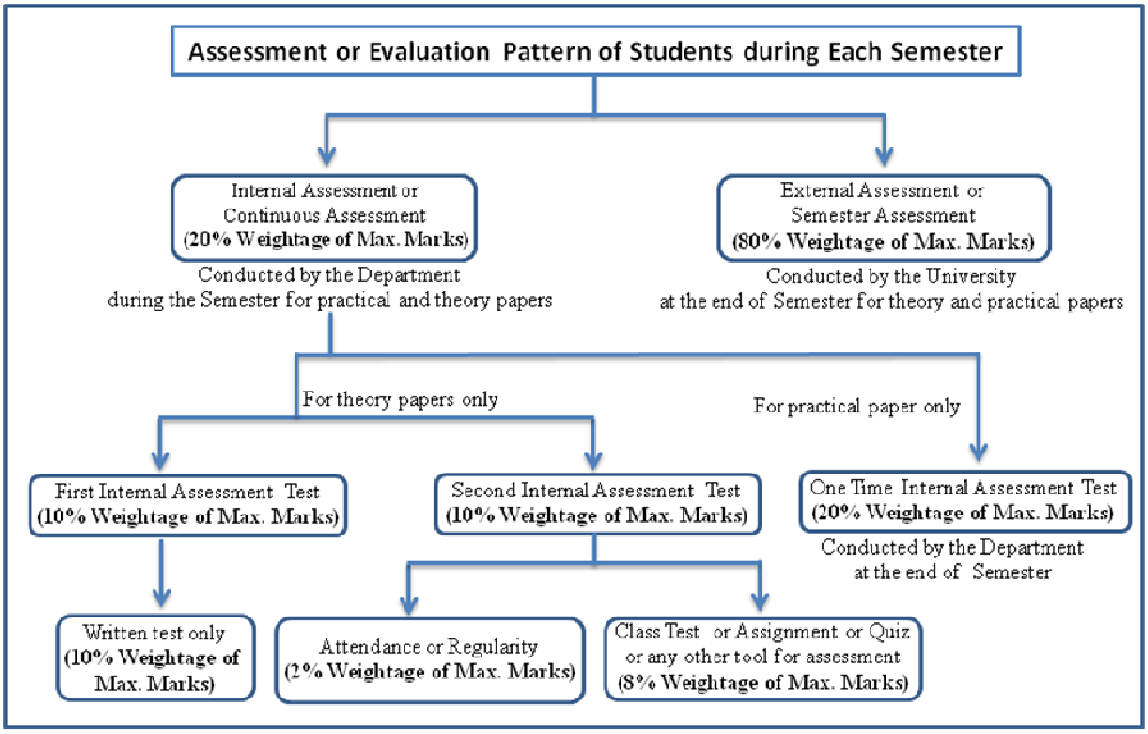
should earn 75% attendance in the courses of the particular semester failing which he or she will not be permitted to sit in the End-Semester Examinations. However, it shall be open to the authorities to grant exemption to a candidate who has failed to obtain the prescribed 75% attendance for valid reasons and such exemptions should not under any circumstance be granted for attendance below 65%.

Teaching Methodologies:

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

Assessment Pattern:

The assessment of the student shall be divided into two parts in which first part is continuous assessment or internal assessment and second part is semester assessment or external assessment. Assessment pattern and distribution of maximum marks is summarized as given below:



(i) Continuous Assessment or Internal Assessment:

(a) The continuous assessment or internal assessment for each theory and practical paper shall be taken by the faculty members in the Department during each semester. There will be two internal assessment tests (*i.e.* First Internal Assessment Test and Second Internal Assessment Test) for theory papers and only one internal assessment test for practical work / laboratory work in each

semester. Each internal assessment test shall be of one hour duration for theory paper and three hours duration for practical paper and shall be taken according to academic calendar which will be notified by the Department / University.

(b) A student cannot repeat or re-appear in any internal assessment test in the same or in the next semesters means student has to clear internal assessment test in the appearing semester only with single chance. If the attendance / regularity factor is similar for all the students, then it may be merged with the weightage of second internal assessment test (class test / home assignment / quiz, *etc.*).

(c) In case a candidate remains absent at any one of the internal assessment tests for valid reasons, he/she may be given a chance by the Head of the Department on production of satisfactory evidence about the reason of his/her absence at the tests.

(d) Paper wise consolidated marks for each theory and practical / dissertation / seminar (*i.e.* total marks obtained during various modes of internal assessment) obtained by the students (out of the 20% weightage of the maximum marks of the paper) shall be forwarded by the Head of the Department (in two copies) to the Controller of Examination of the University within a week from the date of last internal assessment test for incorporation in the tabulation register.

(e) The consolidated marks obtained by the students be also made known to them before being communicated by the Head of the Department concerned 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 Head of the Department 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.

(f) Consolidated marks 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 to avoid any fraction.

(g) All test copies and other material related to the internal assessment shall also be sent to the Controller of Examination of the University to keep in record as per the University guidelines.

(h) The Head of the Department concerned shall be responsible for proper conduct of internal assessment tests and for communication of the consolidated marks to the University within the prescribed time.

(i) 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 should represent the matter to the Head of the Department.

(j) The marks in internal assessment for practical shall be awarded on the basis of three minor experiments, day to day performance in the laboratory, follow cleaning and safety norms, regularity in the laboratory, viva-voce, practical record and oral presentation given by each student.

(ii) Semester Assessment or External Assessment:

(a) The semester assessment or external assessment shall be three hours duration to each theory paper and twelve hours duration spread over two days (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 of equally divided in ten short answer type questions (about 20 words) and examiners are advised to set two short answer type questions from each unit.
- **Section-B** will carry 40 marks with equally divided five long answer type questions (about 200 words) and examiners are advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit, and
- **Section-C** will carry 30 marks with equally divided three very long answer type questions (about 400 words) and examiners are advised to set five questions one from each unit and students are instructed to attempt any three questions out of five questions.

(c) The syllabus of practical paper is divided according to Inorganic Chemistry, Organic Chemistry, Physical Chemistry, Analytical Chemistry, Environmental Chemistry, *etc.* in the first & second semesters and according to various types of industries in the third & fourth semesters. Marks shall be awarded on the basis of major & minor experiments, viva-voce, practical record, regularity factor and maintain cleanness of workplace.

Question Paper Pattern:

(A) Continuous or Internal Assessment:

20% weightage of Maximum Marks (20 Marks out of 100 Maximum Marks)

(i) First Internal Assessment Test:

Format for Internal Assessment

Department of Pure & Applied Chemistry
University of Kota
Kota (Rajasthan)-324 005

First Internal Assessment Test 20… - 20….

Class	**:**	**Max. Marks**	**:**
Semester	**:**	**No. of Students**	**:**
Subject	**:**	**Duration of Exam**	**:**
Paper	**:**	**Name of Teacher**	**:**

Note: All questions are compulsory and marks are given at the end of the each question. Two or three sub-divisions may be given in the question.

Q. No. 1. …… (without option).
4 Marks

Q. No. 2. ……..
or
…….
3 Marks

Q. No. 3. ……..
or
…….
3 Marks

(ii) Second Internal Assessment Test:

(a) Attendance:

Marks shall be given by the faculty member in each paper according to its weightage.

Max. Marks: 2

(b) Class Test:

Format for Internal Assessment

Department of Pure & Applied Chemistry
University of Kota
Kota (Rajasthan)-324 005

Second Internal Assessment Test 20… - 20….

Class	**:**	**Max. Marks**	**:**
Semester	**:**	**No. of Students**	**:**
Subject	**:**	**Duration of Exam**	**:**
Paper	**:**	**Name of Teacher**	**:**

Note: All questions are compulsory and marks are given at the end of the each question. Two or three sub-divisions may be given in the question.

Q. No. 1. …… (without option).
3 Marks

Q. No. 2. ……..
or
…….
2 ½ Marks

Q. No. 3. ……..
or
…….
2 ½ Marks

or

(b) Assignment:

(May be divided in parts or questions or may not be. It will be depending on the nature of assignment).

Max. Marks: 8

or

(b) Quiz:

(May be divided in parts or questions or may not be. It will be depending on the nature of quiz).

Max. Marks: 8

or

(b) Any Other tool for Assessment

Max. Marks: 8

(B) Semester or External Assessment:

80% weightage of Max Marks (80 Marks out of 100 Max Marks)

Duration of Examination: 3 Hours **Max. Marks: 80**

***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 of equally divided in ten short answer type questions (about 25 words) and examiners are advised to set two short answer type questions from each unit.*

***Section-B** will carry 40 marks with equally divided five long answer type questions (about 200 words) and examiners are 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 30 marks with equally divided three very long answer type questions (about 400 words) and examiners are advised to set five questions one from each unit and students are instructed to attempt any three questions out of five questions.*

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. . ……..…… **8 Marks**

or

Q. 3. ……...…… **8 Marks**

Unit-II

Q. 4. . ……...…… **8 Marks**

or

Q. 5. ……..…..…… **8 Marks**

Unit-III

Q. 6. . ……..…… **8 Marks**

or

Q. 7. ……..…..…… **8 Marks**

Unit-IV

Q. 8. . ……..…..…… **8 Marks**

or

Q. 9. ……..……..…….. **8 Marks**

Unit-V

Q. 10. . …… **8 Marks**

or

Q. 11. ……..……..… **8 Marks**

SECTION-C

Unit-I

Q. 12. ……..…… **10 Marks**

Unit-II

Q. 13. ……..…… **10 Marks**

Unit-III

Q. 14. ……..…… **10 Marks**

Unit-IV

Q. 15. ……..…… **10 Marks**

Unit-V

Q. 16………..…….. **10 Marks**

Distribution of Marks for Practical Examinations:

A. Continuous or Internal Assessment:

Duration of Exam: 03 Hours Maximum Marks: 60

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Minor Experiment	10
2.	Exercise No. 2: Minor Experiment	10
3.	Exercise No. 3: Minor Experiment	10
4.	Viva-voce Examination	10
5.	Oral Presentation (by Power Point Presentation)	20
	Total Marks	**60**

B. Semester or External Assessment:

Duration of Exam: 12 Hours Maximum Marks: 240

S. No.	Name of Exercise	Marks
1.	Exercise No. 1 : Major Experiment	40
2.	Exercise No. 2 : Major Experiment	40
3.	Exercise No. 3 : Major Experiment	40
4.	Exercise No. 4 : Minor Experiment	20
5.	Exercise No. 5 : Minor Experiment	20
6.	Exercise No. 6 : Minor Experiment	20
7.	Viva-voce Examination	30
8.	Weekly attendance, Regularity, Participation in Departmental activities, other related components	10
9.	Lab. Skills, Cleaning of Work Place, *etc.*	10
10.	Practical Record	10
	Total Marks	**240**

Dissertation / Project Work (if carried out by the student):

S. No.	Name of Exercise	Marks
1.	Full Dissertation / Project Work	50
2.	Concise Dissertation or Summery	10
3.	Viva-voce Examination	40
	Total Marks	**100**

(a) Topic:

The topic of the dissertation shall be assigned to the candidate before the end of first semester and a copy of the same should be submitted to the Department / College / University for Approval.

