DR. SHYAMA PRASAD MUKHERJEE UNIVERSITY, RANCHI

UNIVERSITY DEPARTMENT OF CHEMISTRY

B.Sc. Honours/Research Programme in Chemistry

(Based on NEP)



Guideline and syllabus for four years B.Sc. Honours/Research Programme in Chemistry

2023-27 onwards

APPROVED BY

THE BOARD OF STUDIES,

UNIVERSITY DEPARTMENT OF CHEMISTRY

DR. SHYAMA PRASAD MUKHERJEE UNIVERSITY, RANCHI

FOREWORD

National Education policy 2020 has been one among the intensely debated policies in the recent times. Given the long reach of Education as a social and economic transformation tool - more so for a developing nation like ours- the debate it has garnered in public domain is not surprising that JHARKHAND is among the states in the country to implement NEP in higher education. But playing the role of a pioneer is not child's play. Transforming the policy into a working framework and befitting a competent curriculum and syllabus is always a challenging task. The state has come up with the NEP framework for all the UG programmes starting from the academic year 2022. Undergraduate programmes were traditionally conceived as preparation for post graduation. Since decades its structure remained unchanged and was long due for an overhaul. The rigidity in choosing subjects through fixed combinations had to be reconsidered. The aspects of all-round development of the students, skill acquisition outside chosen subjects and research were undermined but NEP has changed all of these in one stroke.

The prominent features of the NEP framework are:

- I. Flexibility in choosing subjects and even disciplines for the graduate programmes
- II. Vertical and horizontal mobility across subjects throughout the programme
- III. Multiple entry and exit points
- IV. Main-streaming of skill based courses
- V. Credit based evaluation system
- VI. Integration of research into 4th year of the programme leading to Honours degree

Such radical modifications have put the learner at the centre of the education system. The framework has nudged the academic faculty to work out syllabi aligned with national standards, if not global. The road map is in place. It is the implementation of NEP in its letter and spirit that would catalyze raising the bar for the quality in Higher Education. I place on record my appreciation and regard to all those who were involved in the endeavour of the syllabus preparation for the undergraduate Chemistry programme of Dr. Shyama Prasad Mukherjee University. The fact that all efforts have been made to align the syllabus with the NEP structure is further satisfying. I sincerely hope that periodical revisions will take place in coming years.

Khurshid Akhtar Head, University Department of Chemistry, DSPMU and Chairman of the Syllabus Preparing Committee

Chemistry Syllabus for B.Sc. / B.Sc. (Honours) Programme Discipline Core: Chemistry Total Credits for the Programme: 160, Year of implementation: 2023-24

Programme Outcomes: By the end of the programme the students will:

- 1. Understand the basic principles of various branches of Chemistry
- 2. Demonstrate a range of practical skills to conduct and infer experiments independently and in groups
- 3. Apply the key concepts and standard methodologies to solve problems related to Chemistry
- 4. Apply methodologies to the solution of unfamiliar types of problems
- 5. Exhibit skills leading to employability in Chemistry and allied industries
- 6. Comprehend the fundamental aspects of research in Chemistry

7. Possess the level of proficiency in subject required for post graduation as well as for pursuing research in Chemistry and related interdisciplinary subjects

8. Design solutions stemming from the application of Chemistry to the local issues

Salient Features:

- 1. Introduction to B.Sc. (Hons.) Chemistry
 - Just like the Choice Based Credit System (CBCS),NEP provides an opportunity to a student to choose courses from the syllabus comprising Core, Elective and Skill based courses. It offers a flexibility of programme structure while ensuring that the student gets a strong foundation in the subject and gains in-depth knowledge. The learning outcome based curriculum framework (LOCF) will provide students with a clear purpose to focus their learning efforts and enable them to make a well judged choice regarding the course they wish to study. This will suit the present day needs of students in terms of securing their paths towards higher studies or employment.
- 2. *Programme Duration and Design:* The B.Sc. (Hons.) Chemistry course is **an eight semester course spread over four academic years.** The teaching learning process involves theory and practical classes and will be student centered. Apart from the conventional chalk and talk method, power point presentations, audio video tools, class discussions, simulations and virtual labs (wherever possible) will be used. Students will be encouraged to carry out short term projects and participate in industrial and institutional visits, seminars and workshops. Assessment will be based on continuous evaluation (class test, presentation, group discussion, quiz, assignment etc.) and end of semester examination.

Each theory paper will be of 75 marks out of which 15 marks are for internal assessment(in the form of Mid Sem or similar test) while a practical paper will be of 25 marks .

3. Learning Outcome-based Curriculum Framework in BSc (Hons.) Chemistry:

The Learning Outcomes-based Curriculum Framework (LOCF) for the B.Sc. (Hons.) degree in Chemistry provides a broad structural framework that can accommodate the current curricular needs as well as gives sufficient flexibility to include changes in content that assume importance as the frontiers of science grow. The inherent flexibility in framework allows design of course basket in tune with individual preferences. The basic uniformity in core course design ensures smooth movement across universities in the country.

3.1 Nature and Extent of B.Sc. (Hons.) Chemistry: The B.Sc. (Hons.) Chemistry programme covers a wide range of basic and applied courses as well as courses of interdisciplinary nature.

- 3.2 Aims of the Bachelors Degree Programme in B.Sc. (Hons.) Chemistry: The core courses offered in the programme aim to build a strong conceptual chemical knowledge base in the students, the contents of electives and skill enhancement courses help them explore their fitness and suitability to pursue studies in these areas.
- 4. *Graduate Attributes in B.Sc. (Hons.) Chemistry:* Though a student pursuing an undergraduate degree in a science discipline is inherently curiosity driven and has the ability to observe and integrate rationally, here are the additional attributes that distinguish a student graduating with an honours degree in chemistry.
- (i) *Disciplinary Knowledge:* The student is expected to acquire in-depth knowledge of the various concepts and theoretical principles and to be aware of their manifestations. An understanding of the centrality of chemistry is usually evident from familiarity with interfacial disciplines .A graduate in chemistry is expected to be thoroughly conversant with all basic analytical, qualitative and quantitative laboratory techniques and demonstrate meticulousness in operation. She/he should be aware of the importance of working with safety and consciousness in laboratory and actively seeks information about health and environmental safety of chemicals that are used in the laboratories and follows protocols for their safe disposal.
- (ii) *Communication skills:* Effective communication is a much desirable attribute across courses. However, a chemistry honours student is expected to assimilate technical information about chemistry from various sources and convey it to intended audience, both orally and in writing in an intelligible manner.
- (iii) *Critical thinking:* Critical thinking as an attribute enables a student to analyze a problem, assess it, reconstruct it and solve it.
- (iv) *Problem solving quality:* An integral part of chemistry curriculum is problem solving. The student will be equipped to solve problems of numerical, synthetic and analytical nature that are best approached with critical thinking.
- (v) *Analytical reasoning:* The student will be able to draw logical conclusions based on a group of observations, facts and rules.
- (vi) *Research related skills:* The student should be inquisitive about processes and phenomena happening during experiments in laboratories and seeks answers through the research path.
- (vii) *Cooperation/Team work:* Teams may comprise of peers in classroom, laboratory or any other team of members from diverse fields. The student should be capable of contributing meaningfully to team ethos and Increasing use of instruments having interface with computers and use of computers in laboratory work. A student with degree in chemistry is expected to be able to employ knowledge and skill in computers in a variety of situations- data analysis, computing as well as information retrieval and library use.
- (viii) *Scientific reasoning:* Students should learn to investigate, experiment, relate information and draw logical conclusions based on scientific reasoning.
- (ix) *Reflective thinking:* Reflective thinking focuses on the process of making judgments about what has happened. The students should learn to review their experience and make a plan for future actions in a similar situation with a view to improve.
- (x) Information/digital literacy : This will be an essential by product of the course.
- (xi) *Self-directed learning:* Students will be encouraged to explore the many sources of information available to them. Various activities require the students to find relevant information and educate themselves.
- (xii) *Multicultural competence:* The student should recognize that all persons are unique in their own way and must appreciate the differences in cultural background, religious beliefs, and socio-economic status.
- (xiii) *Moral and ethical awareness/reasoning:* The student should be aware of what constitutes unethical behaviour-plagiarism, fabrication and misrepresentation or manipulation of data.
- (xiv) *Leadership readiness/qualities:* Leadership is essential in making teamwork into a reality. Working in teams promotes both teamwork and leadership qualities in the student.
- (xv) *Lifelong learning:* Having a strong conceptual framework in the subject along with the skills of teamwork, analytical reasoning, problem solving, critical thinking etc. will make the students lifelong learners.

UNIVERSITY DEPARTMENT OF CHEMISTRY BOARD OF STUDIES FOREWORD

A meeting of the BOARD OF STUDIES was held in the University Department of Chemistry, DSPM University, Ranchi. Following members participated in the syllabus approval meeting. The Draft Syllabus was then approved by the BOARD OF STUDIES and finally placed before the ACADEMIC COUNCIL of DSPM UNIVERSITY for approval.

1. External Subject Expert

Prof.(DR) Sanjoy Misra Ex-Head, University Department of Chemistry, R.U.

- 2. External Subject Expert Dr. Anil Kumar Delta Head, University Department of Chemistry, R.U.
- 3. Dr. N. K. Roy Faculty Member Assistant Professor University Department of Chemistry, DSPMU, Ranchi Dr. A. K. Acharya Faculty Member 4. Assistant Professor University Department of Chemistry, DSPMU, Ranchi 5. Dr. Poonam Bhardwaj Faculty Member Assistant Professor University Department of Chemistry, DSPMU, Ranchi Dr. Rajeev Ranjan Faculty Member 6. Assistant Professor University Department of Chemistry, DSPMU, Ranchi
- 7. Dr. Khurshid AkhtarFaculty Member &
Chairperson & HOD
University Department of Chemistry,
DSPMU, Ranchi

UNIVERSITY DEPARTMENT OF CHEMISTRY

DEPARTMENT COUNCIL FOREWORD

In the UNIVERSITY DEPARTMENT OF CHEMISTRY, DR. SHYAMA PRASAD MUKHERJEE UNIVERSITY, the faculty members participated in the syllabus preparation meetings. Keeping in view the aims of the UGC and NEP Model in developing interdisciplinary skills in students and linking chemistry studies with professional development of students, the teachers of different branches of chemistry, namely Inorganic, Organic and Physical chemistry had joint brainstorming sessions and arrived at a Draft Syllabus in Chemistry for Eight semesters B.Sc. Honours / Research course. The Draft Syllabus was then approved by the Department Council and finally placed before the ACADEMIC COUNCIL of DR. SHYAMA PRASAD MUKHERJEE UNIVERSITY for approval.

Signature

1.	Dr. N. K. Roy Assistant Professor University Department of Chemistry, DSPMU, Ranchi	Faculty Member
2.	Dr. A. K. Acharya Assistant Professor University Department of Chemistry, DSPMU, Ranchi	Faculty Member
3.	Dr. Poonam Bhardwaj Assistant Professor University Department of Chemistry, DSPMU, Ranchi	Faculty Member
4.	Dr. Rajeev Ranjan Assistant Professor University Department of Chemistry, DSPMU, Ranchi	Faculty Member
5.	Dr. Khurshid Akhtar Associate Professor University Department of Chemistry, DSPMU, Ranchi	Faculty Member & Chairperson & HOD

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DR. SHYAMA PRASAD MUKHERJEE UNIVERSITY, RANCHI UNIVERSITY DEPARTMENT OF CHEMISTRY B.Sc. Honours/Research Programme in Chemistry

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6	Major Course- MJ 01	MJ-101T/P (3/1)
	SEMESTER II	
7	Major Course- MJ 02	MJ-201T/P (3/1)
8	Major Course- MJ 03	MJ-202T/P (3/1)
	SEMESTER III	
9	Major Course- MJ 04	MJ-301T/P (3/1)
10	Major Course- MJ 05	MJ-302T/P (3/1)
	SEMESTER IV	
11	Major Course- MJ 06	MJ-401T/P (3/1)
12	Major Course- MJ 07	MJ-402T/P (3/1)
13	Major Course- MJ 08	MJ-403T/P (3/1)
	SEMESTER V	
14	Major Course- MJ 09	MJ-501T/P (3/1)
15	Major Course- MJ 10	MJ-502T/P (3/1)
16	Major Course- MJ 11	MJ-503T/P (3/1)
	SEMESTER VI	
17	Major Course- MJ 12	MJ-601T/P (3/1)
18	Major Course- MJ 13	MJ-602T/P (3/1)
19	Major Course- MJ 14	MJ-603T/P (3/1)
20	Major Course- MJ 15	MJ-604T/P (3/1)
	SEMESTER VII	
21	Major Course- MJ 16	MJ-701T/P (3/1)
22	Major Course- MJ 17	MJ-702T/P (3/1)
23	Major Course- MJ 18	MJ-703T/P (3/1)
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	MINOR COURSES ELECTIVE	Paper Code/Credits
32	Minor Courses – MN 1	MN-101T/3(3/1)
33	Minor Courses – MN 2	MN-301T/3(3/1)
34	Minor Courses – MN 3	MN-501T/3(3/1)
35	Minor Courses – MN 4	MN-701T/3(3/1)
	MINOR COURSE(VOCATIONAL)	
36	Minor Courses (Vocational) – MNV 1	MNV-201T/3(3/1)
37	Minor Courses (Vocational) – MNV 2	MNV-401T/3(3/1)
38	Minor Courses (Vocational) – MNV3	MNV-601T/3(3/1)
39	Minor Courses (Vocational) – MNV 4	MNV-801T/3(3/1)
	MULTI DISCIPLINARY COURSE	
40	Multi-Disciplinary Course– MDC I/II/III	MDCT/P(101,201, 301) 2/1
	SKILL ENHANCEMENT COURSES	
41	Skill Enhancement Courses- SEC 1	SEC-101 (T/P)2/1
42	Skill Enhancement Courses- SEC 2	SEC-201 (T/P)2/1
43	Skill Enhancement Courses- SEC 3	SEC-301 (T/P)2/1

HIGHLIGHTS AND REGULATIONS OF FOUR YEAR U.G. PROGRAM IN CHEMISTRY

COURSES OF STUDY:

Courses of the study indicate pursuance of study in a Chemistry. Every discipline shall offer four categories of courses of study, viz. Major Paper (MJ) courses, Minor Course (MN), Skill Enhancement Courses (SEC) and Minor Vocational (MNV). Besides these four courses, a student will select Ability Enhancement Courses (AECs) and Value-Added Courses (VACs) from the respective pool of courses offered by the University.

- a) **Major Paper (MJ)**: Major Paper is a course of study, which should be pursued by a student as a mandatory requirement of his/ her programme of study. In Bachelor of Science (Hons.) Chemistry programme, MJs are the core credit courses of Chemistry which will be appropriately graded and arranged across the semesters of study, being undertaken by the student, with multiple exit options as per NEP 2020.
- b) **Minor Paper (MN):** The Minor course (MN) is a pool of credit courses of Chemistry from which a student with major other than Chemistry will choose to study based on his/ her interest.
- c) Minor (vocational) Paper (MNV): Minor vocational is a pool of courses offered by Chemistry which is meant to provide multidisciplinary or interdisciplinary education to students. A student has to opt for MNVs beyond his/ her discipline specific course(s) of study.
- d) Ability Enhancement course (AEC), Skill Enhancement Course (SEC) and Value Addition Course (VAC): These three courses are a pool of courses offered by all the Departments in groups of odd and even semesters from which a student can choose.
 - I. **AEC:** AEC courses are the courses based upon the content that leads to knowledge enhancement through various areas of study. They are based on Language and Literature, and Environmental Science which are mandatory for all disciplines.
 - II. SEC: SECs are skill-based courses in all disciplines and are aimed at providing hands-on training, competency, proficiency and skills to students. SEC courses may be chosen from a pool of courses offered by parent Department designed to provide skill-based instruction.
- **VAC:** VACs are common pool of courses offered by different disciplines and aimed towards personality building, embedding ethical, cultural and constitutional values; promote critical thinking, Indian knowledge systems, scientific temperament, communication skills, creative writing, presentation skills, sports and physical education and team work which will help in *all round development* of students.

GENERAL GUIDELINES

- 1. B.Sc. (Hons./Res.) Course in Chemistry shall be of four years duration.
- 2. There shall be semester wise examination.
- 3. There shall be eight semester (08) in four years, Semester-I and Semester-II in first year (1st year), Semester-III and Semester-IV in the second year (2nd year), Semester-V and Semester-VI in the third year (3rd year) and Semester-VII and Semester-VIII in the fourth year (4th year).
- 4. There shall be TWENTY (20) Compulsory Core Papers (MJ).
- 5. In addition, there shall be THREE (03) Compulsory Research Course /Advance Major Course Papers (RC/AMJ).
- 6. There shall be THREE (03) Skill Enhancement Compulsory Papers (SEC).
- 7. There shall be THREE (04) Ability Enhancement Compulsory Papers (AEC).
- 8. There shall be THREE (03) Multi-disciplinary Compulsory Papers (MDC) available in EACH of the first three semesters and each will be from different subjects.
- 9. There shall be THREE (03) Value Added Compulsory Papers(VAC).
- 10. For students opting to quit the course after 2nd Semester or after 4th Semester he/she has to undertake Internship/Apprenticeship/Project mandatorily so as to become eligible for Certificate or Diploma respectively, provided 44 or 84 credits have been earned respectively.4 credits from Internship/Apprenticeship/Project have to be in excess to the requirement for continuous study(40 or 80 for the latter).
- 11. Another exit point is available after VI Semester and Degree will be awarded if one has acquired 120 credits.
- 12. For Promotion to 4th year, a minimum of 7.5 CGPA and NO backlog till VIth Semester is a MUST. **Degree with Honours will be awarded** provided total credits earned is 160, if THREE Advanced Major Papers have been chosen. If in lieu of Advanced Major Papers, THREE Research Papers have been cleared the student will get **Degree with Honours and Research provided total credits earned is 160.**

GROUP OF OPTIONAL PAPERS:

Semester-VIII

Research Course-RC 1
Research Course-RC 2
Research Course-RC 3

Or

Semester-VIII

Advance Major Course-AMJ 1
Advance Major Course-AMJ 1
Advance Major Course-AMJ 1

- 11. Each theory paper in each END SEMESTER EXAMINATION shall carry SIXTY (60) as FULL MARKS.
- 12. There shall be MID SEMESTER EXAMINATION/ INTERNAL EVALUATION/ASSIGNMENT in the middle of each Semester carrying FIFTEEN (15) as FULL MARKS.
- 13. There shall be total EIGHT (08) questions in each End-Semester Theory Examinations. Examinees are required to answer any FIVE (05) questions..
- 14. The duration of End-Semester Examination shall be of THREE HOURS (**3 Hrs**) in each Theory Paper of each Semester.
- 15. The duration of End-Semester Examination shall be of ONE AND A HALF HOURS $(1^{1}/_{2} \text{ Hrs})$ in each Practical Paper of each Semester.

