

FAROOK COLLEGE (AUTONOMOUS)

Farook College PO, Kozhikode-673632

P.G Programme in Chemistry

Under

Choice Based Credit Semester System

SYLLABUS

(2022 Admission Onwards)



Prepared By:

Board of Studies in Chemistry

Farook College (Autonomous)

CERTIFICATE

I hereby certify that the documents attached are the bona fide copies of the syllabus of M.Sc. Chemistry programme to be effective from 2022 admission onwards.

Date:
Place: Farook College

Principal

FAROOK COLLEGE (AUTONOMOUS)
MSc. CHEMISTRY (CSS PATTERN)
Regulations and Syllabus with effect from 2022 admission

Pattern of the Programme

- a. The name of the programme shall be M.Sc. Chemistry under CSS pattern.
- b. The programme shall be offered in four semesters within a period of two academic years.
- c. Eligibility for admission will be as per the rules laid down by the College from time to time.
- d. Details of the courses offered for the programme are given in Table 1.

The programme shall be conducted in accordance with the programme pattern, scheme of examination and syllabus prescribed.

Of the 25 hours per week, 13 hours shall be allotted for theory and 12 hours for practical; 1 theory hour per week during even semesters shall be allotted for seminar.

Theory Courses

In the first three semesters, there will be four theory courses; and in the fourth semester, three theory courses. All the theory courses in the first and second semesters are core courses. In the third semester there will be three core theory courses and one elective theory course. College can choose any one of the elective courses given in Table 1. In the fourth semester there will be one core theory course and two elective theory courses. College can select any two of the elective courses given in Table 1. However, a student may be permitted to choose any other elective course of his choice given in Table 1 in the third and fourth semesters, without having any lecture classes.

One elective course in the Third semester and Two elective courses in the Fourth semester chosen by the college will be considered for calculating the workload of teachers.

All the theory courses in the first, third, and fourth semesters (both core and elective) are of 4 credits while the theory courses (both core and elective) in the **second semester** are of 3 credits.

Practical Courses

In each semester, there will be three core practical courses. However the practical examinations will be conducted only at the end of second and fourth semesters. At the end of second semester, three practical examinations with the codes MCH 1 L 01 & MCH 2 L 04 (Inorganic chemistry practical I and II), MCH 1 L 02 & MCH 2 L 05 (Organic chemistry practical I and II) and MCH 1 L 03 & MCH 2 L 06 (Physical chemistry practical I and II) will be conducted. Practical examinations for the codes MCH 3 L 07 & MCH 4 L 10 (Inorganic chemistry practical III and IV), MCH 3 L 08 & MCH 4 L 11 (Organic chemistry practical III and IV) and MCH 3 L 09 & MCH 4 L 12 (Physical chemistry practical III and IV) will be conducted at the end of fourth semester. Each practical examination will be of six hour duration and 3 credits. Three hours per

week in the fourth semester are allotted for conducting individual project work by the students under the guidance of a faculty and it can be treated as practical hours while calculating the workload of teachers.

Project and Viva Voce

Each student has to perform an independent research project work during the programme under the guidance of a faculty member of the college/ scientists or faculties of recognized research institutions. Projects done in the quality control or quality analysis division of the industries will not be considered. At the same time, projects done in the R & D division of reputed industry can be considered. Each student has to submit three copies of the project dissertation for valuation at the end of fourth semester. After the valuation one copy may be returned to the student, one may be given to the project supervisor and the third one should be kept in the department/college library.

Evaluation of the project work (4 credits) will be done on a separate day at the end of fourth semester, after the theory examinations. Viva voce on the project will also be done on the same day. A comprehensive viva voce examination (2credits), based on all the theory and practical courses, will be conducted at the end of the fourth semester, on a separate day.

Grading and Evaluation

1. Accumulated minimum credit required for successful completion of the programme shall be 80.
2. A project work of 4 credits is compulsory and it should be done during the programme.

Project evaluation should be conducted at the end of the fourth semester, by three external examiners: one each from inorganic chemistry, organic chemistry and physical chemistry area, on a separate day.

Also, a comprehensive Viva Voce Examination (carrying 2 credits) may be conducted by three external examiners: one each from inorganic chemistry, organic chemistry and physical chemistry area; at the end of the fourth semester on a separate day.

Evaluation and Grading should be done by direct grading system. All grading during the evaluation of courses and the semester is done on 6 point scale (A+, A, B, C, D, E). Grading in 6 point scale is as given below.

Grade	Grade Point
A+	5
A	4
B	3
C	2
D	1
E	0

The calculation of GPA, SGPA & CGPA Shall be based on the direct grading system using 10 point scale as detailed below.

Letter Grade	Grade Range	Range of Percentage (%)	Merit / Indicator
O	4.25 – 5.00	85.00 – 100.00	Outstanding
A+	3.75 – 4.24	75.00 – 84.99	Excellent
A	3.25 – 3.74	65.00 – 74.99	Very Good
B+	2.75 – 3.24	55.00 – 64.99	Good
B	2.50 – 2.74	50.00 – 54.99	Above Average
C	2.25 – 2.49	45.00 – 49.99	Average
P	2.00 -2.24	40.00 – 44.99	Pass
F	< 2.00	Below 40	Fail
I	0	-	Incomplete
Ab	0	-	Absent

Pass in a course

P grade and above (GPA 2.00 and above).

Pass in all courses in a semester is compulsory to calculate the SGPA.

GPA, SGPA and CGPA – between 0 to 5 and in two decimal points.

An overall letter grade (Cumulative Grade) for the whole programme shall be awarded to the student based on the value of CGPA using a 10-point scale given below.

CGPA	Overall Letter Grade
4.25 – 5.00	O
3.75 – 4.24	A+
3.25 – 3.74	A
2.75 – 3.24	B+
2.50 – 2.74	B
2.25 – 2.49	C
2.00 -2.24	P
< 2.00	F
0	I
0	Ab

(1) Weightage of Internal and External valuation:

The evaluation scheme for each course shall contain two parts

(a) *Internal evaluation*

(b) *External evaluation.*

Its weightages are as follows:

<i>Evaluation</i>	<i>Weightage</i>
Internal	1 (or 20%)
External	4 (or 80%)

Both internal and external evaluation will be carried out using Direct Grading System, in 6 point scale

Internal evaluation (must be transparent and fair):

a) Theory: 5 weightage

- i. Internal Examinations- weightage = 2 (2 internal exams, both should be considered)
- ii. Assignments and Exercises- weightage =1
- iii. Seminars/Viva Voce- weightage =1
- iv. Attendance - weightage =1

b) Practical: 10 weightage

- i. Attendance - weightage =2
- ii. Lab skill/quality of their results- weightage =2
- iii. Model practical test-weightage= 2 (Best one, out of two model exams
- iv. is considered)
- v. Record – weightage = 2
- vi. Viva Voce- weightage =2

c) Project: 10 weightage

- i. Literature survey and data collection -weightage=2
- ii. Interpretation of data & Preparation of Project report - weightage =2
- iii. Research attitude - weightage = 2
- iv. Viva Voce- weightage =4

The internal evaluation of Project work of each student should be done by the supervising faculty assigned by the department.

d) Viva Voce:

No internal evaluation for viva voce examinations (at the end of 4th semester).

e) Attendance:

Percentage	Grade
Above 90%	A+,
85 – 89.99%	A,
75 – 84.99%	B,
75 -79.99%	C
70 - 74.99%	D,
< 70%	E

External evaluation:

a. Theory:

In all semesters the theory courses have 30 weightage each. Pattern of question Papers for theory courses is as follows

Division	Type	No. of Questions	Weightage	Total Weightage
Section A	Short Answer	8 out of 12	1	8
Section B	Short Essay	4 out of 7	3	12
Section C	Essay	2 out of 4	5	10
Total weightage in a question paper				30

b) Practicals:

At the end of II and IV semesters. There will be three practical examinations at the end of second semester as well as at the end of fourth semester. Each examination has 30 weightage and 3 credits

c) Comprehensive Viva Voce:

At the end of IV semester on a separate day (2credits). Viva voce will be based on both the theory and practical courses during the programme.

Component	Weightage
Physical & Theoretical Chemistry – theory	5

courses	
Physical Chemistry – practical courses	5
Inorganic Chemistry – theory courses	5
Inorganic Chemistry – practical courses	5
Organic Chemistry – theory courses	5
Organic Chemistry – practical courses	5
Total weightage	30

d) Project Evaluation:

End of IV semester on a separate day. Evaluation is based on:

- a) Significance and relevance of the project-weightage=5
- b) Project report - weightage =8
- c) Presentation- weightage = 5
- c) Viva Voce- weightage =12

Total weightage 30 and credit for project is 4.

(Further details regarding the grading and evaluation are as per the University PG regulations 2019)

Audit courses:**Ability Enhancement Courses (AEC):**

This course aims to have hands on experience for the students in their respective field of study, both in the core and elective subject area. Also it is a platform for the student community to have basic concepts of research and publication.

AEC is 4 credit course and should be conducted during the first semester of the programme. Credit of the AE course will not be considered while calculating the SGPA/CGPA. But the student has to obtain minimum pass requirements in this course, which is compulsory for overall pass in the programme

One particular AEC may be selected for all the students in a batch in the department or each student in a batch may choose one AEC, among the pool of courses suggested below. Either a single faculty from the department may be in charge of this course for a batch or each student may be assigned to a particular faculty in the department, in charge of this AEC, which will be decided by the department council/ HoD.

- a) Industrial/Research institution visit/visits
- b) Publication of a research article/articles in national/international journal
- c) Presentation of research paper/papers in national level seminar/conference, which should be published in the seminar/conference proceedings
- d) Review article/articles on research topics which is presented in a national level seminar/conference and published in the proceedings
- e) Internships at any reputed research institutions/R&D centre/Industry

After conducting the AEC, the evaluation/examination should be done either common for all students in a batch or individually depending upon the AEC conducted. The evaluation/examination must be conducted jointly by the teacher in charge of the AEC and the head of the department. The result of the AEC, duly signed and sealed by both teacher in charge and head of the department, should be uploaded to the University during the stipulated time period in the third semester of the programme. Evaluation/examination must be conducted by 30 weightage pattern, as in the theory courses and the GPA and overall grade of the AEC should be uploaded to the University. Evaluation/examination on AEC must contain the following components: MCQ type written examination, Report on AEC, Presentation of AEC, Viva voce on AEC. Distribution of 30 weightage may be done by the teacher in charge in concurrence with the Head of the department.

Professional Competency Course (PCC):

This course particularly aims to improve the skill level of students, especially for using specific as well as nonspecific software useful in their respective field of study, both related to the core and elective subject area. Also, it is a platform for the student community to undertake socially

committed projects and thereby developing a method of learning process by through the involvement with society.

PCC is a 4 credit course and should be conducted during the second semester of the programme. The credit of the PC course will not be considered while calculating the SGPA/CGPA. But the student has to obtain minimum pass requirements in this course, which is compulsory for an overall pass in the programme.

One particular PCC may be selected for all the students in a batch in the department or each student in a batch may choose one PCC, among the pool of courses suggested below. The exact title of the course may be decided by the department, but the area of study should be from the pool of courses suggested below. Either a single faculty from the department may be in charge of this course for a batch or each student may be assigned to a particular faculty in the department, in charge of this PCC, which will be decided by the department council/ HoD.

- a) Development of skills on using softwares like Gaussian, Gamesetc which is useful in molecular modeling, drug designing, etc.
- b) Development of skills on using softwares like Chemdraw, Chemwindow, ISIS draw, etc which is useful in drawing purposes, structural predictions, etc.
- c) Training on computational chemistry
- d) Case study and analysis on any relevant issues in the nearby society(for example water analysis, soil analysis, acid/alkali content analysis, sugar content analysis, etc)
- e) Any community linking programme relevant to the area of study(For example Training for society on soap/perfume making, waste disposal, plastic recycling, etc)

After conducting the PCC, the evaluation/examination should be done either common for all students in a batch or individually depending upon the PCC conducted. The evaluation/examination must be conducted jointly by the teacher in charge of the PCC and the head of the department. The result of the PCC, duly signed and sealed by both teacher in charge and head of the department, should be uploaded to the University during the stipulated time period in the third semester of the programme. Evaluation/examination must be conducted by 30 weightage pattern, as in the theory courses and the GPA and overall grade of the PCC should be uploaded to the University. Evaluation/examination on PCC must contain the following components: MCQ type written examination, Report on PCC, Presentation on PCC, Viva voce on PCC. Distribution of 30 weightage may be done by the teacher in charge in concurrence with the Head of the department.

Programme Outcome

After completing M.Sc. Chemistry Programme, students will be able to:

- PO1:** Demonstrate and apply the fundamental knowledge of the basic principles in various fields of Chemistry.
- PO2:** Create awareness and sense of responsibilities towards environment and apply knowledge to solve the issues related to Environmental pollution.
- PO3:** Apply knowledge to build up small scale industry for developing endogenous product.
- PO4:** Apply various aspects of chemistry in natural products isolations, pharmaceuticals, dyes, textiles, polymers etc. and also to develop interdisciplinary approach of the subject.
- PO5:** collaborate effectively on team-oriented projects in the field of Chemistry or other related fields.
- PO6:** Communicate scientific information in a clear and concise manner both orally and in writing.
- PO7:** Inculcate logical thinking to address a problem and become result oriented with a positive attitude.
- PO8:** Explain environmental pollution issues and the remedies thereof.
- PO9:** Apply the knowledge to develop the sustainable and eco-friendly technology in Industrial Chemistry.
- PO10:** Have developed their critical reasoning, judgment and communication skills.
- PSO11:** Augment the recent developments in the field of green and eco-friendly reactions, pharmaceutical, Bioinorganic Chemistry and relevant fields of research and development.
- PO12:** Enhance the scientific temper among the students so as to develop a research culture and implementation of the policies to tackle the burning issues at global and local level.

Programme Specific Outcome

- PSO1:** Provide theoretical background and develop practical skills for analysing materials using modern analytical methods and instruments.
- PSO2:** Inculcate a problem solving approach by coordinating the different branches of chemistry
- PSO3 :** Becomes professionally skilled for higher studies in research institutions and to work in chemical industries.
- PSO4:** In-depth knowledge helps to qualify in competitive exams.

TABLE 1
Courses offered for M.Sc. Chemistry Programme under CSS Patten in Affiliated Colleges
(2022 onwards)

Semester	Course Code	Course Title	Instructions / Week	Credits
I	MCH 1 C 01	Quantum Mechanics and Computational Chemistry	4	4
	MCH 1 C 02	Chemistry of Elements	3	4
	MCH 1 C 03	Structure and Reactivity of Organic Compounds	3	4
	MCH 1 C 04	Thermodynamics, Kinetics and Catalysis	3	4
	MCH 1 L 01	Inorganic Chemistry Practical I	4	-
	MCH 1 L 02	Organic Chemistry Practical I	4	-
	MCH 1 L 03	Physical Chemistry Practical I	4	-
	Total credits:		Core	
II	MCH 2 C 05	Group Theory and Chemical Bonding	3	3
	MCH 2 C 06	Coordination Chemistry	3	3
	MCH 2 C 07	Organic Reaction Mechanisms	3	3
	MCH 2 C 08	Electrochemistry, Solid State Chemistry and Statistical Thermodynamics	3	3
	MCH 2 L 04	Inorganic Chemistry Practical II	4	3
	MCH 2 L 05	Organic Chemistry Practical II	4	3
	MCH 2 L 06	Physical Chemistry Practical II	4	3
	Total credits:		Core	
III	MCH 3 C 09	Molecular Spectroscopy	4	4
	MCH 3 C 10	Organometallic & Bioinorganic Chemistry	3	4
	MCH 3 C 11	Reagents and Transformations in Organic Chemistry	3	4
	MCH 3 L 07	Inorganic Chemistry Practical III	4	
	MCH 3 L 08	Organic Chemistry Practical III	4	
	MCH 3 L 09	Physical Chemistry Practical III	4	
	MCH 3 E 01	Synthetic Organic Chemistry (Elective)	3	4
	MCH 3 E 02	Computational Chemistry (Elective)	3	4
	MCH 3 E 03	Green and Nanochemistry (Elective)	3	4
	Total Credits:		Core	
		Elective		4

			Total	16	
IV	MCH 4 C 12	Instrumental Methods of Analysis	4	4	
	MCH 4 L 10	Inorganic Chemistry Practical IV	3	3	
	MCH 4 L 11	Organic Chemistry Practical IV	3	3	
	MCH 4 L 12	Physical Chemistry Practical IV	3	3	
	MCH 4 E 04	Petrochemicals and Cosmetics(Elective)	4	4	
	MCH 4 E 05	Industrial Catalysis(Elective)	4	4	
	MCH 4 E 06	Natural Products & Polymers (Elective)	4	4	
	MCH 4 E 07	Material Science (Elective)	4	4	
	MCH 4 E 08	Organometallic Chemistry (Elective)	4	4	
	MCH 4 P 01	Research Project	3	4	
	MCH 4 V 01	Viva Voce		2	
			Core		13
			Elective		8
		Project		4	
		Viva Voce		2	
		Total		27	
Total Credits of the Programme			Core	62	
			Elective	12	
			Project	4	
			Viva Voce	2	
			Total Credits	80	

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER I
MCH 1 C 01 – QUANTUM MECHANICS AND GROUP THEORY
(4 Credits, 72 hours)

Specific Objectives

- (1) Conceptual understanding of the laws of quantum mechanics necessary for the description of atoms and molecules and their chemical reaction
- (2) Develop working knowledge of terminology and tools used by quantum chemists
- (3) Translate a physical description of quantum mechanics problem into the mathematical equation necessary to solve it. Explain the physical meaning of the formal and/or mathematical formulation of and/or solution to a quantum mechanics problem.
- (4) Achieve physical insight through the mathematics of a problem.
- (5) Recognize symmetries and be able to take advantage of them in order to choose the appropriate method for solving a problem
- (6) Understand advantages and limitations of group theory for solving complex chemical problems

Unit 1: Mathematics for Chemists (6 hrs)

Matrix Algebra

Addition and multiplication, inverse, adjoint and transpose of matrices, special metrics (symmetric, skew –symmetric, Hermitian, skew- Hermitian, unit diagonal, unitary etc) and their properties. block factored matrices, Matrix equations: Homogenous, non-homogenous linear equations and conditions for the solution, linear dependence and independence.

Differential calculus

Functions, continuity and differentiability, rules for differentiation, application of differential calculus including maxima and minima, Functions of various variables, partial differentiation,

Integral calculus.

Basic rules for integration, integration by parts, partial fraction and substitution, Reduction formulae, applications of integral calculus.

Coordinate Systems

Cartesian, and spherical polar coordinates and their relationships

Complex Numbers

Algebraic operations, modulus and conjugate

Unit 2: Introduction to Quantum Mechanics (9 hrs)

Black body radiation and Planck's quantum postulate. Einstein's photoelectric equation, Schrodinger's wave mechanics,

Detailed discussion of postulates of quantum mechanics – State function or wave function

postulate, Born interpretation of the wave function, well behaved functions, orthonormality of wave functions

Operator postulate, operator algebra, linear and nonlinear operators, Non-commuting operators and the Heisenberg's Uncertainty principle, Laplacian operator, Hermitian operators and their properties, eigen functions and eigen values of an operator

Eigen value postulate, eigen value equation, Expectation value postulate;

Postulate of time- dependent Schrödinger equation of motion, conservative systems and time independent Schrödinger equation. Stationary states.

Unit 3: Quantum Mechanics of Translational & Vibrational Motions (9 hrs)

Free particle in one-dimension; Particle in a one-dimensional box with infinite potential walls, important features of the problem; Particle in a one-dimensional box with one finite potential wall, Particle in a rectangular well, (no derivation), Significance of the problem, Introduction to tunnelling; Particle in a three-dimensional box, Separation of variables, degeneracy, Symmetry breaking.