(b) Advisory Committee:

Each guide shall have a maximum of five students. There will be an advisory committee consisting of the guide as chairman and one member from the same Department or allied Departments of the College / University.

(c) Plan of Work:

The student should prepare plan of work for the dissertation, get the approval of the advisory committee and should be submitted to the College / University during the concerned semester of their study. In case the student wants to avail the facility from other University/laboratory, they will undertake the work with the permission of the guide and acknowledge the alien facilities utilized by them.

The duration of the dissertation research shall be a minimum of three months in the concerned semester.

(d) Dissertation Work outside the Department:

In case the student stays away from the Department for work for more than one month, specific approval of the Department / College / University should be obtained.

(e) No. of copies / Distribution of Dissertation:

The students should prepare three copies of dissertation and submit the same for the evaluation by the Examiners. After evaluation, one copy is to be submitted to the Department / College, one copy is to be retained in the Department / University Library and one copy can be kept by the student.

(f) Format to be followed:

The format for dissertation to be submitted by the students is given below:

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. References …
7. Publication, if any …

Acknowledgement

Format of the Cover and Title Page:

----------TITLE OF THE DISSERTATION----------

A dissertation

Submitted in part fulfilment of the requirement for 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)
(Designation)

Department of ……..
(Name of College, if any)
University of Kota
Kota

(Year)

Format of the Bonafide Certificate (on Letter Head):

CERTIFICATE

This is to certify that the dissertation entitled ″---------- ----------″ submitted in part fulfilment of the requirement of the degree of Master of Science in Chemistry or Industrial 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
Chairman, Advisory Committee,

Approved by
Members:
1. Name Signature
2. Name Signature
External Examiner:

Signature
Chairperson/Head of the Department

Minimum Pass Marks and Rules regarding Determination of Results:

The result of the each semester examination shall be worked out separately (even if candidate has appeared at the paper of the lower semester along with the papers of higher semester) in accordance with the following conditions:

(i) 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 alongwith the papers of higher semester examination.

(ii) A candidate for a semester examination shall be offered all the papers prescribed for that semester examination and besides he/she also shall be offered paper(s) not cleared by him/her at any of the lower semester examination subject to the limitation that the number of un-cleared papers of the lower semester examinations shall not be exceed the total number of the papers prescribed for any one semester.

(iii) The candidate shall be declared to have passed the examination, if the candidate secures at least 36% marks in each theory paper and 40% marks in each practical / project / dissertation / seminar separately prescribed for each semester

examination. There is no minimum pass marks for the practical record / notebook. However, submission of a practical record / notebook is a mandatory during the practical examination. The candidate should compulsorily attend viva-voce / presentation examination to secure pass in practical / project / dissertation / seminar.

(iv) The candidate have to secure 36% in the each theory paper and 40% in each practical paper / lab work / dissertation / seminar in internal or continuous assessment and external or semester assessment separately also.

(v) A candidate, who does not fulfil either of the aforesaid conditions, shall be declared as failed in that particular paper and 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.

(vi) If a candidate fails in the internal assessment, he/she shall be declared failed in that paper(s) of the semester. In such a case, he/she shall re-appear in the same paper as due paper in the next odd/even semester examination of next year and the marks for internal assessment component shall be calculated in the proportion of the marks obtained by him/her out of external component for working out the result.

(vii) A candidate failing or absenting in one or more theory paper(s) at a semester examination shall be permitted to join the courses of study for the next higher semester *i.e.* third semester after first and second semester examinations, fifth semester after third and fourth semester examinations and so on and eligible to re-appear in that paper(s) as due paper(s) along with higher semester (next year) examinations 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. No student would be allowed to avail more than three chances including the first attempt to pass / clear any paper theory paper only. Only one chance shall be given to pass / clear any internal assessment / practical / project / dissertation / seminar.

(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 does not pass even in 50% of the papers prescribed for the first and second semester examination collectively in accordance with the above rules shall not be eligible for admission to the third semester examination and he/she will be required to re-appear at the first semester (previous) examination in all the prescribed papers alongwith practical /dissertation/seminar as well as in the internal assessment also.

(x) 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.

(xi) Candidate shall not be permitted to re-appear or improve the marks obtained in the internal assessment / practical / dissertation / seminar in any condition.

(xii) If a candidate, who has been promoted to the next semester, wishes to improve his / her performance 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. In such a case, he/she shall have to appear in these papers alongwith the papers of his/her own semester.

(xiii) 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 36% of the aggregate marks of the maximum marks and 40% of the aggregate marks of the maximum marks for practical / dissertation / presentation / seminar prescribed for four semesters Master's programme.

(xiv) 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.

(xv) 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.

(xvi) 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 36% 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.

(xvii) 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 Board of Management.

(xviii) The grace marks scheme shall be applicable as per University norms.

Classification of Successful Candidates:

Description of Marks Obtained	Division / Result
• Candidates who have secured aggregate 60% or above of the maximum marks	First Division
• Candidates who have secured aggregate 50% or above but less than 60% marks of the maximum marks	Second Division
• Candidates who have secured aggregate 40% or above but less than 50% marks of the maximum marks	Third Division
• Candidates who have secured aggregate 36% or above but less than 40% marks of the maximum marks	Passed only
• Candidates who have not secured a aggregate minimum 36% of maximum marks in whole examination	Failed

Candidates who obtain 75% of the aggregate marks shall be deemed to have passed the examination in First Division with Distinction provided they pass all the examinations prescribed for the course at the first appearance. 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).

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Syllabus

M. Sc. Chemistry
Third Semester Examination

Paper-3.1: CHEM-631: Spectroscopy

Max. Marks	: 100	Contact Hours / Week: 4 Hours
Continuous Assessment	: 20 Marks	Duration of Exam. : 3 Hours
Semester Assessment	: 80 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 one compulsory question of equally divided in ten short answer type questions (about 25 words) and examiners are advised to set two short answer type questions from each unit.*

***Section-B** will carry 40 marks with equally divided five long answer type questions (about 200 words) and examiners are 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 30 marks with equally divided three very long answer type questions (about 400 words) and examiners are advised to set five questions one from each unit and students are instructed to attempt any three questions out of five questions.*

Unit-I: Fundamental Principles of Spectroscopy:

Electromagnetic radiation, interaction of electromagnetic radiation with matter: absorption, emission, transmission, reflection, refraction, dispersion, polarisation and scattering; uncertainty relation, natural line width and natural line broadening, transition probability, results of the time dependent perturbation theory, transition moment, selection rules, intensity of spectral lines, Born-Oppenheimer approximation; rotational, vibrational and electronic energy level and transitions.

Microwave Spectroscopy:

Classification of molecules, rigid rotator model, effect of isotopic substitution on the transition frequencies, intensities, non-rigid rotor, Stark effect, nuclear and electron spin interaction and effect of external field applications.

Unit-II: Infrared Spectroscopy:

Review of linear harmonic oscillator, vibrational energies of diatomic molecules, zero point energy, force constant and bond strengths; anharmonicity, potential energy diagram, vibration-rotation spectroscopy, PQR branches, breakdown of Oppenheimer approximation; vibrations of polyatomic molecules. Selection rules, normal modes of vibration, vibrations of polyatomic molecules, the Hook's law and calculation of frequencies for different types of bonds, group frequencies, Fermi resonance, combination bands, overtones, hot bands, factors affecting the band positions and intensities, sample handling, far IR region, metal-ligand vibrations, normal co-ordinate analysis, applications infrared spectroscopy.

Unit-III: Raman Spectroscopy:

Classical and quantum theories of Raman effect, pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, mutual exclusion principle,

resonance Raman spectroscopy (RRS), coherent anti-stokes Raman spectroscopy (CARS): basic principle and experimental techniques, advantages and disadvantages, applications; brief introduction to surface plasma resonance (SPR) and surface enhanced Raman scattering (SERS).

Ultraviolet-Visible Spectroscopy:
Principles of absorption spectroscopy, nature of electronic excitations, chromophores, auxochromes, the origin of UV bands, factors affecting the position of UV bands, calculation of λ_{max}, qualitative and quantitative applications.

Unit-IV: Electron Spectroscopy:

Atomic Spectroscopy: Energies of atomic orbitals, vector representation of momenta and vector coupling, spectra of hydrogen atom and alkali metal atoms.

Molecular Spectroscopy: Franck-Condon principle, electronic spectra of polyatomic molecules, emission spectra; radiative and non-radiative decay, internal conversion, charge-transfer spectra.

Photoelectron Spectroscopy: Basic principles, photo-electric effect, ionization process, Koopman's theorem, photoelectron spectra of simple molecules (ESCA), chemical information from ESCA, Auger electron spectroscopy: basic idea.

Unit-V: Mossbauer Spectroscopy:

Basic principles, Mossbauer effect, Lamb Mossbauer factor, Mossbauer nuclides and their formation, spectral parameters and spectrum display, application of the technique to the studies of (i) bonding and structures of Fe^{+2} and Fe^{+3} compounds including those of intermediate spin, (ii) Sn^{+2} Sn^{+4} compounds nature of M-L bond, coordination number, structure and (iii) detection of oxidation state and in equivalent MB atoms.