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COURSE STRUCTURE FOR FOUR YEAR UNDER UNDERGRADUATE PROGRAM 'HONOURS/RESEARCH'

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Credit Framework for Four Year Undergraduate Program under State Universities of Jharkhand [Total Credits=160]

Level of Courses	Semester	MJ: Discipline Specific Courses- Core or Major	MN: Minor from Discipline (16)	MN: Minor from Vocational (16)	MDC: Multidisciplinary Courses (9)	AEC: Ability Enhancement Courses (Modern Indian Languages and English) (8)	SEC: Skill Enhancement Courses (9)	VAC: Value Added Courses (6)	IAP: Internship / Dissertation (4)	RC: Research Courses (12)	AMJ: Advanced Courses in lieu of Research (12)	Credits
1	2	3	4	5	6	7	8	9	10	11	12	13
Foundation or	Ι	4	4		3	2	3	4				20
Courses	II	4+4		4	3	2	3					20
	Exit P (4 Cre	oint: Under dits)	gradu	uate (Certifi	icate provid	led w	ith Su	mme	r Inte	rnship/ P	roject
Intermediate -	III	4+4	4		3	2	3					20
Courses	IV	4+4+4		4		2		2				20
	Exit P Projec	oint: Under ct (4 Credits	gradı	uate I	Diplor	na provideo	l with	Sum	mer l	Intern	ship in 1	st or 2 nd /
Higher – Level	V	4+4+4	4						4			20
Courses	VI	4+4+4+4		4								20
	Exit Point: Bachelor's Degree											
Advanced Courses	VII	4+4+4+4	4									20
Advanced Courses	VIII	4		4						12	4+4+4	20
	Exit Point: Bachelor's Degree with Hons. / Hons. With Research							160				

Note: Honours students not undertaking research will do 3 courses for 12 credits in lieu of a research Project / Dissertation.

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COURSES OF STUDY FOR FOUR YEAR UNDERGRADUATE PROGRAMME Semester wise Course Code and Credit Points for Single Major

Compostor	Common, Introductory, Major, Minor, Vocational & Internship Courses				
Semester	Code	Papers	Credits		
	AEC-1	Language and Communication Skills (MIL-1; Modern Indian Language including TRL)	2		
	VAC-1	Value Added Course-1	2		
	VAC-2	Value Added Course-2	2		
Ι	SEC-1	Skill Enhancement Course-1	3		
	MDC-1	Multi-Disciplinary Course-1	3		
	MN-1	Minor From Discipline-1	4		
	MJ-1	Major Paper-1(Disciplinary / Interdisciplinary Major)	4		
	AEC-2	Language and Communication Skills (English 1)	2		
	SEC-2	Skill Enhancement Course-2	3		
II	MDC-2	Multi-Disciplinary Course-2	3		
	MNV-1	Minor From Discipline-2(Vocational Studies)	4		
	MJ-2	Major Paper-2(Disciplinary / Interdisciplinary Major)	4		
	MJ-3	Major Paper-3(Disciplinary / Interdisciplinary Major)	4		
	AEC-3	Language and Communication Skills (MIL-2; Modern Indian Language including TRL)	2		
	SEC-3	Skill Enhancement Course-3	3		
	MDC-3	Multi-Disciplinary Course-3	3		
III	MN-2	Minor From Discipline-1	4		
	MJ-4	Major Paper-4(Disciplinary / Interdisciplinary Major)	4		
	MJ-5	Major Paper-5(Disciplinary / Interdisciplinary Major)	4		
	AEC-4	Language and Communication Skills (English 2)	2		
	VAC-2	Value Added Course-2	2		
IV	MNV-2	Minor From Discipline-2 (Vocational Studies)	4		
	MJ-6	Major Paper-6(Disciplinary / Interdisciplinary Major)	4		
	MJ-7	Major Paper-7(Disciplinary / Interdisciplinary Major)	4		

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	MJ-8	Major Paper-8(Disciplinary / Interdisciplinary Major)	4		
Somostor	Common, Introductory, Major, Minor, Vocational &Internship Courses				
Semester	Code	Papers	Creatis		
	MN-3	Minor From Discipline-1	4		
	MJ-9	Major Paper-9 (Disciplinary / Interdisciplinary Major)	4		
V	MJ-10	Major Paper-10(Disciplinary / Interdisciplinary Major)	4		
	MJ-11	Major Paper-11(Disciplinary / Interdisciplinary Major)	4		
	IAP	Internship/Apprenticeship/ Field Work/Dissertation/ Project	4		
	MNV-3	Minor From Discipline-2 (Vocational Studies)	4		
X 7 X	MJ-12	Major Paper-12(Disciplinary / Interdisciplinary Major)	4		
VI	MJ-13	Major Paper-13(Disciplinary / Interdisciplinary Major)	4		
	MJ-14	Major Paper-14(Disciplinary / Interdisciplinary Major)	4		
	MJ-15	Major Paper-15(Disciplinary / Interdisciplinary Major)	4		
	MN-4	Minor From Discipline-1			
	MJ-16	Major Paper-16(Disciplinary / Interdisciplinary Major)	4		
VII	MJ-17	Major Paper-17(Disciplinary / Interdisciplinary Major)	4		
	MJ-18	Major Paper-18(Disciplinary / Interdisciplinary Major)	4		
	MJ-19	Major Paper-19(Disciplinary / Interdisciplinary Major)	4		
	MNV-4	Minor From Discipline-2 (Vocational Studies)			
	MJ-20	Major Paper-20(Disciplinary / Interdisciplinary Major)	4		
	RC	Research Internship/ Field Work/ Dissertation OR	12/		
VIII	AMJ-1	Advanced Major Paper-1(Disciplinary / Interdisciplinary Major)			
	AMJ-2	Advanced Major Paper-2(Disciplinary / Interdisciplinary Major)	4		
	AMJ-3	Advanced Major Paper-3(Disciplinary / Interdisciplinary Major)	4		
		Total Credit	160		

			Distribution of Marks				
COURSE OPTED	COURSE NAME	NEW CODE	END SEM	MID SEM/ Assignment	PRACTICAL	TOTAL	
SEMESTER - I				1			
Major Course-MJ 1	Inorganic Chemistry-I	CCU-101T/P (3/1)	60	15	25	100	
SEMESTER - II							
Major Course-MJ 2	Organic Chemistry-I	CCU-201T/P (3/1)	60	15	25	100	
Major Course-MJ 3	Physical Chemistry-I	CCU-202T/P (3/1)	60	15	25	100	
SEMESTER – III			1	1	1		
Major Course-MJ 4	Organic Chemistry-II	CCU-301T/P (3/1)	60	15	25	100	
Major Course-MJ 5	Physical Chemistry-II	CCU-302T/P (3/1)	60	15	25	100	
SEMESTER – IV			1	1	1		
Major Course-MJ 6	Inorganic Chemistry-II	CCU-401T/P (3/1)	60	15	25	100	
Major Course-MJ 7	Organic Chemistry-III	CCU-402T/P (3/1)	60	15	25	100	
Major Course-MJ 8	Physical Chemistry-III	CCU-403T/P (3/1)	60	15	25	100	
SEMESTER – V					-		
Major Course-MJ 9	Inorganic Chemistry-III	CCU-501T/P (3/1)	60	15	25	100	
Major Course-MJ 10	Organic Chemistry-IV	CCU-502T/P (3/1)	60	15	25	100	
Major Course-MJ 11	Physical Chemistry-IV	CCU-503T/P (3/1)	60	15	25	100	
SEMESTER - VI					-		
Major Course-MJ 12	Inorganic Chemistry-IV	CCU-601T/P (3/1)	60	15	25	100	
Major Course-MJ 13	Organic Chemistry-V	CCU-602T/P (3/1)	60	15	25	100	
Major Course-MJ 14	Physical Chemistry-V	CCU-603T/P (3/1)	60	15	25	100	
Major Course-MJ 15	Polymer Chemistry	CCU-604T/P (3/1)	60	15	25	100	
SEMESTER - VII					-		
Major Course-MJ 16	Inorganic Chemistry-V	CCU-701T/P (3/1)	60	15	25	100	
Major Course-MJ 17	Organic Chemistry-VI	CCU-702T/P (3/1)	60	15	25	100	
Major Course-MJ 18	Physical Chemistry-VI	CCU-703T/P (3/1)	60	15	25	100	
Major Course-MJ 19	Analytical Chemistry	CCU-704T/P (3/1)	60	15	25	100	
SEMESTER - VII				T	•		
Major Course-MJ 20	Environmental Chemistry	CCU-801T/P (3/1)	60	15	25	100	
Research Course-RC 1	Inorganic Chemistry	RC-801T/P (3/1)	60	15	25	100	
Research Course-RC 2	Organic Chemistry	RC-802T/P (3/1)	60	15	25	100	
Research Course-RC 3	Physical Chemistry	RC-803T/P (3/1)	60	15	25	100	
Advance Major Course- AMJ 1	Inorganic Chemistry-VI	MJ-802T/P (3/1)	60	15	25	100	
Advance Major Course- AMJ 2	Organic Chemistry-VII	MJ-803T/P (3/1)	60	15	25	100	
Advance Major Course- AMJ 3	Physical Chemistry-VII	MJ-804T/P (3/1)	60	15	25	100	

B.Sc. HONOURS/ RESEARCH IN CHEMISTRY CORE COURSE

Semester I **Course Code: CHE-MJ-01** Paper Code: CHE-MJ-101 T Course Title: Inorganic Chemistry-I (Theo) 3 Credits (54 Lectures each of 50 minutes)

	Marks Distribution	
Mid Sem:15	End Sem: 60	Full Marks:75

Eight questions are to be set out of which five are to be answered.

I Atomic Structure:

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2 . Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

II Periodicity of Elements:

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements with reference to s & p-block : (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table, (b) Atomic radii, (c) Ionic and crystal radii, (d) Covalent radii, (e) Ionization enthalpy, factors affecting ionization energy. Applications of ionization enthalpy, (f) Electron gain enthalpy, trends of electron gain enthalpy, (g) Electronegativity, Pauling's / Mulliken's / Allred Rachow's / and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, group electronegativity. Sanderson's electron density ratio.

III Chemical Bonding:

(A) Ionic bond and Covalent bond:

General characteristics, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Lattice energy, Madelung constant, Born-Haber cycle and its application, Solvation energy. Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization. Bent's rule. Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N₂, O₂, C₂, B₂, F₂, CO and NO. Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths.

(B) Covalent character and Ionic Character:

Covalent character in ionic compounds: polarizing power and polarizability. Fajan's rules and consequences of polarization.

12 Lectures

26 Lectures

(12 Lectures)

(14 Lectures)

Time: 3 Hrs

12 Lectures

Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

Metallic Bond: Qualitative idea of band theories. Semiconductors and insulators.

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Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions. Repulsive forces, Hydrogen bonding. Effects of chemical force on melting and boiling points.

IV Oxidation-Reduction:

4 Lectures

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Principles involved in volumetric analysis to be carried out in class.

Reference Books:

1. Concise Inorganic Chemistry, Lee, J.D. ELBS, 1991.

2. Concepts & Models of Inorganic Chemistry, Douglas, B.E. and Mc Daniel, D.H., Oxford, 1970

3. Physical Chemistry, Atkins, P.W. & Paula, J. Oxford Press, 2006.

Theoretical Inorganic Chemistry, Day, M.C. and Selbin, J. ACS Publications 1962.

4. Inorganic Chemistry, P. Shriver & Atkins' 5th Ed. Oxford University Press (2010).

5.., Basic Inorganic Chemistry, Cotton, F.A., Wilkinson, G. and Gaus, P.L, 3rd Ed.; Wiley India.

6. Inorganic Chemistry, Sharpe, A.G., 4th Indian Reprint (Pearson Education) 2005.

7. Inorganic Chemistry, Principles of Structure and Reactivity Huheey, J. E.; Keiter, E.A., Medhi & Keiter, R.L 4th Ed., Harper Collins 1993, Pearson, 2006.

8. Essential trends in inorganic chemistry, Mingos, D.M.P., Oxford University Press (1998).

9..An illustrated gallery of atomic and molecular orbitals. Winter, M. J., The Orbitron, http://winter.group.shef.ac.uk/orbitron/ (2002)

10. Ions in solution: basic principles of chemical interactions, Burgess, J., Ellis Horwood (1999).

11. Atomic Structure and Chemical bond, Manas Chanda, Tata-McGraw-Hill

12. Modern Inorganic Chemistry, R.C. Agarwal, Kitab Mahal

13. Fundamental Concepts of Inorganic Chemistry, Asim K Das and Mahua Das, CBS Publishers

& Distributors

Semester I Course Code: CHE-MJP-02 Paper Code: CHE-MJ-101P Course Title: Inorganic Chemistry-I (Prac) 1 Credit 18 Lectures Full Marks: 25

One question is to be set.

Time: 1¹/₂ Hrs

(A) Titrimetric Analysis

- (i) Calibration and use of apparatus
- (ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-Base Titrations

- (i) Estimation of carbonate and hydroxide present together in mixture.
- (ii) Estimation of carbonate and bicarbonate present together in a mixture.
- (iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

- (i) Estimation of Fe(II) using standardized KMnO₄ solution.
- (ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
- (iii) Estimation of Fe(II) with K₂Cr₂O₇ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference text:

- 1. A Textbook of Quantitative Inorganic Analysis, Vogel, A.I. ELBS.
 - 2. A Vogel's Quantitative Chemical Analysis Mendham, J., I 6th Ed., Pearson, 2009
 - 3. B, Vogel's Qualitative Inorganic Analysis, Svehala G. and Sivasankar I Pearson, India, 2012.
 - 4. Practical Inorganic Chemistry, Shikha Gulati ,J L Sharma and Shagun Manocha,CBS Publishers & Distributors.
 - 5. College Practical Chemistry, V K Ahluwalia, Sunita Dhingra and Adarsh Gulati, Universities Press
 - 6. An Advanced Course in Practical Chemistry, Ghoshal, Mahapatra and Nad, New Central Book Agency (P) Ltd
 - 7. University Practical Chemistry, PC Kamboj, Vishal Publishing Co.
 - 8. Advanced Practical Chemistry, Gurdeep Raj, Krishna Prakashan Media (P) Ltd.

Practical-1: 20 Marks, Note Book: 2¹/₂ Marks, Viva: 2¹/₂ Marks.

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	Semester II	
	Course Code: CHE-MJ-02	
	Paper Code : CHE-MJ-201 T	
	Course Title: Organic Chemistry-I (Theo)	
	3 Credits (54 Lectures each of 50 minutes)	
	Marks Distribution	
Mid Sem:15	End Sem: 60	Full Marks:75
Eight questions are to	Time: 3 Hrs	

I Basics of Organic Chemistry

Organic Compounds: Classification, Hybridization, Shapes of molecules.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications, Dipole moment, Organic acids and bases, their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilcity and basicity; Types, shape and relative stability of Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

II Stereochemistry

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversion. Geometrical isomerism: cis-trans and syn-anti isomerism, E/Z notations with Cahn Ingold and Prelog (CIP) rules for determining absolute configuration.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, Meso structures, Racemic mixture. Resolution of Racemic mixtures. Relative and absolute configuration: D/L and R/S designations.

III Chemistry of Aliphatic Hydrocarbons

A. Carbon-Carbon sigma bonds

Chemistry of alkanes: Classification of carbon atoms in alkanes, Isomerism in alkanes, Methods of formation of alkanes- Wurtz Reaction, Wurtz-Fittig Reaction, Kolbe Reaction, Corey-House Reaction and Decarboxylation of carboxylic acids. Free radical substitutions: Halogenation orientation, reactivity and selectivity.

B. Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff / Anti-Markownikoff addition), Mechanism of Oxymercuration-demercuration, Hydroboration-oxidation, Ozonolysis, Reduction (catalytic and chemical), syn and anti-hydroxylation. 1,2-and 1,4-addition reactions in conjugated dienes. Allylic and benzylic bromination and mechanism. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

C. Cycloalkanes and Conformational Analysis

Types of cycloalkanes and their relative stability, Bayer's strain theory, Methods of formation of cycloalkanes : Diel's Alder Reaction, Simmons-Smith Reaction, Demjanov Rearrangement-

8 Lectures

10 Lectures

10 Lectures

10 Lectures

Time: 3 Hrs

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8 Lectures

reduction, and addition of carbenes to olefins. Conformation analysis of cycloakanes, Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms - Relative stability with energy diagrams.

IV Aromatic Hydrocarbons

8 Lectures

Aromaticity: Hückel's rule, aromatic/anti-aromatic/non-aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples.

Electrophilic aromatic substitution: Halogenation, Nitration, Sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of mono-functional groups.

Reference Books:

- Morrison, R. N. & Boyd, R. N Organic Chemistry,. , Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- •. Finar, I. L Organic Chemistry (Volume 1), ,Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L Organic Chemistry (Volume 2): Stereochemistry and the Chemistry of Natural Products), ., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). .
- Kalsi, P. S. Stereochemistry, Conformation and Mechanism; New Age International, 2005.

•, Clayden, J., Greeves, N. & Warren, S., Organic Chemistry Second edition, Oxford University Press, 2012.

- •. Smith, J. G Organic Chemistry, Tata McGraw-Hill Publishing Company Limited.
- •. Nasipuri, D, Stereochemistry of Organic Compounds, Wiley Eastern Limited.
- •. James, J., Peach, J. M, Stereochemistry at a Glance, Blackwell Publishing, 2003.
- Robinson, M. J. T Stereochemistry, , Oxford Chemistry Primer, Oxford University Press, 2005.
- M K Jain and S C Sharma Modern Organic Chemistry, Vishal Publishing Company
- Organic Chemistry: A Modern Approach and Vol I, II and III, McGraw Hill
- Nimai Tiwari, Problems & Solutions: Advanced Organic Reaction Mechanism, N. Tiwari, Books and Allied Ltd
- Nimai Tiwari, Advanced Organic Stereochemistry, Books and Allied Ltd.

• Ernest L Eliel, Samuel H Wilen and Lewis N Mander, Stereochemistry of Organic Compounds, Wiley Student Edition

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Semester II Course Code: CHE-MJP-02 Paper Code : CHE-MJ-201 P Course Title: Organic Chemistry-I (Prac) 1 Credit

18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

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1. Checking the calibration of the thermometer

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- 2. Purification of organic compounds by crystallization using the following solvents:
 - a. Water
 - b. Alcohol
 - c. Alcohol-Water
- 3. Determination of the melting points of unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
- 4. Determination of boiling point of liquid compounds. (boiling point lower than 100 °C by distillation and capillary method)
- 5. Chromatography
 - a. Separation of a mixture of two amino acids by paper chromatography
 - b. Separation of a mixture of o-and p-nitrophenol by thin layer chromatography (TLC)

Reference Books :

Mann, F.G. & Saunders, B.C, Practical Organic Chemistry,. Pearson Education (2009) Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R Practical Organic Chemistry,. 5th Ed., Pearson (2012

. Vogel, A., Elementary Practical Organic Chemistry, I Part 2: Qualitative Organic Analysis, Raj K Bansal, Laboratory Manual of Organic Chemistry, New Age International Publishers Ghoshal, Mahapatra and Nad , An Advanced Course in Practical Chemistry, , New Central Book Agency (P) Ltd

,P C Kamboj, University Practical ChemistryVishal Publishing Co.