One-dimensional harmonic oscillator (complete treatment):- Method of power series, Hermite equation and Hermite polynomials, recursion relation, wave functions and energies, important features of the problem, harmonic oscillator model and molecular vibrations.

Unit 4 : Quantum Mechanics of Rotational Motion (9 hrs)

Planar rigid rotor (or particle on a ring), the Φ -equation, solution of the Φ -equation

One particle Rigid rotator (non-planar rigid rotator or particle on a sphere) (complete treatment): The wave equation in spherical polar coordinates, separation of variables, the Φ -equation and the Θ -equation and their solutions, Legendre and associated Legendre equations, Legendre and associated Legendre polynomials, Rodrigue's formula, spherical harmonics (imaginary and real forms), polar diagrams of spherical harmonics.

Quantization of angular momentum, quantum mechanical operators corresponding to angular momenta (L_x , L_y , L_z), commutation relations between these operators, Ladder operator method for angular momentum, space quantization.

Unit 5: Quantum Mechanics of Hydrogen-like Atoms (9hrs)

Potential energy of hydrogen-like systems, the wave equation in spherical polar coordinates, separation of variables, the R , Θ and Φ equations and their solutions, Laguerre and associated Laguerre polynomials, wave functions and energies of hydrogen-like atoms, orbitals, radial functions and radial distribution functions and their plots, angular functions (spherical harmonics) and their plots.

The postulate of spin by Uhlenbeck and Goudsmith, Dirac's relativistic equation for hydrogen atom and discovery of spin (qualitative treatment),

Spin orbitals, construction of spin orbitals from orbitals and spin functions.

Unit 6: Basic principles of group theory and Representation of Point groups (12 hrs)

Introduction - the defining properties of mathematical groups, finite and infinite groups, Abelian and cyclic groups, group multiplication tables (GMT), similarity transformation, sub groups & classes in a group. Molecular Symmetry & point groups - symmetry elements and symmetry operations in molecules, relations between symmetry operations, complete set of symmetry operations of a molecule, point groups and their systematic identification, GMT of point groups

Representations of point groups - basis for a representation, representations using vectors, atomic orbitals and Cartesian coordinates positioned on the atoms of molecule (H₂O as example) as bases, reducible representations and irreducible representations (IR) of point groups, construction of IR by reduction (qualitative demonstration only), Great Orthogonality Theorem (GOT) (no derivation) and its consequences, derivation of characters of IR using GOT, construction of character tables of point groups (C_{2v}, C_{3v}, C_{2h} and C_{4v} and C₃ as examples), nomenclature of IR - Mulliken symbols, symmetry species; Reduction formula - derivation of reduction formula using GOT, reduction of reducible representations, (e.g., G_{cart}) using the reduction formula; Relation between group theory and quantum mechanics – wavefunctions (orbitals) as bases for IR of point groups.

Unit 7: Applications of Group Theory to Molecular Spectroscopy (9hrs)

Molecular vibrations - symmetry species of normal modes of vibration, construction of G_{cart}, normal coordinates and drawings of normal modes (e.g., H₂O and NH₃), selection rules for IR and Raman activities based on symmetry arguments, determination of IR active and Raman active modes of molecules (e.g., H₂O, NH₃, CH₄, SF₆), complementary character of IR and Raman spectra.

Spectral transition probabilities - direct product of irreducible representations and its use in identifying vanishing and non-vanishing integrals, transition moment integral and spectral transition probabilities.

Electronic Spectra – electronic transitions and selection rules, Laporte selection rule for Centro symmetric molecules.

Unit 8: Applications of Group Theory to Chemical Bonding (9hrs)

Hybridisation - Treatment of hybridization in BF₃ and CH₄, Inverse transformation and construction of hybrid orbitals. Molecular orbital theory – HCHO and H₂O as examples, classification of atomic orbitals involved into symmetry species, group orbitals, symmetry adapted linear combinations (SALC), projection operator, construction of SALC using projection operator, use of projection operator in constructing SALCs for the pMOs in cyclopropenyl (C₃H₃⁺) cation.

References

For units 1 -5

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- (2) I.N. Levine, Quantum Chemistry, 6th Edition, Pearson Education Inc.,

- (3) P.W. Atkins and R.S. Friedman, *Molecular Quantum Mechanics*, 4th Edition, Oxford University Press, 2005.
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- (6) Thomas Engel, *Quantum Chemistry & Spectroscopy*, Pearson Education, 2006.
- (7) J.P. Lowe, *Quantum Chemistry*, 2nd Edition, Academic Press Inc., 1993.
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- (10) L. Pauling and E.B. Wilson, *Introduction to Quantum Mechanics*, McGraw-Hill, 1935 (A good source book for many derivations).
- (11) R.L. Flurry, Jr., *Quantum Chemistry*, Prentice Hall, 1983.
- (12) R.K. Prasad, *Quantum Chemistry*, 3rd Edition, New Age International, 2006.

For units 6 -8

- (1) F.A. Cotton, *Chemical applications of Group Theory*, 3rd Edition, John Wiley & Sons Inc., 2003.
- (2) H. H. Jaffe and M. Orchin, *Symmetry in Chemistry*, John Wiley & Sons Inc., 1965.
- (3) L.H. Hall, *Group Theory and Symmetry in Chemistry*, McGraw Hill, 1969.
- (4) R. McWeeny, *Symmetry: An Introduction to Group Theory and its Applications*, Pergamon Press, London, 1963.
- (5) P.H. Walton, *Beginning Group Theory for Chemistry*, Oxford University Press Inc., New York, 1998.
- (6) Mark Ladd, *Symmetry & Group Theory in Chemistry*, Horwood 1998.
- (7) A. Salahuddin Kunju & G. Krishnan, *Group Theory & its Applications in Chemistry*, PHI Learning, Pvt. Ltd. 2010.
- (8) Arthur M Lesk, *Introduction to Symmetry & Group theory for Chemists*, Kluwer Academic Publishers, 2004.
- (9) K. Veera Reddy, *Symmetry & Spectroscopy of Molecules 2nd Edn.*, New Age International 2009.
- (10) A.W. Joshi, *Elements of Group Theory for Physicists*, New Age International Publishers, 1997

M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER I
MCH1C02 – CHEMISTRY OF ELEMENTS
(4 Credits, 54hrs)

Specific Objectives

- To learn about the basic concepts of acids and bases.
- To understand the various reactions in non-aqueous solvents.
- To understand the chemistry of main group elements.
- To acquire information about the magnetic properties.
- To learn the basics of nuclear chemistry and different types of nuclear reactions.

Unit 1: Concepts of Acids and Bases, and Nonaqueous Solvents (9hrs)

Major acid-base concepts, Arrhenius, Bronsted-Lowry, Solvent system, Lux-Flood, Lewis and Usanovich concepts. HSAB principle.-Theoretical basis of hardness and softness. The Drago-Wayland equation, E and C parameters- Symbiosis. Applications of HSAB concept. Super acids, superbases, surface acidity.

Chemistry of nonaqueous solvents- NH_3 , SO_2 , H_2SO_4 , BrF_3 , HF , N_2O_4 and HSO_3F . Nonaqueous solvents and acid-base strength.

Unit 2: Chemistry of Main Group Elements-I (9hrs)

Boron hydrides-preparation, reactions, structure, and bonding. Styx numbers-closo, nido, arachno polyhedral structures. Boron cluster compounds-Wade's rule. Polyhedral borane anion-carboranes, metallaboranes and metallocarboranes. Borazines and borides.

Unit 3: Chemistry of Main Group Elements-II (9hrs)

Silicates and alumino silicates-Structure, molecular sieves-Zeolite. Silicones-Synthesis, structure and uses. Carbides and silicides. Synthesis, structure, bonding and uses of Phosphorous-Nitrogen, Phosphorous -Sulphur and Sulphur-Nitrogen compounds.

Unit 4: Standard reduction potentials and their diagrammatic representations (9hrs)

Ellingham diagram. Latimer and Frost diagrams. Pourbaix diagram.

Heteropoly and isopoly anions of V, Cr, W, Mo, Polyatomic Zintl anions and cations. Chevrel phases.

Unit 5: Magnetic properties of Transition Inner Transition Elements (9hrs)

Term symbols. Magnetic property - Paramagnetism, Diamagnetism, Ferromagnetism, Antiferromagnetism, Ferrimagnetism. Magnetic susceptibility. Curie and Curie-Weiss Law. Magnetic moment and its expressions. Quenching of orbital magnetic moment. Magnetic exchange interactions-Superexchange and direct exchange. Determination of magnetic

moment of complexes -Gouy Method, Faraday Method, VSM and SQUID. Uranyl compounds. Trans-actinide elements.

Unit 6: Nuclear and Radiation Chemistry (9hrs)

Structure of nucleus: shell, liquid drop, Fermi gas, collective and optical models. Nuclear reaction: Bethe`s notation of nuclear process- Types-reaction cross section- photonuclear and thermonuclear reactions. Super heavy elements –production and chemistry.

Nuclear fission: Theory of fission- neutron capture cross section and critical size. Nuclear fusion. Neutron activation analysis

Radiation chemistry: Interaction of radiation with matter. Detection and measurement of radiation- GM and scintillation counters – radiolysis of water - radiation hazards - radiation dosimetry.

References

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FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER I
MCH 1 C 03 - STRUCTURE AND REACTIVITY OF ORGANIC COMPOUNDS
(4 Credits, 54hrs)

Specific objectives

1. To give a broad understanding on structure, stability and bonding in organic molecules
2. To give an idea on the impact of molecular structure on reactivity.
3. To obtain the idea of molecular conformation of reactivity, mechanism and stereochemical outcome.
4. To apply the concept of stereochemistry to different compounds and reactions.
5. To gain idea on different methods of asymmetric synthesis.

Unit 1: Structure and Bonding in Organic Molecules (9hrs)

Nature of Bonding in Organic Molecules: Localized and delocalized chemical bonding, bonding weaker than covalent bond, cross- conjugation, resonance, rules of resonance, resonance hybrid and resonance energy, tautomerism, hyperconjugation, π - π interactions, $p\pi$ - $d\pi$ bonding (ylides). Stability of benzylic cations and radicals. Effect of delocalized electrons on pKa.

Hydrogen bonding: Inter and intra-molecular hydrogen bonding. Range of the energy of hydrogen bonding. Physical and chemical properties of organic compounds- volatility, acidity, basicity and stability, stabilization of hydrates of glyoxal, chloral, and ninhydrin, high acid strength of maleic acid compared to fumaric acid. Effect of hydrogen bond on conformation,

Electron donor-acceptor complexes, crown ether complexes, cryptates, inclusion compounds and cyclodextrins.

Hückel MO method. MO's of simple molecules, ethylene, allyl radical and 1,3-butadiene. Hückel rule and modern theory of aromaticity, criteria for aromaticity and antiaromaticity, MO description of aromaticity and antiaromaticity. Homoaromaticity. Aromaticity of annulenes and heteroannulenes, fused ring systems, fulvenes, fulvalenes, azulenes, pentalenes and heptalenes.

Unit 2: Structure and Reactivity (9hrs)

Transition state theory, Potential energy vs reaction co-ordinate curve, substituent effects (inductive, mesomeric, inductomeric, electomeric and field effects) on reactivity. Qualitative study of substitution effects in S_N1 - S_N2 reactions. Neighbouring group participation, participation of carboxylate ion, halogen, hydroxyl group, acetoxy group, phenyl group and pi -bond. Classical and nonclassical carbocations

Basic concepts in the study of organic reaction mechanisms: Application of experimental criteria to mechanistic studies, kinetic versus thermodynamic control- Hammond postulate, Bell-Evans-Polanyi principle, Marcus equation, Curtin-Hammet principles,. Acidity constant, Hammett acidity function.

Isotope effect (labeling experiments), stereochemical correlations. Semiquantitative study of substituent effects on the acidity of carboxylic acids. Quantitative correlation of substituent effects on reactivity. Linear free energy relationships. Hammett and Taft equation for polar effects and Taft's steric substituent constant for steric effect. Solvent effects- Dimroth parameter

Unit 3: Conformational Analysis – I (9hrs)

Factors affecting the conformational stability of molecules – dipole interaction, bond opposition strain, bond angle strain. Conformation of acyclic compounds – Ethane, n- butane, Influence of dipole moment and hydrogen bonding on conformational stability- Conformation of alkene dihalides, glycols, chlorohydrins, tartaric acid, erythro and threo isomer.

Interconversion of axial and equatorial bonds in chair conformation of cyclohexane– distance between the various H atoms and C atoms in chair and boat conformations. Monosubstituted cyclohexane–methyl and t-butyl cyclohexanes–flexible and rigid systems. Conformation of 1,2-, 1,3-, and 1,4 disubstituted cyclohexane Conformation of substituted cyclohexanone, 2-bromocyclohexanone, dibromocyclohexanone, (cis & trans), 2-bromo-4,4-dimethyl cyclohexanone. Anchoring group and conformationally biased molecules. Conformations of 1,4 -cis and -trans disubstituted cyclohexanes in which one of the substituent is 1-butyl and their importance in assessing the reactivity of an axial or equatorial substituent. Conformation of 1,2-, 1,3-, and 1,4-cyclohexane diol.

Unit 4: Conformational Analysis – II (9 hrs)

Effect of conformation on the course and rate of reactions in (a) debromination of dl and meso 2,3-dibromobutane or stilbene dibromide using KI. (b) semipinacolic deamination of erythro and threo 1,2-diphenyl-1-(p-chlorophenyl)-2-amino ethanol. (c) dehydro halogenation of stilbene dihalide (dl and meso) and erythro threo- bromo-1,2-diphenyl propane.

Effect of conformation on the course and rate of reactions in cyclohexane systems illustrated by: (a) S_N2 and S_N1 reactions for (i) an axial substituent, and (ii) an equatorial substituent in flexible and rigid systems. (b) E1, E2 eliminations illustrated by the following compounds. (i) 4-t-Butylcyclohexyl tosylate (cis and trans) (ii) 2- Phenylcyclohexanol (cis and trans) (iii) Menthyl and neomenthyl chlorides and benzene hexachlorides. (c) Pyrolytic elimination of

esters (cis elimination) (d) Esterification of axial as well as equatorial hydroxyl and hydrolysis of their esters in rigid and flexible systems. (Compare the rate of esterification of methanol, isomenthol, neomenthol and neoisomenthol). (f) Esterification of axial as well as equatorial carboxyl groups and hydrolysis of their esters. (g) Hydrolysis of axial and equatorial tosylates. (h) Oxidation of axial and equatorial hydroxyl group to ketones by chromic acid. Bredt's rule. Stereochemistry of fused, bridged and caged ring systems-decalins, norbornane, barrelene and adamantanes.

Unit 5: Stereochemistry (9hrs)

Conformation and configuration, Fischer, Newman and Sawhorse projection formulae and their interconversion. Concept of chirality, recognition of symmetry elements and chiral structures, conditions for optical activity, optical purity. Specific rotation and its variation in sign and magnitude under different conditions, relative and absolute configurations, Fisher projection formula, sequence rule – *R* and *S* notation in cyclic and acyclic compounds, Cahn-Ingold-Prelog (CIP) rule. Mixtures of stereoisomers; enantiomeric excess and diastereomeric excess and their determination. Methods of resolution diastereomers. Resolution of racemates after conversion into diastereomers; use of *S*-brucine, kinetic resolution of enantiomers, chiral chromatography.

Optical isomerism of compounds containing one or more asymmetric carbon atoms, enantiotopic, homotopic, diastereotopic hydrogen atoms, prochiral centre. Pro-*R*, Pro-*S*, Re and Si.

Optical isomerism in biphenyls, allenes and nitrogen and sulphur compounds, conditions for optical activity, *R* and *S* notations. Optical activity in cis-trans conformational isomers of 1,2-, 1,3- and 1,4-dimethylcyclohexanes.

Restricted rotation in biphenyls – Molecular overcrowding. Chirality due to folding of helical structures. *P/M* notations, Chirality due to chiral plane-*R/S* notation

Geometrical isomerism – *E* and *Z* notation of compounds with one and more double bonds in acyclic systems. Configuration of cyclic compounds-monocyclic, fused and bridged ring systems, inter conversion of geometrical isomers. Methods of determination of the configuration of geometrical isomers in acyclic and cyclic systems, stereochemistry of aldoximes and ketoximes IUPAC nomenclature of regio and stereo isomers of organic molecules.

stereoselectivity and stereospecificity, enatio selectivity and diastereo selectivity. Stereoselective and stereospecific reactions: (i) Bromination of *E*-and *Z*-2-butene-a

stereospecific anti addition, (ii) Epoxidation of E- and Z-2 butene- a stereospecific reaction, (iii) Bromination of cyclohexene- a stereoselective reaction, (iv) Hydroboration-Oxidation hydration of alkenes- a stereospecific anti-Markovnikov hydration (v) Addition of carbenes to alkenes.

Unit 6: Asymmetric Synthesis (9 hrs)

Asymmetric synthesis, need for asymmetric synthesis, stereoselectivity and stereospecificity. Chiral pool: chiral pool synthesis of beetle pheromone component (S)- (-)-ipsenol from (S)- (-)-leucine. Conversion of L-tyrosine into L-Dopa.

Classification of Asymmetric reactions into (1) Substrate controlled (2) Chiral auxiliary controlled (3) Chiral reagent controlled and (4) Chiral catalyst controlled.

Substrate controlled asymmetric synthesis: Nucleophilic addition to chiral carbonyl compounds. 1,2-asymmetric induction, Cram's rule and Felkin-Anh model.

Chiral auxiliary controlled asymmetric synthesis: α -Alkylation of chiral enolates, azaenolates, imines and hydrazones, chiral sulfoxides. 1,4-Asymmetric induction and Prelog's rule. Use of chiral auxiliary in Diels-Alder and Cope reactions.

Chiral reagent controlled asymmetric synthesis: Asymmetric reduction using BINAL- H. Asymmetric hydroboration using IPC_2BH and IPCBH_2 . Reduction with CBH reagent. Stereochemistry of Sharpless asymmetric epoxidation and dihydroxylation

Asymmetric aldol reaction: Diastereoselective aldol reaction and its explanation by Zimmermann-Traxler model. Auxiliary controlled aldol reaction. Double diastereoselection- matched and mismatched aldol reactions Chiral catalyst controlled: Ruthenium catalyst with chiral phosphine, Reduction with CBS reagent, Sharpless asymmetric epoxidation and dihydroxylation.

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FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER I
MCH 1 C 04 – THERMODYNAMICS, KINETICS AND CATALYSIS
(4 Credits, 54hrs)

Specific Objectives

- To learn and apply laws and concepts in thermodynamics to solve real life processes.
- To understand various approximations and mechanisms needed to explain kinetics of fast reactions, chain reactions and those involving reactive atoms and free radicals.
- To learn basics of various theories in Chemical Kinetics.
- To understand fundamental theories and methods in surface chemistry.
- To acquire knowledge regarding various mechanisms of catalyzed reactions.

Unit 1: Thermodynamics (9hrs)

Review of First and Second law of thermodynamics, Third law of thermodynamics, Need for third law, Nernst heat theorem, Apparent exceptions to third law, Applications of Third law, Determination of Absolute entropies, Residual entropy.

Thermodynamics of Solutions: Partial molar quantities, Chemical potential, Variation of chemical potential with temperature and pressure, Partial molar volume and its determination, Gibbs-Duhem equation, Thermodynamics of ideal and real gases and gaseous mixtures, Fugacities of gases and their determinations, Activity, Activity coefficient, standard state of substance (for solute and solvents), Duhem-Margules equation and its applications. Thermodynamics of ideal solutions, Deduction of the laws of Raoult's ebullioscopy, cryoscopy, and osmotic pressure. Non ideal solutions, Deviations from Raoult's law, Excess functions- excess free energy, excess entropy, excess enthalpy, excess volume.

Unit 2: Thermodynamics of Irreversible Processes (9 hrs).