Photoacoustic Spectroscopy:
Basic principle, photoacoustic effect, photoacoustic spectra, instrumentation, advantages of PAS over absorption spectroscopy, applications.

Books:

- *Introduction to Spectroscopy, Donald L. Pavia, Cengage Learning, 2009*
- *Organic Spectroscopy, Jag Mohan, Narosa Publication.*
- *Spectroscopy of Organic Compounds, P. S. Kalsi, New Age International.*
- *Identification of Organic Compounds, R. M. Silverstien, G. C. Hassler and T. C. Morill, John Wiley.*
- *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*
- *Encyclopedia of Spectroscopy and Spectrometry, Three-Volume Set*
- *NMR Spectroscopy: Basic Principles, Concepts, and Applications in Chemistry, Harald Günther, Wiley; 2 edition, 1995.*
- *Carbon-13 NMR spectroscopy, Hans-Otto Kalinowski, Stefan Berger, Siegmar Braun, Wiley, 1988.*
- *NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R. V. Parish, Ellis Harwood.*
- *Physical Methods in Chemistry, R. S. Drago, Saunders College.*
- *Introduction to Photoelectron Spectroscopy, P. K. Ghosh, John Wiley.*
- *Introduction to Magnetic Resonance, A. Carrington and A. D. Maclachalan, Harper & Row.*

Paper-3.2: CHEM-632: Chromatography

Max. Marks	: 100	Contact Hours / Week: 4 Hours
Continuous Assessment	: 20 Marks	Duration of Exam. : 3 Hours
Semester Assessment	: 80 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 one compulsory question of equally divided in ten short answer type questions (about 25 words) and examiners are advised to set two short answer type questions from each unit.*
***Section-B** will carry 40 marks with equally divided five long answer type questions (about 200 words) and examiners are 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 30 marks with equally divided three very long answer type questions (about 400 words) and examiners are advised to set five questions one from each unit and students are instructed to attempt any three questions out of five questions.*

Unit-I: Nature of separation process, classification of separation methods.

Chromatography:
General introduction to principles and types of chromatography according to shape of chromatographic bed, physical sate of mobile phase, mechanism of separation and techniques involved.

Paper Chromatography:
Principle, types, choice of paper and solvent, location of spot and measurement of Rf values, visualization, applications.

Liquid-Liquid Chromatography (LLC):
Introduction, pumps, columns and their preparation, selection of solid supports, selection of liquid-liquid systems, gradient elution, detectors, types of LLC, molecular sieves and gel permeation chromatography or gel chromatography, partition chromatography.

Unit-II: Thin Layer Chromatography (TLC):
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

Supercritical Fluid Chromatography (SFC):
Principle, instrumentation, qualitative and quantitative analysis

Unit-III: Column Chromatography:
Principle, column efficiency, factors influencing column efficiency, experimental set up and applications, principle and application of flash chromatography.

Gas Chromatography (GC):
Principle, instrumentation, column efficiency, solvent efficiency, solid supports, liquid phase, liquid phase percentage, column temperature, detectors, chromatographic identification, multi-dimensional GC, fast GC, applications.

Unit-IV: High Performance Liquid Chromatography (HPLC):
Principle, instrumentation, identification of solute peaks, effect of temperature and packing material, types-partition, adsorption, ion-exchange, size-exclusion or gel; derivatization in HPLC: post and pre-columns, applications.

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:
Theory and classification, factors affecting mobility, macromolecular size and charge interactions with supporting electrolyte, pH and concentration discontinuities, factors affecting electrophoresis phenomena: electrolysis, electro-osmosis, temperature and supporting media; instrumentation, methodology, preparation of gel-staining and de-staining, preparative zone electrophoresis, continuous electrophoresis, applications.

Capillary Electrophoresis (CE):
Principle, theory, instrumentation, sample preparation and applications, capillary electro-chromatography and miscellar electro-kinetic capillary chromatography.

Books:

- *Chromatography: Basic Principles, Sample Preparations and Related Methods by Elsa Lundanes, Leon Reubsaet, Tyge Greibrokk, John Wiley and Sons, 2013*
- *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, 2004.*
- *Principles of Instrumental Analysis by D.A. Skoog, F.J. Holler and T.A. Nieman, 5th Edition (1998), 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-3.3: CHEM-633: IPR, QA & QC and Regulatory Affairs

Max. Marks	: 100	Contact Hours / Week: 4 Hours
Continuous Assessment	: 20 Marks	Duration of Exam. : 3 Hours
Semester Assessment	: 80 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 one compulsory question of equally divided in ten short answer type questions (about 25 words) and examiners are advised to set two short answer type questions from each unit.*

***Section-B** will carry 40 marks with equally divided five long answer type questions (about 200 words) and examiners are 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 30 marks with equally divided three very long answer type questions (about 400 words) and examiners are advised to set five questions one from each unit and students are instructed to attempt any three questions out of five questions.*

Unit-I: Intellectual Property Rights:

Concept and fundamentals of IPR, need and economic importance of IPR, detail description of various IP Properties (Patents, Trademarks, Copyrights, Geographical Indications Industrial Designs and Trade secrets), IPR with emphasis on patent regime, factors affecting IP protection, penalties for violation or infringement, trade related aspects of IPR, concepts behind GATT, WTO, TRIPS, TRIMS and GATS.

Unit-II: R & D and Technology Transfer:

Role of R&D, functional structure of R&D, unit research strategies and manufacturing interface, laboratory-industry interface, technology transfer

Pilot Plant Operation and Scale up:

Purpose planning, design and operation, analysis of results, assessment of flexibility of design comprises to cope-up for safety and economic in construction and operation.

Unit-III: Quality Control:

Concept of quality and quality control, nature of variability's, design of QC laboratory for chemical, instrumental and microbiological laboratories, schedule L1, standardization of reagents, labeling of reagents, control samples, data generation and storage, QC documentation, LIMS sampling techniques, sampling plans, steps to improve quality with reference to ISO and TQM, preparation of control charts, sampling, inspection, cost reduction & quality improvement.

Unit-IV: Quality Assurance:

Concepts of Quality Assurance, Total Quality Management, Philosophy of GMP and cGMP, preparation of audit, Conducting audit, Audit Analysis, Audit Report and Audit follow up. Premises: Location, design, plant layout, construction, maintenance of sterilite areas, control of contamination.

Unit-V: Industrial Standards and Control:

Government standards like Agmark, Hallmark, ISI, MINAS, IP, BP, USP; an introduction of ISO, OSHA, CDSCO, USFDA, ICH, FPO, MHRA, SUPAC

Books:

- *Harold Koontz, H. Weihrich, and A.R. Aryasri, Principles of Management, Tata McGraw-Hill, New Delhi, 2004.*
- *Dr. B. L.Wadhera-Intellectual Property Law Handbook, Universal Law Publishing Co. Ltd. 2002.*
- *Handbook of Small Scale Industry by P.M. Bhandari.*
- *Dr. T Ramakrishna -Ownership and Enforcement of Intellectual Property Rights, CIPRA, NSLIU-2005.*
- *Intellectual Property Law (Bare Act with short comments) - Universal Law Publishing Co. Ltd. 2007.*
- *The Trade marks Act 1999 (Bare Act with short comments) - Universal Law Publishing Co. Ltd. 2005.*
- *The Patents Act, 1970 (Bare Act with short comments) - as amended by Patents (Amendment) Rules 2006 w.e.f. 5-5-2006. Commercial law publishers (India) Pvt. Ltd. 2006.*
- *Thomas T Gordon and Arthur S Cookfair -Patent Fundamentals for Scientist and Engineers, CRC Press 1995.*
- *Prabuddha Ganguli -Intellectual Property Rights, TMH Publishing Co. Ltd.2001*
- *Steinborn L. GMP/ISO Quality Audit Manual for Healthcare Manufacturers and Their Suppliers, Sixth Edition, (Volume 1 with Checklists and Software Package). Taylor & Francis; 2003.*
- *Hoyle D. ISO 9000 Quality Systems Handbook -updated for the ISO 9001:2008 standards. Routledge; 2012.*

Paper-3.4: CHEM-634: Electro-analytical Chemistry

Max. Marks	: 100	Contact Hours / Week: 4 Hours
Continuous Assessment	: 20 Marks	Duration of Exam. : 3 Hours
Semester Assessment	: 80 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 one compulsory question of equally divided in ten short answer type questions (about 25 words) and examiners are advised to set two short answer type questions from each unit.*

***Section-B** will carry 40 marks with equally divided five long answer type questions (about 200 words) and examiners are 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 30 marks with equally divided three very long answer type questions (about 400 words) and examiners are advised to set five questions one from each unit and students are instructed to attempt any three questions out of five questions.*

Unit-I: Basic Electro-analytical Chemistry:

Electrochemical cells, cell potentials, electrode potentials, calculation of cell potentials and currents in electrochemical cells, types of polarization, types of electroanalytical methods, problems.

Ion-selective Electrodes:

Types of ion-selective electrodes: Glass, liquid ion exchange membrane, neutral carrier membrane, coated wire, gas sensing, air gap and biomembrane electrodes; theory of ion selective electrode and ion-selectivity coefficient; problems.

Unit-II: Polarography:

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

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

Unit-III: Electrogravimetry:
Current-voltage relationship during electrolysis, effect of current on cell potential and over voltage, selectivity of electrolysis, electrolysis at constant working electrode potentials.

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

Unit-IV: Potentiometry:
Metal electrodes for measuring the metal's cation, metal-metal salt electrodes, redox electrodes, calomel electrode, measurement of potential, determination of concentrations, residual liquid-junction potential, accuracy on direct potentiometric, glass p*H* electrode, ion-selective electrodes.

Coulometry: Types of coulometric methods: Potentiostatic and amperostatic; principles, instrumentation and applications, applications.