Practical-1: 20 Marks, Note Book: 2¹/₂ Marks, Viva: 2¹/₂ Marks.

	Semester II	
	Course Code: CHE-MJ-03	
	Paper Code : CHE-MJ-202 T	
	Course Title: Physical Chemistry-I (Theo)	
	3 Credits (54 Lectures each of 50 minutes)	
	Marks Distribution	
Mid Sem:15	End Sem: 60	Full Marks:75
Eight questions are to	be set out of which five are to be answered.	Time: 3 Hrs

I Gaseous state:

(A) Kinetic molecular model:

Kinetic molecular model of a gas, Postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η ; variation of viscosity with temperature and pressure.

Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

(B) Real gas behaviour:

Behaviour of real gases, Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. vander Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and vander Waals constants, law of corresponding states.

II Liquid state:

Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids. Qualitative discussion of structure of water.

III Solid state:

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method. Defects in crystals.

IV Ionic equilibria:

10 Lectures

8 Lectures

10 Lectures

8 Lectures

18 Lectures

22

(A) Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, p^H scale, common ion effect; dissociation constants of mono-, di-and triprotic acids (exact treatment). Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers.

(**B**) Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

Reference Books:

- Atkins, P. W. & Paula, J. de Atkin's, Physical Chemistry Ed., Oxford University Press (2006).
- Ball, D. W., Physical Chemistry, Thomson Press, India (2007).

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- Castellan, G. W. , Physical Chemistry, 4th Ed. Narosa (2004).
- Mortimer, R. G , Physical Chemistry,. 3rd Ed. Elsevier: NOIDA, UP (2009).
- •. McQuarrie, D. A. & Simons, J. D, Physical Chemistry: A Molecular Approach: Viva Press.
- Engel, T. & Reid, P , Physical Chemistry,. Pearson.
- •. Levine, I. N, Physical Chemistry, Tata McGraw-Hill.
- Maron, S. & Prutton, Principle of Physical Chemistry. CBS Publishers
- Laidler, K. J , Chemical Kinetics,. Pearson.
- •. Glasstone, S. & Lewis, D, Elements of Physical Chemistry, VAN Nostrand Co
- Rakshit, P.C, Physical Chemistry, Sarat Book House.
- Sharma, Puri and Patania, Principle of Physical Chemistry, , Vishal Publishing Co.
- K L Kapoor, A Text Book of Physical Chemistry, McGraw Hill
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Course Code: CHE-MJP- 03 Paper Code : CHE-202 P Course Title: Physical Chemistry-I (Prac) 1 Credit

18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

1. Surface tension measurements.

- a. Determine the surface tension by (i) drop number (ii) drop weight method.
- 2. Viscosity measurement using Ostwald's viscometer.
 - a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
- 3. Indexing of a given powder diffraction pattern of a cubic crystalline system.
- 4. p^H metry
 - a. Study the effect on p^H of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
 - b. Preparation of buffer solutions of different p^H
 - i. Sodium acetate-acetic acid
 - ii. Ammonium chloride-ammonium hydroxide
 - c. p^H metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
 - d. Determination of dissociation constant of a weak acid.

Any other experiment carried out in the class.

Reference Books :

• Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

• Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).

• Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

Reference Books:

- Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009).
- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson.
- Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007).
- Palit, S.R., De, S. K. Practical Physical Chemistry Science Book Agency.
- University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta.
- Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
- Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd. Raj K Bansal, Laboratory Manual of Organic Chemistry, New Age International Publishers Ghoshal, Mahapatra and Nad, An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd

P C Kamboj, University Practical Chemistry, Vishal Publishing Co. Practical-1: 20 Marks, Note Book: $2^{1}/_{2}$ Marks, Viva: $2^{1}/_{2}$ Marks

SEMESTER-III

Course Code: CHE-MJ-04 Paper Code : CHE-MJ-301 T Course Title: Organic Chemistry-II (Theo) 3 Credits (54 Lectures each of 50 minutes) Marks Distribution End Sem: 60

Eight questions are to be set out of which five are to be answered.

I Chemistry of Halogenated Hydrocarbons

Alkyl halides: Methods of preparation, nucleophilic substitution reactions $-S_N 1$, $S_N 2$ and $S_N i$ mechanisms with stereo-chemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. Nucleophilic aromatic substitution; S_NAr, Benzyne mechanism.

Organometallic compounds of Mg and Li –Use in synthesis of organic compounds.

II Alcohols, Phenols, Ethers and Epoxides

(A) Alcohols

Mid Sem:15

Preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

(B) Phenols

Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann Reactions, Kolbe's–Schmidt Reactions, Fries rearrangement, Claisen Rearrangement, Houben-Hoesch reaction, Leaderer-Manasse Reaction, Gatterman Reaction.

(C) Ethers and Epoxides

Preparation and reactions. Acid and base catalysed ring opening of epoxides, Orientation and stereochemistry of epoxide ring opening, Reactions with Grignard reagents and Organolithium compounds, Reactions of epoxides with alcohols, ammonia derivatives and LiAlH₄

III Carbonyl Compounds

Structure, reactivity and preparation: Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisan-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α -substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, LiAlH₄, NaBH₄, and MPV), Michael addition.

IV Active methylene compounds

Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

6 Lectures

6 Lectures

10 Lectures

6 Lectures

5 Lectures

8 Lectures

Full Marks:75

Time: 3 Hrs

25

V Carboxylic Acids and their Derivatives

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Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids.

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic sustitution at acyl group-Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degradation and Curtius rearrangement.

VI Sulphur containing compounds

5 Lectures

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8 Lectures

Preparation and reactions of thiols and thioethers.

Reference Books:

- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
- Clayden, J., Greeves, N., Warren, S. Organic Chemistry, Second edition, Oxford University Press 2012.
- Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
- Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited.
- Carey, F. A. & Guiliano, R. M. Organic Chemistry, Eighth edition, McGraw Hill Education, 2012.
- Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press, 2008.
- Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited.
- Maskill, H., Mechanisms of Organic Reactions, Oxford Chemistry Primer, Oxford University Press

M K Jain and S C Sharma Modern .Organic Chemistry, ,Vishal Publishing Company

• Nimai Tiwari, Organic Chemistry: A Modern Approach and Vol I, Iland III, McGraw Hill

• Nimai Tiwari, Problems & Solutions :Advanced Organic Reaction Mechanism, Books and Allied Ltd

• Nimai Tiwari, Advanced Organic Stereochemistry, Books and Allied Ltd.

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Semester III Course Code: CHE-MJP-04 Paper Code : CHE-MJ-301 P Course Title: Organic Chemistry-II (Prac) 1 Credit

36 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.

- 2. Organic preparations:
 - (i). Acetylation of any one of the following compounds: amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine)
 - (ii). Acetylation of any one of the following compounds: phenols (β-naphthol, vanillin, salicylic acid) by any one method:
 - (iii). Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p- anisidine) or any one of the following phenols (β-naphthol, resorcinol, p- cresol)
 - (iv). Oxidation of ethanol/ isopropanol (Iodoform reaction).

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- (v). Bromination of any one of the following:
 - a. Acetanilide by conventional methods
 - b. Acetanilide using green approach (Bromate-bromide method)

Reference Books :

• Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)

• Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)

• Vogel, A. I. Elementary Practical Organic Chemistry, Part 1: Small scale Preparations, CBS Publishers and Distributors.

• University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003.

• Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).

- Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.
- Vishnoi, N. K., Advanced Practical Organic Chemistry.

Raj K Bansal Laboratory Manual of Organic Chemistry, , New Age International Publishers Ghoshal, Mahapatra and Nad An Advanced Course in Practical Chemistry, , New Central Book Agency (P) Ltd

P C Kamboj, University Practical Chemistry, Vishal Publishing Co.

Practical-1: 20 Marks, Note Book: 2¹/₂ Marks, Viva: 2¹/₂ Marks.

Semester III

	Course Code: CHE-MJ-05	
	Paper Code : CHE-MJ-302 T	
	Course Title: Physical Chemistry-II (Theo)	
	3 Credits (54 Lectures each of 50 minutes)	
	Marks Distribution	
Mid Sem:15	End Sem: 60	Full Marks:75
Eight questions are to be set out of which five are to be answered.		Time: 3 Hrs

I Chemical Thermodynamics

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

First law: Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and vander Waals) under isothermal and adiabatic conditions.

Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions.

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics. Calculation of entropy change for reversible and irreversible processes.

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; Gibbs-Helmholtz equation; Maxwell relations.

II Systems of Variable Composition

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs- Duhem equation, chemical potential of ideal mixtures.

III Chemical Equilibrium

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants Kp, Kc and Kx. Le Chatelier principle (quantitative treatment).

IV Solutions and Colligative Properties

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression

8 Lectures

12 Lectures

22 Lectures

12 Lectures

of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Reference Books :

• Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).

- Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).

• McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).

- Levine, I.N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010).
- Atkins, P. W. & Paula, J. de Atkins', Physical Chemistry, Oxford University Press.
- Castellan, G. W. Physical Chemistry, Narosa.
- Rakshit, P.C., Physical Chemistry, Sarat Book House.
- Moore, W. J. Physical Chemistry, Orient Longman.
- Mortimer, R. G. Physical Chemistry, Elsevier.
- Denbigh, K. The Principles of Chemical Equilibrium Cambridge University Press.
- Engel, T. & Reid, P. Physical Chemistry, Pearson.
- Zemansky, M. W. & Dittman, R.H. Heat and Thermodynamics, Tata-McGraw-Hill.
- Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas.
- Klotz, I.M., Rosenberg, R. M. Chemical Thermodynamics: Basic Concepts and Methods Wiley.
- Alberty, R. A., Sibley, R., Physical Chemistry, 5th Ed., Wiley, (2018).
- Kapoor, K. L., A Textbook of Physical Chemistry, Vols. 1 & 4, Macmillan Publishers India Limited, (2006)
- •, J. Rajaram and Kuriacose, Chemical Thermodynamics: Classical, Statistical and Irreversible, Pearson Publication -----

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Semester III Course Code: CHE-MJP-05 Paper Code : CHE-302 P Course Title: Physical Chemistry-II (Prac) 1 Credit

36 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

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Thermochemistry

(a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).

(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

(c) Calculation of the enthalpy of ionization of ethanoic acid.

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(d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.

(e) Determination of enthalpy of hydration of copper sulphate.

Reference Books :

- Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Athawale, V. D. & Mathur, P., Experimental Physical Chemistry New Age International: New Delhi (2001).
- Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009).
- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson.
- Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007).
- Palit, S.R., De, S. K. Practical Physical Chemistry Science Book Agency.
- University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta.
- Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
- Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd Raj K Bansal, Laboratory Manual of Organic Chemistry, New Age International Publishers

Ghoshal, Mahapatra and Nad An Advanced Course in Practical Chemistry, , New Central Book Agency (P) Ltd

P C Kamboj, University Practical Chemistry, Vishal Publishing Co.

Practical-1: 20 Marks, Note Book: 2¹/₂ Marks, Viva: 2¹/₂ Marks.

Semester IV

	Course Code: CHE-MJ-06	
	Paper Code : CHE-MJ-401 T	
	Course Title: Inorganic Chemistry-II (Theo)	
	3 Credits (54 Lectures each of 50 minutes)	
	Marks Distribution	
Mid Sem:15	End Sem: 60	

Eight questions are to be set out of which five are to be answered.

I General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

II Acids and Bases

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Solvent System Concept, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

III Chemistry of s- and p- Block Elements

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements.

Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate.

IV Study of the Inorganic compounds

Study of the inorganic compounds with emphasis on structure, bonding, preparation, properties and uses : Boric acid and borates, boron nitrides, borohydrides, carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

V Noble Gases:

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF₂, XeF₄ and XeF₆; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF₂). Molecular shapes of noble gas compounds (VSEPR theory).

VI Inorganic Polymers:

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.

Reference Books:

• Lee, J. D. Concise Inorganic Chemistry, ELBS, 1991.

12 Lectures

8 Lectures

8 Lectures

12 Lectures

8 Lectures

6 Lectures

Full Marks:75

Time: 3 Hrs

31

• Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.

• Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth- Heinemann. 1997.

- Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
- Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.

• Shriver & Atkins, Inorganic Chemistry 5th Ed.

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• Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.

• Porterfield, H. W., Inorganic Chemistry, Second Edition, Academic Press, 2005.

• Purecell, K.F. and Kotz, J.C., An Introduction to Inorganic Chemistry, Saunders: Philadelphia,

1980. 6. Cotton, F.A., Wilkinson, G., & Gaus, P.L. Basic Inorganic Chemistry 3rd Ed.; Wiley India.

• Gillespie, R. J. and Hargittai, I., The VSEPR Model of Molecular Geometry, Prentice Hall (1992).

• Albright, T., Orbital interactions in chemistry, John Wiley and Sons (2005).

• Mingos, D.M.P., Essential trends in inorganic chemistry. Oxford University Press (1998).

- Asim K. Das and Mahua Das Fundamental Concepts of Inorganic Chemistry, , CBS Publication
- R. C. Agarwal, Modern Inorganic Chemistry, Kitab Mahal

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Semester IV Course Code: CHE-MJP-06 Paper Code : CHE-MJ-401P Course Title: Inorganic Chemistry-II (Prac) 1 Credit

18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

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(A) Iodo / Iodimetric Titrations

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(i) Estimation of Cu(II) using sodium thiosulphate solution (Iodimetrically).

- (ii) Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically
- (iii) Estimation of available chlorine in bleaching powder iodometrically.

(B) Inorganic preparations

- (i) Cuprous Chloride, Cu₂Cl₂
- (ii) Preparation of Manganese(III) phosphate, MnPO₄.H₂O
- (iii) Preparation of Aluminium potassium sulphate KAl(SO₄)₂.12H₂O (Potash alum) or Chrome alum.

Reference Books:

- Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. 1978
- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009 .
- Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.

• Shikha Gulati ,J L Sharma and Shagun Manocha, Practical Inorganic Chemistry, ,CBS Publishers & Distributors.

• V K Ahluwalia, Sunita Dhingra and Adarsh Gulati College Practical Chemistry, , Universities Press

Raj K Bansal Laboratory Manual of Organic Chemistry, New Age International Publishers

, Ghoshal, Mahapatra and Nad, An Advanced Course in Practical ChemistryNew Central Book Agency (P) Ltd

P C Kamboj, University Practical Chemistry, Vishal Publishing Co

Practical-1: 20 Marks, Note Book: 2¹/₂ Marks, Viva: 2¹/₂ Marks.

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Semester-IV

	Course Code: CHE-MJ-07	
	Paper Code : CHE-MJ-402 T	
	Course Title: Organic Chemistry-III (Theo)	
	3 Credits (54 Lectures each of 50 minutes)	
	Marks Distribution	
Mid Sem:15	End Sem: 60	Full Marks:75
Eight questions are to be set out of which five are to be answered.		Time: 3 Hrs

I Nitrogen Containing Functional Groups

Preparation and important reactions of nitro and compounds, nitriles and isonitriles Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.

II Polynuclear Hydrocarbons

Reactions of naphthalene, phenanthracene and anthracene; Structure, Prepration and structure elucidation and important derivatives of naphthalene and anthracene.

III Heterocyclic Compounds

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction.

IV Alkaloids

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Basic concept of medicinal importance of alkaloids.

V Terpenes

Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral, Neral and α-terpineol.

Reference Books:

• Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

• Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

34

10 Lectures

16 Lectures

8 Lectures

10 Lectures

10 Lectures

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• Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

• Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976).

• Clayden, J., Greeves, N., Warren, S. Organic Chemistry, Second edition, Oxford University Press 2012.

• Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.

• Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited.

- Carey, F. A., Guiliano, R. M. Organic Chemistry, Eighth edition, McGraw Hill Education, 2012.
- 5. Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press, 2008.

• Norman, R.O. C., Coxon, J. M. Principles of Organic Synthesis, Third Edition, Nelson Thornes, 2003.

- Graham Solomons, T.W., Fryhle, C. B. Organic Chemistry, John Wiley & Sons, Inc.
- March, J. Advanced Organic Chemistry, Fourth edition, Wiley

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J A Joule, K Mills Heterocyclic Chemistry, ,Wiley

J A Joule, G F Smith, Heterocyclic Chemistry, van Nosrand

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Semester IV Course Code: CHE-MJP-07 Paper Code: CHE-MJ-402 P Course Title: Organic Chemistry-III (Prac) 1 Credit

18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

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Qualitative Analysis of Single Solid Organic Compounds

1. Detection of special elements (N, S, Cl, Br) by Lassaigne's test

2. Solubility and classification (solvents: H2O, 5% HCl, 5% NaOH and 5% NaHCO3)

3. Detection of the following functional groups by systematic chemical tests:

4. aromatic amino (-NH2), aromatic nitro (-NO2), amido (-CONH2, including imide), phenolic – OH, carboxylic acid (-COOH), carbonyl (-CHO and >C=O); only one test for each functional group is to be reported.

5. Melting point of the given compound 6. Preparation of one derivative of the given sample

Each student, during laboratory session, is required to carry out qualitative chemical tests for all the special elements and the functional groups with relevant derivatisation in known and unknown (at least six) organic compounds.

Reference Books :

- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
- Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, CBS Publishers and Distributors.
- University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003.
- Clarke, H. T., A Handbook of Organic Analysis (Qualitative and Quantitative), Fourth Edition, CBS Publishers and Distributors (2007).
- Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.
- Ghoshal, A., Mahapatra, B., Nad, A. K. An Advanced Course in Practical Chemistry, New Central Book Agency (2007).

Raj K Bansal, Laboratory Manual of Organic Chemistry, New Age International Publishers P C Kamboj, P C Kamboj, University Practical Chemistry, Vishal Publishing Co

Practical-1: 20 Marks, Note Book: 2¹/₂ Marks, Viva: 2¹/₂ Marks.
Semester IV

Course Code: CHE-MJ-08
Paper Code : CHE-MJ-403 T
Course Title: Physical Chemistry-III (Theo)
3 Credits (54 Lectures each of 50 minutes)
Marks DistributionMid Sem:15End Sem: 60

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Eight questions are to be set out of which five are to be answered.

I Phase Equilibria:

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications.

Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions.

Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, steam distillation. Nernst distribution law: its derivation and applications.

II Chemical Kinetics

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.

Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

III Catalysis:

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

IV Surface Chemistry-I

Surface tension and energy: Surface tension, surface energy, excess pressure, capillary rise and surface tension; Work of cohesion and adhesion, spreading of liquid over other surfaces; Vapour pressure over curved surface; Temperature dependence of surface tension. Adsorption: Physical and chemical adsorption; Freundlich and Langmuir adsorption isotherms; multilayer adsorption and BET isotherm (no derivation required); Gibbs adsorption isotherm and surface excess; Heterogenous catalysis (single reactant); Zero order and fractional order reaction

16 Lectures

12 Lectures

8 Lectures

18 Lectures

Full Marks:75

Time: 3 Hrs

Reference Books:

- Peter Atkins & Julio De Paula, Physical Chemistry 9th Ed., Oxford University Press (2010).
- Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004).

- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
- Zundhal, S.S. Chemistry: Concepts and applications. Cengage India (2011).
- Ball, D. W. Physical Chemistry Cengage India (2012).
- Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
- Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
- Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).
- McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press.
- Levine, I. N. Physical Chemistry, Tata McGraw-Hill.
- Moore, W. J. Physical Chemistry, Orient Longman.
- Mortimer, R. G. Physical Chemistry, Elsevier.
- Engel, T. & Reid, P. Physical Chemistry, Pearson.
- Maron, S.H., Prutton, C. F., Principles of Physical Chemistry, McMillan.
- Klotz, I.M., Rosenberg, R. M. Chemical Thermodynamics: Basic Concepts and Methods Wiley.
- Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas Publication Chemical Kinetics, K J Laidler, Pearson.

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Semester IV Course Code: CHE-MJP-08 Paper Code: CHE-MJ-403 P Course Title: Physical Chemistry-III (Prac) 1 Credit 18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

- 1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
- 2. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method: a. simple eutectic and b. congruently melting systems.
- 3. Distribution of acetic/ benzoic acid between water and cyclohexane.
- 4. Study the equilibrium of at least one of the following reactions by the distribution method:

(i) $I_2(aq) + I \rightarrow I_3(aq)^{2+}$

(ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)n$

5. Study the kinetics of the following reactions.

- a. Initial rate method: Iodide-persulphate reaction
- b. Integrated rate method:
 - (i). Acid hydrolysis of methyl acetate with hydrochloric acid.
 - (i). Saponification of ethyl acetate.
- c. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.
- 6. Determination of partition co-efficient of benzoic acid between water and benzene.
- 7. Determination of solubility of sparingly soluble salt in water, in electrolyte with common ions and in neutral electrolyte (using common indicator).
- 8. Potentiometric titration of Mohr's salt solution against standard K2Cr2O7 solution.
- 9. Determination of Ksp for AgCl by potentiometric titration of AgNO3 solution against standard KCl solution.
- 10. Effect of ionic strength on the rate of Persulphate-Iodide reaction.
- 11. Study of phenol-water phase diagram.

Reference Books:

• Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

• Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).

• Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

Ghoshal, Mahapatra and Nad An Advanced Course in Practical Chemistry, , New Central Book Agency (P) Ltd

P C Kamboj ,University Practical Chemistry, ,Vishal Publishing Co

Semester V

Course Code: CHE-MJ-09
Paper Code : CHE-MJ-501 T
Course Title: Inorganic Chemistry-III (Theo)
3 Credits (54 Lectures each of 50 minutes)
Marks DistributionMid Sem:15End Sem: 60

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Eight questions are to be set out of which five are to be answered.

I Co-ordination Chemistry -I

Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of 10 Dq (Δ o), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δ o, Δ t). Octahedral vs. tetrahedral co-ordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes.

II Transition Elements

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series.

Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excluding their metallurgy)

III Ionic Crystals

Ionic crystals and their structures, radius ratio rule, effect of polarization on crystals. Covalent structure type- Sphalerite & Wurtzite, Geometry of simple crystal AB type: NaCl, CsCl & NiAs, reasons for preference for a particular structure in above AB type of compounds. AB₂ type: Fluorite, antifluorites, Rutile structures. Li₂O, Na₂O, CdCl₂, CdI₂ structures. Defects in Solids: Point defects, Line defects and Plane defects.

IV Lanthanoids and Actinoids

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides by ion-exchange method.

V Bioinorganic Chemistry

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. $Na^{+/}K^{+}$ -pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems. Haemoglobin: Storage and transfer of iron.

10 Lectures

16 Lectures

Full Marks:75

Time: 3 Hrs

12 Lectures

10 Lectures

Reference Books:

• Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977.

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- Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
- Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. Wiley-VCH, 1999 Basolo, F, and Pearson, R.C., Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
- Greenwood, N.N. & Earnshaw A., Chemistry of the Elements, Butterworth- Heinemann, 1997.
- Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.
- Greenwood, N.N. & Earnshaw A. Chemistry of the Elements, Butterworth-Heinemann, 1997.
- Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.
- Mingos, D.M.P., Essential trends in inorganic chemistry. Oxford University Press (1998)
- Sarkar, R, General and inorganic chemistry, Volume II, New central book agency, (2012)
- D. Banerjia, Co-ordination Chemistry, Asian Book Pvt. Ltd.
- •, S. P.Banerjee Comprehensive Co-ordination Chemistry, Books & Allied Pvt Ltd
- , J D Lee, , Concise Inorganic ChemistryPearson

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Semester V Course Code: CHE-MJP-09 Paper Code: CHE-MJ-501 P Course Title: Inorganic Chemistry-III (Prac) 1 Credit 18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

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Gravimetric Analysis:

i. Estimation of nickel (II) using Dimethylglyoxime (DMG).

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- ii. Estimation of copper as CuSCN
- iii. Estimation of iron as Fe₂O₃ by precipitating iron as Fe(OH)₃.
- iv. Estimation of Al (III) by precipitating with oxine and weighing as Al(oxine)₃ (aluminium oxinate).

Inorganic Preparations:

- i. Tetraamminecopper (II) sulphate, [Cu(NH₃)₄]SO₄.H₂O
- ii. Cis and trans $K[Cr(C_2O_4)_2, (H_2O)_2]$ Potassium dioxalatodiaquachromate (III)
- iii. Tetraamminecarbonatocobalt (III) ion
- iv. Potassium tris(oxalate)ferrate(III)
- v. Acetylacetonate of Cr and Fe
- vi. Reineck's salt

Chromatography of metal ions

Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

- i. Ni (II) and Co (II)
- ii. Fe (III) and Al (III)

Reference Book:

- Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.
- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
- Shikha Gulati, J.L. Sharma and Shagun Manocha, Practical Inorganic Chemistry, CBS Publisher

•, V. K. Ahluwalia, Sunita Dhingra and Adarsh Gulati College Practical Chemistry, Universities Press

•, P. C. Kamboj, University Practical ChemistryVishal Publication

Course Code: CHE-MJ-10 Paper Code : CHE-MJ-502 T Course Title: Organic Chemistry-IV (Theo) 3 Credits (54 Lectures each of 50 minutes) Marks Distribution End Sem: 60

Eight questions are to be set out of which five are to be answered. Time: 3 Hrs

I Nucleic Acids

Mid Sem:15

Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

II Amino Acids, Peptides and Proteins

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Amino acids, Peptides and their classification. α-Amino Acids-Synthesis, ionic properties and reactions. Zwitterions, pKa values, isoelectric point and electrophoresis. Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting and C-protecting groups. Solid-phase peptide synthesis.

III Enzymes

Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism and kinetics of enzyme action (taking trypsin as example), factors affecting enzyme action, co-enzymes and co-factors and their role in biological reactions, specificity of enzyme action, enzyme inhibitors and their importance, phenomenon of inhibition.

IV Lipids

Introduction to oils and fats, common fatty acids present in oils and fats, Hydrogenntion of fats and oils, Saponification value, Acid value, Iodine number. Reversion and rancidity.

V Concept of Energy in Biosystems

Energy by the oxidation of foodstuff. ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems (structure): NAD⁺, FAD. Glycolysis, fermentation, Krebs cycle. Catabolic pathways of fat and protein. Interrelationship in the metabolic pathways of protein, fat and carbohydrate.

Reference Books:

- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VIth Edition. W.H. Freeman and Co.
- Nelson, D.L., Cox, M.M. and Lehninger, A.L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.
- Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill.
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).

10 Lectures

12 Lectures

10 Lectures

Full Marks:75

14 Lectures

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- Clayden, J., Greeves, N., Warren, S., Organic Chemistry, Second edition, Oxford University Press 2012.
- March, J. Advanced Organic Chemistry, Fourth edition, Wiley.
- Bailey, Morgan, Organonitrogen Chemistry, Oxford Chemistry Primer, Oxford University Press.
- Trevor Palmer and Philip Bonner Enzymes, , EWP
- , Taylor, Enzyme Kinetics and Mechanism, Springer

M Y Khan And Farha Khan, Principles of Enzyme Technology, PHI Learning

Semester V Course Code: CHE-MJP-10 Paper Code: CHE-MJ-502 P Course Title: Organic Chemistry-IV (Prac) 1 Credit 18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

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- 1. Functional group tests for aliphatic and aromatic amines, amides, and nitro group.
- 2. Estimation of glycine by Sorenson's formalin method.

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- 3. Estimation of proteins by Lowry's method.
- 4. Study of the action of salivary amylase on starch at optimum conditions.
- 5. Effect of temperature on the action of salivary amylase.
- 6. Saponification value of an oil or a fat.
- 7. Determination of Iodine number of an oil/ fat.
- 8. Preparation of acetanilide.

Reference Books:

- Arthur, I. V. Quantitative Organic Analysis, Pearson.
- University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta.
- Ghoshal, A., Mahapatra, B., Nad, A. K. An Advanced Course in Practical Chemistry, New Central Book Agency (2007).
- Ahluwalia, V. K., Agarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, Universities Press (India) Pvt. Ltd. (2000).
 Raj K Bansal, Laboratory Manual of Organic Chemistry, New Age International Publishers Ghoshal, Mahapatra and Nad, An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd

P C Kamboj, University Practical Chemistry, Vishal Publishing Co

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Semester V

Course Code: CHE-MJ-11
Paper Code : CHE-MJ-503 T
Course Title: Physical Chemistry-IV (Theo)
3 Credits (54 Lectures each of 50 minutes)
Marks DistributionMid Sem:15End Sem: 60Full Marks:75Eight questions are to be set out of which five are to be answered.

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I Electrochemistry

Arrhenius theory of electrolytic dissociation. Conductance, equivalent and molar conductance and their variation with dilution for weak and strong electrolytes. Molar conductance at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

II Electrochemistry

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.

Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone and glass. Concentration cells with and without transference, liquid junction potential. Qualitative discussion of potentiometric titrations.

III Electrical & Magnetic Properties of Atoms and Molecules

Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

IV Symmetry and Group Theory

Symmetry elements and symmetry operations, Group and Subgroup, Point group, Classification and representation of groups, The defining property of a group, Sub group and Class, Generators and Cyclic groups.

Reference Books:

- Atkins, P.W & Paula, J.D. Physical Chemistry, 9th Ed., Oxford University Press (2011).
- Castellane, G. W. Physical Chemistry 4th Ed., Narosa (2004).

6 Lectures

10 Lectures

18 Lectures

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- Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
- Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- Rogers, D. W. Concise Physical Chemistry Wiley (2010).
- F.A. Cotton, Chemical Application of Group Theory, John wiley and Sons Inc., Newyork.

A K Mukherjee and B C Gosh, Group Theory in Chemistry: Bonding and Molecular Spectroscopy, The Orient Blackswan

S Swarnalakshmi, T Saroja and R M Ezhilarasi Group Theory in Chemistry, Universities Press R L Carter, R L Carter, Molecular Symmetry and Group Theory, Wiley

- , R K Roy(ed), Application of Group Theory in ChemistryCBS Publishers and Distributors
- M S Gopinathan and V Ramakrishnan ,Group Theory in Chemistry, , Vishal Publishing Co.

S C Rakshit, Physical Chemistry, Sarat Book House

Semester V Course Code: CHE-MPJ-11 Paper Code : CHE-MJ-503 P Course Title: Physical Chemistry-IV (Prac) 1 Credit 18 Lectures Full Marks: 25

One question is to be set.

Time: 1¹/₂ Hrs

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Conductometry :

- I Determination of cell constant
- II Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
- III Perform the following conductometric titrations:

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- i. Strong acid vs. strong base
- ii. Weak acid vs. strong base
- iii. Mixture of strong acid and weak acid vs. strong base
- iv. Strong acid vs. weak base
- IV i. Determination of partition co-efficient of benzoic acid between water and benzene.
 - iii. Find out the surface tension and parachor of benzene & toluene further to find the parachore of -CH₂ group.
- V Perform the following potentiometric titrations:
 - i. Strong acid vs. strong base
 - ii. Weak acid vs. strong base
 - iii. Dibasic acid vs. strong base
 - iv. Potassium dichromate vs. Mohr's salt

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

Ghoshal, Mahapatra and Nad, An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd

,P C Kamboj, University Practical Chemistry, Vishal Publishing Co

Semester VI

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	Paper Code : CHE-MJ-601 T	
(Course Title: Inorganic Chemistry-IV (T	heo)
	3 Credits (54 Lectures each of 50 minut	es)
	Marks Distribution	
Mid Sem:15	End Sem: 60	Full Marks:75

Eight questions are to be set out of which five are to be answered.

I Theoretical Principles in Qualitative Analysis (H₂S Scheme)

Basic principles involved in analysis of cations and anions, solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions: Fluoride, borate, oxalate and phosphate, and need to remove them after Gr. II.

II Organometallic Compounds

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands.

a) Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π -acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

b) Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

c) Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler-Natta catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

d) **Ferrocene:** Preparation and reactions: Acetylation, alkylation, metallation, Mannich condensation. Structure and aromaticity. Comparison of aromaticity and reactivity with benzene.

III Reaction Kinetics and Mechanism

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans-effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.

IV Catalysis by Organometallic Compounds

Study of the following industrial processes and their mechanism:

- 1. Alkene hydrogenation (Wilkinsons Catalyst)
- 2. Hydroformylation (Co salts)

14 Lectures

Time: 3 Hrs

10 Lectures

20 Lectures

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- 3. Wacker Process
- 4. Synthetic gasoline (Fischer Tropsch reaction)
- 5. Synthesis of gas by metal carbonyl complexes

Reference Books:

- Cotton, F.A. G.; Wilkinson & Gaus, P.L. Basic Inorganic Chemistry 3rd Ed.; Wiley India,
- Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.
- Collman, James P. et al. Principles and Applications of Organotransition Metal Chemistry. Mill Valley, CA: University Science Books, 1987.
- Crabtree, Robert H. The Organometallic Chemistry of the Transition Metals. New York, NY: John Wiley, 2000.
- Greenwood, N.N. & Earnshaw A. Chemistry of the Elements, Butterworth-Heinemann. 1997.
- Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).
- Purecell, K.F. and Kotz, J.C., An Introduction to Inorganic Chemistry, Saunders: Philadelphia, 1980.
- Sinha, S. P., Ed., Lanthanide and Actinide Research (Journal, Vol. 1, 1986).
- Wulfsberg, G., Principles of Descriptive Inorganic Chemistry, Brooks/Cole: Monterey, CA, 1987 Lee, J. D. Concise Inorganic Chemistry, Wiley, 5th Edⁿ.
- B.E. Douglas, D.H. McDaniel, J.J. Alexander, Concepts & Models of Inorganic Chemistry, (Third Edition) John Wiley & Sons, 1999.
- F. Basalo and R. C. Pearson, Mechanism of Inorganic Chemistry, John Wiley and Sons.
- R.C. Agarwal ,Modern Inorganic Chemistry, , Kitab Mahal
- Asim K Das and Mahua Das, Fundamental Concepts of Inorganic Chemistry, , CBS Publishers & Distributors
- •, D. Banerjia, Co-ordination Chemistry ,Asian Book Pvt. Ltd.
- S.P.Banerjee, Comprehensive Co-ordination Chemistry, Books & Allied Pvt Ltd
- Shriver, Atkins and Langford, Inorganic Chemistry, W H Freeman and Co(Sd)

Semester VI Course Code: CHE—MJP-12 Paper Code: CHE-MJ-601 P Course Title : Inorganic Chemistry-IV (Prac) 1 Credit 18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

1. Qualitative semimicro-analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

 $CO_3^{2^-}$, NO^{2^-} , S^{2^-} , $SO_3^{2^-}$, $S_2O_3^{2^-}$, CH_3COO^- , F^- , CI^- , Br^- , Γ , NO^{3^-} , $BO_3^{3^-}$, $C_2O_4^{2^-}$, $PO_4^{3^-}$, NH^{4+} , K^+ , Pb^{2+} , Cu^{2+} , Cd^{2+} , Bi^{3+} , Sn^{2+} , Sb^{3+} , Fe^{3+} , AI^{3+} , Cr^{3+} , Zn^{2+} , Mn^{2+} , Co^{2+} , Ni^{2+} , Ba^{2+} , Sr^{2+} , Ca^{2+} , Mg^{2+}

Mixtures should preferably contain one interfering anion, or insoluble component (BaSO₄, SrSO₄, PbSO₄, CaF₂ or Al₂O₃)

Spot tests should be done whenever possible.

2. Chromatography of metal ions:

Principles involved in chromatographic separations.

Paper chromatographic separation of following metal ions: 1. Ni (II) and Co (II) 2. Fe (III) and Al (III) Gravimetry

- Estimation of nickel (II) using Dimethylglyoxime (DMG).
- Estimation of copper as CuSCN
- Estimation of Al (III) by precipitating with oxine and weighing as Al(oxine)₃ (aluminium oxinate)
- Estimation of chloride

Reference Books:

- Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla.
- Marr & Rockett, Inorganic Preparations.
- Shikha Gulati, J.L. Sharma and Shagun Manocha, Practical Inorganic Chemistry, , CBS Publisher
- V. K. Ahluwalia, Sunita Dhingra and Adarsh Gulati College Practical Chemistry, , Universities Press
- P. C. Kamboj, University Practical Chemistry, Vishal Publication

Semester VI

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	Course Code: CHE-MJ-13	
	Paper Code : CHE-MJ-602 T	
	Course Title: Organic Chemistry-V (Theo)	
	3 Credits (54 Lectures each of 50 minutes)	
	Marks Distribution	
Mid Sem:15	End Sem: 60	Full Marks:75
Eight questions are to be set out of which five are to be answered.		Time: 3 Hrs

I UV Spectroscopy

Introduction to absorption and emission spectroscopy, Types of electronic transitions, Effect of solvent polarity on electronic transitions, Chromophores and Auxochromes, Absorption and Intensity shift; Bathochromic and Hypsochromic shifts, Hyperchromic and Hypochromic shifts. Application of Fieser-Woodward Rules for calculation of λ_{max} for Conjugated dienes and α , β – unsaturated carbonyls, Distinction between cis and trans isomers.