Thermodynamics of irreversible process: Stationary state concept. Principle of local equilibrium. Simple examples of irreversible processes, general theory of non-equilibrium processes, forces and fluxes, entropy production in simple irreversible systems (closed systems) involving heat flow only and both heat flow and matter flow, the phenomenological relations, Onsager relations: Linear relations-coupled flows.

Onsager reciprocal relations (no derivation), application to the theory of diffusion, thermal diffusion, thermo-osmosis and thermo- molecular pressure difference, electro-kinetic effects, the Glansdorf Pregogine equation.

Unit 3: Chemical Kinetics (9 hrs)

Kinetics of reactions involving reactive atoms and free radicals - Rice - Herzfeld mechanism and steady state approximation in the kinetics of organic gas phase decompositions (acetaldehyde & ethane); Kinetics of chain reactions – branching chain and explosion limits (H₂-O₂ reaction as an example); Kinetics of fast reactions- relaxation methods, molecular beams, flash photolysis; Solution kinetics: Factors affecting reaction rates in solution, Effect of solvent and ionic strength (primary salt effect) on the rate constant, secondary salt effects.

Unit 4: Molecular Reaction Dynamics (9 hrs)

Reactive encounters: Collision theory, diffusion controlled reactions, the material balance equation, Activated Complex theory – the Eyring equation, thermodynamic aspects of ACT; Comparison of collision and activated complex theories; The dynamics of molecular collisions – Molecular beams, principle of crossed-molecular beams; Potential energy surfaces - attractive and repulsive surfaces, London equation, Statistical distribution of molecular energies; Theories of unimolecular reactions - Lindemann's theory, Hinshelwood's modification, Rice -Ramsperger and Kassel (RRK) model.

Unit 5: Surface Chemistry (9 hrs)

Structure and chemical nature of surfaces, Adsorption at surfaces - Adsorption isotherms, Langmuir's unimolecular theory of adsorption, BET equation, derivation, Determination of surface area and pore structure of adsorbents - physical adsorption methods, X-ray methods, mercury intrusion method, chemisorption methods. Determination of surface acidity - TPD method. Heat of adsorption and its determination.

Unit 6: Catalysis (9hrs)

Features of homogeneous catalysis – Enzyme catalysis - Michaelis-Menten Mechanism. Features of heterogeneous catalysis - Langmuir-Hinshelwood mechanism and Eley-Rideal mechanism – illustration using the reaction $2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$. Methods of preparation of heterogeneous catalysts - precipitation and co-precipitation methods, sol gel method, flame hydrolysis. Preparation of Zeolites and silica supports. Auto catalysis - oscillating reactions – mechanisms of oscillating reactions (Lotko -Volterra, brusselator and oregonator).

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FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER II
MCH 2 C 05 - QUANTUM MECHANICS AND COMPUTATIONAL CHEMISTRY

(3 Credits, 54hrs)

Specific Objectives

- (1) Develop working knowledge of terminology and tools used by quantum chemists
- (2) Learn how quantum mechanics manifests itself in nature and experimental science.
- (3) Able to choose the appropriate method (in terms of applicability, accuracy, and economy) for the calculation of a given chemical problem
- (4) Learn how computational chemistry can be a valid alternatives and complements to the experimental methods in chemistry.

Unit 1: Approximation Methods in Quantum Mechanics (9hrs)

Many body problem and the need of approximation methods; Independent particle model; Variation method – variation theorem with proof, illustration of variation theorem using a trial function [e.g., $x(a-x)$] for particle in a 1D-box, variation treatment for the ground state of helium atom; Perturbation method – time-independent perturbation method (non-degenerate case only), illustration by application to particle in a 1D-box with slanted bottom, perturbation treatment of the ground state of the helium atom.

Unit 2: Quantum Mechanics of Many-electron Atoms (9hrs)

Hartree's Self-Consistent Field method for atoms, Fock modification using spin orbitals & Hartree-Fock Self-Consistent Field (HF-SCF) method for atoms, the Fock operator; Pauli's antisymmetry principle – Slater determinants; Roothan's concept of basis functions – Slater type orbitals (STO) and Gaussian type orbitals(GTO).

Unit 3: Chemical bonding in diatomic molecule (9hrs)

Schrödinger equation for a molecule, Born – Oppenheimer approximation; Valence Bond (VB) theory – VB theory of H₂ molecule, singlet and triplet state functions (spin orbitals) of H₂; Molecular Orbital (MO) theory – MO theory of H₂⁺ ion, MO theory of H₂ molecule, MO treatment of homonuclear diatomic molecules – Li₂, Be₂, C₂, N₂, O₂ & F₂ and hetero nuclear diatomic molecules – LiH, CO, NO & HF, bond order, correlation diagrams, non-crossing rule; Spectroscopic term symbols for diatomic molecules; Comparison of MO and VB theories.

Unit 4: Chemical Bonding in polyatomic molecules (9hrs)

Hybridization – quantum mechanical treatment of sp, sp² & sp³ hybridisation; Semi empirical MO treatment of planar conjugated molecules – Hückel Molecular Orbital (HMO) theory of ethylene, butadiene & allylic anion, charge distributions and bond orders from the coefficients

of HMO, calculation of free valence, HMO theory of aromatic hydrocarbons (benzene); formula for the roots of the Hückel determinantal equation, Frost -Hückel circle mnemonic device for cyclic polyenes.

Unit 5: Introduction to Computational Chemistry - I (9hrs)

Electronic structure of molecules – Basics of HF-SCF method of molecules (derivation not required). Classification of Computational Chemistry methods – Molecular mechanics methods (concept of force field) and Electronic structure methods, ab initio and semi-empirical methods (Basic idea only), Concept of electron correlation and post HF methods. (Elementary idea)

Unit 6: Introduction to Computational Chemistry – II (9hrs)

Basis set approximation in ab initio methods -classification of basis sets – minimal, double zeta, triple zeta, split-valence, polarization & diffuse basis sets, Pople-style basis sets and their nomenclature. Simple calculations using Gaussian programme –The structure of a Gaussian input file, Types of key words, Specification of molecular geometry using (a) Cartesian coordinates and (b) Internal coordinates. The Z-matrix - Z- matrices of some simple molecules like H₂, H₂O, formaldehyde, cis and trans H₂O₂, and ammonia.

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FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER II
MCH2C06 – COORDINATION CHEMISTRY
(3Credits, 54hrs)

Objective of the course

- The student shall acquire a foundation of chemistry of sufficient breadth and depth of co-ordination compounds which enable them to understand and apply their knowledge.
- To develop knowledge of coordination compounds and their stability
- To understand the development in the theory of bonding in coordination complexes
- To familiarize the spectral and magnetic properties associated with complexes
- To understand different spectroscopic techniques to characterize complex
- To understand reactions of complexes

Unit 1: Stability of Co-ordination Compounds (6hrs)

Stereochemistry of coordination compounds. Stepwise and overall formation constants and the relationship between them. Trends in stepwise formation constants. Determination of binary formation constants by pH-metry and spectrophotometry. Stabilisation of unusual oxidation states. Ambidentate and macrocyclic ligands. Chelate effect and its thermodynamic origin. Macrocyclic and template effects.

Unit 2: Theories of Bonding in Coordination Compounds (9hrs)

Sidgwick's electronic interpretation of coordination. The valence bond theory and its limitations. The crystal field and ligand field theories. Splitting of d orbitals in octahedral, tetrahedral, square planar, square pyramidal and trigonal bipyramidal fields, LFSE, Dq values, Jahn Teller (JT) effect, theoretical failure of crystal field theory, evidence of covalency in the metal-ligand bond, nephelauxetic effect, ligand field theory, molecular orbital theory- M.O energy level diagrams for octahedral and tetrahedral complexes without and with π -bonding, experimental evidences for pi-bonding.

Unit 3: Spectral and Magnetic Properties of Complexes (9hrs)

Electronic Spectra of complexes: Term symbols of d^n system, Racah parameters, splitting of terms in weak and strong octahedral and tetrahedral fields, d-d transitions, selection rules for electronic transitions-effect of spin orbit coupling and vibronic coupling.

Interpretation of electronic spectra of complexes: Orgel diagrams and demerits, TanabeSugano diagrams, calculation of Dq, B and β (Nephelauxetic ratio) values, spectra of complexes with lower symmetries, charge transfer spectra, luminescence spectra. temperature independent

paramagnetism (TIP), magnetic properties of lanthanoid and actinoid complexes spin state cross over.

Unit 4: Coordination Chemistry of Lanthanoids and Actinoids (6hrs)

Term symbols for lanthanide ions, inorganic compounds and coordination complexes of the lanthanoids, electronic spectra and, General characteristics of actinoid- difference between 4f and 5f orbitals, coordination complexes of the actinoids, comparative account of coordination chemistry of lanthanoids and actinoids with special reference to electronic spectra and magnetic properties.

Unit 5: Characterization of Coordination Complexes (9hrs)

Infrared spectra of metal complexes. Group frequency concept. Changes in ligand vibrations on coordination- metal ligand vibrations (Carbonyls, thiocyanates, nitro). Application in coordination complexes.

ESR spectra – application to copper complexes. *NMR spectroscopy* for structural studies of diamagnetic metal complexes from chemical shift and spin- spin coupling.

Mossbauer spectroscopy- Mossbauer Effect, hyperfine interactions (qualitative treatment). Application to iron and tin compounds.

Unit 6: Kinetics and Mechanism of Reactions in Metal Complexes (9hrs)

Thermodynamic and kinetic stability, kinetics and mechanism of nucleophilic substitution reactions in square planar complexes- trans effect-theory and applications

Kinetics and mechanism of octahedral substitution- water exchange, dissociative and associative mechanisms, base hydrolysis, racemization reactions, solvolytic reactions (acidic and basic).

Electron transfer reactions: Outer sphere mechanism-Marcus theory, inner sphere mechanism-Taube mechanism, mixed outer and inner sphere reactions, two electron transfer and intramolecular electron transfer.

Unit 7: Redox and Photochemical Reactions of Complexes (6hrs)

Photochemical reactions of metal complexes- Prompt and delayed reactions. Excited states of metal complexes- Interligand, ligand field, charge transfer and delocalized states. Properties of ligand field excited states. Photosubstitution-Prediction of substitution lability by Adamson's rules. Photoaquation. Photo isomerization and photo racemization. Illustration of reducing and oxidizing character of $[\text{Ru}(\text{bipy})_3]^{2+}$ in the excited state. Metal complex sensitizers- water photolysis.

References:

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M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER II
MCH 2 C 07 - REACTION MECHANISM IN ORGANIC CHEMISTRY
(3 Credits, 54hrs)

Specific objectives

1. To understand the mechanism, regiochemistry and stereochemistry of aliphatic and aromatic substitution reactions.
2. To give an idea on addition and elimination reactions and their mechanisms
3. To give an idea on reactive intermediates and their transformations
4. To obtain a broad understanding on pericyclic reactions and photochemistry of organic compounds.
5. To gain a broad understanding on molecular rearrangements and reactions of carbonyl compounds.

Unit 1: Aliphatic and Aromatic Substitutions (9 hrs)

Nucleophilic Aliphatic Substitution: Mechanism and Stereochemistry of S_N2 and S_N1 reactions. Ion pair mechanism. The effect of substrate structure, reaction medium, nature of leaving group and nucleophile on S_N2 and S_N1 reactions. S_Ni and neighboring group mechanism. SET mechanism. Allylic and benzylic substitutions. Ambident nucleophiles and substrates regioselectivity.

Electrophilic Aliphatic Substitution: Mechanism and stereochemistry of S_E1 , S_E2 (front), S_E2 (back) and S_{Ei} reactions. The effect of substrate structure, leaving group and reaction medium on S_E1 and S_E2 reactions.

Electrophilic Aromatic Substitution: Arenium ion mechanism, substituent effect on reactivity in mono and disubstituted benzene rings, *ortho/para* ratio, *Ipsa* substitution. Relationship between reactivity and selectivity. Nucleophilic Aromatic substitution: Addition-elimination (S_{NAr}) mechanism, elimination-addition (benzyne) mechanism, *cine* substitution, S_{N1} and S_{RN1} mechanism. The effect of substrate structure, nucleophile and leaving group on aromatic nucleophilic substitution.

Unit 2: Addition & Elimination Reactions and Reactive Intermediates (9hrs)

Mechanistic and stereochemical aspects of addition to $C=C$ involving electrophiles, nucleophiles and free radicals. Effect of substituents on rate of addition, orientation of addition, addition to conjugated systems and cyclopropane rings, Michael reaction.

Mechanistic and stereochemical aspects of $E1$, $E1cB$ and $E2$ eliminations. The effect of substrate structure, base, leaving group and reaction medium on elimination reactions. Saytzev elimination, Hofmann elimination, α -elimination, pyrolytic *syn* elimination (E_i) and conjugate eliminations. Competition between substitution and elimination reactions, basicity

vs nucleophilicity. Extrusion reactions-extrusion of N₂, CO and CO₂.

Reactive Intermediates: Generation, geometry, stability and reactions of carbonium ions and carbanions, free radicals, carbenes, nitrenes and benzyne.

Unit 3: Chemistry of Carbonyl Compounds (9hrs)

Reactions of Carbon-heteromultiple Bonds: Reactivity of carbonyl compounds toward addition, mechanistic aspects of hydration, addition of alcohols, and condensation with nitrogen nucleophiles to aldehydes and ketones. Addition of organometallic reagents- Grignard reagents- organozinc, organocopper and organolithium reagents- to carbonyl compounds. Aldol, Perkin, Claisen, Dieckmann, Stobbe and benzoin condensation. Darzen's, Knoevenagel, Reformatsky, Wittig, Cannizzaro, Mannich and Prins reactions. MPV reduction and Oppenauer oxidation.

Addition to carbon-nitrogen multiple bond: Ritter reaction and Thorpe condensation. Hydrolysis, alcoholysis and reduction of nitriles.

Esterification and Ester Hydrolysis: Mechanisms of ester hydrolysis and esterification, Acyl-oxygen and alkyl oxygen cleavage.

Unit 4: Pericyclic Reactions (9 hrs)

Phase and symmetry of molecular orbitals, FMOs of ethylene, 1,3-butadiene, 1,3,5-hexatriene, allyl and 1,3-pentadienyl systems. Pericyclic reactions: electrocyclic, cycloaddition, sigmatropic, chelotropic and group transfer reactions. Theoretical models of pericyclic reactions: TS aromaticity method (Dewar-Zimmerman approach), FMO method and Correlation diagram method (Woodward-Hoffmann approach). Woodward- Hoffmann selection rules for electrocyclic, cycloaddition and sigmatropic reactions. Stereochemistry of Diels-Alder reactions and regioselectivity. Cope and Claisen rearrangements. Stereochemistry of cope rearrangement and valence tautomerism. 1,3- dipolar cycloaddition reactions and *ene* reactions.

Unit 5: Photochemistry of Organic Compounds (9 hrs)

Photochemical excitation of molecules, spin multiplicity, Jablonski diagram, photosensitization and quenching. Photochemistry of carbonyl compounds: Norrish type-I cleavage of acyclic, cyclic and β , γ -unsaturated carbonyl compounds, β - cleavage, γ -hydrogen abstraction: Norrish type-II cleavage, photo reduction, photoenolization. Photocyclo-addition of ketones with unsaturated compounds: Paterno-Büchi reaction, photodimerisation of α , β -unsaturated ketones, Photo rearrangements: Photo -Fries, di- π -methane, lumiketone, oxa di- π -methane rearrangements. Barton and Hoffmann-Loeffler-

Freytag reactions. Photo isomerisation and dimerisation of alkenes, photo isomerisation of benzene and substituted benzenes, photooxygenation.

Unit 6: Molecular Rearrangements and Transformations (9hrs)

Rearrangements occurring through carbocations, carbanions, carbenes and nitrenes such as Wagner-Meerwein, Demjanov, dienone-phenol, benzyl-benzilic acid, Favorskii, Wolff, Hofmann, Curtius, Lossen, Schmidt, Beckmann, Fries, Bayer-Villiger, Wittig, Orton, and Fries rearrangements. Peterson reaction, Woodward and Prevost hydroxylation reactions. Heck, Negishi, Sonogashira, Stille, and Suzuki coupling reactions (mechanism only).

References:

1. M. B. Smith and J. March, *March's Advanced Organic Chemistry*, 6/e, John Wiley & Sons, 2007.
2. F. A. Carey and R. J. Sundburg, *Advanced Organic Chemistry, Part A & B*, 5/e, Springer, 2007.
3. E. V. Anslyn and D. A. Dougherty, *Modern Physical Organic Chemistry*, University Science Books, 2005.
4. T. H. Lowry and K. S. Richardson, *Mechanism and Theory in Organic Chemistry*, 3/e Addison-Wesley, 1998.
5. R. O. C. Norman and J. M. Coxon, *Principles of Organic Synthesis*, 3/e, CRC Press, 1998.
6. Peter Sykes, *A Guide book to Mechanism in Organic Chemistry*, 6/e, Pearson, 2006.
7. S. Sankararaman, *Pericyclic Reactions-A Textbook: Reactions, Applications and Theory*, Wiley VCH, 2005.
8. Iyan Fleming, *Molecular Orbitals and Organic Chemical Reactions*, Wiley, 2009.
9. J. Sing and J. Sing, *Photochemistry and Pericyclic Reactions*, 3/e, New Age International, 2012.
10. G. M. Loudon, *Organic Chemistry*, 4/e, Oxford University Press, 2008
11. M. B. Smith, *Organic Chemistry: An Acid Base Approach*, CRC Press, 2010.
12. T. Okuyama and H. Maskill, *Organic Chemistry A Mechanistic Approach*, Oxford University Press, 2014.
13. Iyan Fleming, *Selected Organic Synthesis*, John Wiley and Sons, 1982.
14. T. Landbery, *Strategies and Tactics in Organic Synthesis*, Academic Press, London,

1989.

15. E. Corey and I.M. Chang, *Logic of Chemical Synthesis*, John Wiley, New York, 1989.
16. I L. Finar, *Organic Chemistry Vol 2: Stereochemistry and the Chemistry of Natural Products*, 5/e, Pearson, 2006.
17. N. R.Krishnaswamy, *Chemistry of Natural Products: A Laboratory Hand Book*, 2/e, Universities Press.

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER II
MCH 2 C 08 - ELECTROCHEMISTRY, SOLID STATE CHEMISTRY AND
STATISTICAL THERMODYNAMICS
(3 Credits, 54hrs)

Specific Objectives

- To understand basic concepts and theories involved in electrode processes.
- To have a comparative study about the construction and efficiency of electrochemical cells and fuel cells.
- To gain knowledge about crystal symmetry and crystallographic point groups and their applications.
- To understand various theories on structure of solids and to explain their different properties.
- To learn fundamentals of statistical thermodynamics and to have comparative study of Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics.

Unit 1: Ionic Interaction & Equilibrium Electrochemistry (9hrs)

The nature of electrolytes, Ion activity, Ion-ion and ion-solvent interaction, The electrical potential in the vicinity of an ion, Electrical potential and thermodynamic functions. The Debye-Hückel equation, Limiting and extended forms of the Debye-Hückel equation, Applications of the Debye-Hückel equation for the determination of thermodynamic equilibrium constants and to calculate the effect of ionic strength on ion reaction rates in solution

Origin of electrode potentials-half cell potential-standard hydrogen electrode, reference electrodes- electrochemical series, applications- cell potential, Nernst equation for electrode and cell potentials, Nernst equation for potential of hydrogen electrode and oxygen electrode-thermodynamics of electrochemical cells, efficiency of electrochemical cells and comparison with heat engines-primary cells (Zn, MnO₂) and secondary cells (lead acid, Ni-Cd and Ni-MH cells), electrode reactions, potentials and cell voltages, advantages and limitations three types of secondary cells.