Unit-V: Electrochemical Sensors:
Electrochemical impedance spectroscopy and their application–immunosensing; ilectrochemical immunoassay: redox and enzyme laboratory immunoassay.

Electro-chemiluminescence and Immunoassay:
Electrochemical quartz crystal microbalance and its applications; design of in vivo sensor and measurement of biological molecules like glucose, insulin, and cholesterol; electrochemical sensor for food analysis, surface plasmon resonance and its applications.

Books:

- *Introduction to Instrumental Analysis, R. D. Braun, McGraw-Hill Book Company, New Delhi*
- *Vogel's Textbook of Quantitative Chemical Analysis, 6th Edn. Pearson Education Asia*
- *Analytical Chemistry, An Introduction, D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, 7th. Edn., Saunders College publishing, N. Y.*
- *Principles of Instrumental Analysis, D. A. Skoog and J. J. Leary, 4th Edn., N. Y.*
- *The Principles of Electrochemistry, A. Duncan, Mac Innes Dover Publication Inc. N. Y.F. Scholz, Electroanalytical methods, Springer, 2002.*
- *P. Monk, Fundamentals of electroanalytical chemistry, Wiley, 2001.*
- *A.P.F. Turner I. Karube, I. G. Wilson, Biosensors- Fundamentals and applications. Oxford University Press, New York, 1987.*
- *Organic electro chemistry by Henning Lund & Ole Hammerich, , 4th edition, Publisher: Marcel Dekker, Inc, New York.*

Paper-3.5: CHEM-635: Applied Analytical Chemistry

Max. Marks	: 100	Contact Hours / Week: 4 Hours
Continuous Assessment	: 20 Marks	Duration of Exam. : 3 Hours
Semester Assessment	: 80 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 one compulsory question of equally divided in ten short answer type questions (about 25 words) and examiners are advised to set two short answer type questions from each unit.*

***Section-B** will carry 40 marks with equally divided five long answer type questions (about 200 words) and examiners are 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 30 marks with equally divided three very long answer type questions (about 400 words) and examiners are advised to set five questions one from each unit and students are instructed to attempt any three questions out of five questions.*

Unit-I: Analysis of Petroleum and Petroleum Products:

Introduction, constituents and petroleum fractionation, quality control, safety and hazarodous aspects, analysis of petroleum products: specific gravity, viscosity, doctor test, sulphuric acid absorption, aniline point, vapour pressure and colour determination, cloud point, pour point; determination of water, neutralization value (acid and base numbers), ash content, sulphur and mercapton sulphur, determination of lead in petroleum.

Analysis of Coal and Coke:

Types, composition, proximate and ultimate anlaysis calorific value by bomb Calorimetry

Analysis of Gaseous Fuels:

Composition of fuel gases, collection of gas, analysis of fuel gases (coal gas, producer gas, water gas and flue gas)

Unit-II: Analysis of Explosives:

General methods, heat of explosion, hygroscopicity, moisture by Karl-Fischer titration, qualitative tests of explosives, qualitative analysis of explosive mixtures dynamites, blasting caps and electric detonators, primers, liquid propellants and solid propellants

Analysis of Paints and Pigments:

Preliminary inspection of sample, test on the total coating, separation of pigments, binder and thinner of latex paints, separation of pigments, binder and thinner of solvent type coating, modification of binder, identification and analysis of thinner.

Unit-III: Soil Analysis:

Soil sampling, field description of soils, physical analysis, determination of major and minor constituents, exchange capacity, soil reaction (pH), chemical analysis as a measure of soil fertility

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

Analysis of Agrochemicals:
Introduction, classification, analysis of DDT, gammexane, endosulphan, zinab, ziram, malathion, thiram, thiometon, simazine and chloridane.

Unit-IV: Analysis of Minerals, Ores and Alloys:

Minerals and Ores: Hematite, pyrolusite, gypsum, dolomite, chromate, bauxite, limestone, illmenite and uranium ores

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

Unit-V: Analysis of Cement:

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

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

Books:

- *Standard Methods of Chemical Analysis, F. J. Welcher.*
- *Instrumental Methods of Analysis (6th Edition) – H. H. Willard & L. L. Merritt.*
- *A Text Book of Quantitative Inorganic Analysis (3rd Edition) – A. I. Vogel.*
- *Treatise on Analytical Chemistry (Series of Volumes) – I. M. Kolthoff & P. J. Elwing.*
- *Introduction to Instrumental Analysis – R. D. Braun.*
- *Handbook of Industrial Chemistry – Davis Burner*
- *Association of Official Analytical Chemistry (AOAC) – 13th Edition 1980.*
- *Pharmacopoeia of India, British & United States.*
- *Hand Book of Food Analysis – S. N. Mahindru.*
- *Analytical Biochemistry – Holme Peck*
- *Post Graduate Chemistry Practical Part – I – Patel, Gadre & Turkhia.*
- *Agricultural Analysis. By Kanwar.*
- *Soil Analysis. By Jackson.*
- *Encyclopedia of Industrial Methods of Chemical Analysis. By F D Snell (All senus)*
- *Principle and practice of Analytical chemistry by F.U.Fifield and D.Keuley 3rd, Blackie and sons Ltd.*
- *Cosmetics by W D Poucher (Three volumes)*
- *Perfumery Technology (JC1) by B. Bilat and B.V.Well*
- *Laboratory Techniques in Food Analysis by I.M.Kolthof, D.Pearson*
- *Handbook of Analysis and Quality, Control for Fruits and Vegetable Products 2nd by S.Ranganna*
- *Aids to the Analysis of Food and Drug by Nicholls*
- *Analysis of Food Products (Swan Publishers) by S.N.Mahendur*
- *Textbook of Forensic Pharmacy by B M Mithal 9th edition 1993, National Centre Kolcutta.*
- *Forensic Pharmacy by B.S Kuchekar, and A.M Khadatare Nirali Prakshan)*

Paper-3.6: CHEM-636: Practical

Maximum Marks **: 300**
Internal or Continuous Assessment : 60 Marks
External or Semester Assessment : 240 Marks

Duration of Examination:
Internal or Continuous Assessment : 3 Hours
External or Semester Assessment : 12 Hours

Distribution of Marks for Internal or Continuous Assessment:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Minor Experiment	10
2.	Exercise No. 2: Minor Experiment	10
3.	Exercise No. 3: Minor Experiment	10
4.	Viva-voce Examination	10
5.	Oral Presentation (by Power Point Presentation)	20
	Total Marks	**60**

Distribution of Marks for External or Semester Assessment:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1 : Major Experiment	40
2.	Exercise No. 2 : Major Experiment	40
3.	Exercise No. 3 : Major Experiment	40
4.	Exercise No. 4 : Minor Experiment	20
5.	Exercise No. 5 : Minor Experiment	20
6.	Exercise No. 6 : Minor Experiment	20
7.	Viva-voce Examination	30
8.	Weekly attendance, Regularity, Participation in Departmental activities, other related components	10
9.	Lab. Skills, Cleaning of Work Place, *etc.*	10
10.	Practical Record	10
	Total Marks	**240**

Chemical Kinetics:

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

- Flowing clock reactions.
- Oscillatory reactions.

Potentiometry / pH metry

- Determination of EMF of Daniel cell.
- Determination of standard electrode potential (Eo) value of the ferrous-ferric system by titrating ferrous ammonium sulphate against potassium dichromate potentiometrically.
- Determination of pKa of dibasic acid (oxalic acid, succinic acid, *etc*).
- Determination of the formation constant of Ag-ammonia complex and stoichiometry of the complex potentiometrically.
- Determination of hydrolysis constant and degree of hydrolysis of aniline hydrochloride pH metrically
- Determination of thermodynamic parameters for electrochemical reactions (To determine ΔGo, ΔHo and ΔSo for the formation of 1 mole cadmium in 1 wt.% amalgam at 25^{o}C and activity coefficient of solution)
- Estimate the amount of halides present in the given mixture by titrating with $AgNO_3$ solution.
- Determination of strength of acetic acid from the commercial vinegar sample by potentiometric titration and its confirmation by conducltmetric / pH-metric titration using standard solution of NaOH.
- Micro-determination of glucose using potassium ferrocyanide as internal reagent and Ce (IV) solution as standard titrant.
- Determination of the dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by titrating it with KOH.
- Estimation of various transition elements like Zn/Ni/Co/Cd/Al from various commercial samples by complexometric titrations on potentiometer by using mercury electrode
- Determine the amount of HCl by using weak base (NH_4OH) potentiometrically.
- Determine the amount of CH_3COOH by using strong base (NaOH).
- Fabrication of ion-selective electrodes for Co, Ni, Cu, Zn, Pd, Cd, *etc.* ions and record the electrode response and sensitivity.
- Titrate a phosphoric acid solution against alkali using glass electrode potentiometrically and calculate the first and second ionization constants of the acid
- Estimation of heavy metal toxicity using ion-selective electrodes: Pb, Cd, Hg, *etc.*
- Electrochemical Impedance study of metal/solution interface.
- Cyclic Voltametry of the $[Fe(CN)6]^{3-}$/$[Fe(CN)6]^{4-}$ system

Electroanalytical Methods of Analysis:

(i) Oxidation-Reduction Titrations

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

(ii) Precipitation Titrations

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

(iii) Complexometric Titrations:

- Determination of Cu^{2+} and Ni^{2+} by using masking reagent by EDTA titration.
- Determination of Ni^{2+} (back titration).
- Determination of Ca^{2+} (by substitution method).
- Estimation of the purity of oxalic acid employing standard Ce(IV) solution.
- Estimation of various transition elements like Zn/Ni/Co/Cd/Al from various commercial samples by complexometric titrations on potentiometer by using mercury electrode

(iv) Voltametric Titrations:

- Determination of trace metal impurities present in a polluted water sample by anodic stripping voltammetric procedure.