II IR Spectroscopy

Fundamental and non-fundamental molecular vibrations, IR absorption positions of O, N and S containing functional groups, Effect of H-bonding, conjugation, resonance and ring size on IR absorptions, Fingerprint region and its significance, application in functional group analysis.

III NMR Spectroscopy

Basic principles of PMR Spectroscopy, nuclear shielding and deshielding phenomenon, chemical shift and factors influencing it, Spin-Spin coupling and coupling constant, Anisotropic effect. Interpretation of PMR spectra of simple organic compounds such as ethyl bromide, ethanol, acetaldehyde, ethyl acetate and toluene. Applications of IR, UV and NMR for identification of simple organic molecules.

IV Carbohydrates

Occurrence, classification and their biological importance. Monosaccharides - Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Inter-conversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation. Disaccharides - Structure elucidation of maltose, lactose and sucrose.

V Dyes

Classification, Colour and Constitution, Mordant and Vat Dyes, Chemistry of dyeing, Synthesis and applications of (i) Azo dyes-Methyl Orange and Congo Red, Mechanism of Diazo Coupling reaction, (ii) Triphenyl Methane Dyes-Malachite Green, Rosaniline and Crystal Violet, (iii) Phthalein Dyes-Phenolphthalein and Fluorescein. Structure elucidation and synthesis of natural dyes : Indigotin.

VI Polymers

Introduction and classification, Polymerisation reactions-Addition and condensation, Mechanism of cationic, anionic and free radical addition polymerization, Ziegler-Natta polymerisation of

10 Lectures

8 Lectures

10 Lectures

8 Lectures

8 Lectures

alkenes, Preparation and applications of plastics: Thermosetting (phenol-formaldehyde, Polyurethanes) and Thermosoftening (PVC, polythene). Fabrics-Natural and synthetic (acrylic, polyamido and polyester), Rubbers-Natural and synthetic: Buna-S, Buna-N, Chloroprene and Neoprene, Vulcanization, Biodegradable polymers.

Reference Books:

• Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

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- Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.
- Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub.
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Kemp, W. Organic Spectroscopy, Palgrave
- Clayden, J., Greeves, N., Warren, S. Organic Chemistry, Second edition, Oxford University Press 2012.
- Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press.
- Davis, B. G., Fairbanks, A. J., Carbohydrate Chemistry, Oxford Chemistry Primer, Oxford University Press.
- R. N. Silverstein, F. X. Webester, T. J. Kiemle, and D. L. Brye, Spectrometric Identification of Organic Compounds, Wiley Publication

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Semester VI Course Code: CHE—MJP-13 Paper Code: CHE-MJ-602 P Course Title : Organic Chemistry-V (Prac) 1 Credit 18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

- 1. Extraction of caffeine from tea leaves.
- 2. Preparation of sodium polyacrylate.
- 3. Preparation of urea-formaldehyde resin.
- 4. Preparation of phenol-formaldehyde resin.
- 5. Preparation of methyl orange.
- 6. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
- 7. Qualitative analysis of unknown organic compounds containing mono-functional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols etc.
- 8. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).

Chromatographic Separations

- 9. TLC separation of a mixture containing 2/3 amino acids
- 10. TLC separation of a mixture of dyes (fluorescein and methylene blue)
- 11. Column chromatographic separation of mixture of dyes
- 12. Paper chromatographic separation of a mixture containing 2/3 amino acids

Spectroscopic Analysis of Organic Compounds

1. Assignment of labelled peaks in the 1H NMR spectra of the known organic compounds explaining the relative δ -values and splitting pattern.

2. Assignment of labelled peaks in the IR spectrum of the same compound explaining the relative frequencies of the absorptions (C-H, O-H, N-H, C-O, C-N, C-X, C=C, C=O, N=O, C=C, C=N stretching frequencies; characteristic bending vibrations are included).

3. The students must record full spectral analysis of at least 15 (fifteen) compounds from the following list: a. 4-Bromoacetanilide b. 2/ -Bromo-4/ -methylacetophenone c. Vanillin d. 2/ - Methoxyacetophenone e. 4-Aminobenzoic acid f. Salicylamide g. 2/ -Hydroxyacetophenone h. 1,3-Dinitrobenzene i. Benzylacetate j. trans-4-Nitrocinnamaldehyde k. Diethyl fumarate l. 4-Nitrobenzaldehyde m. 4-Methylacetanilide n. Mesityl oxide o. 2-Hydroxybenzaldehyde p. 4-Nitroaniline q. 2-Hydroxy-3-nitrobenzaldehyde r. 2,3-Dimethylbenzonitrile s. Pent-1-yn-3-ol t. 3-Nitrobenzaldehyde u. 3-Ethoxy-4-hydroxybenzaldehyde v. 2-Methoxybenzaldehyde w. Methyl 4-hydroxybenzoate x. Methyl 3-hydroxybenzoate y. 3-Aminobenzoic acid z. Ethyl 3-

aminobenzoate aa. Ethyl 4-aminobenzoate bb. 3-nitroanisole cc. 5-Methyl-2-nitroanisole dd. 3-Methylacetanilide

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Reference Books:

- Vogel, A.I. Quantitative Organic Analysis, Part 3, Pearson (2012).
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003.
- Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.
- P. C. Kamboj, University Practical Chemistry, Vishal Publication

Semester VI

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	Course Code: CHE-MJ-14	
	Paper Code : CHE-MJ-603 T	
	Course Title: Physical Chemistry-V (Theo)	
	3 Credits (54 Lectures each of 50 minutes)	
	Marks Distribution	
Mid Sem:15	End Sem: 60	Full Marks:75
		 T: 0.11

Eight questions are to be set out of which five are to be answered. Time: 3 Hrs

I Quantum Chemistry-I

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and particle-in-a-box (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wave functions. Vibrational energy of diatomic molecules and zero-point energy.

Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component.

Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Solution for hydrogenic systems

II Molecular Spectroscopy:

Interaction of electromagnetic radiation with molecules and various types of spectra, Born-Oppenheimer approximation.

Lectures)

(A) Rotation spectroscopy

Classification of molecules, Expression of Rotational energy for simple rigid & non-rigid rotors, Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

(B) Vibrational spectroscopy

Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential energy diagram, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.

(C) Raman spectroscopy

Raman Effect, Explanation by Classical and Quantum mechanics, Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, Mutual exclusion principle.

26 Lectures

(4 Lectures)

(6 Lectures)

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(5 Lectures)

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(D) Electronic spectroscopy

Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, electronic transitions of polyenes.

(E) Basic Principles of NMR and ESR spectroscopy (5 Lectures) Principles of NMR spectroscopy, Larmor precession, chemical shift, spin-spin coupling, ESR: Its principle, hyperfine structure.

III Photochemistry:

Characteristics of electromagnetic radiation, Lambert-Beer's law, physical significance of absorption coefficients. Laws of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. photostationary states.

Reference Books:

- Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
- Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
- House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
- Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
- D. A. McQuarrie, Quantum chemistry, University Science Book
- R. K. Prasad, Quantum Chemistry, New Age International Publication
- R. K. Prasad, Quantum Chemistry: Through Problems and Solutions, New Age International Publication
- R. Anantharaman, Fundamentals of Quantum Chemistry, R. Anantharaman, Macmilan India Publication
- A. B. Sannigrahi, Quantum Chemistry, Booka and Allied Pvt. Ltd.
- N. J. Turro, Ramamurthi and J. C. Scaiano, Principles of Molecular Photochemistry, , Viva Books
- Rohtagi and Mukherjee, Fundamentals of Photochemistry, New Age International Publication _____

(4 Lectures)

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Semester VI Course Code: CHE-MPJ-14 Paper Code : CHE-MJ-603 P Course Title: Physical Chemistry-V (Prac) 1 Credit 18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

1. Colorimetry :

- I. Determine the concentrations of KMnO₄ and K₂Cr₂O₇ in a mixture.
- II. Study the kinetics of iodination of propanone in acidic medium.
- III. Determine the amount of iron present in a sample using 1,10-phenathroline.
- IV. Determine the dissociation constant of an indicator (phenolphthalein).
- V. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
- 2. Determination of partition co-efficient of iodine between water and carbon tetrachloride.
- 3. Find the pKa value of a dibasic acid (oxalic acid) p^{H} -metrically at room temperature.

Reference Books :

- C. J. Crammer ,Essentials of computational chemistry Theories and models, , Wiley, 2nd Edn.,
- •. V.K.Gupta ,Principle and applications of quantum chemistry, , Elsevier, 2016.
- P.S.Sindhu, Practicals in Physical chemistry a modern approach, Macmillan,
- •, J.M.Wilson, R.J.Newcomb, A.R.Denaro Experiments in Physical Chemistry, 2nd Edn., Elsevier.
- A.R. Leach, Molecular Modelling Principles and Application, Longman, 2001.
- J.M. Haile, Molecular Dynamics Simulation Elementary Methods, John Wiley and Sons, 1997.
- Gupta, S.P. QSAR and Molecular Modeling, Springer Anamaya Publishers, 2000
- •, P. C. Kamboj, University Practical ChemistryVishal Publication

Semester VI

Course Code: CHE-MJ-15 Paper Code : CHE-MJ-604 T Course Title: Polymer Chemistry (Theo) 3 Credits (54 Lectures each of 50 minutes) Marks Distribution End Sem: 60

Eight questions are to be set out of which five are to be answered.

I Introduction of polymeric materials

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers.

II Kinetics of Polymerization

Mid Sem:15

Mechanism and kinetics of step growth, Radical chain growth, Ionic chain (both cationic and anionic) and Coordination polymerizations, Mechanism and kinetics of copolymerization.

III Molecular weight of polymers

Determination of molecular weight of polymers (Mn, Mw, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods, Molecular weight distribution and its significance, Polydispersity index.

IV Polymer Solution:

Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory.

V Preparation and Properties of Polymers:

Brief introduction to preparation, structure, properties and application of the following polymers: Polyolefins, Polystyrene, Polyvinyl chloride, Polyvinyl acetate, Acrylic polymers, Fluoro polymers, Polyamides. Phenol-formaldehyde resins (Bakelite, Novalac), Urea-formaldehyde resins, Polyurethanes, Polycarbonates, Conducting Polymers (polyacetylene, polyaniline, polypyrrole, polythiophene).

VI Characterization of Polymers:

Molecular Weight Determination by Light Scattering, Osmometry, End-Group Analysis, Viscosity, Gel Permeation Chromatography; Application, of FTIR, UV-visible, NMR, and Mass Spectroscopy for Identification of polymers.

Reference Books:

- Seymour's Polymer Chemistry, Marcel Dekker, Inc.
- G. Odian, Principles of Polymerization, John Wiley.
- F.W. Billmeyer, Text Book of Polymer Science, John Wiley.

10 lectures

10 lectures

14 lectures

5 lectures

10 lectures

Time: 3 Hrs

5 lectures

Full Marks:75

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• Handbook of Physical Properties of Polymers, J. E. Mark(Edt.), AIP

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•, V. R. Gwariker, N. V. Vishwanathan and J. Shridhar Polymer Science, New Age International Publication

• C. E. Carraher Jr Introduction to Polymer Chemistry,., Taylor and Francis

60

Semester VI Course Code: CHE-MJP-15 Paper Code: CHE-MJ-604 P Course Title : Polymer Chemistry-IV (Prac) 1 Credit 18 Lectures Full Marks: 25

One question is to be set.

Time: 1¹/₂ Hrs

I. Polymer synthesis

- 1. Free radical solution polymerization of styrene (St)/ Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
- 2. Preparation of nylon 66/6
- 3. Interfacial polymerization : preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein
- 4. Redox polymerization of acrylamide
- 5. Precipitation polymerization of acrylonitrile
- 6. Preparation of urea-formaldehyde resin
- 6. Preparation of phenol-formaldehyde resin
- 7. Preparations of novalac resin resin.

II. Polymer characterization

- 1. Determination of molecular weight by viscometry:
 - (a) Polyacrylamide-aq.NaNO₂ solution
 - (b) Polyvinyl proplylidine (PVP) in water

III. Polymer analysis

- 1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
- 2. Preparation of polyacrylamide and its electrophoresis

Reference Books:

- Malcohm P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed.
- Fred W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)
- Joel R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003)
- L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
- Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

Ghoshal, Mahapatra and Nad, An Advanced Course in Practical Chemistry, , New Central Book Agency (P) Ltd

P C Kamboj, University Practical Chemistry, Vishal Publishing Co

Semester VII

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Course Code: CHE-MJ-16 Paper Code : CHE-MJ-701 T Course Title: Inorganic Chemistry-V (Theo) 3 Credits (54 Lectures each of 50 minutes) Marks Distribution End Sem: 60

Mid Sem:15

Eight questions are to be set out of which five are to be answered.

Reaction Mechanism of Transition Metal Complexes I

Labile, inert, stable and unstable complexes. Classification of mechanisms, Energy profile of reactions having different mechanisms. Kinetics and factors affecting substitution in octahedral complexes, reactions without metal-ligand bond cleavage. Substitution reactions in square planar complexes, Factors affecting substitution in square planar complexes, Reactivity of platinum complexes: Influences of entering and leaving groups. Trans effect, Theories and applications of trans-effect.

Acid-Base catalysis: Acid catalysed aquation and anation reactions, acid hydrolysis, base hydrolysis, conjugate base hydrolysis, mechanism of acid hydrolysis and base hydrolysis, stereochemistry of octahedral substitution. Conjugate base mechanism, evidences in favour of the mechanism, application in the synthesis of platinum and cobalt complexes.

Electron transfer reactions: Outer sphere electron transfer reaction, Marcus equation, Inner sphere electron transfer reaction, formation and rearrangement of precursor complexes, the bridging ligand, successor complexes, cross reactions and Marcus-Hush theory. Use of electron transfer reactions.

Π **Stereochemistry of Transition Metals Complexes**

Stereochemical aspects-Stereoisomerism in inorganic complexes, isomerism arising out of ligand distribution and ligand conformation, chirality and nomenclature of chiral complexes.

Stability of Transition Metals Complexes III

Stability of complexes - Factors affecting stability of complexes, thermodynamic aspects of complex formation, Stepwise and overall formation constants, stability correlations, statistical and chelate effects, Determination of stability constant - Polarographic, photometric and potentiometric methods.

Electronic Spectra of Transition Metal Complexes IV

Spectroscopic ground states, selection rules, term symbols for dⁿ ions, Racah parameters, Orgel diagrams, Correlation and Tanabe-Sugano diagrams for transition metal complexes $(d^{1}-d^{9}$ states). Spectra of 3d metal-aqua complexes of trivalent (V and Cr) and divalent (Mn, Co and Ni) complexes. Calculations of Dq, B and b parameters, Charge transfer spectra. Spectral properties of lanthanide and actinide metal complexes.

20 Lectures

6 Lectures

8 Lectures

10 Lectures

Time: 3 Hrs

Full Marks:75

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V Magnetic Properties of Transition Metal Complexes

10 Lectures

Magnetic properties of coordination compounds - Types of magnetic behaviour, magnetic susceptibility and its determination: Gouy, Faraday, and VSM method. Diamagnetic correction, orbital contribution, spin-orbital coupling, ferro- and antiferro- magnetic coupling, magnetic exchange coupling and spin-crossover. Anomalous magnetic moments and their explanation. Magnetic properties of Lanthanide and Actinide metal complexes.

Reference Books

- •; J. E. Huheey, E. A. Keiter, Medhi and R. L. Keiter Inorganic Chemistry IV edition, Addison; Wesley (1993).
- Advanced Inorganic Chemistry, 6th edition; F. A. Cotton and G. Wilkinson.

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- , D. F. Shriver, P. W. Atkins and C. H. Langford Inorganic Chemistry, II edition, ELBS; Oxford University Press, 1994.
- Concise Inorganic Chemistry, 5th edition; (1996)., Pearson
- Gary. L. Miessler and Donald . A. Tarr Inorganic Chemistry, 3rd Edition; (2007).
- Physical Methods in Chemistry, R.S. Drago, Saunders College.
- N.N. Greenwood and A. Earnshow, Chemisiry ol the Elements, Pergamon.
- A. B. P. Lever, Inorganic Electron Spectroscopy, Elsevier (1968)
- , R.L. Carlin, MagnetochemistrySpringer Verlag,
- D. N. Sathyanarayana Electronic Absorption Spectroscopy and Related Techniques, , University Press (2001).
- eds., Q. Wilkinson, R.D. Gillars and J.A. McCleverty, Comprehensive Coordination Chemistry
- Pergamon.
- Sarkar, R, General and inorganic chemistry, Volume II, New central book agency, (2012)
- •, D. Banerjia Co-ordination Chemistry, Asian Book Pvt. Ltd.
- S.P.Banerjee, Comprehensive Co-ordination Chemistry, Books & Allied Pvt Ltd

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Semester VI Course Code: CHE-MJP-16 Paper Code: CHE-MJ-701 P Course Title : Inorganic Chemistry-V (Prac) 1 Credit 18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

I Estimation of the following

- (i) Magnesium by EDTA (Volumetrically)
- (ii) Zinc by Potassium ferrocyanide (Volumetrically)
- (iii) Nickel by Dimethylglyoxime (Gravimetrically)
- (iv) Managnese in steel by Sodium bismuthate method.

2. Inorganic preparations:

- i. Controlled synthesis of two copper oxalate hydrate complexes.
- ii. Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+} .
- iii.Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.Reference Books
- Vogel, A.I. Quantitative Organic Analysis, Part 3, Pearson (2012).
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
- University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003.
- Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.
- University Practical Chemistry, P. C. Kamboj, Vishal Publication

Ghoshal, Mahapatra and Nad, An Advanced Course in Practical ChemistryNew Central Book Agency (P) Ltd

P C Kamboj, University Practical Chemistry, Vishal Publishing Co

Semester VII

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Course Code: CHE-MJ-17 Paper Code : CHE-MJ-702 T Course Title: Organic Chemistry-VI (Theo) 3 Credits (54 Lectures each of 50 minutes) Marks Distribution End Sem: 60

Eight questions are to be set out of which five are to be answered.

I Stereochemistry-II

Mid Sem:15

Elements of symmetry, chirality, molecules with more than one chiral center, three and erythro isomers, methods of resolution, optical activity, enantiotopic and diastereotopic atoms, groups and faces. Stereospecific synthesis, stereoselective synthesis. Asymmetric synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape. Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus. Regeoselectivity.

Π **Aliphatic Nucleophilic Substitution**

Classical and nonclassical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements. The neighbouring group participation and mechanism. Classical and nonclassical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements. The S_Ni mechanism, Nucleophilic substitution at an allylic, aliphatic trigonal and vinylic carbon. Reactivity, effects of substrate structure, attacking nucleophile, leaving group and reaction medium, ambident nucleophile, regioselectivity.