Fuel cells; polymer electrolyte fuel cell (PEMFCs), alkaline fuel cells (AFCs), phosphoric acid fuel cells (PAFCs), direct methanol fuel cells, electrode reactions and potentials, cell reactions and cell voltages, advantages and limitations of four types of fuel cells

Unit 2: Dynamic Electrochemistry (9hrs)

Electrical double layer-electrode kinetics of electrode processes, the Butler-Volmer equation-

The relationship between current density and overvoltage, the Tafel equation. Polarization-electrolytic polarization, dissolution and deposition potentials, concentration polarization; Overvoltage: hydrogen overvoltage and oxygen overvoltage: decomposition potential and overvoltage, individual electrode over voltages and its determination-metal deposition over voltage and its determination- theories of hydrogen overvoltage, the catalytic theory, the slow discharge theory, the electrochemical theory. Principles of polarography-dropping mercury electrode, the half wave potential.

UNIT 3: Solid State – I (9hrs)

Crystal symmetry: Symmetry elements and symmetry operations, mathematical proof for the non-existence of 5-fold axis of symmetry, crystal systems, Bravais lattices and crystal classes, Crystallographic point groups - Schönflies & Hermann–Mauguin notations, Stereographic projections of the 27 axial point groups, translational symmetry elements & symmetry operations - screw axes and glide planes, introduction to space groups.

Bragg's law and applications, lattice planes and miller indices, *d*-spacing formulae, crystal densities and unit cell contents,

Imperfections in solids - point, line and plane defects, non-stoichiometry.

UNIT 4: Solid State – II (9hrs)

Electronic structure of solids – free electron theory, band theory & Zone theory, Brillouin zones; Electrical properties - electrical conductivity, Hall effect, dielectric properties, piezo electricity, ferro-electricity and ionic conductivity; Superconductivity- Meissner effect, brief discussion of Cooper theory of superconductivity; Optical properties - photo conductivity, luminescence, colour centers, lasers, refraction & birefringence; Magnetic properties - diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism & ferrimagnetism; Thermal properties - thermal conductivity & specific heat

Unit 5: Statistical Thermodynamics- I (9hrs)

Fundamentals – concept of distribution, thermodynamic probability and most probable distribution, ensembles, statistical mechanics for systems of independent particles and its importance in chemistry, thermodynamic probability & entropy, idea of microstates and macrostates, statistical weight factor (*g*), Sterling approximation, Maxwell- Boltzman statistics. The molecular partition function and its relation to the thermodynamic properties, derivation of third law of thermodynamics, equilibrium- constant & equi-partition principle in terms of partition functions, relation between molecular & molar partition functions, factorisation of the molecular partition function into translational, rotational, vibrational and

electronic parts, the corresponding contributions to the thermodynamic properties; Evaluation of partition functions and thermodynamic properties for ideal mono-atomic and diatomic gases.

Unit 6: Statistical Thermodynamics- II (9hrs)

Heat capacities of solids - classical and quantum theories, Einstein's theory of atomic crystals and Debye's modification.

Quantum Statistics: Bose - Einstein distribution law, Bose-Einstein condensation, application to liquid helium; Fermi - Dirac distribution law, application to electrons in metals; Relationship between Maxwell-Boltzman, Bose-Einstein, and Fermi-Dirac statistics.

Reference:

For Units 1-4

1. D. R. Crow, Principles and Applications of Electrochemistry, Chapman and Hall London, 1979.
2. J.O.M. Bockris and A.K.N. Reddy, *Modern Electrochemistry, Vol. I and II*, Kluwer Academic, Plenum Publishers, 2000.
3. Carl. H. Hamann, A. Hamnett, W.Vielstich, *Electrochemistry 2nd edn.*, Wiley- VCH, 2007.
4. Philip H Reiger, *Electrochemistry 2nd edn.*, Chapman & Hall, 1994.
5. Praveen Tyagi, *Electrochemistry*, Discovery Publishing House, 2006.
6. D.A. McInnes, *The Principles of Electrochemistry*, Dover publications, 1961.
7. L.V. Azaroff, *Introduction to Solids*, McGraw Hill, NY, 1960.
8. A.R. West, Basic Solid State Chemistry 2nd edn., John Wiley & Sons, 1999.
9. A.R. West, *Solid State Chemistry & its Applications*, John Wiley & Sons, 2003 (Reprint 2007).
10. Charles Kittel, *Introduction to Solid State Physics, 7th edn*, John Wiley & Sons, 2004 (Reprint 2009).
11. Mark Ladd, *Crystal Structures: Lattices & Solids in Stereo view*, Horwood, 1999.
12. Richard Tilley, *Crystals & Crystal Structures*, John Wiley & Sons, 2006.
13. C. Giacovazzo (ed.) *Fundamentals of Crystallography 2nd edn.*, Oxford Uty. Press, 2002.
14. Werner Massa, *Crystal Structure Determination 2nd edn.*, Springer 2004.
15. N.B. Hanna, *Solid state Chemistry*, Prentice Hall

For Units 5 & 6

16. G.S. Rush Brooke, *Statistical mechanics*, Oxford University Press.
17. T.L. Hill, *Introduction to statistical thermodynamics*, Addison Wesley.
18. K. Huary, *Statistical mechanics, Thermodynamics and Kinetics*, John Wiley.
19. O.K.Rice, *Statistical mechanics, Thermodynamics and Kinetics*, Freeman and Co.
20. F.C. Andrews, *Equilibrium statistical mechanics*, John Wiley and sons, 1963.
21. M.C. Guptha, *Statistical Thermodynamics*, Wiley eastern Ltd., 1993.

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY – SEMESTER I & II
MCH 1 L 01 & MCH 2 L 04 – INORGANIC CHEMISTRY PRACTICALS– I & II
(3 Credits)

UNIT 1: Inorganic Cation Mixture Analysis

Separation and identification of four metal ions of which two are less familiar elements like W, Se, Te, Mo, Ce, Th, Ti, Zr, V, U and Li. (Eliminating acid radicals not present).
Confirmation by spot tests.

UNIT 2: Volumetric Analysis

Volumetric Determinations using: EDTA (Al, Ba, Ca, Cu, Fe, Ni, Co, hardness of water)
Crimetry (Fe^{2+} , nitrite)
Potassium Iodate (Iodide, Sn^{2+})

UNIT 3: Colorimetric Analysis

Colorimetric Determinations of metal ions Fe, Cr, Ni, Mn and Ti.

References

1. G.H. Jeffery, J. Basset, J. Mendham and R.C. Denny, *Vogel's Text book of Quantitative Chemical Analysis*, 5th Edition, ELBS, 1989.
2. D.A. Skoog and D.M. West, *Analytical Chemistry, An Introduction*, 4th Edition, CBS Publishing Japan Ltd., 1986.
3. E.J. Meehan, S. Bruckenstein and I.M. Kolthoff and E.B. Sandell, *Quantitative Chemical Analysis*, 4th Edition, The Macmillan Company, 1969.
4. R.A. Day (Jr.) and A.L. Underwood, *Quantitative Analysis*, 6th Edition, Prentice Hall of India, 1993.

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY – SEMESTER I & II
MCH 1 L 02 & MCH 2 L 05 – ORGANIC CHEMISTRY PRACTICALS– I & II
(3 Credits)

Unit 1: Laboratory Techniques

Methods of Separation and Purification of Organic Compounds – fractional, steam and low-pressure distillations, fractional crystallisation and sublimation.

Unit 2: Separation and identification of the components of organic binary mixtures.

Microscale analysis is preferred

Analysis of about ten binary mixtures, some of which containing compounds with more than one functional group. Separation and identification of a few ternary mixtures.

Unit 3: Organic preparations-double stage (minimum six) and three stage (minimum two)

References:

5. B.S. Furnis, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5/e, Pearson, 1989.
6. Shriner, Fuson and Curtin, *Systematic Identification of Organic Compounds*, 1964.
7. Fieser, *Experiments in Organic Chemistry*, 1957.
8. Dey, Sitaraman and Govindachari, *A Laboratory Manual of Organic Chemistry*, 3rd Edition, 1957.
9. P.R. Singh, D.C. Gupta and K.S. Bajpal, *Experimental Organic Chemistry*, Vol. I and II, 1980.
10. Vishnoi, *Practical Organic Chemistry*.
11. Pavia, Kriz, Lampman, and Engel, *A Microscale Approach to Organic Laboratory Techniques*, 5/e, Cengage, 2013.
12. Mohrig, Hammond and Schatz, *Techniques in Organic Chemistry: Miniscale, Standard Taper Microscale and Williamson Microscale*, 3/e, W. H. Freeman and Co., 2010.

FAROOK COLLEGE (AUTONOMOUS) M.Sc. CHEMISTRY – SEMESTER I & II
MCH 1 L 03 & MCH 2 L 06 – PHYSICAL CHEMISTRY – I & II
(3 Credits)

SECTION A

Unit 1: Solubility and Heat of solution (minimum 2 experiments)

1. Determination of molar heat of solution of a substance (e.g., ammonium oxalate, succinic acid) from solubility data - analytical method and graphical method

Unit 2: Phase Equilibria (minimum 3 experiments)

(a) Determination of phase diagram of a simple eutectic system (e.g., Biphenyl, Naphthalene-Diphenyl amine) (b) Determination of the composition of a binary solid mixture.
Determination of phase diagram of a binary solid system forming a compound (e.g., Naphthalene – m-dinitrobenzene).

Unit 3: Viscosity (minimum 2 experiments)

Viscosity of mixtures - Verification of Kendall's equation (e.g., benzene - nitrobenzene, water-alcohol).

Determination of molecular weight of a polymer (e.g., polystyrene in

Unit 4: Distribution Law (minimum 3 experiments)

Determination of distribution coefficient of I_2 between CCl_4 and H_2O .

Determination of equilibrium constant of $KI + I_2 = KI_3$

Determination of concentration of KI solution

SECTION B

Unit 5: Refractometry (minimum 3 experiments)

Determination of molar refractions of pure liquids (e.g., water, methanol, ethanol, chloroform, carbon tetrachloride, glycerol)

Determination of composition of liquid mixtures (e.g., alcohol-water, glycerol-water)

Determination of molar refraction and refractive index of a solid

Unit 6: Conductivity (minimum 4 experiments)

Determination of equivalent conductance of a weak electrolyte (e.g., acetic acid), verification of Ostwald's dilution law and calculation of dissociation constant.

Determination of solubility product of a sparingly soluble salt (e.g., $AgCl$, $BaSO_4$)

Conductometric titrations

HCl vs NaOH

(HCl + CH₃-COOH) vs NaOH

Determination of the degree of hydrolysis of aniline hydrochloride

Unit 7: Potentiometry (minimum 3 experiments)

Potentiometric titration: HCl vs NaOH, CH₃-COOH vs NaOH

Redox titration: KI vs KMnO₄, FeSO₄ vs K₂Cr₂O₇

Determination of dissociation constant of acetic acid by potentiometric titration

Determination of pH of weak acid using Potentiometry

Determination of pH of acids and bases using pH meter

Reference:

1. J.B. Firth, *Practical Physical Chemistry*, Read Books (Reprint 2008).
2. A Finlay, *Practical Physical Chemistry*, Longman's Green & Co.
3. A.M. James, *Practical Physical Chemistry*, Longman, 1974.
4. F. Daniel, J.W. Williams, P. Bender, R.A. Alberty, C.D. Cornwell and J.E. Harriman,
5. *Experimental Physical Chemistry*, McGraw Hill, 1970.
6. W.G. Palmer, *Experimental Physical Chemistry*, 2nd Edition, Cambridge University Press, 1962.
7. D.P. Shoemaker and C.W. Garland, *Experimental Physical Chemistry*, McGraw Hill.
8. J. B. Yadav, *Advanced Practical Physical Chemistry*, Goel Publications, 1989.
9. B. Viswanathan & R.S. Raghavan, *Practical Physical Chemistry*, Viva Books, 2009

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER III
MCH 3 C 09 - MOLECULAR SPECTROSCOPY
(4 Credits, 72hrs)

Specific Objectives

- (1) Understand quantum chemical principles
- (2) Understand basic physical chemistry law that govern molecular spectroscopy
- (3) Understand basic information on molecular methods (IR, Raman, UV-VIS, NMR, EPR)
- (4) Able to select molecular spectroscopy methods suitable for solving given scientific problem
- (5) To analyse results of measurements using molecular spectroscopy methods
- (6) Understand interaction of light with matter in terms of the relationship with the molecular structure

Unit 1: Basic Aspects and Microwave Spectroscopy - Theory only (9hrs)

Electromagnetic radiation & its different regions, Interaction of matter with radiation and its effect on the energy of a molecule, Factors affecting the width and Intensity of Spectral lines- *Microwave spectroscopy* - Rotation spectra of diatomic and poly atomic molecules - rigid and non-rigid rotator models, asymmetric, symmetric and spherical tops, isotope effect on rotation spectra, Stark effect, nuclear and electron spin interactions, rotational transitions and selection rules, determination of bond length using microwave spectral data.

Unit 2: Infrared, Raman and Electronic Spectroscopy - Theory only (9hrs)

Vibrational spectroscopy -Normal modes of vibration of a molecule; Vibrational spectra of diatomic molecules, anharmonicity, Morse potential, fundamentals, overtones, hot bands, combination bands, difference bands; Vibrational spectra of polyatomic molecules; Vibration-rotation spectra of diatomic and polyatomic molecules, spectral branches -P, Q & R branches. Attenuated total reflectance-Fourier transform infrared (ATR-FTIR) spectroscopy

Raman spectroscopy –Classical and Quantum theory of Raman effect Pure rotational & pure vibrational Raman spectra, vibrational-rotational Raman spectra, selection rules, mutual exclusion principle; Introduction to Resonance Raman spectroscopy (basics only).

Electronic Spectroscopy- Characteristics of electronic transitions – Vibrational coarse structure, intensity of electronic transitions, Franck - Condon principle, types of electronic transitions; Dissociation and predissociation; Ground and excited electronic states of diatomic molecules; Electronic spectra of polyatomic molecules; Electronic spectra of conjugated molecules.

Fluorimetry: General discussion-relationship between intensity and concentration-

applications

Unit 3: Magnetic Resonance Spectroscopy - Theory only (9hrs)

NMR: Quantum mechanical description of Energy levels-Population of energy-Nuclear shielding- Chemical shift- Spin-Spin coupling and splitting of NMR signals- Quantum mechanical Description- AX and AB NMR pattern- Karplus relationship - Nuclear Overhauser Effect- FT NMR- 2D NMR COSY

Electron Spin Resonance: Quantum mechanical description of electron spin in a magnetic field- Energy levels-Population- Mc Connell Relation-Equivalent and non-equivalent nucleus - g anisotropy

Unit 4: NQR, Mossbauer and Surface Enhanced Raman Scattering (9 hrs)

Nuclear Quadrupole Resonance Spectroscopy: Principle, transitions for axially symmetric systems, transitions for Nonaxial symmetric systems, NQR group frequencies

Mossbauer Spectroscopy: The Mossbauer effect, hyperfine interactions, isomer shift, electric quadrupole and magnetic hyperfine interactions.

Surface Enhanced Raman Scattering: Introduction, Surfaces for SERS study, Surface Selection Rules, Representative Spectra, Applications of SERS

UNIT 5: Electronic & Vibrational Spectroscopy in Organic Chemistry (9hrs)

UV-Visible spectroscopy: Factors affecting the position and intensity of electronic absorption bands – conjugation, solvent polarity and steric parameters. Empirical rules for calculating λ_{max} of dienes, enones and benzene derivatives.

Optical Rotatory Dispersion and Circular Dichroism: Linearly and circularly polarized lights, circular birefringence, ellipticity and circular dichroism, ORD and Cotton effect. Octant rule and Axial haloketone rule for the determination of conformation and configuration of 3-methyl cyclohexanone and *cis*- and *trans* decalones. CD curves.

Infrared Spectroscopy: Functional group and finger print regions, Factors affecting vibrational frequency: Conjugation, coupling, electronic, steric, ring strain and hydrogen bonding. Important absorption frequencies of different class of organic compounds- hydrocarbons, alcohols, thiols, carbonyl compounds, amines, nitriles.

UNIT 6: NMR Spectroscopy in Organic Chemistry - I (9hrs)

¹H NMR: Chemical shift, factors influencing chemical shift, anisotropic effect. Chemical shift values of protons in common organic compounds, Chemical, magnetic and stereochemical equivalence. Enantiotopic, diastereotopic and homotopic protons. Protons on oxygen and

nitrogen. Quadrupole broadening. Spin – spin coupling, types of coupling. Coupling constant, factors influencing coupling constant, effects of chemical exchange, fluxional molecules, hindered rotation on NMR spectrum, First order and non first order nmr spectra, Karplus relationship.

UNIT 7: NMR Spectroscopy in Organic Chemistry - II (9hrs)

Simplification of NMR spectra: double resonance, shift reagents, increased field strength, deuterium labelling. NOE spectra, heteronuclear coupling. Introduction to COSY, HMBC, HMQC spectra. ¹³CNMR: General considerations, comparison with PMR, factors influencing carbon chemical shifts, carbon chemical shifts and structure-saturated aliphatics, unsaturated aliphatics, carbonyls, and aromatics. Off-resonance and noise decoupled spectra, Introduction to DEPT, INEPT, INADEQUATE.

UNIT 8: Mass Spectrometry and Spectroscopy for Structure Elucidation (9hrs)

Mass Spectrometry: Basic concept of EIMS. Molecular ion and meta stable ion peaks, Isotopic peaks. Molecular weight and molecular formula. Single and multiple bond cleavage, rearrangements -McLafferty rearrangements. Fragmentation pattern of some common organic compounds – saturated and unsaturated hydrocarbons, ethers, alcohols, aldehydes and ketones, amines and amides. High resolution mass spectrometry, index of hydrogen deficiency, Nitrogen rule and Rule of Thirteen. Ionization techniques. FAB spectra.

Structural determination of organic compounds using spectroscopic techniques (Problem solving approach)

References

For Units 1, 2, 3 & 4

- 1) G.M. Barrow, Introduction to Molecular Spectroscopy, McGraw Hill, 1962.
- 2) C.N. Banwell & E. M. McCash, *Fundamentals of Molecular Spectroscopy*, Tata McGraw Hill, New Delhi, 1994.
- 3) Thomas Engel, *Quantum Chemistry & Spectroscopy*, Pearson education, 2006.
- 4) P. Atkins & J. De Paula, *Atkins's Physical Chemistry*, 8th Edition, W.H. Freeman & Co., 2006.
- 5) D.A. McQuarrie and J.D. Simon, *Physical Chemistry - A Molecular Approach*, University Science Books, 1997.
- 6) D.N. Sathyanarayana, *Electronic Absorption Spectroscopy and Related Techniques*, University Press, 2000.
- 7) R.S. Drago, *Physical methods for Chemists*, Second edition, Saunders College Publishing 1977 (For NMR and EPR, Mossbauer)
- 8) Gunther, *NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry*, 2/e, John Wiley
- 9) Ferraro, Nakamoto and Brown, *Introductory Raman Spectroscopy*, 2/e, Academic Press, 2005.

For Units 5, 6, 7 & 8

- 1) Lambert, *Organic Structural Spectroscopy*, 2/e, Pearson
- 2) Silverstein, *Spectrometric Identification of Organic Compounds*, 6/e, John Wiley
- 3) Pavia, *Spectroscopy*, 4/e, –Cengage
- 4) Jag Mohan, *Organic Spectroscopy: Principles and Applications*, 2/e, Narosa

- 5) Fleming, Spectroscopic Methods in Organic Chemistry, 6/e McGraw-Hill
- 6) P S Kalsi, Spectroscopy of organic compounds, New Age International, 2007
- 7) William Kemp, Organic Spectroscopy, 3e, Palgrave, 2010

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER III
MCH3C10 - ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY
(4 Credits, 54hrs)

Specific Objectives

- The learners should be able to apply and analyse the methods of synthesis and the mechanism of selected catalytic organic reactions from the structure-bonding aspects and reactivity of simple organometallic compounds.
- To acquire basic information about organometallic polymers.
- To understand the functions of transition metal ions in biological systems.