(v) Electrogravimetric Titartions:

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

(vi) Amperometric Titrations:

- Amperometric determination of Zinc with standard EDTA solution.
- Amperometric titration of lead with standard potassium dichromate solution.
- Amperometric determination of magnesium (or cadmium) by precipitating it as oxinate and titrating against standard $KBrO_3$ solution.
- Estimation of the mercapto group in thioglycollic acid by titrating with standard $AgNO_3$ solution amperometrically.
- Amperometric titration of (i) thiourea v/s silver nitrate (ii) vitamin C v/s ferric nitrate
- Amperometric titration of (a) Pb v/s SO_4^{2-} (b) Pb v/s $K_2Cr_2O_7$ (c) Ni v/s DMG.
- Estimation of sulphadizine in sulpha tablet by amperometric titration method

Analysis of Alloys & Ores:

- Analysis of Nichrome alloy:
  - Cr by colorimetry
  - Ni by gravimetry
- Analysis of Zinc blend ore
  - Zn by complexometry
  - Fe by volumetry
- Analysis of Calcite ore
  - Ca by complexometry
  - Fe by colorimetry
- Analysis of felspar ore

- Analysis of steel and ferrous alloy:
  Carbon, silicon, manganese, phosphorous, sulphur, selenium, copper, nickel, chromium, vanadium, tungsten, molybdenum, cobalt, aluminium, titanium, nitrogen, lead, niobium, iron

Analysis of Ferrous Slugs:

- Determination of iron, calcium and magnesium, total oxides

Analysis of Cement and building materials:

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

Analysis of Quartzes:

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

Analysis of clays and feldspars:

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

Analysis of Glasses:

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

Analysis of Ceramics:

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

Analysis of Fuel / Petroleum / Petroleum Products:

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

Analysis of Agrochemicals:

- Analysis of soil sample, soil micronutrients for Ca, Fe and P content
- Analysis of pigments with respect to Zn and Cr.
- Analysis of pesticide residue and toxicological effects.
- Analysis of malathion by colorometry.
- Determination of organic carbon in soil by Walk Ley and Black method.
- Determination of available chlorine in bleaching powder by Bunsen method.
- Determination of total chlorine in pesticide formulation.
- Determination of copper in fungicide.
- Estimation of nitrogen from given fertilizer by Kjeldahl method.
- Estimation of phosphorus from given fertilizer by volumetry / colourimetry.
- Estimation of potassium from given fertilizer by gravimetry / Flame photometry.
- Determination of K_2O content in given sample of potash fertilizer.
- Determination of P_2O_5 content in give n sample of phosphatic fertilizers.
- Determination of moisture content in given sample of urea
- Analysis of insecticides: DDT, BHC, aldrin, endosulfon, malathion, parathion.
- Analysis of herbicides: 2,4-Dichlorophenoxyacetic acid, dalapon, paraquat, Banalin, Butacarb.
- Analysis of fungicides: Boardeaux mixture, copper oxychloride, zineb, benomyl.

Chromatographic Analysis:

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

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

Ion Chromatography

(i) Chemical Applications

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

- Determination of trace anions in organic solvents and concentrated hydrofluoric acid.
- Determination of trace transition metals in reagent grade acids, bases, salts, and organic solvents using chelation Ion Chromatography
- Determination of polyphenols
- Determination of N,N-dimethyl-o-toluidine and N,N-diethyl-o-toluidine in ethylene gas samples.
- Determination of transition metals at ppt levels in High-Purity Water and SC2 (D-clean) Baths

(ii) Petroleum Refining

- Extraction of total petroleum hydrocarbon contaminants (diesel and waste oil) in soils
- Extraction of hydrocarbon contaminants (BTEX, Diesel, and TPH) in soils
- Extraction of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans
- Extraction of PAHs from environmental samples by accelerated solvent extraction (ASE)
- Determination of thiosulfate in refinery and other wastewaters
- Automated solid phase extraction (SPE) of total petroleum hydrocarbons using Dionex AutoTrace® Instrument
- Determination of biofuel sugars by Ion Chromatography
- Determination of cations in biodiesel using a Reagent-Free Ion Chromatography.
- Determination of 32 low molecular mass organic acids in biomass by Ion Chromatography Mass Spectrometry

(iii) Safety and Security Applications

- Extraction of explosives from soils by accelerated solvent extraction (ASE)
- Determination of monovalent cations in explosives

(iv) Cosmetics

- Rapid Determination of benzalkonium chloride in cosmetics

(v) Polymers

- Polysialic acid analysis: Separating polymers with high degrees of polymerization

Any other relevant experiments may be added / performed.

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Syllabus

M. Sc. Chemistry
Fourth Semester Examination

Paper-4.1: CHEM-641: Spectroscopy

Max. Marks	: 100	Contact Hours / Week: 4 Hours
Continuous Assessment	: 20 Marks	Duration of Exam. : 3 Hours
Semester Assessment	: 80 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 one compulsory question of equally divided in ten short answer type questions (about 25 words) and examiners are advised to set two short answer type questions from each unit.*

***Section-B** will carry 40 marks with equally divided five long answer type questions (about 200 words) and examiners are 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 30 marks with equally divided three very long answer type questions (about 400 words) and examiners are advised to set five questions one from each unit and students are instructed to attempt any three questions out of five questions.*

Unit-I: One-dimensional Nuclear Magnetic Resonance Spectroscopy:

Nuclear spin, nuclear resonance, basic theory, shielding and deshielding of magnetic nuclei, chemical shift and its measurements, factors influencing chemical shift, spin-spin interactions, factors influencing coupling constant "J", spin systems, classification of spectra (AX, ABX, AMX, ABC, A_2B_2, *etc.*), simplification of spectra: shift reagents and spin decoupling; proton exchange, nuclear overhauser effect, basic ideas about instrument, FT NMR, advantages of FT NMR, NMR studies of nuclei other than proton and carbon: ^{11}B, ^{15}N, ^{19}F and ^{31}P, use of NMR in medical diagnostics, applications of NMR spectroscopy.

Unit-II: Two-dimensional Nuclear Magnetic Resonance Spectroscopy:

Introduction, pulse sequence, 2D-experiments, data collection, processing and plotting of 2D spectra, general procedure for running 2D spectra, COSY, HETCOR, HSQC, HMQC, HMBC, DQF-COSY, TOCSY, NOESY, ROESY, APT, INADEQUATE.

^{13}C NMR Spectroscopy:

Carbon-13 nucleus, chemical shifts and their calculation, spin-spin coupling with ^{1}H, ^{13}C, cross-polarization, nuclear overhauser effect, DEPT.

Unit-III: Electron Spin Resonance Spectroscopy:

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

Nuclear Quadrupole Resonance spectroscopy:
Quadrupole nuclei, quadrupole moment, electric field gradient, quadrupole coupling constant, splitting pattern, applications

Unit-IV: Mass Spectrometry:

Basic principles, production of ions by electron impact, chemical ionization and field desorption techniques, separation and detection of ions, fragmentation of organic molecules, McLafferty rearrangement, factors affecting identification of molecular ion peaks, base peaks and isotopic peaks, determination of molecular weight and molecular formula of compounds, hydrogen deficiency index, nitrogen rule, high resolution mass spectrometry, introduction to hyphenated techniques likes GC-MS, LC-MS, LC-MS-MS, FT-NMR-MS, *etc*.

Atomic Absorption Spectroscopy or Absorption Flame Photometry:
Basic principle of AAS, flameless AA spectroscopy including graphite furnace and hydride generation, interference

Flame Emission Photometry or Flame Photometry:
Basic principle, use of atomic spectra for detection and determination of elements, instrumentation involved in FES, applications and limitations

Unit-V: Structure Elucidation:

Combined structure elucidation problems based on UV, IR, NMR, 2D-NMR, MS, hyphenated technique spectral data (including reaction sequences also) and analytical data including CHNS/O percentage to find out the structure of simple organic compounds.

Books:

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

Paper-4.2: CHEM-642: Recent Advances in Chemistry

Max. Marks	: 100	Contact Hours / Week: 4 Hours
Continuous Assessment	: 20 Marks	Duration of Exam. : 3 Hours
Semester Assessment	: 80 Marks	

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***Section-C** will carry 30 marks with equally divided three very long answer type questions (about 400 words) and examiners are advised to set five questions one from each unit and students are instructed to attempt any three questions out of five questions.*

U nit-I: Introduction, Principles and Concepts of Green Chemistry:

Definition, need of green chemistry: inception and evolution of green chemistry, twelve principles of green chemistry with explanations and examples, designing a green synthesis using these principles, green chemistry in day to day life, atom economy and waste minimization.

Unit-II: Non-traditional Greener Alternative Approaches:

Different approaches to green synthesis:

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

Green Catalysts: Oxidation catalysts, basic catalysts, polymer supported catalysts; phase transfer catalysts: Advantages of PTC reaction to green synthesis, application of PTC in N/C-alkylation, Darzens reaction, Wittig reaction, heterocyclic compound synthesis: 3-alkyl coumarins, flavones; oxidation using H_2O_2 under PTC conditions; use of crown ethers in esterifications, aromatic substitutions and elimination reactions.

Bio-catalysts: Introduction, microbial oxidation and reduction, production of fine chemicals.

Unit-III: Application of Non-conventional Energy Sources:

Microwave Assisted Synthesis: Introduction of microwave assisted organic and inorganic synthesis; microwave activation, equipment, time and energy benefits, limitations; synthesis of N/O/S donor ligands and their coordination complexes, synthetic organic transformations under microwave, reactions in organic solvents: esterification, Fries rearrangement, Diels-Alder reaction, decarboxylation; solvent free reactions (solid state reactions): deacetylation, deprotection, saponification, alkylation of reactive methylene compounds, synthesis of nitriles from aldehydes, synthesis of β-lactams, pyrroles, quinolines.

Ultrasound Assisted Synthesis: Introduction, instrumentation, physical aspects, oxidation, reduction, substitution, chromenes synthesis.

Unit-IV: Organic Synthesis in Green Solvents:

Alternatives of organic solvents:

Synthesis in Aqueous Phase: Organic reactions in pseudo organic solvents; (a) applications in oxidation of nitro, aromatic and carbonyl compounds; reduction of carbon-carbon multiple bonds, benzoin condensation, Michael condensation, Claisen rearrangement, Knoevenageal reaction (b) electrochemical synthesis: introduction, synthesis of sebacic acid and adiponitrile.