III Aromatic Nucleophilic Substitution

The S_NAr, S_{ON}2, S_{RN}1, S_N1, and benzyne mechanisms. Reactivity-effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser, and Smiles rearrangements.

Aliphatic Electrophilic Substitution IV

Bimolecular mechanisms - $S_E 1$, $S_E 2$ and $S_E i$. Electrophilic substitution accompanied by double bond shifts. Effects of substrates, leaving group and solvent polarity on reactivity.

V **Aromatic Electrophilic Substitution**

The ortho/para ratio, ipso attack, Quantitative treatment of reactivity in substrates and electrophiles. Diazo-coupling reaction, Vilsmeir reaction, Gattermann-Koch reaction.

VI Free Radical Reactions

Types of free radical reactions, mechanism of free radical substitution, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivty in the attacking radicals. The effect of solvents on

6 Lectures

6 Lectures

Time: 3 Hrs

Full Marks:75

12 Lectures

6 Lectures

12 Lectures

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reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, autooxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction.

Reference Books

• , D. Nasipuri, Stereochemistry of Organic Compounds: Principles and Applications New Age International Publishers.

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- Jerry March, Advanced Organic Chemistry-Reactions, Mechanism and Structure, , John Wiley.
- F. A. Carey and . J Sundberg R ,Advanced Organic Chernistry,., Plenum.
- Peter Sykes, A Guide Book to Mechanism in Organic Chemistry, Longman.
- C. K. Ingold Structure and Mechanism in Organic Chemistry, , Cornell University Press.
- R. T. Morrison and R. N. Boyd Organic Chemistry, , Prentice-Hall.
- •, S. P. Singh and S. M. Mukherji, Reaction Mechanism in Organic ChemistryMacmillan.
- •, D. Nasipuri, Stereochemistry of Organic CompoundsNew Age international.
- S. N. Sanyal Reactions, Rearrangements and Reagents, , Bharati Bhawan Publishers.

• F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part A: Structure and Mechanism, Springer.

• F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part B: Reactions and Synthesis, Springer.

- J. March Advanced Organic Chemistry: Reaction, Mechanism and Structure, 7th Ed, Michael B. Smith, Wiley.
- , J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, 1st Ed Oxford University Press

M K Jain and S C Sharma, Modern .Organic Chemistry, Vishal Publishing Company

• Nimai Tiwari, Organic Chemistry: A Modern Approach and Vol I, IIand III, McGraw Hill

• Nimai Tiwari, Problems & Solutions :Advanced Organic Reaction Mechanism, Books and Allied Ltd

• Nimai Tiwari, Advanced Organic Stereochemistry, Books and Allied Ltd.

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Semester VII

Course Code: CHE-MJ-17 Paper Code : CHE-MJ-702 P Course Title: Organic Chemistry-VI (Prac) 1 Credit 18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

I Preparation of organic compounds using methods not involving more than two steps:

- (i) Preparation of Methyl Orange
- (ii) Preparation of Martius yellow
- (iii) Preparation of p-Nitro aniline from Acetanilide
- (iv) Preparation of Cinnamic acid from Benzaldehyde

II Estimation of

- (i) Glucose using Fehling's solution
- (ii) Carbonyl group using 2,4-Dinitrophenyl hydrazine

Reference Books:

- Vogel, A.I. Quantitative Organic Analysis, Part 3, Pearson (2012).
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003.
- Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.
- P. C. Kamboj, University Practical Chemistry, Vishal Publication

Practical-1: 20 Marks, Note Book: 2¹/₂ Marks, Viva: 2¹/₂ Marks.

Semester VII

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Course Code: CHE-MJ-18 Paper Code : CHE-MJ-703 T **Course Title: Physical Chemistry-VI (Theo)** 3 Credits (54 Lectures each of 50 minutes) **Marks Distribution** End Sem: 60

Mid Sem:15

Eight questions are to be set out of which five are to be answered.

I. Quantum Chemistry -II

A. Approximate Methods: The variation theorem, linear variation principle. Perturbation theory (first order). Applications of variation method and perturbation theory to the Hydrgen atom.

B. Qualitative treatment of hydrogen atom: Setting up of Schrödinger equation in spherecal polar coordinates, radial part, quantization of energy (only final energy expression).

C. Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+ . Bonding and antibonding orbitals. Qualitative extension to H_2 . Comparison of LCAO-MO and VB treatments of H₂ (only wave functions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH₂, H2O) molecules. Qualitative MO theory and its application to AH₂ type molecules.

D. Electronic Structure of Atoms: Electronic configuration, Russell-Saunders terms and coupling schemes, Slater-Condon parameters, term separation energies of the p^n configuration, term separation energies for the dⁿ-configurations, magnetic effects: spin-orbit coupling and Zeeman splitting, introduction to the methods of self-consistent field, the virial theorem.

II. Surface Chemistry

Surface chemistry, types of adsorption curves, experimental methods of determining adsorption, Freundlich adsorption isotherm and its derivation, Traube's rule, Langmuir adsorption isotherm and its derivation, BET isotherm for multilayers and its derivation, properties of BET equation, methods for determining surface area, heat of adsorption and its calculation, entropy of adsorption, Polanyi's potential theory, kinetics of gaseous reactions on solid surface: unimolecular and bimolecular surface reaction, temperature dependence of surface reactions. Gibb's adsorption equation and its derivation, verification of Gibb's adsorption equation, surface excess.

III. Classical Thermodynamics

Brief resume of concepts of laws of thermodynamics, free energy, chemical potential and entropies.Partial molar properties; partial molar free energy, partial molar volume and partial molar heat content and their significances. Determinations of these quantities. Concept of fugacity and determination of fugacity. Activity, activity coefficient, Debye-Huckel theory for

12 Lectures

10 Lectures

Full Marks:75

Time: 3 Hrs **12 Lectures**

activity coefficient of electrolytic solutions, Gibb's Duhen equation, Nernst heat theorem and its applications, Determination of ablolute entropy, Maxwell's thermodynamic relation.

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IV Chemical Dynamics

Activated complex theory, ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, treatment of unimolecular reactions. Oscillatory reactions (Belousov-Zhabotinsky reaction), homogeneous catalysis, kinetics of enzyme reactions, general features of fast reactions, study of fast reactions. Lindemann -Hinshelwood and Rice-Ramsperger-Kassel-Marcus [RRKM] theories of unimolecular reactions.

V. Nuclear Chemistry

Nuclear Chemistry-The atomic nucleus-elementary particles, quarks, classification of nuclides based on Z and N values, nuclear stability, nuclear potential, binding energy. Nuclear Models: Shell model-salient features, forms of the nuclear potential, nuclear configuration, Liquid drop model, Fermi gas model. Radioactivity, radioactive decay kinetics, Parent-daughter decay-growth relationship-secular and transient equilibria, theories of α , β^{-} , β^{+} and γ -decay, internal conversion.

Reference Books

- K. J. Laidler, Chemical Kinetics, Mcgraw-Hill.
 - J. Rajaraman and J. Kuriacose ,Kinetics and Mechanism of Chemical Transformations, , McMillan.
- Peter Atkins & Julio De Paula, Physical Chemistry 9th Ed., Oxford University Press (2010).
- Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
- Zundhal, S.S. Chemistry: Concepts and applications. Cengage India (2011).
- Ball, D. W. Physical Chemistry Cengage India (2012).
- Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
- Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
- Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).
- McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Pre
- Moore, W. J. Physical Chemistry, Orient Longman.
- Mortimer, R. G. Physical Chemistry, Elsevier.
- Engel, T. & Reid, P. Physical Chemistry, Pearson..
- Klotz, I.M., Rosenberg, R. M. Chemical Thermodynamics: Basic Concepts and Methods Wiley.
- Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas Publication

10 Lectures

- Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006)
- House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).

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- Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
- D. A. McQuarrie, Quantum chemistry, University Science Book
- R. K. Prasad, Quantum Chemistry, New Age International Publication
- R. K. Prasad, Quantum Chemistry: Through Problems and Solutions, New Age International Publication
- R. Anantharaman, Fundamentals of Quantum Chemistry, R. Anantharaman, Macmilan India Publication
- A. B. Sannigrahi, Quantum Chemistry, Booka and Allied Pvt. Ltd.
- Principles of Molecular Photochemistry, N. J. Turro, Ramamurthi and J. C. Scaiano, Viva Books
- Fundamentals of Photochemistry, Rohtagi and Mukherjee, New Age International Publication . Glasstone, S. & Lewis, G.N. Elements of Physical Chemistry.
- . Rakshit, P.C., Physical Chemistry Sarat Book House.

.Puri,Sharma and Patania Principle of Physical Chemistry. Vikash Publication

K L Kapoor, A Text Book of Physical Chemistry, McGraw Hill Surface Chemistry, Elaine M McCash, Oxford University Press

A Goel, Surface Chemistry, Discovery Publishing House Pvt Ltd

Arthur W Adamson and Alice P Gast, Physical Chemistry of Surfaces, Wiley India

. Jagddamba Singh and Jaya Singh ,Photochemistry and Pericyclic Reactions, ,New Age International Publishers

,Lowry T H and Richardson K S,.Mechanism and Theory in Organic chemistryAWL

Satyajit Dey and N K Hazra Pericyclic Reactions and Organic Photochemistry: Through solved Problems, , Techno World

Turro N J,Ramamurthy ,Scaiano J C ,Principles of Molecular Photochemistry, , Viva Books

Course Code: CHE-MJ-18 Paper Code : CHE-MJ-703 P Course Title: Physical Chemistry-VI (Prac) 1 Credit 18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

1. Measurement of density of gases and vapours

- (a) Victor Meyer's Method Determination of Molecular weight of Acetone, Chloroform, Benzene, (Mixture).
- (b) Duma's Method Determination of molecular weight of acetone, Carbon-Tetrachloride.

2. Determination of Molecular weight of substances

- (a) Beckmann's freezing point Method
- (b) Beckmann's Boiling point method.
- **3.** Viscosity of liquids and solution by Ostwald tube Determination of percentage composition of a mixture of two liquids.

4. Surface Tension of liquids and solutions

- (a) Study of the effect of conc. on surface tension of acetic acid and Sod. Chloride solutions.
- (b) Determination of Parachor.

5. Thermochemistry

- (a) Determination of water equivalent of a calorimeter
- (b) Determination of the Heat of Neutralization of :
 - (i) Strong acid and strong base (HCl and NaOH)
 - (ii) Weak acid and strong base (NaOH and CH₃ COOH).
- (c) Determination of Heat of solution of Potassium Nitrate
- (d) Determination of basicity of succinic Acid by Thermochemical Method.

6. Partition Co-efficient

Determination of partition coefficient of:

- (a) Benzoic acid between water and Benzene
- (b) Iodine between water and carbon tetrachloride
- Reference Books
- Vogel, A.I. Quantitative Organic Analysis, Part 3, Pearson (2012).
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003.
- Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.
- P. C. Kamboj, University Practical Chemistry, , Vishal Publication

Semester VII

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Course Code: CHE-MJ-19 Paper Code : CHE-MJ-704 T **Course Title: Analytical Chemistry (Theo)** 3 Credits (54 Classes each of 50 minutes) Marks Distribution End Sem: 60

Mid Sem:15

Eight questions are to be set out of which five are to be answered.

I Qualitative and quantitative aspects of analysis:

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

II Optical methods of analysis:

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument.

Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques. Structural illustration through interpretation of data, Effect and importance of isotope substitution.

Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

III Thermal methods of analysis:

Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

IV Electroanalytical methods:

Classification of electroanalytical methods, basic principle of p^H metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

20 Lectures

8 Lectures

5 Lectures

5 Lectures

Time: 3 Hrs

Full Marks:75
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V Separation techniques:

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

VI Chromatography:

Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects.

Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents.

Reference Books:

- Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman .
- Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
- Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.
- Ditts, R.V. Analytical Chemistry-Methods of separation.

8 Lectures

8 Lectures

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Semester VII Course Code: CHE-MJP-19 Paper Code : CHE-MJP-704 P Course Title: Analytical (Prac.) (1 Credit) 18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

- **I.** Determine the p^{H} of the given aerated drinks fruit juices, shampoos and soaps.
- II. Analysis of water:
 - (i) Determination of p^H of water.
 - (ii) Total soluble salt
 - (iii) Estimation of calcium and magnesium

III. Analysis of soil:

- (i) Determination of p^{H} of soil.
- (ii) Total soluble salt
- (iii) Estimation of calcium and magnesium

IV. Separation Techniques

Chromatography: Separation of mixtures

- (i) Paper chromatographic separation of Fe^{3+} , Al^{3+} , and Cr^{3+} .
- (ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.

Reference Books:

- Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman .
- Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003.
- Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.
- P. C. Kamboj, University Practical Chemistry, , Vishal Publication

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Practical-1: 20 Marks, Note Book: 2¹/₂ Marks, Viva: 2¹/₂ Marks.

Semester VIII

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Course Code: CHE-MJ-20 Paper Code : CHE-MJ-801 T **Course Title: Environmental Chemistry** 3 Credits (54 Classes each of 50 minutes) **Marks Distribution** End Sem: 60

Mid Sem:15

Eight questions are to be set out of which five are to be answered.

Environment

Composition of atmosphere, Temperature variation of earth atmospheric system (temperature vs. altitude curve), bio-geochemical cycles of C, N, P, S and O system.

Bio-distribution of elements, Chemical composition of atmosphere-particles ,ions, radicals and there formation, Chemical & Photochemical reactions in atmosphere

Atmosphere

Chemical composition of atmosphere - particle, ions, and radicals in their formation, chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, and O and their effect, pollution by chemicals, CFC, Green House effect, acid rain, air pollution and control.

Hvdrosphere

Hydrological cycle, aquatic pollution and water quality parameters - Dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, Analytical methods for the determination fluoride, chromium and arsenic, residual chlorine and chlorine demand, purification and treatment of municipal water and waste water.

Aquatic chemistry

Water and its necessities, various water quality parameters (DO, BOD, COD, conductivity, pH, alkalinity, hardness) and its determination, Industrial, municipal water treatment processes, Waste water treatment procedure (primary, secondary and tertiary), Solid waste treatment. Soil pollution and Noise pollution.

Soil

Composition: micro and macro nutrients, Pollutants, fertilizers, pesticides, plastics and metals. Waste treatments. Analysis of soils

Environmental Toxicology

Chemical Solutions to environmental problems ,bio-degradability, principles of decompositiotn, atbetter industrial practices. Some important terrible environmental disasters: Bhopal gas tragedy, Cherbonyl nuclear plant incident, three rnile island case, Sewozo and Minimata disasters.

Pollution: Different types, their analysis and remedies.

4 Classes

10 Classes

10 Classes

Time: 3 Hrs

10 Classes

Full Marks:75

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Reference Books:

- E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
- R. M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
- A. K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.

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- S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.
- S.E. Manahan, Environmental Chemistry, CRC Press (2005).
- G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
- Miller T. G. Jr., Environmental Science, Wadsworth Publishing House, MeerutOdum.E.P.1971.
- Odum, E.P. (1971) Fundamentals of Ecology. Third Edition, W.B. Saunders Co., Philadelphia
- Sharma and Kaur, Environmental chemistry, 2016, Krishna publishers
- C. Baird, M. Cann, Environmental chemistry, 5th Edn, 2012, W. H. Freeman Publication.
- G. S. Sodhi, Fundamental Concepts of Environmental Chemistry (Third Edition) Narosa (2009).
- D. A. Skoog ,Principles of instrumental analysis:, Fifth Edition, Sauns College Publishing (London)
- •: S. M. Khopkar, Basic concepts of analytical chemistry, Wiley Eastern (1995)

Semester VIII

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Course Code: CHE-MJP-20 Paper Code : CHE-MJP-801 P Course Titl : Environmental Chemistry (Prac) 1 Credit 18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

- 1. Estimation of any one of the followings in the supplied water sample: Ca, Iron, Lead, Mg, Nitrate, Chloride
- 2. Estimation of any one of the followings in the supplied soil sample: Ca, Mg, carbon, Organic matter, Total nitrogen, Ammonia, Nitrate nitrogen
- 3. Determination of dissolved oxygen in water.
- 4. Determination of Chemical Oxygen Demand (COD)
- 5. Determination of Biological Oxygen Demand (BOD)
- 6. Percentage of available chlorine in bleaching powder.
- 7. Measurement of chloride, sulphate and salinity of water samples by simple titration method (AgNO₃ and potassium chromate).
- 8. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^{-}) using double titration method.
- 9. Measurement of dissolved CO₂.
- 10. Preparation of borax/ boric acid.
- 11. Determination of dissolved oxygen in given water (chemical method/instrumentation method).

Reference Books:

- R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, John Wiley & Sons, Inc. Publishers, New Delhi.(2005 edition).
- J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
- S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
- A. K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
- S. M. Khopkar, Environmental Pollution Analysis: New Age Int. Publisher, New Delhi.

Practical-1: 20 Marks, Note Book: 2¹/₂ Marks, Viva: 2¹/₂ Marks.

Semester VIII

Course Code: CHE-RC-01 Paper Code : CHE-RC-801 T Course Title: Inorganic Chemistry Research Marks Distribution

Full Marks: 100

Time: 06 Hrs

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Research work related to the Inorganic Industrial topics.

The paper will consist of

- 1. Research work / Lab work related to the research topic.
- 2. Preparation of dissertation based on the work undertaken.
- 3. Presentation of Research work by the student on the assigned topic in a seminar in the examination & open viva there on by research guide and one external special paper faculty Member. Marks will be jointly allotted by both the examiners. The students will complete their research in consultation with the special paper faculty of

the Department.

Each student has to submit two copies of the Research Report duly forwarded by the concerned faculty member.

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Semester VIII

Course Code: CHE-RC-02 Paper Code : CHE-RC-802 T Course Title: Organic Chemistry Research Marks Distribution

Full Marks: 100

Time: 06 Hrs

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Research work related to the Organic Industrial topics.

The paper will consist of

- 1. Research work / Lab work related to the research topic.
- 2. Preparation of dissertation based on the work undertaken.
- 3. Presentation of Research work by the student on the assigned topic in a seminar in the examination & open viva there on by research guide and one external special paper faculty. member. Marks will be jointly allotted by both the examiners. The students will complete their research in consultation with the special paper faculty of the Department.

Each student has to submit two copies of the Research Report duly forwarded by the concerned faculty member.

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Semester VIII

Course Code: CHE-RC-02 Paper Code : CHE-RC-802 T Course Title: Physical Chemistry Research Marks Distribution

Full Marks: 100

Time: 06 Hrs

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Research work related to any relevant Physical Industrial topics.

The paper will consist of

- 1. Research work / Lab work related to the research topic.
- 2. Preparation of dissertation based on the work undertaken.
- 3. Presentation of Research work by the student on the assigned topic in a seminar in the examination & open viva there on by research guide and one external special paper faculty. member. Marks will be jointly allotted by both the examiners. The students will complete their research in consultation with the special paper faculty of the Department.