Unit 1: Organometallic Compounds-Synthesis, Structure and Bonding (9hrs)

Denticity and hapticity of common ligands, organometallic compounds with linear pi donor ligands-olefins, acetylenes, dienes and allyl complexes-synthesis, structure and bonding. Synthesis and structure of complexes with cyclic pi donors, metallocenes and cyclic arene complexes, bonding in ferrocene and dibenzenechromium, carbene and carbyne complexes.

Unit 2: Metal clusters (9hrs)

Metal carbonyls: CO as a π -bonding ligand, synergism, preparation, properties, structure and bonding of simple mono and binuclear metal carbonyls, metal nitrosyls, metal cyanides and dinitrogen complexes. Polynuclear metal carbonyls with and without bridging. Carbonyl clusters-LNCC and HNCC, Isoelectronic and isolobal analogy, Wade-Mingos rules, cluster valence electrons. IR spectral studies of bridging and non-bridging CO ligands. Carbide clusters.

Unit 3: Reactions of organometallic compounds and catalysis (12hrs)

Organometallic reactions - ligand dissociation and substitution- Oxidative addition and reductive elimination. Insertion reactions involving CO and alkenes, α , β , γ and δ eliminations. Carbonylation by Collman's reagent. Electrophilic and Nucleophilic attack on coordinated ligand. Redistribution reactions, fluxional isomerism of allyl, cyclopentadienyl and allene systems.

Homogeneous and heterogeneous catalysis: Tolman catalytic loops, alkene hydrogenation using Wilkinson catalyst, Hydroformylation of olefins using cobalt and rhodium catalysts, Wacker process, Monsanto acetic acid process, Cativa process and olefin metathesis.

Heterogeneous catalysis by organometallic compounds: Polymerization by organometallic initiators and templates for chain propagation-Ziegler Natta catalysts, polymerisation by

metallocene catalysts., Reactions of carbon monoxide and hydrogen-the water gas shift reaction, the Fischer-Tropsch reaction (synthesis of gasoline).

Unit 4: Organometallic Polymers (6 hrs)

Polymers with organometallic moieties as pendant groups, polymers with organometallic moieties in the main chain, condensation polymers based on ferrocene and on rigid rod polyynes, polymers prepared by ring opening polymerization, organometallic dendrimers.

Unit 5: Bioinorganic Chemistry-I (9hrs)

Occurrence of inorganic elements in biological systems- bulk and trace metal ions. Emergence of bioinorganic chemistry. Coordination sites in biologically important ligands. Role of alkali metal ions in biological systems. Structural role of calcium. Storage and transport of metal ions- ferritin, transferrin and siderophores. Oxygen transport by heme proteins-hemoglobin and myoglobin-structure of the oxygen binding site-nature of heme-dioxygen binding-cooperativity. Hemerythrin and hemocyanin. Ion transport across membranes. The sodium/potassium pump.

Unit 6: Bioinorganic Chemistry-II (9hrs)

Electron carrier proteins. Iron-Sulphur proteins and cytochromes. Metallo enzymes-Iron enzymes: Cytochrome P-450, catalase and peroxidase. Copper enzymes: Oxidase, superoxide dismutase and tyrosinase. Zinc enzymes: Carboxypeptidase and carbonic anhydrase. Cobalt enzymes Vitamin B12 and coenzymes. Vitamin B12 and coenzymes. Chlorophyll II-Photosystem I and II. Nitrogen fixation-Nitrogenases. Anticancer drugs. Action of Cis-platin.

References:

10. N.N. Greenwood and A.Earnshaw, Chemistry of Elements, 2/e, Elsevier Butterworth-Heinemann, 2005.
11. J.E.Huheey, E.A.Keiter, R.L.Keiter. O.K.Medhi, Inorganic Chemistry, principles of structure and reactivity, Pearson Education, 2006.
12. G.L.Miessler, D.A.Tarr, Inorganic Chemistry, Pearson, 2010.
13. D.F.Shriver, P.W.Atkins, Inorganic Chemistry, Oxford University Press, 2002
14. William W Porterfield, Inorganic Chemistry-A unified approach, Academic Press, 2005.
15. Keith F Purcell, John C Kotz, Inorganic Chemistry, Cengage Learning, 2010.
16. James E House, Inorganic Chemistry, Academic Press, 2008.
17. B.Douglas, D.McDaniel, J.Alexander, Concepts and Models of Inorganic Chemistry, Wiley Student Edition, 2006.

18. F.A.Cotton and G.Wilkinson, Advanced Inorganic Chemistry, Wiley.
19. R.C.Mehrothra and A.Singh, Organometallic Chemistry, A Unified Approach, Wiley Eastern.
20. P.Powell, Principles of Organometallic Chemistry, ELBS.
21. B.D.Gupta and A.J.Elias, Basic Organometallic Chemistry, Concepts, Synthesis and Applications, Universities Press, 2010.
22. Piet W.N. M.van Leeuwen, Homogeneous Catalysis, Springer, 2010.S.J. Lippard and J.M.Berg, Principles of Bioinorganic Chemistry, University Science Books.
23. Ivano Bertini, H.B. Grey, S.J. Lippard and J.S.Valentine, Bioinorganic Chemistry, Viva Books Pvt. Ltd., 1998

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER III
MCH 3 C 11 - REAGENTS AND TRANSFORMATIONS IN ORGANIC CHEMISTRY
(4 Credits, 54hrs)

Specific objectives

1. To understand the common reagents, mechanism, regiochemistry and stereochemistry of organic oxidative and reductive transformations.
2. To give an idea on synthetic reagents and their applications in organic transformations.
3. To understand the synthesis and structure of synthetic and biopolymers.
4. To give an idea on synthesis, structure and reactions of some important heterocyclic compounds.
5. To apply the modern organic reactions for the specific synthetic purposes.

Unit 1: Oxidations (9hrs)

Oxidation of alcohols to carbonyls using DMSO, oxoammonium ions and transition metal oxidants (chromium, manganese, iron, ruthenium). Epoxydation of alkenes by peroxy acids, Sharpless asymmetric epoxidation, Jacobsen epoxidation, dihydroxylation of alkenes using permanganate ion and osmium tetroxide, Prévost and Woodward dihydroxylations, Sharpless asymmetric dihydroxylation. Allylic oxidation with CrO₃-Pyridine reagent. Oxidative cleavage of alkenes to carbonyls using O₃. Oxidative decarboxylation, Riley reaction, Baeyer-Villiger oxidation, Dess- Martin oxidation, Swern oxidation, hydroboration-oxidation.

Unit 2: Reductions (9hrs)

Catalytic hydrogenation of alkenes and other functional groups (heterogeneous and homogeneous), Noyori asymmetric hydrogenation, hydrogenolysis. Liquid ammonia reduction with alkali metals. Metal hydride reductions. Reduction of carbonyl group with hydrazine, p-tosylhydrazine, diimide and semicarbazide. Clemmensen reduction, Birch reduction. Wolff-Kishner reduction, Bouveault- Blanc reduction, MPV reduction, hydroboration, Pinacol coupling, McMurry coupling, Shapiro reaction.

Unit 3: Synthetic Reagents (9 hrs)

Synthetic applications of Crown ethers, β-cyclodextrins, PTC, ionic liquids, Baker's yeast, NBS, LDA, LiAlH₄, LiBH₄, DIEA, BuLi, diborane, 9-BBN, t-butoxycarbonylchloride, DCC, Gilman's reagent, lithium dimethyl cuprate, tri-n-butyltinhydride, 1,3-dithiane, trimethyl silyl chloride, Pb(OAc)₄, ceric ammonium nitrate, DABCO, DMAP, DBU, DDQ, DEAD and Lindlar catalyst in organic synthesis.

Unit 4: Chemistry of Polymers (9 hrs)

Classification of polymers, chain, step, free-radical and ionic polymerizations. Plastics, rubbers and fibers, thermosets and thermoplastics, linear, branched, cross-linked and network polymers, block and graft copolymers.

Natural and synthetic rubbers.

Biopolymers: Primary, secondary and tertiary structure of proteins, Merrifield solid phase peptide synthesis, Protecting groups, sequence determination of peptides and proteins, Structure and synthesis of glutathione, structure of RNA and DNA, structure of cellulose and starch, conversion of cellulose to rayon.

Unit 5: Heterocyclic chemistry (9 hrs)

Aromatic and nonaromatic heterocyclics. Structure, synthesis and reactions of a few heterocyclics- aziridine, oxirane, pyridine, imidazole.

Structure, synthesis and reactions of fused ring heterocycles: Benzofuran, Indole, Benzothiophene, Quinoline, Benzoxazole, Benzthiazole, Benzimidazole, Triazoles , Oxadiazoles and Tetrazole.

Structure and synthesis of Azepines, Oxepines, Thiepins, Diazepines and Benzodiazepines
Structure and synthesis (Reichstein process) of Vitamin C (Reichstein process). Synthesis of uracil, thymine, adenine and guanine

Unit 6: New reactions in organic synthesis (9 h)

Carbon- Carbon double bond forming reactions: Bamford-Stevens reaction, Shapiro reaction, Julia olefination and Peterson olefination. Ring Formation Reactions: Pauson-Khand reaction, Bergman cyclisation and Nazarov cyclisation, Tiffeneau–Demjanov rearrangement
Multicomponent Reactions: Biginelli synthesis; multicomponent reactions using alkyl isocyanides–Passerini and Ugi-4-component synthesis. Olefin metathesis using Grubb's catalyst. Other important synthetic reactions: Mukaiyama esterification, Mitsunobu reaction and Baylis Hillman reaction.

References:

1. M. B. Smith, *Organic Synthesis*, 3/e, Academic Press, 2011.
2. R. O. C. Norman and J. M. Coxon, *Principles of Organic Synthesis*, 3/e, CRC Press, 1998.
3. W. Carruthers and I. Coldham, *Modern Methods of Organic Synthesis*, 4/e, Cambridge University Press.
4. R. R. Carey and R. J. Sundburg, *Advanced Organic Chemistry*, Part B, 5/e, Springer,

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 6. J. Clayden, N. Greeves, S. Warren and P. Wothers, *Organic Chemistry*, 2/e, Oxford University Press, 2012.
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 14. T. H. Lowry and K. S. Richardson, *Mechanism and Theory in Organic Chemistry*, 3/e Addison-Wesley, 1998.
 15. F. Vogtle, *Supramolecular Chemistry*, John Wiley & Sons, Chichester, 1991.
 16. J.M.Lehn, *Supramolecular Chemistry*, VCH.

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) – SEMESTER III
MCH 3 E 01 - SYNTHETIC ORGANIC CHEMISTRY (ELECTIVE)
(4 Credits, 54hrs)

Specific objectives

1. To understand the common reagents, mechanism, regiochemistry and stereochemistry in organic oxidative and reductive transformations.
2. To give an idea on organometallic and organo nonmetallic reagents and their applications in organic transformations.
3. To give a broad introduction to palladium catalyzed carbon-carbon bond forming reactions and their synthetic applications.
4. To understand the principles and strategies involved in the multistep synthesis.
5. To obtain the importance of retrosynthetic analysis in multistep synthesis and synthetic planning.
6. To employ the reagents and methods in organic synthesis on the synthesis of natural products.

Unit 1: Reagents for Oxidation and Reduction (9hrs)

Reagents for oxidation and reduction: Oxone, IBX, PCC, osmium tetroxide, ruthenium tetroxide, selenium dioxide, molecular oxygen (singlet and triplet), peracids, hydrogen peroxide, aluminum isopropoxide, periodic acid, lead tetraacetate. Wacker oxidation, TEMPO oxidation, Swern oxidation, Woodward and Prevost hydroxylation, Sharpless asymmetric epoxidation.

Catalytic hydrogenations (heterogeneous and homogeneous), metal hydrides, Birch reduction, hydrazine and diimide reduction.

Unit 2: Organometallic and Organo-nonmetallic Reagents (9hrs)

Synthetic applications of organometallic and organo-nonmetallic reagents: Reagents based on chromium, aluminium, nickel, palladium, silicon, and boron, Gilman reagent, phase transfer catalysts, hydroboration reactions, synthetic applications of alkylboranes. Gilman's reagent, Tri-n-butyl tin hydride, Benzene Tricarbonyl Chromium

Unit- 3. Coupling Reactions (9hrs)

Coupling Reactions: Palladium Catalysts for C-N and C-O bond formation, Palladium catalyzed amine arylation (Mechanism and Synthetic applications). Sonogashira cross coupling reaction (Mechanism, Synthetic applications in Cyclic peptides) Stille carbonylative cross coupling reaction (Mechanism and synthetic applications). Mechanism and synthetic applications of Negishi, Hiyama, Kumada, Heck and Suzuki-Miyaura coupling reactions.

Unit 4: Multi step Synthesis (9hrs)

Multi step Synthesis: Synthetic analysis and planning, Target selection, Elements of a

Synthesis (Reaction methods, reagents, catalysts, solvents, protective groups for hydroxyl, amino, Carbonyl and carboxylic acids, activating groups, leaving groups synthesis and synthetic equivalents. Types of selectivities (Chemo, regio, stereo selectivities) synthetic planning illustrated by simple molecules, disconnections and functional group interconversions, uplong reactions and use in synthesis, Introduction to retrosynthetic analysis, Synthesis of longifolene, Corey lactone, Djerassi Prelog lactone

Unit 5: Retro Synthetic Analysis (9hrs)

Retrosynthesis: General principles of retrosynthetic analysis- synthons and reagents, donor and acceptor synthons, umpolung, protecting group chemistry and functional group interconversions. One group and two group C-X and C-C disconnections, functional group transposition. Examples for a few retrosynthetic analyses- paracetamol from phenol, benzocain from toluene and propranolol from 1-naphthol. ongifolene, Corey lactone, Djerassi Prelog lactone.

Unit 6: Chemistry of Natural Products (9 h)

Chemical classification of natural products. Classification of alkaloids based on ring structure, isolation and general methods of structure elucidation based on degradative reactions. Structure elucidation of atropine and quinine.

Terpenoids - Isolation and classification of terpenoids, structure of steroids classification of steroids. Woodward synthesis of cholesterol, conversion of cholesterol to testosterone. Total synthesis of Reserpine, Cephalosporin, General structure of anthocyanins and flavonoids.

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1. M. B. Smith, *Organic Synthesis*, 3/e, Academic Press, 2011.
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4. H. O. House: *Modern Synthetic Reactions*, W. A. Benjamin
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7. M B Smith and J. March: *Advanced Organic Chemistry-Reactions, Mechanisms and Structure*, 6th ed., John Wiley
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10. A. Pross: *Theoretical and Physical Principles of Organic Chemistry*, John Wiley
11. T.W. Graham Solomons: *Fundamentals of Organic Chemistry*, 5th ed., John Wiley
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FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER III
MCH 3 E 02 - COMPUTATIONAL CHEMISTRY (ELECTIVE)
(4 credits, 54 hrs)

Unit 1: Introduction to Computational Chemistry (9 hrs)

Theory, computation & modeling – Definition of terms; Need of approximate methods in quantum mechanics; Computable Quantities – structure, potential energy surfaces and chemical properties; Cost & Efficiency – relative CPU time, software & hardware; Classification of computational methods.

Unit 2: Computer Simulation Methods- I (9 hrs)

Introduction – molecular dynamics and Monte Carlo methods, calculation of simple thermodynamic properties - energy, heat capacity, pressure and temperature, phase space, practical aspects of computer simulation, periodic boundary conditions, Monitoring the equilibration, analyzing the results of a simulation, error estimation.

Unit 3: Computer Simulation Methods- II (9 hrs)

Molecular dynamics (MD) method – molecular dynamics using simple models – MD with continuous potentials, finite difference methods, choosing the time step, setting up and running a MD simulation; Monte Carlo (MC) method - calculating properties by integration, Metropolis method, random number generators, MC simulation of rigid molecules.

UNIT 4: ab initio Methods in Computational Chemistry (9hrs)

Review of Hartree – Fock method for atoms, SCF treatment of polyatomic molecules; Closed shell systems - restricted HF calculations; Open shell systems – ROHF and UHF calculations; The Roothan – Hall equations, Koopmans theorem, HF limit & electron correlation, Introduction to electron correlation (post -HF) methods.

UNIT 5: Density Functional Methods (9 hrs)

Introduction to density matrices, N-representability & V-representability problems, Hohenberg – Kohn theorems, Kohn-Sham orbitals; Exchange correlation functionals
– Thomas-Fermi-Dirac model, Local density approximation, generalised gradient approximation, hybrid functionals; Comparison between DFT and HF methods.

UNIT 6: Basis Set Approximation (9 hrs)

Hydrogen-like, Slater-type & Gaussian type basis functions, classification of basis sets – minimal, double zeta, triple zeta, split-valence, polarization & diffuse basis sets, even tempered & well tempered basis sets, contracted basis sets, Pople-style basis sets and their

nomenclature, correlation consistent basis sets, basis set truncation error, effect of choice of method/ basis set (model chemistries) on cpu time.

References:

1. C. J. Cramer, *Essentials of computational Chemistry: Theories and models*, John Wiley & Sons 2002.
2. Frank Jensen, *Introduction to Computational Chemistry*, John Wiley & Sons LTD 1999.
3. J. Foresman & Aelieen Frisch, *Exploring Chemistry with Electronic Structure Methods*, Gaussian Inc., 2000.
4. David Young, *Computational Chemistry- A Practical Guide for Applying Techniques to Real- World Problems*”, Wiley -Interscience, 2001.
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FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER III
MCH 3 E 03 - GREEN CHEMISTRY AND NANOCHEMISTRY (ELECTIVE)
(4 credits, 54 hrs)

Unit I: Introduction to green chemistry (9hrs)

Green chemistry-relevance and goals, Anastas' twelve principles of green chemistry - Tools of green chemistry: alternative starting materials, reagents, catalysts, solvents and processes with suitable examples.

UNIT-2: Microwave mediated organic synthesis (MAOS) (9hrs)

Microwave activation –advantage of microwave exposure – specific effects of microwave – Neat reactions – solid supports reactions _ Functional group transformations – condensations reactions
oxidations – reductions reactions – multi-component reactions.

Unit 3: Alternative synthesis, reagents and reaction conditions (9hrs)

Introduction – synthesis of ionic liquids – physical properties – applications in alkylation – hydroformylations – epoxidations – synthesis of ethers – Friedel-craft reactions – Diels-Alder reactions – Knoevengal condensations – Wittig reactions – Phase transfer catalyst - Synthesis – applications. A photochemical alternative to Friedel-crafts reactions - Dimethyl carbonate as a methylating agent – the design and applications of green oxidants – super critical carbon dioxide for synthetic chemistry.

Unit 4: Nanomaterials – An Introduction & Synthetic Methods (9hrs)

Definition of nanodimensional materials - Historical milestones - unique properties due to nanosize, Quantum dots, Classification of Nanomaterials .General methods of synthesis of nanomaterials – Hydrothermal synthesis, Solvothermal synthesis, Microwave irradiation, sol – gel and Precipitation technologies, Combustion Flame-Chemical Vapor Condensation Process, gas Phase Condensation Synthesis, Reverse Micelle Synthesis, Polymer – Mediated Synthesis, Protein Microtube – Mediated Synthesis Synthesis of Nanomaterials using microorganisms and other biological agents, Sonochemical Synthesis, Hydrodynamic Cavitation. Inorganic nanomaterials – Typical examples –nano TiO₂ / ZnO/CdO/CdS , Organic nanomaterials – examples – Rotaxanes and Catenanes

Unit 5: Techniques for Characterisation of nanoscale materials (9hrs)

Principles of Atomic force microscopy (AFM)- Transmission electron microscopy (TEM)- Resolution and scanning transition electron microscopy (STEM) Scanning Tunneling

Microscopy (STM) Scanning nearfield optical microscopy (SNOM), Scanning ionconductance microscope, scanning thermal microscope, scanning probe microscopes and surface plasmon spectroscopy.