Synthesis in Ionic Liquids: Introduction, properties and types of ionic liquids, synthetic applications: Diels-Alder reaction, epoxidation, Heck reaction, Knoevenagel condensation, preparation of active pharmaceutical ingredients (APIs).

Synthesis in Supercritical Liquids: The phase diagram of CO_2, supercritical CO_2, its properties and applications in dry cleaning, decaffeination of coffee and synthesis.

Unit-V: Nanoscience & Nanotechnology:

Definition of nano-dimensional materials, historical milestones, unique properties due to nano-size, quantum dots, classification of nano-materials, general methods of synthesis of nano-materials : hydrothermal synthesis, solvo-thermal synthesis, microwave irradiation, sol-gel and precipitation technologies, combustion, flame-chemical vapour condensation process, gas phase condensation synthesis, reverse micelle synthesis, polymer-mediated synthesis, protein microtube-mediated synthesis, synthesis of nanomaterials using microorganisms and other biological agents, sonochemical synthesis, hydrodynamic cavitation.

Inorganic nanomaterials: Typical examples- nano TiO_2 / ZnO / CdO / CdS.
Organic nanomaterials: Typical examples- carbon tubes, rotaxanes and catenanes.

Books:

- *Green Chemistry, Theory and Practice, Paul T. Anastas and John C. Warner*
- *Microwaves in Organic Synthesis, Antonio de la Hoz (Ed), André Loupy (Ed), Wiley-VCH; 2013*
- *Organic Synthesis in Water, Paul A Grieco Blackie.*
- *Organic Synthesis: Special Techniques, V. K. Ahluwalia and Renu Aggrawal*
- *Green Chemistry: An Introductory Text, The Royal Society of Chemistry, 2002*
- *Chemical Reviews 2007, 107, 2167-2820 (Special issue on Green Chemistry)*

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

Max. Marks	: 100	Contact Hours / Week: 4 Hours
Continuous Assessment	: 20 Marks	Duration of Exam. : 3 Hours
Semester Assessment	: 80 Marks	

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Section-C *will carry 30 marks with equally divided three very long answer type questions (about 400 words) and examiners are advised to set five questions one from each unit and students are instructed to attempt any three questions out of five questions.*

Unit-I: X-rays Diffraction:

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

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

Unit-II: Electron Diffraction:

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

Neutron Diffraction:

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

Unit-III: Thermo-analytical Methods:

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

Unit-IV: Radio-analytical Methods:

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

Nephlometry and Turbidometry:

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

Unit-V: Polarimetry:

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

Refractometry:

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

Books:

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

Paper-4.4: CHEM-644: Pharmaceutical Analysis

Max. Marks	: 100	Contact Hours / Week: 4 Hours
Continuous Assessment	: 20 Marks	Duration of Exam. : 3 Hours
Semester Assessment	: 80 Marks	

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***Section-C** will carry 30 marks with equally divided three very long answer type questions (about 400 words) and examiners are advised to set five questions one from each unit and students are instructed to attempt any three questions out of five questions.*

Unit-I: Classifications of Drugs:

Chemical, pharmacological and therapeutic classifications, some examples of recent drugs

Introduction to Pharmaceutical Formulations:

Processed used in different pharmaceutical formulation, outline of pharmaceuticals.

Sources of Impurities in Pharmaceutical Raw Materials and Finished Products: Raw materials, method of manufacture, reagents, solvents, contamination-atmospheric, particulate, cross contamination, microbiological, process errors, packing errors, chemical instability, container contamination (in brief) physical changes, temperature effects, general manufacturing processes; stability studies, shelf life fixation for formulated products.

Unit-II: Test and assay of raw materials and finished products:

Chemical Tests and Assays: Limit test, characteristics of limit tests, specificity sensitivity, control of personal errors, loss on drying (NaCl), loss on ignition (ZnO), limit test for lead, arsenic, chloride and sulphate, moisture determination by KFR titration method and assay of steroids.

Physical Tests and Assays: Disintegration tests for tablets, capsules, pessaries and suppositories, dissolution of tests tablets and capsules.

Analysis of Vegetable drugs: Sampling, foreign organic matter, ash values and water soluble ash (ginger), acid insoluble ash, sulphated ash.

Unit-III: Microbiological Tests and Assays:

Microbiological assay of antibiotics, (std. preparations and units of activity, test organisms and inoculum, apparatus, methods: cylinder or cup plate method and two level factorial assay (ampicillin), microbial limit test (preliminary testing, medium soyabean casein digest agar medium only) and total microbial count only), test of sterility-membrane filtration method, determination of thiomersal.

Biological Assays:

Introduction, precision of biological assays in brief (estimation of errors is excluded), biological assay of insulin, tetanus antitoxin, determination of proteolytic activity, determination of ABO group and Rh group, photometric haemoglobinometry, haemolysins.

Unit-IV: Standardization and Quality Control of different Dosage Forms:

Brief introduction to different dosage forms with the IP requirements, analytical methods for the following: Tablets (aspirin), additives used in tablet manufacture, capsules (Rifampicin), powders (Sodium benzoate), solutions (saline, NaCl) suspensions (barium sulphate–limit test for impurity), mouthwashes (Ointments (salicylic acid) and creams dimethicone by IR), injections (Mannitol), ophthalmic preparations (sulphacteamine), aerosols (salbutamol), blood products and reporting protocols.

Unit-V: Role of FDA in Pharmaceutical Industry:

Drug cosmetic act, definitions drugs, misbranded, adulterated and spurious drugs, new drug cosmetics, blood bank, manner of labeling, GMP in brief (Schedule M), FDA; role of FDA, introduction to new drugs, brief summary of different phases of test and approval for formulation of a drug.

Standard Specifications:

Pharmacopoeia specifications, stability studies and expiry date fixation.

Books

- *Practical Pharmaceutical chemistry third edition volume 1. By A.H.Beckett & J.B.Stenlake*
- *Pharmacoepia of India Volume I and II.*
- *British Pharmacopoeia*
- *United States Pharmacopoeia*
- *Remington's Pharmaceutical sciences.*
- *Forensic pharmacy by B.S Kuchekar, A.M Khadatare (Nirali Prakashan)*
- *Practical pharmaceutical analysis by Ashitosh Kaur*
- *Analytical problems of drug substances and Exp by Florey*
- *The theory and practice of Ind pharmacy Leon lachmann,Herbert Liebermann and Joseph L.Karnic 3rd edition By Varghese Publication House, Hind Rajasthan Building Dadar Mumbai –14*

Paper-4.5: CHEM-645: Applied Analytical Chemistry

Max. Marks	: 100	Contact Hours / Week: 4 Hours
Continuous Assessment	: 20 Marks	Duration of Exam. : 3 Hours
Semester Assessment	: 80 Marks	

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Unit-I: Clinical Analysis-I:

Scope of Clinical Chemistry: Philosophy of clinical analysis, practical aspects of analysis: sample types, collection of specimens (samples) like blood, urine, serum; cleaning of glass apparatus; storage of clinical samples; general techniques for analysis, brief principle and applications of following techniques: colorimetric, spectrophotometric, turbidimetric, fluorimetric, flame photometry, auto-analysis, paper electrophoresis, gel-electrophoresis, chromatography; units of expressing biochemical values; blood: estimation of glucose, chlolesterol, urea, hemoglobin and bilirubin; urine: urea, uric acid, creatinine, calcium, phosphate, sodium, potassium and chloride.

Unit-II: Clinical Analysis-II:

Protein Structure and Analysis: Definition of protein and peptides; structure of protein; types of proteins; physical and chemical properties of protein; analysis of proteins: total protein, albumin and globulin from serum samples.

Hormone Analysis: Introduction, classification and general characteristics of hormones; determination of cortisol from blood and urine samples; determination of oestrogens from urine samples

Unit-III: Forensic Analysis:

Analysis of various types of poisons such as corrosive, irritant, analgesic, hypnotic, tranquillizer, narcotic, stimulants, paralytic, anti-histamine, domestic and industrial (gaseous and volatile) poisoning, food poisonings, etc.), explosive and explosion residue analysis, lethal dose, significance of LD-50 and LC-50, lethal drug analysis (sampling, sealing, packing, laboratory methods of testing, reporting the analysis results, court evidence and medico-legal aspects for the consideration of chemical data as a proof for crime), estimation of poisonous materials, importance of physiological tests in forensic toxicology.

Unit-IV: Food Analysis:

Food flavors, food colour, food preservatives, milk and milk products, floor starches, honey, jam and their major component analysis; introduction to natural fats and oils, analysis of oils and fats: softening point, congent point, titrepoint, cloud point, Iodine value, saponification value, acid value by R-M and Polenske value, Elaiden test.