Each student has to submit two copies of the Research Report duly forwarded by the concerned faculty member.

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Semester VIII

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Course Code: CHE-AMJ-01 Paper Code : CHE-AMJ-802 T Course Title: Inorganic Chemistry-VII 3 Credits (54 Classes each of 50 minutes) Marks Distribution End Sem: 60

Eight questions are to be set out of which five are to be answered.

I Bioinorganic Chemistry

Mid Sem:15

Elements of life: essential and beneficial elements, major, trace and ultratrace elements. Role of metal ions (specially Na⁺, K⁺, Mg²⁺, Ca²⁺, Fe^{3+/2+}, Cu^{2+/+}, and Zn²⁺)in biological systems. Metal ion transport across biological membrane Na⁺/K⁺-ion pump. Oxygen transport in biological systems: Haemoglobin, Myoglobin, Hemocyanine and Hemerythrin. Electron transfer proteins: Cytochromes and Ferredoxins. Hydrolytic enzymes: carbonate bicarbonate buffering system, carbonic anhydrase and carboxyanhydrase A. Biological nitrogen fixation, Photosynthesis: Photosystem-I and Photosystem-II. Toxic metal ions and their effects, chelation therapy (examples only), Pt and Au complexes as drugs (examples only), metal dependent diseases (examples only).

II Organometallic Chemistry

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. 18-electron and 16-electron rules (pictorial MO approach). Applications of 18-electron rule to metal carbonyls, nitrosyls, cyanides. General methods of preparation of mono and binuclear carbonyls of 3d series

Structures of mononuclear and -acceptor properties of CO, synergic effect and use of IR data to explain π binuclear carbonyls. extent of back bonding. Zeise's salt: Preparation, structure, evidences of synergic effect. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Reactions of organometallic complexes: substitution, oxidative addition, reductive elimination and insertion reactions.

III Catalysis by Organometallic Compounds: Study of the industrial processes 6 Classes

Alkene hydrogenation (Wilkinson's Catalyst), 2. Hydroformylation, 3. Wacker Process, 4. Synthetic gasoline (Fischer Tropsch reaction), 5. Ziegler-Natta catalysis for olefin polymerization.

IV Reaction Kinetics and Mechanism

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect and its application in complex synthesis, theories of trans effect,

17 Classes

14 Classes

Full Marks:75

Time: 3 Hrs

17 Classes

Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution reactions, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.

Reference Books

- Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima P
- Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.
- Greenwood, N.N. & Earnshaw A. Chemistry of the Elements, Butterworth-Heinemann, 1997.
- Cotton, F.A., Wilkinson, G., Murrillo, C. A., Bochmann, M., Advanced Inorganic Chemistry 6th Ed. 1999., Wiley.
- Bertini, I., Gray, H. B., Lippard, S.J., Valentine, J. S., Viva, 2007.
- Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
- Purecell, K.F. and Kotz, J.C., An Introduction to Inorganic Chemistry, Saunders: Philadelphia, 1980. 8. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
- Collman, J. P. et al. Principles and Applications of Organotransition Metal Chemistry. Mill Valley, CA: University Science Books, 1987.
- Crabtree, R. H. The Organometallic Chemistry of the Transition Metals. New York, NY: John Wiley, 2000.

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Semester VII Course Code: CHE-AMJ-01 Paper Code : CHE-AMJ-802 T Course Title : Inorganic Chemistry-VII (Prac) 1 Credit 18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

Qualitative semimicro analysis Qualitative semimicro analysis of mixtures containing four radicals. Emphasis should be given to the understanding of the chemistry of different reactions and to assign the most probable composition.

Cation Radicals: Na⁺ , K⁺ , Ca²⁺ , Sr²⁺ , Ba²⁺ , Al²⁺ , Cr²⁺ , Mn²⁺/Mn⁴⁺ , Fe³⁺ , Co²⁺/Co³⁺ , Ni²⁺ , Cu²⁺ , Zn²⁺ , Pb²⁺ , Cd²⁺ , Bi³⁺ , Sn²⁺/Sn⁴⁺ , As³⁺/As⁵⁺ , Sb³⁺ / ⁵⁺ , NH⁴⁺ , Mg²⁺ .

Anion Radicals: F^{-} , Cl^{-} , Br^{-} , BrO^{3-} , I^{-} , IO^{3-} , SCN^{-} , S^{2-} , SO_{4}^{2-} , NO^{3-} , NO^{2-} , PO_{4}^{3-} , AsO_{4}^{3-} , BO_{3}^{3-} , $CrO_{4}^{2-}/Cr_{2}O_{7}^{2-}$, $Fe(CN)_{6}^{4-}$, $Fe(CN)_{6}^{3-}$.

Insoluble Materials: Al₂O₃(ig), Fe₂O₃(ig), Cr₂O₃(ig), SnO₂, SrSO₄, BaSO₄, CaF₂, PbSO₄.

Reference Books

- Svehla, G., Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
- Das, A. K., A text book on medicinal aspects of bio-inorganic chemistry, CBS Publishers & Distributors, New Delhi, 2nd edition.
- Das, A. K., Bio-Inorganic chemistry, Books & Allied, Kolkata (2007).
- Karmakar, P., Sarkar (Sain), R., Ray, S., Ghosh, A.K. Concise Practical Chemistry (B.Sc. General and Honours), PART-I, The New Book Stall, Kolkata (2018).

Practical-1: 20 Marks, Note Book: 2¹/₂ Marks, Viva: 2¹/₂ Marks.

Semester VIII

Course Code: CHE-AMJ-02 Paper Code : CHE-AMJ-803 T Course Title: Organic Chemistry-VII 3 Credits (54 Classes each of 50 minutes) Marks Distribution End Sem: 60

Mid Sem:15

Eight questions are to be set out of which five are to be answered.

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I Retro-synthesis

Retro synthetic analysis : Definition, Synthon approach, Synthetic equivalent, Linear and convergent method in organic synthesis, Disconnection approach : One group disconnection, Retro synthesis of alcohols, Retro Diels-Alder reaction, Retro synthesis of olefins.

II Pericyclic Reactions

Orbital symmetry, Pericyclic reactions: Classification. Electrocyclic, cycloaddition and sigmatropic reactions: selection rules and stereochemistry of electrocyclic, cycloaddition and sigmatropic reactions, analysis by Frontier molecular orbital method.

III Organic Photochemistry

Photochemical reactions of saturated ketones : Norrish Type I and Norrish Type II reaction, Photoreduction of ketone, Photoaddition reactions, Paterno Buchi reaction. Photochemistry of simple olefins: cis-trans isomerization. Oxidative couplings: Barton reaction.

IV Oxidation Reactions

Study of the following oxidation reactions with mechanism: Oxidation of alcohols by CrO₃, DMSO, DCC, allylic oxidation of olefins, oxidative cleavage of glycols, oxidative cleavage of double bonds by ozonolysis, Lead tetra acetate, Periodic acid, MnO₂.

V Reduction Reactions

Study of the following reactions with mechanism : Reduction of carbonyl compounds by hydrides, Birch reduction, MPV reduction, Homogeneous and heterogeneous hydrogenation (Reduction of alkenes and alkynes), Use of complex metal hydrides as reagent: NaBH₄, LiAlH₄.

Reference Books:

- R.W. Lenz, Organic Chemistry of Synthetic High Polymers.
- W. Carruthers, Some modern methods of organic synthesis , OUP, 1982.
- R.O.C. Norman, Principles of Organic Synthesis, Second Edition, Chapman and Hall, 1978.
- R.K. Mackie and Smith, Organic Synthesis , II Ed., Longman Group UK Ltd, 1990.
- H.O. House, Modern synthetic reactions, Allied Publishers.
- Norman, R.O. C., Coxon, J. M. Principles of Organic Synthesis, Third Edition, Nelson Thornes, 2003.
- Warren, S. Organic Synthesis the Disconnection Approach, John Wiley and Sons.

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10 Lecture

10 Lecture

12 Lecture

10 Lecture

Full Marks:75

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12 Lecture

Time: 3 Hrs

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• Warren, S., Designing Organic Synthesis, Wiley India, 2009.

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- Carruthers, W. Modern methods of Organic Synthesis, Cambridge University Press.
- Willis, C. A., Wills, M., Organic Synthesis, Oxford University Press.

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Semester VIII

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Course Code: CHE-AMJP-02 Paper Code : CHE-AMJP-803 P Course Title : Organic Chemistry-VII (Prac) 1 Credit

> Organic Synthesis 18 Lectures Full Marks: 25

One question is to be set.

Time: 1¹/₂ Hrs

I. Preparation of Organic Compounds:

- 1. Beta naphthyl methyl ether from beta naphthol
- 2. Methyl orange from sulphanilic acid
- 3. ortho-Benzoyl benzoic acid from phthalic anhydride
- 4. Resacetophenone from resorcinol
- 5. para-Nitrobenzoic acid from para nitrotoluene
- 6. meta-Nitroaniline from meta dinitrobenzene
- 7. Anthraquinone from anthracene
- 8. Preparation of any red dye using aniline/phenol

Reference Books:

- Malcohm P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed.
- Harry R. Allcock, Frederick W. Lampe and James E. Mark, Contemporary Polymer Chemistry, 3rd ed. Prentice-Hall (2003)
- Fred W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)
- Joel R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003)
- Petr Munk and Tejraj M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John Wiley & Sons (2002)
- L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
- Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd ed. Oxford University Press (2005)
- Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

Practical-1: 20 Marks, Note Book: $2^{1}/_{2}$ Marks, Viva: $2^{1}/_{2}$ Marks.

Semester VIII

Course Code: CHE-AMJ-03 Paper Code : CHE-AMJ-804 T **Course Title: Physical Chemistry-VII** 3 Credits (54 Classes each of 50 minutes) Marks Distribution End Sem: 60

Mid Sem:15

Eight questions are to be set out of which five are to be answered.

I Statistical Thermodynamics

Concept of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging, Canonical, grand canonical and microcanonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers). Partition functions-translational, rotational, vibrational and electronic partition functions. Applications of partition functions, Fermi-Dirac statistics, distribution law and applications to metal. Bose-Einstein statistics. Distribution law and its application to helium.

II Potential Energy Surfaces

Mechanism of activation, Potential energy surface for three atom reaction, Potential energy curve for successive reactions, Properties of potential energy surfaces, Inter conversion of translational and vibrational energies, Combination of atoms, Ortho-para conversion, Activated state of three atom and four atom reactions, Potential energy profile, reaction co-ordinate, Transmission co-efficient, non-adiabatic reaction.

III Kinetics of condensed phase reactions

Rate determining steps in diffusion controlled reactions and activation controlled reactions, Stokes-Einstein equation and dependence of rate constant on co-efficient of viscosity of medium, Kinetics of ionic reactions in solution-electrostatic contribution to free energy in single and double spherical models of activated complex, entropy of activation for ion-ion reactions; Kinetics of dipole-dipole reaction, ion-dipole reaction, dependence of rate constant on ionic strength and dielectric constant of medium, Bronsted-Bjerrum equation.

IV Study of Fast Reactions

Photophysical Chemistry - Flash Photolysis, Relaxation technique, Nuclear Magnetic Resonance Method, Molecular Beam and Shock-tube Kinetics, Flow method. Reactions of Protons, Electrons metal ions.

V Surface Chemistry

Adsorption : Surface tension, capillary action, pressure difference across curved surface (Laplace equation), Vapour pressure of droplets (Kelvin equation), Classical and modern methods for determining surface structure and composition, Surface films on liquids (Electro-kinetic phenomena), criteria for spreading of one liquid on another, Surface pressure and measurement of surface pressure, Langmuir surface balance and molecular dimensions, states of mononuclear films, reaction in monomolecular films, types and structure of surface films: optical method, electrical method.

Micelles : Surface active agents, classification of surface active agents, micellization, hydrophobic interaction, critical micellar concentration (CIVIC), factors affecting the CIVIC of surfactants, counter ion

6 Hrs

Time: 3 Hrs

10 Hrs

Full Marks:75

10 Hrs

10 Hrs

18 Hrs

binding to micelles, thermodynamics micellization-phase separation and mass action models, solubilization, micro emulsion, reverse micelles.

Macromolecules : Polymer-definition, types of polymers, electrically conducting, fire resistant, liquid crystal polymers, kinetics of polymerization, mechanism of polymerization. Molecular mass, number and mass average molecular mass, molecular mass determination (osmometry, viscometry, diffusion and light scattering methods), sedimentation, chain configuration of macromolecules, calculation of average dimensions of various chain structures.

Reference Books

- Physical Chemistry, Waller J. Moore
- Physical Chemistry, P.W. Atkins, ELBS.
- Principles of polymer chemistry, Cornell , P. J. Flory (Univ. Press)
- Handbook of Conducting Polymers, Vol I & II" T A. Skolhia.
- Introduction to Quantum Chemistry, A.K. Chandra, Tata McGraw Hill.
- Quantum Chemistry, Ira N. Levine, Prentice Hall.
- Coulson's Valence Theory, R. McWeeny, ELBS.
- Chemical Kinetics, K. J. Laidler, Mcgraw-Hill.
- Kinetics and Mechanism of Chemical Transformations, J. Rajaraman and J. Kuriacose, McMillan.
- Modern Electrochemistry, Vol. I and Vol. II, J.O.M. Bockris and A.K.N. Reddy, Plenum.
- Introduction to Polymer Science, V.R. Gowarikar, N.V. Vishwanathan and J. Sridhar, Wiley Eastern

Practical-1: 20 Marks, Note Book: 2¹/₂ Marks, Viva: 2¹/₂ Marks.

SKILL ENHANCEMENT COURSE

Semester-I Skill Enhancement Course-1 SEC-101T Pesticide Chemistry Credits: 02

Theory: 36 Lectures Full Marks: 75

Eight questions are to be set out of which five are to be answered.

Time: $2^{1}/_{2}$ Hrs

I General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship. 13 Lectures

II Synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).

23 Lectures

Reference Book:

- R. Cremlyn: Pesticides, John Wiley.
- N. K. Roy, Chemistry of Pesticides, Atithibooks.com
- Kuldeep Singh & Raman Singh, An introduction to Pesticide Chemistry, Notion Press.
- Chandan Saha, B. Chakraborty, S. Chakraborty, K. Basu : Lectures on Pharmaceutical Chemistry & Pesticide Chemistry, Technoworld.

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Semester-I Skill Enhancement Course-1 (Lab/Internal Evaluation/Assignment) SEC-101P Pesticide Chemistry Credit: 01 18 Lectures Full Marks: 25

One question is to be set.

Time: 1¹/₂ Hrs

Practicals:

- 1. Determination of p^Hof a given sample of pesticide solution.
- 2. Determination of viscosity of aqueous solutions of a pesticide at room temperature.
- 3. Determination of surface tension of aqueous solutions of a pesticide by
 - (a) Drop number method or,
 - (b) Drop weight method
- 4. Find out the surface tension of benzene & toluene.
- 5. Preparation of Aspirin and its analysis.

Reference Books :

• Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

• Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).

• Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

Practical/Assignment-1: 20 Marks, Note Book: 2¹/₂ Marks, Viva: 2¹/₂ Marks.

Semester-II Skill Enhancement Course-2 SEC-201T Fuel Chemistry Credits: 02 Theory: 36 Lectures Full Marks: 75 Eight questions are to be set out of which five are to be answered.

Time: $2^{1}/_{2}$ Hrs

I Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value 06 Lectures

II Coal: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal.Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.
 12 Lectures

III Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining and different types of petroleum products and their applications.

Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

12 Lectures

IV Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants.

Properties of lubricants (viscosity index, cloud point, pore point) and their determination.

06 Lectures

Reference Books:

- E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
- P.C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
- B.K. Sharma: Industrial Chemistry, Goel Publishing House, Meerut.
- S. Saha & D. Bhattacharya, Fuel Chemistry, Technoworld.
- D. Mohanty, Fuel and Pesticide Chemistry, Kalyani Publishers.
- B. Shaikia, Fuel Chemistry, Mahaveer Publications.

Semester-II Skill Enhancement Course-2 (Lab/Internal Evaluation/Assignment) SEC-201P Fuel Chemistry Credit: 01 18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

Practicals:

- 1. Determination of p^{H} of a given sample of pesticide solution.
- 2. Determination of viscosity of a given sample of lubricant at room temperature.

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3. Determination of surface tension of aqueous solutions of a lubricant by

(a) Drop number method

(b) Drop weight method

- 4. Determination of partition co-efficient of benzoic acid between water and benzene.
- 5. Preparation of Magnesium bisilicate (Antacid).

Practical/Assignment-1: 20 Marks, Note Book: 2¹/₂ Marks, Viva: 2¹/₂ Marks.

Semester-III Skill Enhancement Course-2 SEC-301T Pharmaceutical Chemistry Credits: 02

Theory: 36 Lectures Full Marks: 75 Eight questions are to be set out of which five are to be answered.

Drugs & Pharmaceuticals

Drug discovery, design and development: Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, lbuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam),Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

Fermentation

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

14 Lectures

Reference Books:

- Girish Kumar Vyas, Pharmaceutical Chemistry
- Mukesh Chandra Joshi, Krishan Kumar, Pharmaceutical Chemistry, I. K. International Publishing Co.
- B. Jayalakshmi & N. Murugesh, Pharmaceutical Chemistry, Stya Publisher.

Time: $2^{1}/_{2}$ Hrs

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Semester-III Skill Enhancement Course-2 (Lab/Internal Evaluation/Assignment) SEC-301P Pharmaceutical Chemistry Credit: 01 18 Lectures Full Marks: 25

One question is to be set.

Time: $1^{1}/_{2}$ Hrs

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Practicals

1. Preparation of Aspirin and its analysis.

2. Preparation of magnesium bisilicate (Antacid).

Reference Books:

- G.L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK.
- Hakishan, V.K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.
- William O. Foye, Thomas L., Lemke , David A. William: Principles of Medicinal Chemistry, B. I. Waverly Pvt. Ltd. New Delhi.

MINOR COURSE (Minor - Chemistry) Semester-I Course Code : CHE-MN-01 Paper Code : CHE MN-01 (Theory) Course Title: Inorganic Chemistry 3 Credits (54 Classes each of 50 minutes) Marks Distribution

Full Marks:75

Time: 3 Hrs

Eight questions are to be set out of which five are to be answered.

I. Atomic Structure: Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.

Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2 , Schrödinger equation for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation).. Significance of quantum numbers, Shapes of s, p and d atomic orbitals, nodal planes.

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, Relative energies of atomic orbitals, Anomalous electronic configurations.

II. Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Concept of resonance and resonating structures in various inorganic

compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing). Comparison of VB and MO approaches.

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III. General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Hydrometallurgy, Methods of purification of metals (Al, Pb, Fe, Ni, Zn): electrolytic, oxidative refining, Kroll process, Parting process, van Arkel-de Boer process and Mond's process.