Unit 6: Carbon Clusters and Nanostructures (9hrs)

Nature of carbon bond - New carbon structures - Carbon clusters: Discovery of C₆₀ - Alkali doped C₆₀ - Superconductivity in C₆₀ - Larger and smaller fullerenes. Carbon nanotubes: Synthesis - Single walled carbon nanotubes - Structure and characterization - Mechanism of formation - Chemically modified carbon nanotubes - Doping - Functionalizing nanotubes - Application of carbon nanotubes. Nanowires - Synthetic strategies - Gas phase and solution phase growth - Growth control - Properties.

References:

For Units 1, 2 & 3

1. V. K. Ahluwalia, *Green Chemistry – Environmentally benign reactions*, Ane Books India (Publisher), (2006).
2. V. K. Ahluwalia, *Green Chemistry: A Textbook*, Narosa Publishing House, 2013.
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6. *Green Chemistry – Environment friendly alternatives*- edited by Rashmi Sanghi & M. M. Srivastava, Narora Publishing House, (2003).

For Units 4, 5 & 6

7. C.N.R. Rao, A. Muller, A.K. Cheetam (Eds), *The Chemistry of Nanomaterials*, Vol.1, 2, Wiley –VCH, Weinheim, 2004.
8. C.P. Poole, Jr: F.J. Owens, *Introduction to Nanotechnology* Wiley Interscience, New Jersey, 2003
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11. H. Fujita (Ed.), *Micromachines as tools in nanotechnology*, Springer- Verlag, Berlin, 2003.

12. Bengt Nolting, *Methods in modern biophysics*, Springer-Verlag, Berlin, First Indian Reprint, 2004. (Pages 102-146 for Unit II and 147 – 163 for Unit V)
13. H. Gleiter, *Nanostructured Materials: Basic Concepts, Microstructure and Properties*
14. W. Kain and B. Schwederski, *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life*, John-Wiley R Sons, New York.
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19. Nano letters - <http://pubs.acs.org/journals/nalefd/index.html> Nanotation - <http://www.acsnanotation.org/>

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER IV
MCH 4 C 12- INSTRUMENTAL METHODS OF ANALYSIS
(4 Credits, 72 hrs)

Specific Objectives

- To have an idea about fundamentals of different analytical tools.
- To acquire knowledge about various errors and methods to minimize them.
- To understand the principle, working and applications of various instrumentation techniques.

Unit 1: Errors in Chemical Analysis (9hrs)

Treatment of analytical data, accuracy and precision, Absolute and relative errors, classification and minimization of errors, significant figures, Statistical treatment- mean and standard deviation, variance, confidence limits, student-t and f tests, detection of gross errors, rejection of a result-Q test. Least square method, linear regression; covariance and correlation coefficient

Unit 2: Conventional Analytical Procedures (9hrs)

Gravimetry: solubility product and properties of precipitates-nucleation, growth and aging, co- precipitation and post precipitation, drying and ignition. Inorganic precipitating agents: NH_3 , H_2S , H_2SO_4 , $(\text{NH}_4)_2\text{MoO}_4$ and NH_4SCN .

Organic precipitating agents: oxine, cupron, cupferron, 1-nitroso-1-naphthol, dithiocarbamates, Acid-Base and precipitation titrations: theory of neutralisation titrations, indicators for acid/base titrations, titration curves of strong acid, strong base, weak acid, weak base and polyprotic acids. Buffer solutions.

Titration in nonaqueous media. Different solvents and their selection for a titration. Indicators for non-aqueous titrations

Redox titrations: Permanganometry, dichrometry, iodometry, cerimetry. Variation of potential during a redox titration, formal potential during a redox titration, Redox indicators.

Precipitation titrations, adsorption indicators

Complexometric titrations: Types of EDTA titrations (direct, back, replacement, alkalimetric and exchange reactions), masking and demasking agents, selective demasking, metal ion indicators - murexide, eriochrome black T, Patton and Reeder's indicators, bromopyrogallol red, xylenol orange, variamine blue.

Unit 3: Electro Analytical Methods- I (9hrs)

Potentiometry: techniques based on potential measurements, direct potentiometric systems, different types of indicator electrodes, limitations of glass electrode, applications in pH

measurements, modern modifications, other types of ion selective electrodes, solid, liquid, gas sensing and specific types of electrodes, biomembrane, biological and biocatalytic electrodes as biosensors, importance of selectivity coefficients. Polarography micro electrode and their specialities, potential and current variations at the micro electrode systems, conventional techniques for concentration determination, limitations of detection at lower concentrations, techniques of improving detection limit-rapid scan, ac, pulse, differential pulse square wave polarographic techniques. Applications of polarography.

Unit 4 Electro Analytical Methods II (9hrs)

Amperometry: biamperometry, amperometric titrations. Coulometry-primary and secondary coulometry, advantages of coulometric titrations, applications. Principle of chronopotentiometry. Anodic stripping voltammetry-different types of electrodes and improvements of lower detection limits. Voltammetric sensors. Organic polarography.

Unit 5 Optical Methods - I (9 hrs)

Fundamental laws of spectrophotometry, nephelometry and turbidometry and fluorimetry. UV- visible and IR spectrophotometry – instrumentation, single and double beam instruments, Spectrophotometric titrations. Atomic emission spectrometry – excitation sources (flame, AC and DC arc), spark, inductively coupled plasma, glow discharge, laser microprobes, flame structure, instrumentation, and qualitative and quantitative analysis. Atomic absorption spectrometry: sample atomization techniques, instrumentation, interferences, background correction, and analytical applications.

Unit 6 Optical Methods - II (9 hrs)

Theory, instrumentation and applications of: - Atomic fluorescence spectrometry, X-ray methods, X-ray absorption and X-ray diffraction, photoelectron spectroscopy, Auger, ESCA. SEM, TEM, AFM,

Unit 7: Thermal Methods (9hrs)

Thermogravimetry (TG), Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC) Thermomechanical Analysis (TMA), Dynamic Mechanical Analysis (DMA), and their instrumentation. Thermometric Titrations.

Unit 8: Chromatography (9 hrs)

Chromatography-classification-column-paper and thin layer chromatography. HPLC-outline study of instrument modules. Ion – exchange chromatography-Theory. Important applications of chromatographic techniques. Gel Permeation Chromatography.

Gas chromatography – basic instrumental set up-carriers, columns, detectors and comparative study of TCD, FID, ECD and NPD. Qualitative and quantitative studies using GC, Preparation of GC columns, selection of stationary phases of GLC, Gas adsorption chromatography, applications, CHN analysis by GC

References:

1. J.M. Mermet, M. Otto, R. Kellner, *Analytical Chemistry*, Wiley-VCH, 2004.
2. D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, *Fundamentals of Analytical Chemistry*, 9th Edn., Cengage Learning., 2014.
3. J.G. Dick, *Analytical Chemistry*, R.E. Krieger Pub., 1978, 50
4. J.H. Kennedy, *Analytical Chemistry: Principles*, Saunders College Pub., 1990.
5. G.H. Jeffery, J. Bassett, J. Mendham, R.C. Denney, *Vogel's Text Book of Quantitative Chemical Analysis*, 5th Edn., John Wiley & sons, 1989.
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9. A.I. Vogel, *A Textbook of Practical Organic Chemistry*, 5/e Pearson, 1989.
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FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER IV
MCH4C13- ADVANCED TOPICS IN CHEMISTRY (4 Credits, 72 hrs)

Specific Objectives

1. To gain a broad understanding on nanomaterials, synthesis, characterizations techniques and applications
2. To obtain an understanding on computational quantum chemistry
3. To understand the concepts of supramolecular chemistry and their applications.
4. To obtain an in-depth knowledge on principles of medicinal chemistry
5. To gain a detailed understanding on industrial catalysis.
6. To give an idea on renewable energy resources and technologies.
7. To get a broad idea on organic materials and their optical and electronic applications

Unit 1: Chemistry of Nanomaterials (18 hrs)

History of Nanomaterials - Classification. Size- dependence of properties. Electronic structure theory of metals and semiconductors. Quantum size effects. Synthesis of nanostructures: bottom-up-approach, top - down approach, self assembly, lithography techniques – photolithography, soft lithography, dip-pen nanolithography. Introduction to carbon nanomaterials.

Characterizations of Nanomaterials: UV-Visible spectroscopy, Photoluminescence spectroscopy, Raman Spectroscopy, Dynamic light scattering (DLS), X-ray diffraction (XRD), Energy Dispersive X-ray analysis (EDAX), X-ray photoelectron spectroscopy (XPS), Electron microscopic techniques - SEM, TEM. Scanning probe microscopies - STM, AFM – Scanning tunneling spectroscopy - Measurement of electrical properties of nanomaterials.

Applications: Nanoelectronics, nanosensors, nanocatalysts, nanofiltration, diagnostic and therapeutic applications and targeted drug delivery.

Unit 2: Introduction to computational quantum chemistry (9hrs)

Electronic structure of molecules-Review of Hartree-Fock SCF method. Basis sets STO and GTOs . Nomenclature of Basis sets. Semi empirical and ab initio methods. Calculations using Gaussian programme . Specification of molecular geometry using a) Cartesian coordinates and b) Internal coordinates. The Z-matrix . Z- matrices of some simple molecules like H₂, H₂O, formaldehyde ammonia and methanol.

Unit 3: Supramolecular Chemistry (9hrs)

Concepts and language. Molecular recognition: Molecular receptors for different types of molecules, design and synthesis of coreceptors and multiple recognition. Host-guest systems – Crown ether, cryptands, podands, calixarenes, Cucurbituril. Supramolecular Strong, weak and very weak Hydrogen bonds. Utilisation of H-bonds to create supramolecular structures. Use of H bonds in crystal engineering and molecular recognition. Supramolecular reactivity and catalysis. Transport processes and carrier design. Supramolecular devices. Supramolecular

photochemistry, supramolecular electronic, ionic and switching devices some examples of self-assembly in supramolecular chemistry.

Unit 4: Medicinal Chemistry (9hrs)

Drugs: Introduction, different classes of drug, drug action, drug design, pro drugs, factors governing drug design, rational approach to drug design. SAR and QSAR, physico chemical factors and biological activities. Factors governing ability of drugs. General methods of drug synthesis. Analgesics (phenazones and phenylbutzone as examples). Antipyretic (paracetamol) Antibiotics (penicillins, chloramphenicol).

Unit 5: Introduction to Industrial Catalysis (9hrs)

Structure and chemical nature of surfaces. Physisorption and chemisorptions. Energy exchange at surface. Determination of surface area and pore structure of catalysts - physical adsorption methods, X-ray methods, mercury intrusion method, chemisorptions methods. Determination of surface acidity-TPD method. Catalyst selectivity, effect of pore size on selectivity. Homogeneous and heterogeneous catalysts. Preparative methods for heterogeneous catalysts- precipitation and coprecipitation methods, sol gel method, flame hydrolysis. Preparation of Zeolites and silica supports. Mesoporous materials. Introduction to Phase transfer catalysis, biocatalysis, nanocatalysis and polymer supported catalysis. Application of heterogeneous catalysts in water gas shift reaction, ammonia synthesis, catalytic cracking, Fisher-Tropsch process, three way catalysis.

Unit 6: Renewable Energy Sources (9h)

World's reserve of commercial energy sources and their availability, various forms of energy, Renewable and conventional energy systems, comparison - coal, oil and natural gas, availability, applications, merits and demerits. Renewable energy sources - solar energy, nature of solar radiation, components- solar heaters, solar cookers, water desalination. Photovoltaic generation – basics, merits and demerits of solar energy. i) Solid state junction solar cells:- principle of solar cells, Fabrication of CdS/Cu₂S and CdS/CuInSe₂ solar cells, performance testing, stability and efficiency consideration. Dye sensitized solar cells (DSSC)-Working principle, Fabrication of DSSCs based on TiO₂ and ZnO, stability and performance of dyes.

Unit 7: Organic semiconductors and electronics (9h)

General overview of organic semiconductors and electronics - Bonding, Conjugation, Hybridization, Electronic structure. Charge injection and transport in organic semi conductors, optical phenomenon. Representative materials and their processing Film deposition techniques structure-property relationships Patterning, Printing, Encapsulation Electro-optical devices theory and fabrication of - organic Light emitting diodes, thin film transistors, Solar cells, memory devices and sensors.

References:

1. C.P. Poole (Jr.) and F.J. Owens, *Introduction to Nanotechnology*, Wiley India, 2007.
2. G.A. Ozin and A.C. Arsenault, *Nanochemistry*, RSC Publishing, 2008.
3. T. Pradeep, *The essentials of Nanotechnology*, Tata McGraw Hill, New Delhi, 2007.

4. K.J.Klabunde(Ed.), *Nanoscale Materials in Chemistry*, John Wiley&Sons,2001.
5. P.T.Anastas and J.C.Warner, *Green Chemistry:Theory and Practice*, Oxford University Press,1998.
6. James Clark and Duncan Macquarrie, *Hand Book of Green Chemistry and Technology*, Blackwell Science,2002.
7. J.H.Clark,*The Chemistry of waste minimization*, Blackie Academic, London,1995.
8. C.J.Cramer, *Essentials of computational Chemistry:Theories and models*, John Wiley & Sons,2002.
9. Frank Jensen, *Introduction to Computational Chemistry*, John Wiley & Sons,1999.
10. Errol G Lewars *Computational Chemistry: Introduction to the theory and applications of molecular quantum mechanics*, Springer, 2001.
11. David Young, *Computational Chemistry*, Wiley –Interscience,2001.
12. F. Vogtle,*Supramolecular Chemistry*, John Wiley & Sons, Chichester,1991.
13. J. M.Lehn, *Supramolecular Chemistry*, VCH.
14. Lemke, Williams, Roche and Zito, *Principles of Medicinal Chemistry*, 7/e, Wolters Kluwer, 2012.
15. G.Thomas, *Fundamentals of Medicinal Chemistry*, Wiley.
16. G. Gringauz, *Introduction to Medical Chemistry*, Wiley-VCH,1997.
17. Harkishan Singh and V.K.Kapoor, *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan,2008.
18. A. W. Adamson and A. P. Gast; *Physical Chemistry of Surfaces* 6 Ed, Wiley, 2011.
19. Jens Hajen; *Industrial Catalysis: A Practical Approach*. 2nd Edn.Wiley VCH 2006.
20. Dipak Kumar Chakrabarty; *Adsorption and Catalysis by Solids*, New Age. 2007.
21. C.H. Bartholomew and R.J. Farrauto; *Fundamentals of Industrial Catalysis Process*. 2nd Edn. Wiley & Sons Inc. 2006.
22. Woodruff, D. P. and Delchar T. A.; *Modern Techniques of Surface Science*, Cambridge Solid State Science Series 1994.
23. Kurt K. Kolasinski, *Surface Science: Foundations of Catalysis and Nanoscience*, 3rd Edn. Wiley U. K. 2012.
24. Bansal N K, Kleeman M and Mells M (1990) *Renewable Energy Sources and Conversion Technology*, 460 pp. New Delhi: Tata McGraw-Hill.
25. Kothari D.P., “Renewable energy resources and emerging technologies”, Prentice Hall of India Pvt. Ltd., 2008.
26. Rai G.D, "Non-Conventional energy Sources", Khanna Publishers, 2000.
27. Michael Grätzel, J. Photochemistry and Photobiology C: Photochemistry Reviews 4 (2003) 145–153, *Solar Energy Conversion by Dye-Sensitized Photovoltaic Cells*, *Inorg. Chem.*, Vol. 44, No. 20, 2005 6841-6851.
28. Yoshihiro Hamakawa, *Thin-Film Solar Cells-Next Generation Photovoltaics and Its Applications*, SPRINGER SERIES IN PHOTONICS 13, 2004.
29. Hagen Klauk, 302223 *Organic Electronics: Materials, Manufacturing and Applications* 302224, Wiley-VCH, 2006.
30. Wolfgang Bruetting, 302221 *Physics of Organic Semiconductors* 302222, Wiley-VCH, 2005

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER IV
MCH 4 E 04 - PETROCHEMICALS AND COSMETICS (ELECTIVE)
(4Credits, 72hrs)

Unit 1: Introduction to Petrochemistry (9hrs)

Introduction – Petroleum – Refining of crude oil – Fuels for internal combustion engines. Knocking, Octane number. Unleaded petrol. Diesel Engine and Cetane number. Cracking – Thermal, Catalytic. Mechanism of cracking process. Reforming Activation Gasoline. Petrochemicals.

Unit 2: Hydrocarbons from Petroleum (9hrs)

Introduction. Raw materials. Saturated hydrocarbons from natural gas. Uses of saturated hydrocarbons. Unsaturated hydrocarbons – Acetylene, Ethylene, Propylene, Butylenes. Aromatic hydrocarbons - Benzene. Toluene. Xylenes. Chemical processing of paraffin hydrocarbons. Chemical processing of ethylene hydrocarbons. Chemical processing of acetylene. Chemical processing of aromatic hydrocarbons.

Unit 3: Industrial Organic Synthesis (9hrs)

Introduction. The raw materials and basic processes. Chemical process used in industrial organic synthesis. Petrochemicals- Methanol. Important points. Ethanol. Important points. Rectified spirit from beer. Methylated spirit. Proof spirit. Preparation of the absolute alcohol from rectified spirit. Acetaldehyde. Acetic acid. Isopropanol. Ethylene glycol. Glycerine. Acetone. Phenol. Formaldehyde. Important points. Ethyl acetate. Important points.

Unit 4: Composition of Petroleum Crude (9hrs)

Composition of petroleum crude. Composition of the petroleum products. Isomeric compounds. Classification of petroleum crude. A survey of the world crude. Sulphur compounds in petroleum.

Physical Properties and Test Methods

Viscosity: Other methods for finding out viscosity. Viscosity of an oil blend. Use of the figure for finding out viscosity. Viscosities of hydrocarbons. 2. Density, 3. Surface and interfacial tensions. 4. Refractive Index. 5. Flash and fire points. 6. Cloud and pour points. 7. Aniline point. 8. Diesel index. 9. Cetane number. 10. Octane number and knock characteristics. 11. Distillation curves. (a) ASTM (American Society for Testing Materials) distillation curve. (b). Hempel or semi fractionating distillation curve.

Unit 5: Distillation of Crude Petroleum (9hrs)

Preparation of petroleum for processing. Destruction of petroleum emulsion. Electric

desalting plants. Fundamentals of preliminary distillation. Methods of petroleum distillation. Distillation of crude petroleum. Treatment of the residual liquid processing of liquid fuels such as petroleum and petroleum products. Petroleum processing equipments. Storage tanks. Rectification columns. Cap tray or bubble tray columns. Heat exchange apparatus. Steam space heaters or boilers. Condensers. Pipe furnaces. Pipelines. Fitting Compressors and pumps.

Unit 6: Petroleum Products (9hrs)

Introduction. Classification of petroleum products. Liquefied hydrocarbons, gases and fuels. Fuel oils or boiler oils. Fuel for Jet engines and gas turbine engines. Lubricants, products of oil paraffine processing and other petroleum products. Lubricating and other oils. Paraffins, ceresins, petroleum. Miscellaneous petroleum products. Products of petrochemical and basic organic synthesis. Dye intermediates. Lacquers. Solvents. Thinners.

Unit 7: Purification of Petroleum Products (9hrs)

Absorptive and adsorptive purification. Sulphuric acid purification. Alkaline purification. Hydrorefining. Purification in a DC electric field. New methods of purification. De mercaptanisation. Stabilisation.

Unit 8: Perfumes and Cosmetics (9hrs)

Perfumes: Introduction. Esters. Alcohols. Ketones. Ionones. Nitromusks. Aldehydes. Diphenyl compounds. Production of natural perfumes. Flower perfume. Fruit flavours. Artificial flavours.

Cosmetics: Introduction. Toothpaste. Ingredients. Preparation. Recipe for toothpaste. Shampoos. Ingredients. Recipe. Hair dyeing. Materials used. Colour and Curl of Hair. Creams and Lotions. Skin Chemicals. Their ingredients. Preparation and recipe. Lipsticks. Ingredients. Preparation and recipe. Perfumes, Colognes and after shave preparation.