Unit-V: Analysis of Cosmetics and Deodorants:

Composition of creams and lotions- determination of water, propylene glycol, non-volatile matter and ash content, determination of borates, carbonates, sulphates, phosphates, chlorides, titanium and zinc oxides; analysis of face powder: Estimation of boric acid, Mg, Ca, Zn, Fe, Al, Ba, Ti, phenol, hexachlorophenone, methanamine, sulphonates and urea

Analysis of Soaps and Detergents:

Determination of soap composition-fatty acids, total anhydrous soap and combined alkali, potassium, water, determination of inorganic fillers and soap builders, determination of surfactants, determination of other constituents and additives

Books:

- *Standard Methods of Chemical Analysis, F. J. Welcher.*
- *Instrumental Methods of Analysis (6th Edition) – H. H. Willard & L. L. Merritt.*
- *A Text Book of Quantitative Inorganic Analysis (3rd Edition) – A. I. Vogel.*
- *Treatise on Analytical Chemistry (Series of Volumes) – I. M. Kolthoff & P. J. Elwing.*
- *Introduction to Instrumental Analysis – R. D. Braun.*
- *Handbook of Industrial Chemistry – Davis Burner*
- *Association of Official Analytical Chemistry (AOAC) – 13th Edition 1980.*
- *Pharmacopoeia of India, British & United States.*
- *Hand Book of Food Analysis – S. N. Mahindru.*
- *Analytical Biochemistry – Holme Peck*
- *Post Graduate Chemistry Practical Part – I – Patel, Gadre & Turkhia.*
- *Agricultural Analysis. By Kanwar.*
- *Encyclopedia of Industrial Methods of Chemical Analysis. By F D Snell (All senus)*
- *Principle and practice of Analytical chemistry by F.U.Fifield and D.Keuley 3rd, Blackie and sons Ltd.*
- *Cosmetics by W D Poucher (Three volumes)*
- *Perfumery Technology (JC1) by B. Bilat and B.V.Well*
- *Laboratory Techniques in Food Analysis by I.M.Kolthof, D.Pearson*
- *Handbook of Analysis and Quality, Control for Fruits and Vegetable Products 2nd Ed by S.Ranganna*
- *Aids to the Analysis of Food and Drug by Nicholls*
- *Analysis of Food Products (Swan Publishers) by S.N.Mahendur*
- *Textbook of Forensic Pharmacy by B M Mithal 9th edition 1993, National Centre Kolcutta.*
- *Forensic Pharmacy by B.S Kuchekar, and A.M Khadatare Nirali Prakshan)*

Paper-4.6: CHEM-646: Practical

Maximum Marks **: 300**
Internal or Continuous Assessment : 60 Marks
External or Semester Assessment : 240 Marks

Duration of Examination:
Internal or Continuous Assessment : 3 Hours
External or Semester Assessment : 12 Hours

Distribution of Marks for Internal or Continuous Assessment:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1: Minor Experiment	10
2.	Exercise No. 2: Minor Experiment	10
3.	Exercise No. 3: Minor Experiment	10
4.	Viva-voce Examination	10
5.	Oral Presentation (by Power Point Presentation)	20
	Total Marks	**60**

Distribution of Marks for External or Semester Assessment:

S. No.	Name of Exercise	Marks
1.	Exercise No. 1 : Major Experiment	40
2.	Exercise No. 2 : Major Experiment	40
3.	Exercise No. 3 : Major Experiment	40
4.	Exercise No. 4 : Minor Experiment	20
5.	Exercise No. 5 : Minor Experiment	20
6.	Exercise No. 6 : Minor Experiment	20
7.	Viva-voce Examination	30
8.	Weekly attendance, Regularity, Participation in Departmental activities, other related components	10
9.	Lab. Skills, Cleaning of Work Place, *etc.*	10
10.	Practical Record	10
	Total Marks	**240**

Conductometry:

- Determination of the amount of NH_4OH conductometrically by using weak acid CH_3COOH.
- Determination of relative strength of acetic acid, chloroacetic acid and trichloroacetic acid through measuring their Ka-value by conductivity measurement method.
- Conductometric titration of (i) strong acid, monobasic weak acid or polybasic weak acid with strong base (ii) zinc with EDTA, and (iii) KCl v/s $AgNO_3$.
- Determination of the strength of $HCl+CH_3COOH$ mixture against standard NaOH solution.
- Conductometric titration of triple mixture ($HCl+NH_4Cl+KCl$) with (i) NaOH and (ii) $AgNO_3$.

- Determination of thermodynamic ionization constant of a monobasic acid by (i) conductometry and (ii) potentiometry.
- To study the effect of solvent on the conductance of $AgNO_3$/acetic acid and to determine the degree of dissociation and equilibrium constant in different solvents and in their mixtures (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Hűckel-Onsager theory.
- Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Hűckel's limiting law.
- Titration of $ZnSO_4$ / $MgSO_4$ against $BaCl_2$ and $Ba(CH_3COO)_2$ and calculation of amount of sulphate present.

Analysis of Pharmaceuticals:

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

Clinical Analysis:

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

Analysis of Food & Food Products:

- Analysis of moisture content, ash, fibre, nutrients, anti-nutrients, toxicants, microorganism-spoilage, preservatives.
- Analysis of amino acids, proteins, carbohydrates, lipids and fat.
- Analysis of edible oils, dairy products, pickles etc., fruit and vegetable products
- Analysis of food additives.
- Analysis of food adulteration.

- Estimation of vitamin A in food product by Carr-price method.
- Estimation of vitamin C in fruit juice by iodometry.
- Determination of Vitamin B_2 (Riboflavin) by flurometry.
- Estimation of proteins, sugars, vitamins, amino acids, crude fibre, total minerals, metals, crude fat and water in foods.
- Estimation of ascorbic acid by cerric ammonium sulphate method.
- Estimation of Glucose and fructose in honey by Lane and Eynone method.
- Determination of Hydroxymethylfurfural in Honey and Biomass
- Estimation of lactose in milk by iodometry.
- Quantitative analysis of iron, calcium and phosphorus in milk powder. (Fe-Colorimetrically, Ca-Complexometrically, P-Colorimetrically)
- Casein isolation from milk by isoelectric precipitation (Yield expected).
- Analysis of lipids: saponification value, acid value and iodine value.
- Determination of tannins, chemical residues and aflatoxins,
- Estimation of preservative and antioxidants.
- Determination of saccharin in beverages.
- Determination of strength of acetic acid from the commercial vinegar sample by potentiometric titration and its confirmation by conducltmetric / pH-metric titration using standard solution of NaOH
- Determination of commercial washing soda by potentiometric titration method.
- Estimation of amino acid in protein hydrolysate by Sorenson formal titration method.
- Estimation of pectin as Ca-Pectate colorimetrically
- Determination of Ca in egg shell by flame photometry method.
- Determination of fluoride in tooth paste colorimetrically with alizarins.
- Estimation of sodium benzoate / sodium metabisulphite, boric acid and salicylic acid in food.
- Estimation of tannin from tea.
- Isolation of caffeine from tea.
- Analysis of iodized table salt.
- Determination of Sialic Acids
- Determination of carbohydrates in coffee.
- Determination of Na/K/Li/Ca in given sample by flame photometry method.
- Chemical analysis of chilli-powder

Forensic Chemistry:

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

Analysis of Soap, Detergent, Shampoo and Cosmetics:

- Preparation of soaps and detergents.
- Estimation of EDTA in detergent and shampoo.
- Assay of soaps and detergent
- Determination of Na/K/Li/Ca in given sample by flame photometry method.
- Determination of washing strength of detergents by surface tension method.
- Determination of CMC of detergents.
- Determination of composition of perfume by GC/MS
- Estimation of fragrance in the perfumes by GC/MS.

- Estimation of Zinc in face powder by gravimetry
- Analysis of suspected allergens in perfumes by GC/MS.
- Estimation of benzoic acid in ointment.

Analysis of Heavy & Fine Chemicals:

- Preparation and characterization of copper sulphate.
- Preparation and characterization of methyl orange and methyl red.
- Estimation of $Na_2CO_3.10H_2O$ in washing soda.
- Determination of thiosulphate content of a commercial hypo solution.
- Estimation of available chlorine in the sample of bleaching powder

Atomic Absorption Spectroscopy:

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

Flame Photometric Determinations:

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

Fluorimetry & Phosphorimetry:

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

Nephelometry & Turbidimetry:

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

Thermal Analysis:

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

- Copper sulphate pentahydrate
- Calcium oxalate monohydrate
- Zinc hexafluorosilicate

X-Ray Diffraction:

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

Extraction of Organic Compounds from Natural Sources:

- Isolation of oleic acid from olive oil.
- Isolation of eugenol from clove.
- Isolation of nicotine dipicrate from tobacco.
- Isolation of cinchonine from cinchona bark.

- Isolation of piperine from black pepper.
- Isolation of protein from seeds
- Isolation of carbohydrate (as reducing sugars) from seeds

Students are required to try some typical colour reactions and check purity of compounds by paper chromatography and TLC by reporting Rf values and determine the density and refractive index wherever it is possible.

Ion Chromatography:

(i) Medical Science Applications

- Determination of sulfate counter ion and anionic impurities in aminoglycoside drug substances by IC with Suppressed Conductivity Detection
- Determination of tobramycin, neomycin B, streptomycin and impurities Using HPAE-PAD
- Determination of galactosamine containing organic impurities in heparin by HPAE-PAD Using the Dionex CarboPac PA20 Column
- Determination of hemoglobin variants by cation-exchange chromatography
- Determination of transition metals in serum and whole blood by Ion Chromatography
- Analysis of ions in physiological fluids
- Analysis of choline and acetylcholine
- Analysis of fatty acids.
- Determination of oxalate and carbohydrate in urine by Ion Chromatography
- Determination of protein concentrations using AAA-Direct
- Monitoring protein deamidation by cation-exchange Chromatography
- Analysis of mannose-6-phosphate
- Determination of nucleotides by Ion Chromatography with UV absorbance detection
- Determination of residual trifluoroacetate in protein purification buffers and peptide preparations by Reagent-Free Ion Chromatography
- Determination of tryptophan using AAA-Direct
- Identification of a hydroxylysine-containing peptide using AAA-Direct
- High-resolution analysis and purification of oligonucleotides with the DNAPac PA100 Column
- High-resolution cation-exchange alternative to peptide mapping for protein ID and QA/QC

(ii) Food and Beverage Applications

- Determination of mercury contamination in herbal medicines
- Rapid separation of anthocyanins in Cranberry and Bilberry extracts using a Core-Shell Particle Column
- Determination of trace sodium in cranberry powder
- Determination of sudan dyes I–IV in curry paste
- Determination of mono-, di-, and triphosphates and citrate in Shrimp by Ion Chromatography
- Determination of phytic acid in soybeans and black Sesame seeds
- Determination of nitrate and nitrite Ion Chromatography determination in milk samples
- Separation of organic acids and common inorganic anions in wine
- Determination of hydroxymethylfurfural in honey and biomass

- Fast determination of anthocyanins in pomegranate juice
- Determination of lactose in lactose-free milk products by high-performance anion-exchange Chromatography with Pulsed Amperometric Detection
- Fast HPLC Analysis of dyes in foods and beverages

(iii) Electronics Applications

- Determination of trace anion contamination in the extracts of electronic components
- Determination of sodium at the ppt level in the presence of high concentrations of ethanolamine in power plant waters
- Determination of inorganic anions and organic acids in fermentation broths
- Determination of phosphite in electroless nickel plating bath
- Determination of chloride, suppressors, additives and byproducts in acid copper plating baths
- Determination of saccharin in electrolytic nickel sulfate baths
- Determination of an anionic fluorochemical surfactant (FC-95) in a steel bath
- Determination of an anionic fluorochemical surfactant in a semiconductor Etch Bath
- Monitor trace anion contamination in the extracts of electronic components
- Determination of cations and amines in hydrogen peroxide by Ion Chromatography Using a RFIC™ (Reagent-Free) System
- Determination of dissolved silica and common Anions Using Dual Detection

(iv) Agrochemicals

- Determination of perchlorate in high ionic strength fertilizer extracts by Ion Chromatography

Any other relevant experiments may be added / performed.