IV. s- and p-Block Elements

Periodicity Periodicity in s- and p-block elements with respect to electronic configuration, atomic and ionicsize, ionization enthalpy, electronegativity, Allotropy in C and S. Oxidation states, inert pair effect, diagonal relationship and anomalous behaviour of firstmember of each group.

Reference Books

- 1. J. D. Lee: A new Concise Inorganic Chemistry, ELBS.
- 2. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.

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- 3. James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
- 4. R.C. Agarwal, Modern Inorganic Chemistry, Kitab Mahal.
- 5. Asim K. Das, Mahua Das, Fundamental Concepts of Inorganic Chemistry, CBS Publishers and Distributors.

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Semester-I Course Code : CHE-MJP-01 Paper Code : CHE-MJP-101 1Credit 18 Lectures

Full Marks 25

Time : 1¹/₂ Hours

One question is to be set.

- 1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
- 2. Estimation of oxalic acid by titrating it with KMnO4.

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- 3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO4.
- 4. Estimation of Fe (II) ions by titrating it with K2Cr2O7 using internal indicator.
- 5. Estimation of Cu (II) ions iodometrically using Na2S2O3.
- 6. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.

Reference Books

- 1. Vogel A. I., A Text Book of Quantitative/Qualitative Inorganic Analysis, ELBS.
- 2. Advanced Practical Chemistry, J. Singh, R. K. P. Singh, Jaya Singh, L.D.S. Yadav, I.R. Siddiqui & Jaya Srivastava, Pragati Prakashan.

Semester-III

Course Code : CHE-MN-02 Paper Code : CHE MN-201 (Theory) Course Title: Organic Chemistry 3 Credits (54 Classes each of 50 minutes) Marks Distribution

Full Marks:75

Time: 3 Hrs

I. Fundamentals

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. values. Aromaticity: Hückel's rule.

II Stereochemistry

Conformations with respect to ethane and butane Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality

Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro, D and L, cis-trans nomenclature, CIP Rules: R-S (for upto 2 chiral carbon atoms) and E-Z Nomenclature .

III Aliphatic Hydrocarbons

Alkanes: Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.

Alkenes: Preparation: Elimination reactions: Dehydration of alcohols and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis.

Alkynes: Preparation: Acetylene from CaC2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO4, ozonolysis and oxidation with hot alk. KMnO4.

Reference Book.

- 1. T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
- 2. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
- 3. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
- 4. Organic Chemistry, M K Jain and S C Sharma Visal Publication
- 5. Advanced Organic Chemistry, M. K. Jain & S.C. Sharma, Vishal Publication.

Semester-III Course Code : CHE-MJP-02 Paper Code : CHE-MJP-301 1Credit 18 Lectures

Full Marks 25

Time : 1¹/₂ Hours

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One question is to be set.

- 1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
- 2. Criteria of Purity: Determination of melting and boiling points.

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- Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
- (a) Bromination of Phenol/Aniline
- (b) Benzoylation of amines/phenols
- (c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone

Reference Books :

- A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
- F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

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Semester-V Course Code : CHE-MN-03 Paper Code : CHE MN-501 (Theory) Course Title: Physical Chemistry 3 Credits (54 Classes each of 50 minutes) Marks Distribution

Full Marks:75

Time: 3 Hrs

I. Chemical Energetics

Systems ,Process ,Thermodynamic variables E,H,q,w,S,A,G and their variation with T,P,V, Extensive and Intensive properties, Path and State Functions, Laws of Thermodynamics.

II Chemical Equilibrium:

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔGo , Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases.

III Ionic Equilibria:

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts.

IV Quantum Chemistry

Born-Oppenheimer approximation: Separation of molecular energies into translational, rotational, vibrational and electronic components. Postulates of quantum mechanics, quantum mechanical operators. Free particle. quantization, normalization of wave functions, concept of zero-point energy.

V Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law– non-ideal solutions. Vapour pressure-composition and temperature- composition curves of ideal and non-ideal solution.

VI Electrochemistry

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions.

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series.

Recommended books/References:

- 1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press (2006).
- 2. Ball, D. W. Physical Chemistry Thomson Press, India (2007).

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- Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
 Physical Chemistry, P C Rakshit (revised by S C Rakshit), Sharat Book House
 - 5. Principles of Physical Chemistry, Puri, Sharma and Pathania, Vishal publishing and Co.
 - 6. A Text Book of Physical Chemistry, K. L. Kapoor, Vol. 1 to 7, McGraw Hill.

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Semester-V Course Code : CHE-MJP-03 Paper Code : CHE-MJP-501 1Credit 18 Lectures

Full Marks 25 One question is to be set. Time : 1¹/₂ Hours

p^H measurements

- a) Measurement of p^H of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using p^H- meter.
- b) Preparation of buffer solutions:
- (i) Sodium acetate-acetic acid

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(ii) Ammonium chloride-ammonium hydroxide

Reference

- 1. Vogel A. I., A Text Book of Quantitative/Qualitative Inorganic Analysis, ELBS.
- Advanced Practical Chemistry, J. Singh, R. K. P. Singh, Jaya Singh, L.D.S. Yadav, I.R. Siddiqui & Jaya Srivastava, Pragati Prakashan.

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Semester-VII Course Code : CHE-MN-04 Paper Code : CHE MN-701 (Theory) Course Title: Advance Topics in Chemistry 3 Credits (54 Classes each of 50 minutes)

Full Marks:75

Time: 3 Hrs

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Retro-synthesis

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Retro synthetic analysis : Definition, Synthon approach, Synthetic equivalent, Linear and convergent method in organic synthesis, Disconnection approach : One group disconnection, Retro synthesis of alcohols, Retro Diels-Alder reaction, Retro synthesis of olefins.

Pericyclic Reactions

Orbital symmetry, Pericyclic reactions: Classification. Electrocyclic, cycloaddition and sigmatropic reactions: selection rules and stereochemistry of electrocyclic, cycloaddition and sigmatropic reactions, analysis by Frontier molecular orbital method, Claisen rearrangement.

Organic Photochemistry

Photochemical reactions of saturated ketones : Norrish Type I and Norrish Type II reaction, Photoreduction of ketone, Photoaddition reactions, Paterno Buchi reaction. Photochemistry of simple olefins: cis-trans isomerization. Oxidative couplings: Barton reaction. Photo rearrangements: Photo-Fries rearrangement.

Reagents in Synthesis

Some common reagents like KMnO₄, OsO₄,LiAlH₄,NaBH₄, Sn/HCl etc.

Basic Ideas about Redox Reactions

Common redox reactions

Symmetry

Elements of Symmetry and Symmetry Operations

Spectroscopy

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Some basic ideas of Spectroscopy, nteraction of matter with electromagnetic radiation, Born-Oppenheimer Approximation Different types of Molecular Spectra and their applications

Reference Books

• Group Theory in Chemistry, V.Ramakrishnan, M S Gopinathan, Vishal Publication

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- W. Carruthers, Some modern methods of organic synthesis , OUP, 1982.
- R.K. Mackie and Smith, Organic Synthesis, II Ed., Longman Group UK Ltd, 1990.
- H.O. House, Modern synthetic reactions, Allied Publishers.

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- Fundamentals of Organic Synthesis vol II.Ratan Kumar Kar, New Central Book Agency Pvt.Ltd
- Application Redox and Reagents in Organic Synthesis, Ratan Kumar Kar, NewCentral Book Agency Pvt. Ltd

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Semester-VII Course Code : CHE-MJP-04 Paper Code : CHE-MJP-701 1Credit 18 Lectures

Full Marks 25

Time : 11/2 Hours

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One question is to be set.

I. Preparation of Organic Compounds:

1. Beta naphthyl methyl ether from beta naphthol

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- 2. Methyl orange from sulphanilic acid
- 3. ortho-Benzoyl benzoic acid from phthalic anhydride
- 4. Resacetophenone from resorcinol
- 5. para-Nitrobenzoic acid from para nitrotoluene
- 6. meta-Nitroaniline from meta dinitrobenzene
- 7. Anthraquinone from anthracene

Reference Books

- 1. Basic Principles of Practical Chemistry, V. Venkateswaran, R.Veeraswamy, A R Kulandaivelu, S. Chand & Sons
- 2. College Practical Chemistry, Sunita Dhingra, V K Ahluwalia, Orient Blackswan Pvt Ltd.

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Semester-II Course Code : CHE-MNV-01 Paper Code : CHE MN-201 (Theory) Course Title: Materials of Industrial Importance 3 Credits (54 Classes each of 50 minutes)

Full Marks:75

Time: 3 Hrs

I Silicate Industries

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Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass. Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre.

II Fertilizers

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

II Batteries

Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, solar cell and polymer cell.

III Alloys

Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

IV Catalysis

General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts.

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Phase transfer catalysts, application of zeolites as catalysts.

Reference Books:

- E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
- R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.

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- W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
- J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
- R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, NewDelhi.

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Semester-II

Course Code : CHE-MNV-01 Paper Code : CHE-MNV-201 Course Title : Materials of Industrial Importance 1 Credit 18 Lectures

Full Marks 25

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Time : 1¹/₂ Hours

One question is to be set.

- 1. Determination of free acidity in ammonium sulphate fertilizer.
- 2. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
- 3. Estimation of phosphoric acid in superphosphate fertilizer.

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- 4. Electronless metallic coatings on ceramic and plastic material.
- 5. Determination of composition of dolomite (by complexometric titration).
- 6. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
- 7. Analysis of Cement.
- 8. Preparation of pigment (zinc oxide).

Reference Books:

- E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
- R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
- W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
- J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
- R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
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Semester-IV Course Code : CHE-MNV-02 Paper Code : CHE MN-401 (Theory) Course Title: Medicinal Chemistry 3 Credits (54 Classes each of 50 minutes)

Full Marks:75

Time: 3 Hrs

I Structure Prediction and Drug Design

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Structure prediction - Introduction to comparative Modeling. Sequence alignment. Constructing and evaluating a comparative model. Predicting protein structures by 'Threading', Molecular docking. Structure based de novo ligand design,

Drug Discovery - Chemoinformatics - QSAR.

II Force Fields:

Fields. Bond Stretching. Angle Bending. Introduction to nonbonded interactions. Electrostatic interactions. van der Waals Interactions. Hydrogen bonding in Molecular Mechanics. Force FieldModels for the Simulation of Liquid Water.

III Drugs & Pharmaceuticals

Drug discovery, design and development; Basic Retrosynthetic approach. Classification, structure and therapeutic uses.

IV Pharmaceutical Compounds: Structure and Importance

Structure, Synthesis and therapeutic uses of the representative drugs of the following classes:

- (i) Analgesics agents: : Ibuprofen (with synthesis)
- (ii) Antipyretic agents: Paracetamol (with synthesis)
- (iii) Anti-inflammatory agents: Aspirin (with synthesis)
- (iv) Antibiotics: Chloramphenicol (with synthesis)
- (v) Antibacterial and antifungal agents : Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim);
- (vi) Antiviral agents: Acyclovir

- G.L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK.
- Hakishan, V.K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.

• William O. Foye, Thomas L., Lemke , David A. William: Principles of Medicinal Chemistry,

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• B.I. Waverly Pvt. Ltd. New Delhi.

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Semester-IV Course Code : CHE-MNV-02 (Prac) Paper Code : CHE-MNV-401 Course Title : Medicinal Chemistry 1 Credit 18 Lectures

Full Marks 25

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Time : 1¹/₂ Hours

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One question is to be set

Practicals

- 1. Preparation of Aspirin and its analysis.
- 2. Preparation of magnesium bisilicate (Antacid).

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- G.L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK.
- Hakishan, V.K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.
- William O. Foye, Thomas L., Lemke , David A. William: Principles of Medicinal Chemistry, B. I. Waverly Pvt. Ltd. New Delhi.

Semester-VI

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Course Code : CHE-MNV-03 Paper Code : CHE MN-301 (Theory) Course Title: Analytical Methods in Chemistry 3 Credits (54 Classes each of 50 minutes)

Full Marks:75

Time: 3 Hrs

I Qualitative and quantitative aspects of analysis:

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Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

II Optical methods of analysis:

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument.

Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques. Structural illustration through interpretation of data, Effect and importance of isotope substitution.

Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water s

III Separation techniques:

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of

solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects.

- Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery andothers) 5th Ed. The English Language Book Society of Longman .
- Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
- Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson AsiaPvt. Ltd. Singapore.
 - Ditts, R.V. Analytical Chemistry Methods of separation.

Semester-VI

Course Code : CHE-MNV-03 (Prac) Paper Code : CHE-MNV-601 Course Title : Analytical Methods in Chemistry 1 Credit 18 Lectures

Full Marks 25

Time : 1¹/₂ Hours

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One question is to be set.

I. Determine the p^H of the given aerated drinks fruit juices, shampoos and soaps.

II. Analysis of water and Soil:

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(i) Determination of p^{H} of water.

(ii) Total soluble salt

III. Separation Techniques

Chromatography: Separation of mixtures

(i) Paper chromatographic separation of Fe^{3+} , Al^{3+} , and Cr^{3+} .

Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf value

- Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery andothers) 5th Ed. The English Language Book Society of Longman .
- Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth PublishingCompany, Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.

Semester-VIII Course Code : CHE-MNV-04 Paper Code : CHE MN-801 (Theory) Course Title: Green Chemistry 3 Credits (54 Classes each of 50 minutes)

Full Marks:75

Time: 3 Hrs

I Introduction to Green Chemistry

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/Obstacles in the pursuit of the goals of Green Chemistry.

II Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry with their explanations and examples; Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products

III Examples of Green Synthesis/ Reactions

1. Green Synthesis of the following compounds: adipic acid, catechol, BHT, methyl methacrylate, urethane, aromatic amines (4-aminodiphenylamine), benzyl bromide, acetaldehyde, disodium iminodiacetate (alternative to Strecker synthesis).

2. Microwave assisted reactions in water: Hofmann Elimination, Hydrolysis, Oxidation. Microwave assisted reactions in organic solvents: Esterification, Fries rearrangement, Orthoester Claisen Rearrangement, Diels-Alder Reaction, Decarboxylation.

3. Microwave assisted solid state reactions: Deacetylation, Deprotection. Saponification of esters, Alkylation of reactive methylene compounds, reductions, synthesis of nitriles from aldehydes, anhydrides from dicarboxylic acid.

IV Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; oncovalent derivatization; Green

chemistry in sustainable development.

Reference Books:

• V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry, Anamalaya

Publishers(2005).

• P.T. Anastas & J.K. Warner: Oxford Green Chemistry- Theory and Practical, University Press(1998).

• A.S. Matlack: Introduction to Green Chemistry, Marcel Dekker (2001).

• M.C. Cann & M.E. Connely: Real-World cases in Green Chemistry, American ChemicalSociety, Washington (2000).

• M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington (2002).

Semester-VIII Course Code : CHE-MNV-04 (Prac) Paper Code : CHE-MNV-801 Course Title : Green Chemistry 1 Credit 18 Lectures

Full Marks 25

Time : 1¹/₂ Hours

One question is to be set.

1. Safer starting materials

The Vitamin C clock reaction using Vitamin C tablets, tincture of iodine, hydrogen peroxide and liquid laundry starch.

Effect of concentration on clock reaction

2. Using renewable resources

Preparation of biodiesel from vegetable oil.

3. Avoiding waste

Principle of atom economy.

Use of molecular model kit to stimulate the reaction to investigate how the atom economy canillustrate Green Chemistry.

Preparation of propene by two methods can be studied

- (I) Triethylamine ion + $OH^- \rightarrow propene + trimethylpropene + water$
- (II) 1-propanol H2SO4/ $\Delta \rightarrow$ propene + water

4. Use of enzymes as catalysts

Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide AlternativeGreen solvents

- Anastas, P.T & Warner, J.C. Green Chemistry: Theory and Practice, Oxford University Press(1998).
- Kirchoff, M. & Ryan, M.A. Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC (2002).
- Ryan, M.A. Introduction to Green Chemistry, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).

Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi. Bangalore CISBN 978-93-81141-55-7 (2013).

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V. Multidisciplinary- Course of 3 Credits each (Available to Students NOT having Chemistry either as Major or Minor and Intermediate Level/10+2) Semester-II Introductory Chemistry CHE-MDC-01 (2 Credits) Full Marks 50

Language of Chemistry: Chemical equation, Balanced chemical solution, implications of a balanced chemical equation,

Discovery of Electron, Proton and Neutron, atomic number, isotopes and isobars. Thomson's model and its limitations. Rutherford's model and its limitations, Bohr's model and its limitations, concept of shells and subshells, dual nature of matter and light, de Broglie's relationship, shapes of s, p and d orbitals, rules for filling electrons in orbitals - Aufbau principle, Pauli's exclusion principle and Hund's rule, electronic configuration of atoms, stability of half-filled and completely filled orbitals. Valence electrons, ionic bond, covalent bond, bond Hydrogen bond.

Concept of oxidation and reduction, redox reactions, oxidation number, balancing redox reactions, in terms of loss and gain of electrons

Homolytic and heterolytic fission of a covalent bond: free radicals, carbocations, carbanions, electrophiles and nucleophiles, types of organic reactions.

Nomenclature and classification of organic compounds, isomerism, homologous series, types of organic reactions with examples, reagents and intermediates in organic reactions

Rate of chemical reactions, concept of activation energy, Arrhenius equation, energy profile of reaction, order and molecularity of a reaction, rate determining step

Concepts of System and types of systems, surroundings, work, heat, energy, extensive and intensive properties, state functions. First law of thermodynamics -internal energy and enthalpy, heat capacity and specific heat,

Equilibrium in physical and chemical processes, dynamic nature of equilibrium, law of mass action, equilibrium constant Significance of classification,

Brief history of the development of periodic table, modern periodic law and the present form of periodic table, periodic trends in properties of elements -atomic radii, ionic radii, inert gas radii, Ionization enthalpy, electron gain enthalpy, electronegativity, valency.

Solid state: crystalline and amorphous solids types of symmetry in crystals

Liquid state: viscosity and surface tension

Gaseous state: Ideal and real gases, laws of gases ,Boyle's law, Charle's law, Avogadro's number, ideal gas equation.

Practicals CHE—MDCP-01 (1 Credit) Full Marks 25

One Question is to be set.

Finding the p^H of given solutions

Observation of properties of acids and/or bases on the basis of their reactions with a) litmus paper, b) Zinc metal, c) reaction with Sodium Carbonate and acetic acid

Performing and observing following reactions and their classification

Combination, decomposition, displaceme Atoms and Molecules. Atomic and molecular masses, mole concept and molar mass, percentage composition, empirical and molecular formula.

Observing the precipitation reactions (SO₄⁻², X⁻,), effervescence($CO_3^{2^-}$, HCO₃⁻)

Study of properties of acetic acid and aniline

Reference Books:

- Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery andothers) 5th Ed. The English Language Book Society of Longman.
- Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth PublishingCompany, Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.

Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.