Compounds with flowery and fruity odours used in perfumes with their structures. Compounds with unpleasant odours used to fix delicate odours in perfumes. Deodorants and Antiperspirants.

Cosmetics: Economics and Advertising.

References:

1. B. K. Sharma, *Industrial Chemistry*, Goel Publication, Goa.
2. N. K. Sinha, *Petroleum Refining and petrochemicals*,
3. John W. Hill, *Chemistry for Changing times*, Surjeet Publication
4. Uttam Ray Chaudhuri, "Fundamentals of Petroleum and Petrochemical Engineering",,

Boca Raton London New York.

5. S ukumar Maiti, "*Introduction To Petrochemicals*" India Book House Pvt Ltd.
6. Gabriella Baki, Kenneth S. Alexander, "Introduction to Cosmetic Formulation and Technology", Wiley.
7. Tony Curtis, David Williams, "*Introduction to Perfumery*", Micelle Press; 2nd edition

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER IV
MCH 4 E 05 - INDUSTRIAL CATALYSIS (ELECTIVE)
(4 Credits, 72hrs)

Unit 1: Introduction to Adsorption process (9hrs)

Intermolecular interactions, physisorption – the forces of adsorption – dispersion and repulsive forces – classical electrostatic interactions – adsorbate-adsorbate interactions, chemisorption, potential energy curves, thermodynamics of adsorption – isothermal and adiabatic heats of adsorption – variation of heats of adsorption with coverage, adsorption isotherms, Langmuir, BET and Freundlich, kinetics of chemisorption – activated and non-activated chemisorption – absolute rate theory – electronic theories, hysteresis and shapes of capillaries.

Unit 2: Kinetics and Catalysis (9hrs)

Adsorption and catalysis – adsorption and reaction rate – strength of adsorption bond and catalysis – adsorption equilibrium and catalysis, kinetics of heterogeneous catalysis: diffusion steps neglected – unimolecular reactions – bimolecular reactions – Langmuir-Hinshelwood and Eley-Rideal mechanism, kinetics of heterogeneous catalysis: diffusion controlling – mechanism of diffusion – diffusion and reaction in pores – selectivity and diffusion, electronic factors in catalysis by metals, electronic factors in catalysis by semiconductors, geometric factors and catalysis.

References:

1. A.Clark, “Theory of adsorption and catalysis”, Academic Press, 1970.
2. J.M. Thomas & W.J. Thomas, “Introduction to principles of heterogeneous catalysis”, Academic Press, New York, 1967.
3. R.H.P. Gasser, “An introduction to chemisorption and catalysis by metals”, Oxford, 1985.
4. D.K Chakraborty, “*Adsorption and catalysis by solids*”, Wiley Eastern Ltd. 1990.

Unit 3: Catalyst - Preparative Methods (9hrs)

Surface area and porosity measurement – measurement of acidity of surfaces; Support materials

Preparation and structure of supports – surface properties, preparation of catalysts – introduction of precursor compound – pre-activation treatment – activation process. General methods of synthesis of zeolites, mechanism of nuclear formation and crystal growth, structures of some selected zeolites – zeolites A, X and Y, pentasils – ZSM-5, ZSM-11, shape

selective catalysis by zeolites.

Unit 4: Deactivation of Catalysts (9hrs)

Deactivation of catalysts, classification of catalyst deactivation processes, poisoning of catalysts, coke formation on catalysts, metal deposition on catalysts, sintering of catalysts, Regeneration of deactivated catalysts, feasibility of regeneration, description of coke deposit and kinetics of regeneration.

References:

1. J.R. Anderson and M. Boudart (Eds), "*Catalysis, Science and Technology*", Vol 6, Springer- Verlag, Berlin Heildberg, 1984.
2. R.B. Anderson, "*Experimental methods in catalysis research*", Vol I, II, Academic press, NY, 1981.
3. R. Szostak, "Molecular sieves: principles of synthesis and identification", Van Nostrand, NY, 1989.
4. R. Hughes, "*Deactivation of catalysts*", Academic press, London, 1984.

UNIT 5: Phase Transfer Catalysis (9hrs)

Basic concepts in phase transfer catalysis – phase transfer catalyzed reactions – basic steps of phase transfer catalysis – effect of reaction variables on transfer and intrinsic rates – outline of compounds used as phase transfer catalysts. Use of quaternary salts – macrocyclic and macrobicyclic ligands – PEG's and related compounds –use of dual phase transfer catalyst or co-catalyst in phase transfer systems –separation and recovery of phase transfer catalysts. Insoluble phase transfer catalysts.

UNIT 6: Biocatalysis (9hrs)

Enzymes – an introduction to enzymes – enzymes as proteins – classification and nomenclature of enzymes – structure of enzymes – how enzymes work – effect on reaction rate – thermodynamic definitions – catalytic power and specificity of enzymes – optimization of weak interactions between enzyme and substrate in the transition state – binding energy, reaction specificity and catalysis – specific catalytic groups contributing to catalysis. Immobilized biocatalysts – definition and classification of immobilized biocatalysts – immobilization of coenzymes.

References:

1. C.M. Starks, C.L. Liotta And M. Halpern, "Phase Transfer Catalysis – Fundamentals, Applications And Industrial Perspectives", Chapman & Hall, New York, 1994.

2. A.L. Lehninger, "*Principles of Biochemistry*", Worth Publishers, USA, 1987.

UNIT 7: Industrial Catalysis-1 (9hrs)

Oil based chemistry; catalytic reforming; catalytic cracking; paraffin cracking; naphthenic cracking; aromatic hydrocarbon cracking; isomerization; hydrotreatment; hydrodesulphurization; hydrocracking; steam cracking; hydrocarbons from synthesis gas; Fisher-Tropsch process, Mobil process for conversion of methanol to gasoline hydrocarbons. Catalysis for environmental protection, removal of pollutants from exhausts, mobile and static sources.

UNIT 8: Industrial Catalysis-II (9hrs)

Hydroformylation of olefins, carbonylation of organic substrates, conversion of methanol to acetic acid, synthesis of vinyl acetate and acetic anhydride, palladium catalyzed oxidation of ethylene, acrylonitrile synthesis, Zeigler-Natta catalysts for olefin polymerization. Propene polymerization with silica supported metallocene/MAO catalysts.

References:

1. G. Ertl, H. Knozinger and J. Weitkamp, "*Handbook of Heterogeneous Catalysis*" Vol 1-5, Wiley-VCH, Weinheim, 1997.
2. R.J. Farrauto and C.H. Bartholomew, "*Fundamentals of Industrial Catalytic Processes*", Blackie Academic and Professional – Chapman and Hall, 1997.
3. R. Pearce and W.R. Patterson, "*Catalysis and chemical processes*", Academic press, Leonard Hill, London, 1981.

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER IV
MCH 4 E 06 - NATURAL PRODUCTS & POLYMER CHEMISTRY
(4 Credits, 72 hrs)

UNIT 1: Basic aspects of Natural Products (9 hrs)

Classification of Natural Products: Classification of Natural products based on chemical structure, physiological activity, taxonomy and Biogenesis. Carbohydrates, Terpenoids, Carotenoids, alkaloids, steroids, anthocyanins etc. Methods of isolation of each class of compound

Essential Oils: Isolation and study of important constituents of lemon grass oil, citronella oil, cinnamon oil, palmarosa oil, turpentine oil, clove oil, sandalwood oil, Essential oils of turmeric and ginger. Oleoresins of pepper, chilly, ginger and turmeric. Aromatherapy.

UNIT 2: Terpenoids and Steroids (9 hrs)

Terpenoids: classification, structure elucidation and synthesis of abietic acid.

Steroids: Classification - structure of Cholesterol, Ergosterol, Oesterone, Androsterone, Testosterone, Progesterone, Cortisone and Corticosterone. Structural elucidation of Cholesterol. Conversion of cholesterol to progesterone, androsterone and testosterone.

Classification, structure and synthesis of prostaglandins, biosynthesis of fatty acids, prostaglandins, terpenoids and steroids.

UNIT 3: Alkaloids and Anthocyanins (9 hrs)

Alkaloids – classification of alkaloids, structure elucidation based on degradative reactions (quinine and atropine). Biosynthesis of quinine and papaverine.

Anthocyanins: Introduction, General Nature and Structure of Anthocyanidins. Flavone, Flavonol, Isoflavone and Chalcone

UNIT 4: Dyes, Pigments and Supramolecules (9 hrs)

Brief introduction to dyes and pigments (natural and synthetic): b-carotene, indigo, cyclic tetrapyrroles (porphyrins, chlorins, chlorophyll, heme), study of phthalocyanines, squarenes, cyanine dyes.

Introduction to Supramolecular chemistry and Molecular Recognition

References:

1. M. B. Smith, *Organic Synthesis*, 3/e, Academic Press, 2011.
2. F. A. Carey and R. J. Sundberg: *Advanced Organic Chemistry (part B)*, 3rd ed., Plenum Press.
3. T.W. G. Solomons: *Fundamentals of Organic Chemistry*, 5th ed., John Wiley

4. H. O. House: *Modern Synthetic Reactions*, W. A. Benjamin
5. W. Carruthers: *Some Modern Methods of Organic Synthesis*, 4/e, Cambridge University Press.
6. I L. Finar: *Organic Chemistry Volumes 1* (6th ed.) and 2 (5th ed.), Pearson.
7. J. Clayden, N. Green, S. Warren and P. Wothers: *Organic Chemistry*, 2/e, Oxford University Press
8. N. R. Krishnaswamy: *Chemistry of Natural Products; A Unified Approach*, Universities Press
9. R. J. Simmonds: *Chemistry of Biomolecules: An Introduction*, RSC
10. R. O. C. Norman: *Principles of Organic Synthesis*, 3rd ed., CRC Press, 1998.
11. J. M. Lehn, *Supramolecular Chemistry*

UNIT 5: Polymerization Processes (9 hrs)

Polymerization processes. Free radical addition polymerization. Kinetics and mechanism. Chain transfer. Mayo-walling equation of the steady state. Molecular weight distribution and molecular weight control. Radical Atom Transfer and Fragmentation – Addition mechanism. Free radical living polymers. Cationic and anionic polymerization. Kinetics and mechanism, Polymerization without termination. Living polymers. Step Growth polymerization. Kinetics and mechanism. Molecular weight distribution. Linear Vs cyclic polymerization, other modes of polymerization. Group Transfer, metathesis and ring opening polymerization. Copolymerization. The copolymerization equation, Q-e scheme, Gelation and Crosslinking. Copolymer composition drift Polymerization techniques. Bulk Solution, melt, suspension, emulsion and dispersion techniques.

UNIT 6: Characterization and Stereochemistry of Polymers (9 hrs)

Polymer Stereochemistry. Organizational features of polymer chains. Configuration and conformation, Tacticity, Repeating units with more than one asymmetric center. Chiral polymers – main chain and side chain. Stereoregular polymers. Manipulation of polymerization processes. Zeigler-Natta and Kaminsky routes. Coordination polymerization. Metallocene and Metal oxide catalysts.

Polymer Characterization. Molecular weights. Concept of average molecular weights, Molecular weight distribution. Methods for determining molecular weights. Static and dynamic methods, Light scattering and GPC. Crystalline and amorphous states. Glassy and Rubbery States. Glass transition and crystalline melting. Spherulites and Lammellac. Degree of Crystallinity, X-ray diffraction,

UNIT 7: Polymer Solutions, Industrial polymers and Copolymers (9 hrs)

Polymer Solutions. Treatment of dilute solution data. Thermodynamics. Flory-Huggins equation. Chain dimension-chain stiffness – End-to-end distance. Conformation-random coil, Solvation and Swelling. Flory-Reiner equation. Determination of degree of crosslinking and molecular weight between crosslinks.

Industrial polymers. Synthesis, Structure and applications. Polyethylene, polypropylene, polystyrene. Homo and Copolymers. Diene rubbers. Vinyl and acrylic polymers. PVC, PVA, PAN, PA. PMMA and related polymers.

Copolymers. EVA polymers. Fluorine containing polymers. Polyacetals. Reaction polymers. Polyamides, polyesters. Epoxides, polyurethanes, polycarbonates, phenolics, PEEK, Silicone polymers.

UNIT 8: Speciality Polymers (9 hrs)

Reactions of polymers. Polymers as aids in Organic Synthesis. Polymeric Reagents, Catalysts, Substrates, Liquid Crystalline polymers. Main chain and side chain liquid crystalline polymers. Phase morphology. Conducting polymers. Polymers with high bandwidth. Polyanilines, polypyrrols, polythiophenes, poly(vinylene phenylene). Photoresponsive and photorefractive polymers. Polymers in optical lithography. Polymer photoresists. Electrical properties of Polymers, Polymers with NLO properties, second and third harmonic generation, wave guide devices.

References:

1. F.W. Billmeyer. *Textbook of Polymer Science*. 3rd Edn, Wiley. N.Y. 1991.
2. G. Odian, *Principles of Polymerisation*, 4/e, Wiley, 2004.
3. V.R. Gowriker and Others, *Polymer Science*, Wiley Eastern Ltd.
4. J.M.G Cowie. *Polymers: Physics and Chemistry of Modern Materials*. Blackie. London, 1992.
5. R.J.Young, *Principles of Polymer Science*, 3rd Edn. , Chapman and Hall. N.Y. 1991.
6. P.J. Flory. *A Text Book of Polymer Science*. Cornell University Press. Ithacka, 1953.
7. F. Ullrich, *Industrial Polymers*, Kluwer, N.Y. 1993.
8. H.G.Elias, *Macromolecules*, Vol. I & II, Academic, N.Y. 1991.

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER IV
MCH 4 E 07 - MATERIAL SCIENCE (ELECTIVE) (4 credits, 72hrs)

Unit 1: Introduction to Material Science (9hrs)

Introduction, classification of materials, functional classification, classification based on structure, environmental and other effects, material design and selection;

Mechanical properties – significance and terminology, the tensile test, true stress and true strain, bend test, hardness of materials.

Unit 2: Ceramic Materials (9hrs)

Definition of ceramics, traditional and new ceramics, structure of ceramics, atomic interactions and types of bonds, phase equilibria in ceramic systems, one component and multi component systems, use of phase diagrams in predicting material behaviour, electrical, magnetic, and optical properties of ceramic materials.

Unit 3: Nanomaterials and Nanotechnology (9hrs)

Nanomaterials, nanostructures, self-assembly, Nanoparticles- methods of synthesis, sol-gel process, hydrolysis of salts and alkoxides, precipitation, condensation reactions, electrokinetic potential and peptization reactions; Gelatin network- xerogels, aerogels, drying of gels; Chemical modifications of nanosurfaces, applications of sol-gel process, sol-gel coating, porous solids, catalysts, dispersions and powders

Unit 4: Materials for Special Purposes – I (9hrs)

Production of ultra pure materials - zone refining, vacuum distillation and electro refining; Ferroelectric and piezoelectric materials - general properties, classification of ferroelectric materials, theory of ferroelectricity, ferroelectric domains, applications, piezoelectric materials and applications; Metallic glasses - preparation, properties and applications.

Unit 5: Materials for Special Purposes – II (9hrs)

Magnetic materials, ferri and ferro magnetism, metallic magnets, soft, hard & superconducting magnets; Ceramic magnets, low conducting and superconducting magnets; Superconducting materials - metallic and ceramic superconducting materials, theories of superconductivity,

Meissner effect; High temperature superconductors - structure and applications.

Unit 6: Some Special Polymers (9hrs)

Functional polymers - photoconductive, electroconductive, piezoelectric and light sensitive polymers; Industrial polymers - production, properties, & compounding of industrial

polymers; Commodity plastics such as PP, PE, PVC, & PS ; Engineering plastics such as polyacetyl, polyamide (nylon 6 and nylon 66), polyacrylate, polycarbonate, polyester (PET, PBT), polyether ketones; Thermosetting plastics such as PF, UF & MF.

Unit 7: Composite Materials (9hrs)

Definition and classification of composites, fibres and matrices; Composites with metallic matrices – processing, solid and liquid state processing, deposition;

Ceramic matrix composite materials – processing, mixing & Pressing, liquid state processing, sol

-gel processing & vapor deposition technique; Interfaces in composites - mechanical & microstructural characteristics; Applications of composites.

Unit 8: Fracture Mechanics (9hrs)

Importance of fracture mechanics, micro structural features of fracture in metals, ceramics, glasses & composites , Weibull statistics for failure, strength analysis; Fatigue, application of fatigue testing - creep, stress rupture & stress behavior, evaluation of creep behavior.

References:

1. W.D. Eingery, H.K. Downen and R.D. Uhlman, *Introduction to Ceramics*, John Wiley.
2. A.G. Guy, *Essentials of Material Science*, McGraw Hill.
3. M.J. Starfield and Shrager, *Introductory Material Science*, McGraw Hill.
4. S.K. Hajra Choudhary, *Material Science and Engineering*, Indian Book Dist. Co., Calcutta.
5. M.W. Barsoum, *Fundamentals of Ceramics*, McGraw Hill, 1997.
6. M. Tinkham, *Introduction to Superconductivity*, McGraw Hill, 1975.
7. A.V. Narlikar and S.N.Edbote, *Superconductivity and Superconducting Materials*, South Asian Publishers, New Delhi, 1983.
8. S.V. Subramanyan and E.S. Rajagopal, *High Temperature Superconductors*, Wiley Eastern Ltd., 1988.
9. Azaroff and Brophy, *Electronic Processes in Materials*, McGraw Hill, 1985.
10. C.M. Srivastava and C. Srinivasan, *Science of Engineering Materials*, Wiley Eastern Ltd., 1987.
11. R.J. Young, *Introduction to Polymer Science*, John Wiley and Sons.
12. V.R. Gowriker and Others, *Polymer Science*, Wiley Eastern Ltd.
13. H. Ulrich, *Introduction to Industrial Polymers*, Hansen Publishers, 1982.
14. F.R. Jones, *Handbook of Polymer Fibre Composites*, Longman Scientific and Tech.
15. K.K. Chowla, *Composite Materials*, Springer-Verlag, NY, 1987.

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER IV
MCH 4 E 08 – ORGANOMETALLIC CHEMISTRY (ELECTIVE)
(4 credits, 72hrs)

UNIT I (9h)

Organometallic compounds, Classification and nomenclature, the 16 and 18 electron rules, electron counting-covalent and ionic models, Main group organometallics-alkyl and aryl, groups 1, 2, 12, 13, 14 and 15 synthesis structure and applications. Transition metal to carbon multiple bond-the metal carbenes and carbynes, Transition metal complexes with chain π ligands – synthesis, structure, bonding and reactions of complexes of ethylene, allyl, butadiene and acetylene.

UNIT II (9h)

Metal carbonyls- Bonding modes of CO, IR spectroscopy as a tool to study bonding and structure of metal carbonyls, Synthesis of Metal carbonyls Direct and reductive Carbonylation, Reactions of Metal carbonyls-Activation of metal carbonyls, Disproportion, Nucleophilic addition, electrophilic addition to the carbonyl oxygen, Carbonyl cation, anions and hydrides, Collman's reagent, Migratory insertion of carbonyls, Oxidative decarbonylation, Photochemical substitution, Microwave assisted substitution.

UNIT III (9h)

General aspects of synthesis, structure, reactivity and applications of main group organometallic compounds. Metal complexes of NO, H₂, CS, RNC and Phosphines. Metal-carbon multiple bonds - Metal carbenes and carbynes, bridging carbenes and carbynes, N-heterocyclic carbons, multiple bonds to hetero atoms.

UNIT IV (9h)

Organometallic π complexes – synthesis, structure, bonding (molecular orbital treatment) and reactions of C₅H₅, C₆H₆, C₇H₇ and C₈H₈⁻². Polyalkyls, polyhydrides and f-block organometallic complexes, Fluxional organometallics.