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

Sample Question Paper

Paper-1.2: CHEM-512: Organic Chemistry

Duration of Exam: 3 Hours **Maximum Marks: 80**

***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 of equally divided in ten short answer type questions (about 25 words) and examiners are advised to set two short answer type questions from each unit.*

***Section-B** will carry 40 marks with equally divided five long answer type questions (about 200 words) and examiners are advised to set two questions from each unit and students are instructed to attempt five questions by selecting one question from each unit.*

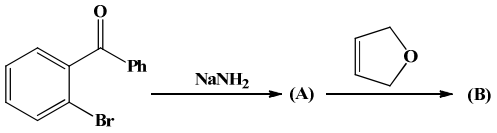
***Section-C** will carry 30 marks with equally divided three very long answer type questions (about 400 words) and examiners are advised to set five questions one from each unit and students are instructed to attempt any three questions out of five questions.*

SECTION-A

Q. 1.

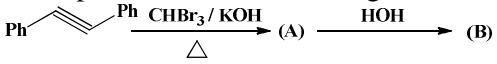
Unit-I

(i) Write the products of the following reaction:



½ + ½ = 1

(ii) Write the products of the following reaction:



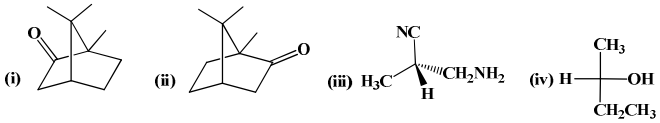
½ + ½ = 1

Unit-II

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

½ + ½ = 1

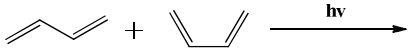
(iv) Write R or S nomenclature for the following compounds:



¼ +¼+¼+¼ = 1

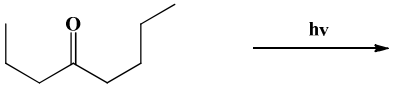
Unit-III

(v) Complete the following reaction:



1

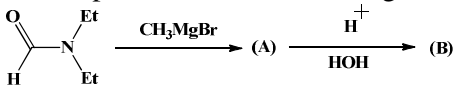
(vi) Complete the following reaction:



1

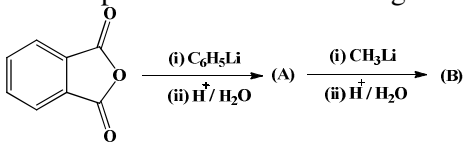
Unit-IV

(vii) Write the products of the following reaction:



½ + ½ = 1

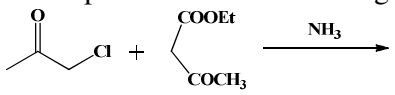
(viii) Write the products of the following reaction:



½ + ½ = 1

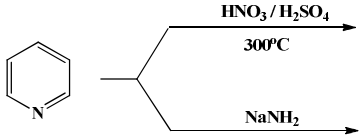
Unit-V

(ix) Write the products of the following reaction:



1

(x) Write the products of the following reaction:



½ + ½ = 1

SECTION-B

Unit-I

Q. 2. Write note on the following (any two):
- (i) Resonance
- (ii) Tautomerism
- (iii) Conjugation
- (iv) Aromaticity

4 + 4 = 8

OR

Q. 3. Give an account on formation, stability and chemical reactions of the following:
- (i) Carbocations
- (ii) Carbenes

4 + 4 = 8

Unit-II

Q. 4. Draw the conformational structures of n-butane and mono- & di-substituted cyclohexane.

3 + 5 = 8

OR

Q. 5. Write note on the following (any two):

(i) Symmetry elements

(ii) Chirality

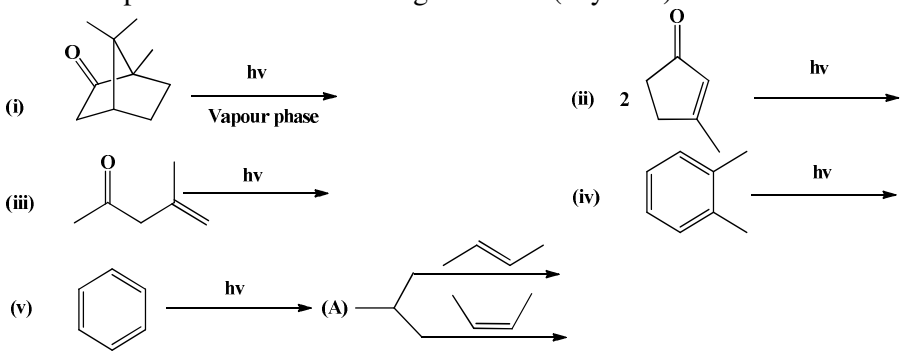
(iii) Threo & Erythro isomers

(iv) Enantiomers & Diastereomers

4 + 4 = 8

Unit-III

Q. 6. Write the products of the following reactions (any four):



2+2+2+2+2 = 8

OR

Q. **7.** Discuss in detail:

(i) Paterno-Büchi reaction

(ii) Photochemistry of 1,5-dienes

4 + 4 = 8

Unit-IV

Q. 8. Write note on the following:

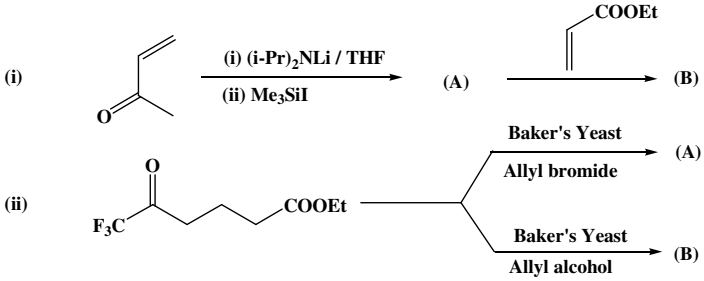
(i) Metal hydrides in organic synthesis

(ii) Phase transfer catalysts

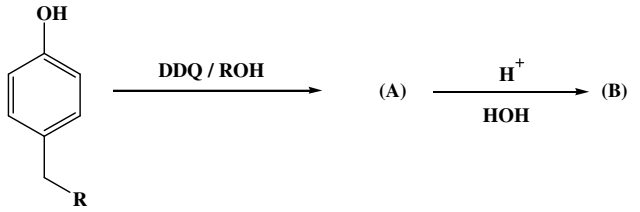
4 + 4 = 8

OR

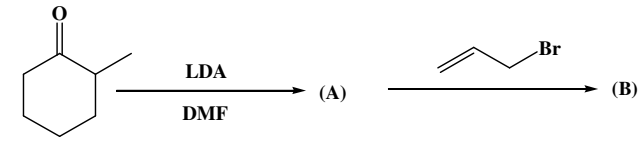
Q. 9. Write the products of the following reactions (any four):



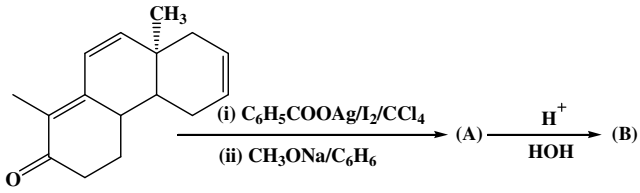
(iii)



(iv)



(v)



2+2+2+2+2 = 8

Unit-V

Q. 10. Give the plausible mechanisms of the following name reactions:

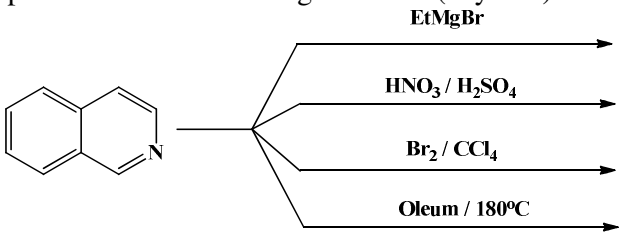
(i) Fischer-indole synthesis
(ii) Doebner-Miller synthesis
(iii) Bischler-Napieralski synthesis
(iv) Skraup synthesis

2+2+2+2 = 8

OR

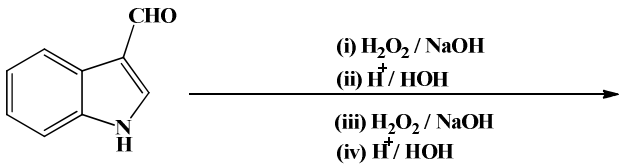
Q. **11.** Write the products of the following reactions (any two):

(i)



(ii)

(iii)



4+4 = 8

SECTION-C

Unit-I

Q. 12. Classify the types of organic reactions. How will you identify the mechanism of a particular type of organic reaction? Explain in detail.

2+8 = 10

Unit-II

Q.13. Describe the nomenclature of organic molecules according to R / S & E / Z systems.

5+5 = 10

Unit-III

Q. 14. Give an account on the following:

(i) Photochemistry of β,γ-unsaturated carbonyl compounds.
(ii) Photo-Fries rearrangement
(iii) Barton reaction

5+3+2 = 10

Unit-IV

Q. 15. Discuss the synthesis and chemical reactions of the following:

(i) Pyrimidines
(ii) Pyrones

5+5 = 10

Unit-V

Q. 16. 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 .....