UNIT V (9h)

Applications of organometallic compounds in organic synthesis and homogeneous catalysis, Complex formation and activation of H₂, N₂, O₂, NO by transition metals. Catalytic steps, Oxidative addition, reductive elimination and insertion reactions Hydrozirconation of alkenes and alkynes. Homogeneous catalysis. Hydrogenation, isomerization of alkenes, alkyne, cycloadditions, Zeigler-Natta catalysis, hydroformylation of alkenes, Monsanto acetic acid process and Wacker process. Metal complexes in enantioselective synthesis

UNIT VI (9h)

Organometallic reactions. SN^2 Reactions, Radical Mechanisms, Ionic Mechanisms, σ -Bond Metathesis, Oxidative Coupling and Reductive decoupling, Reactions involving CO, Insertions Involving Alkenes, Other Insertions, α , β , γ and δ Elimination, Deinsertion and Nucleophilic and electrophilic attack on coordinated ligand.

UNIT VII (9h)

Applications of organometallic reaction- Homogeneous catalysis- General features of catalysis, Types of catalyst, Catalytic steps. Water-gas shift reaction, Fisher-Tropsch reaction, Hydrosilation of alkenes, Hydrocyanation of alkenes.

UNIT VIII (9h)

Organometallic Polymers, Polymers with organometallic moieties as pendant groups, polymers with organometallic moieties in the main chain, condensation polymers based on ferrocene and on rigid rod polyynes, poly(ferrocenylsilane)s, applications of poly(ferrocenylsilane)s and related polymers, applications of rigid-rod polyynes, polygermanes and polystannanes, polymers prepared by ring opening polymerization, organometallic dendrimers.

References:

1. B. D. Gupta, A .J. Elias, Basic Organometallic Chemistry - Concepts, Synthesis and Applications, Second edition, University Press, 2013.
2. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, Fourth edn. 2005, Wiley Interscience.
3. J. E. Huheey, Inorganic Chemistry – Principles of Structure and Reactivity, 4th edition, Pearson education, 1993.
4. F.A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry. 5th edition, John and Wiley, 1999.
5. R.S. Drago. Physical Methods in Inorganic Chemistry, 2nd edition, Affiliated east west press, 1993.
6. P. Powell, Principles of Organometallic Chemistry, 2nd edition, Chapman and Hall, London, 1998.
7. S. F. A. Kettle, Concise co-ordination chemistry, Nelson, 1969.
8. S. F. A. Kettle, Physical Inorganic Chemistry-A Co-ordination chemistry Approach, Spectrum academy publishers, 1996.
9. Purcell and Kotz, Inorganic Chemistry.
10. D. J. Shriver, P. W. Atkins, Inorganic Chemistry, 5th edition, Oxford university press, 2010.

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY – SEMESTER III & IV
MCH 3 L 07 & MCH 4 L 10 – INORGANIC CHEMISTRY PRACTICALS– III & IV
(3 Credits)

Unit 1: Estimation of ions in mixture

Estimation involving quantitative separation of suitable binary mixtures of ions in solution (Cu^{2+} , Ni^{2+} , Zn^{2+} , Fe^{3+} , Ca^{2+} , Mg^{2+} , Ba^{2+} and $\text{Cr}_2\text{O}_7^{2-}$) by volumetric colorimetric or gravimetric methods only one of the components to be estimated.

Unit 2: Colorimetric Estimations

Colorimetric estimations of Ni, Cu, Fe and Mo, after separation from other ions in solution by solvent extraction. (Minimum two expts.)

Unit 3: Ion Exchange Methods

Ion- exchange separation and estimation of binary mixtures (Co^{2+} & Ni^{2+} , Zn^{2+} & Mg^{2+} . Hardness of water).

Unit 4: Preparation of Inorganic Complexes. (5 Nos)

References:

1. Vogel's Text Book of Qualitative Inorganic Analysis.
2. I.M. Kolthoff and E.A. Sanderson, *Quantitative Chemical Analysis*.
3. D.A. Adams and J.B. Rayner, *Advanced Practical Inorganic Chemistry*.
4. W.G.Palmer, *Experimental Inorganic Chemistry*.
5. G. Brauer, *Hand book of Preparative Inorganic Chemistry*.

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY – SEMESTER III & IV
MCH 3 L 08 & MCH 4 L 11 – ORGANIC CHEMISTRY PRACTICALS– III & IV
(3 Credits)

Unit 1: Quantitative Organic Analysis

Estimation of equivalent weight of acids by Silver Salt method, Estimation of nitrogen by Kjeldahl method, Determination of Acid value, iodine value and saponification value of oils and fats (at least one each), Estimation of reducing sugars, Estimation of amino group, phenolic group and esters. Colourimetric estimations: Vitamins (Ascorbic acid), Drugs – sulphadiazine, sulphaguanidine), Antibiotics – Penicillin, Streptomycin.

References:

1. B.S. Furnis, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, ELBS/Longman, 1989.
2. Beebet, *Pharmaceutical Analysis*.

Unit 2: Extractions

Extraction of Natural products and purification by column chromatography and TLC – Caffeine from Tea waste, Chlorophyll Steroids, Flavonoid (Soxhlet extraction), citral from lemon grass (steam distillation). Casein from milk.

Unit 3: Chromatography

Practical application of PC and TLC, Preparation of TLC plates, Activation, Identification of the following classes of compounds using one- and two-dimensional techniques. Identification by using spray reagents and co-chromatography by authentic samples and also from R_f values.

Food additives and Dyes, Artificial sweeteners: Saccharine, cyclamates, Dulcin. Flavour adulterants – piperonal, Benzalacetate, ethyl acetate antioxidants: Butylated hydroxytoluene (BHT) Butylated hydroxy anisole (BHA), Hydroquinone.

Food colours: Permitted – Amaranth, Erythrosine, Tartrazine, sunset yellow, Fast green, Brilliant Blue, Nonpermitted colours: Auramine, Congo red, Malachite green, Metanil yellow, Orange II, Sudan II, Congo red.

Amino acids (Protein hydrolysates), Sugars, Terpenoids, Alkaloids, Flavonoids, Steroids. Pesticides and herbicides: Organochlorine pesticides organo phosphates and carbamate pesticides, Herbicides.

Plant growth stimulants: Indole acetic acid.

References:

1. B.S. Furnis, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5/e, Pearson, 1989.
2. Beebet, *Pharmacuetical Analysis*
3. E. Hoftmann, *Chromatography*, non Nostrand Reinhold Company, New York, 1975.
4. J. Sherma and G. Zwig, *TLC and LC analysis of pesticides of international importance*, Vol. VI & VII, Academic Press.
5. H. Wagner, S. Bladt, E.M. Zgainsti – Tram, Th. A. Scott., *Plant Drug Analysis*, Springer- Verlag, Tokyo, 1984.
6. Vishnoi, *Practical Organic Chemistry*.

FAROOK COLLEGE (AUTONOMOUS)
M.Sc. CHEMISTRY – SEMESTER III & IV
MCH 3 L 09 & MCH 4 L 12 – PHYSICAL CHEMISTRY PRACTICALS– III & IV
(3 Credits)

SECTION A

Unit 1: Chemical Kinetics (4 experiments)

Determination of specific reaction rate of acid hydrolysis of an ester (methyl acetate or ethyl acetate) and concentration of the given acids.

Determination of Arrhenius parameters of acid hydrolysis of an

Determination of specific reaction rate of saponification of ethyl

Iodination of acetone in acid medium – Determination of order of reaction with respect of iodine and acetone.

Unit 2: Adsorption (3 experiments)

Verification of Langmuir adsorption isotherm – charcoal-acetic acid system. Determination of the concentration of a given acetic acid solution using the isotherm

Verification of Langmuir adsorption isotherm – charcoal-oxalic acid system. Determination of the concentration of a given acetic acid solution using the isotherm.

Determination of surface area of adsorbent.

Unit 3: Phase Equilibria (2 experiments)

(a) Determination of phase diagram of a ternary liquid system (e.g. chloroform – acetic acid – water – Benzene – acetic acid – water)

(b) Determination of the composition of a binary liquid mixture (e.g., chloroform-acetic acid, benzene-acetic acid)

(a) Determination of mutual miscibility curve of a binary liquid system (e.g., phenol – water) and critical solution temperature (CST).

Effect of impurities (e.g, NaCl, KCl, succinic acid, salicylic acid) on the CST of water-phenol system

Effect of a given impurity (e.g., KCl) on the CST of water –phenol system and determination of the concentration of the given solution of

Unit 4: Cryoscopy – Beckman Thermometer Method (3 experiments)

Determination of cryoscopic constant of a liquid (water, benzene)

Determination of molecular mass of a solute (urea, glucose, cane sugar, mannitol) by studying the depression in freezing point of a liquid solvent (water, benzene)

Determination of Van't Hoff factor and percentage of dissociation of NaCl.

Study of the reaction $2\text{KI} + \text{HgI}_2 \rightarrow \text{K}_2\text{HgI}_4$ and determination of the concentration of the given KI solution.

Unit 5: Polarimetry (3 experiments)

Determination of specific and molar optical rotations of glucose, fructose and sucrose.

Determination of specific rate of inversion of cane sugar in presence of HCl.

Determination of concentration of HCl

Unit 6: Spectrophotometry (3 experiments)

Determination of equilibrium constants of acid -base indicators.

Simultaneous of determination Mn and Cr in a solution of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$

Investigation of complex formation between Fe (III) and thiocyanate.

References:

7. A Finlay and J.A. Kitchener, Practical Physical Chemistry, Longman.
8. F. Daniels and J.H. Mathews, Experimental Physical Chemistry, Longman.
9. A H. James, Practical Physical Chemistry, J.A. Churchill Ltd., 1961.
10. H.H. Willard, L.L. Merit and J.A. Dean, Instrumental Methods of Analysis, 4th Edition, Affiliated East-West Press Pvt. Ltd., 1965.
11. D.P. Shoemaker and C.W. Garland, Experimental Physical Chemistry, McGraw Hill.
12. J.B. Yadav, Advanced Practical Physical Chemistry, Goel Publications, 1989.

SECTION B

Use of Computational Chemistry softwares like pc GAMESS (firefly), Gaussian etc., to calculate molecular parameters.

Unit 7: Computational Chemistry Calculations

- 1) Single point energy calculations of simple molecules like H_2O and NH_3 at the HF/3-21G level of theory.
- 2) The effect of basis set on the single point energy of H_2O and NH_3 using the Hartree-Fock method (3-21G, 6-31G, 6-31+G, 6-31+G* basis sets can be used).
- 3) Geometry optimization of molecules like H_2O , NH_3 , HCHO & C_2H_4 at the HF/6-31G level of theory.
- 4) Computation of dipole and quadrupole moments of HCHO & C_2H_4 at the HF/6-31G level of theory.
- 5) Effect of basis set on the computation of H-O-H bond angle in H_2O using the Hartree-Fock method (3-21G, 6-31G, 6-31+G, 6-31+G* basis sets can be used).

- 6) Computation of the energy of HOMO and LUMO of formaldehyde and ethylene at the HF/6-31G level of theory.
- 7) Effect of substituent (F & Cl) on the geometric parameters (like C-C bond length) of ethylene at the HF/6-31G level of theory.
- 8) Comparison of stability of cis-planar and trans-planar conformers of H₂O₂ at the HF/6-31G level of theory.
- 9) Comparison of stability of cis- and trans- isomers of difluoroethylene at the HF/6-31G* level of theory.
- 10) Computation of the frequencies of normal modes of vibration of molecules like H₂O, NH₃ and CO₂ at the HF/6-31+G* level of theory.
- 11) Determination of hydrogen bond strength of H₂O dimer and H₂O trimer at the HF/6-31+G* level of theory.
- 12) Determination of hydrogen bond strength of HF dimer and HF trimer at the HF/6-31+G* level of theory.

Reference:

1. J. Foresman & Aelieen Frisch, Exploring Chemistry with Electronic Structure Methods, Gaussian Inc., 2000.
2. David Young, Computational Chemistry- A Practical Guide for Applying Techniques to Real- World Problems”, Wiley -Interscience, 2001.
3. <http://classic.chem.msu.su/gran/gamess/index.html>

Model Question Papers

FAROOK COLLEGE (AUTONOMOUS)

First Semester MSc Degree Examination

MCH 1 C 01 – Quantum Mechanics and Computational Chemistry

Time: 3hours Max.

Weightage 30

Section A Short Answer

Answer 8 Questions out of 12.

Each question carries a weightage of 1 (8 X 1 = 8)

- 1) Explain Born interpretation of wave function
- 2) Differentiate time-dependent and time independent Schrodinger equation.
- 3) Explain tunnelling
- 4) What do you mean by symmetry breaking?
- 5) Determine the commutator of the operator d/dx and $1/x$
- 6) Draw the radial distribution functions of 2s, and 2p
- 7) What are Cartesian and spherical polar coordinates?
- 8) Differentiate Slater type orbitals and Gaussian type orbitals.
- 9) Explain Fock operator.
- 10) Explain Pauli's anti-symmetry principle.
- 11) Differentiate ab initio and semi-empirical methods.
- 12) Give the Z-matrix for H₂O molecule.

Section B Short Essay

Answer 4 Questions out of 7.

Each question carries a weightage of 3 (4 X 3 = 12)

- 13) Explain the postulates of quantum mechanics.
- 14) Explain the system particle in three-dimensional box.
- 15) A hydrogen molecule is confined in a cubic box with sides 1 meter. (i) What is the value of quantum number n at a temperature of 300K? (ii) What is the energy level separation between the levels n and $n+1$? (iii) What is its de Broglie wavelength?
- 16) Discuss Variation method for the helium atom in the ground state.
- 17) Explain Hartree's Self consistent field method for atoms.
- 18) Explain Spin orbitals and their construction.

19) Explain the structure of Gaussian input file. Explain any two key words.

Section B Essay

Answer 2 Questions out of 4.

Each question carries a weightage of 5 (2 X 5 = 10)

20) Derive wave functions and energies of hydrogen-like systems

21) Discuss the harmonic oscillator model and molecular vibrations

22) Explain Perturbation theory. Discuss the perturbation treatment of ground state of helium.

23) Discuss the basis set classification

FAROOK COLLEGE (AUTONOMOUS)
First Semester MSc Degree Examination
MCH 1 C 02 – Chemistry of Elements

Time: 3 hours Max.

Weightage 30

Section A Short Answer

Answer 8 Questions out of 12.

Each question carries a weightage of 1 (8 X 1 = 8)

- 24) Explain symbiosis
- 25) Calculate the styx number of B_5H_9 .
- 26) Discuss Wade's rule as applied to boranes.
- 27) Discuss first and second row anomalies in transition metals.
- 28) What are silicides?
- 29) Distinguish heteropoly and isopoly anions.
- 30) How is 4f orbital different from 5f?
- 31) What are super heavy elements?
- 32) Explain the principle of radiation dosimetry.
- 33) Explain critical size as applied to nuclear reaction.
- 34) With suitable examples, differentiate photo nuclear and thermos nuclear reactions
- 35) What are graphenes?

Section B Short Essay

Answer 4 Questions out of 7.

Each question carries a weightage of 3 (4 X 3 = 12)

- 36) Illustrate the use of SO_2 as a non-aqueous solvent.
- 37) Discuss the classification of borides.
- 38) Explain different types of reactions of boranes.
- 39) Illustrate the structure, bonding and use of SN_x .
- 40) Compare and contrast the spectral properties of lanthanide and actinides.
- 41) Discuss the characteristics of Ellingham diagram.
- 42) Explain template assisted synthesis of nano materials

Section B Essay

Answer 2 Questions out of 4.

Each question carries a weightage of 5 (2 X 5 = 10)

- 43) Discuss different theories of acids and bases.
- 44) Explain the structure, bonding and uses of Phosphorous-Nitrogen compound.
- 45) Illustrate theory of nuclear fusion reaction.
- 46) Write short note on the following characterization techniques
 - (a) SEM
 - (b) TEM
 - (c) AFM
 - (d) XPS
 - (e) XRD

FAROOK COLLEGE (AUTONOMOUS)
First Semester MSc Degree Examination
MCH 1 C 03 - Structure and Reactivity of Organic Compounds

Time: 3hours Max.

Weightage 30

Section A Short Answer

Answer 8 Questions out of 12.

Each question carries a weightage of 1 (8 X 1 = 8)

- 1) What is homo aromaticity
- 2) Explain Hammett acidity function
- 3) What are classical and non classical carbocations?
- 4) Explain neighbouring group participation with carboxylate ion as an example.
- 5) What are the factors affecting conformational stability of a molecule?
- 6) Discuss kinetic control versus thermodynamic control.
- 7) Explain the effect of conformation on the course of E2 elimination (i) 4-t-Butylcyclohexyl tosylate.
- 8) Draw the configurations of decalin.
- 9) Explain Cahn-Ingold-Prelog rule.
- 10) What is the catalyst used in Sharpless asymmetric epoxidation. Explain the mechanism.
- 11) Distinguish , stereoselectivity and stereospecificity

Section B Short Essay

Answer 4 Questions out of 7.

Each question carries a weightage of 3 (4 X 3 = 12)

- 12) What is criteria for aromaticity and antiaromaticity ? Explain the molecular orbital description of aromaticity and antiaromaticity
- 13) Effect of conformation on the course and rate of reactions in the dehydrohalogenation of stilbene dihalide.
- 14) Explain the conformations of cyclohexane, and methyl cyclohexane.

- 15) Compare the rate of esterification of menthol, isomenthol, neomenthol and neoisomenthol.
- 16) Explain Bredt's rule.
- 17) Discuss the stereochemistry of aldoximes and ketoximes.
- 18) What is chiral auxiliary controlled asymmetric synthesis? Explain the use of chiral auxiliary in Diels-Alder reaction.

Section B Essay

Answer 2 Questions out of 4.

Each question carries a weightage of 5 (2 X 5 = 10)

- 19) Discuss the effect of hydrogen bonding on the physiochemical properties and conformations of organic compounds
- 20) Illustrate the conformations of alkene dihalides, glycols, chlorohydrins, and tartaric acid.
- 21) Explain the different methods of resolution
- 22) Discuss Cram's rule and Felkin-Anh model.

FAROOK COLLEGE (AUTONOMOUS)
First Semester MSc Degree Examination
MCH 1 C 04 - Thermodynamics, Kinetics and Catalysis

Time: 3 hours Max.

Weightage 30

Section A Short Answer

Answer 8 Questions out of 12.

Each question carries a weightage of 1 (8 X 1 = 8)

- 1) Explain residual entropy
- 2) Explain Nernst heat theorem
- 3) Define fugacity
- 4) What is Thermo osmosis?
- 5) Explain Electrokinetic effect.
- 6) What is steady state approximation?
- 7) Explain explosion limit with $H_2 - O_2$ reaction as example.
- 8) Compare collision theory and activation complex theory.
- 9) Explain Langmuir theory of adsorption.
- 10) How is surface acidity determined?
- 11) What is TDP method?
- 12) Discuss with an example auto catalysis.

Section B Short Essay

Answer 4 Questions out of 7.

Each question carries a weightage of 3 (4 X 3 = 12)

- 13) Explain chemical potential. Deduce the relation between chemical potential with temperature and pressure
- 14) Explain entropy production
- 15) Discuss Onsager reciprocal relations
- 16) Explain Potential energy surface
- 17) Discuss the kinetics of decomposition of acetaldehyde.
- 18) Discuss the factors affecting the reaction rates in solution.

- 19) Explain the Michaelis – menton mechanism of enzyme catalysis. Michaelis constant of an enzyme catalised reaction at 298K is 0.073 mol/L. At a substrate concentration of 0.8 mol/L, the rate of the reaction is found to be 4.19 mol/L/S. Calculate the maximum velocity

Section B Essay

Answer 2 Questions out of 4.

Each question carries a weightage of 5 (2 X 5 = 10)

- 20) Explain Excess functions. Illustrate the determination of Excess volume.
- 21) Discuss the theories of unimolecular reactions
- 22) Illustrate the determination of surface area and pore structure of adsorbents
- 23) What are oscillation reactions? Explain their mechanism.