COURSE CURRICULUM UNDER CHOICE BASED CREDIT SYSTEM (C.B.C.S.)

SYLLABUS

FOR

Bachelor of Science (B.Sc) in CHEMISTRY

(w.e.f. Academic Session: 2019-2020)

Department of Chemistry

(Faculty of Science & Technology)

Aliah University

IIA/27, Newtown, Kolkata 700160, West Bengal, India

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1. Scheme of CBCS Curriculum

1.1 Basic Courses Types under CBCS

In CBCS, there are some basic types of courses. The ones that are relevant to the B.Sc. curricula have been described below:

I. Core Course (CC):

A discipline specific compulsory basic course. (14 papers each of 6 credit totaling 14×6=84 credit points)

II. Discipline Specific Elective Course (DSE):

A discipline specific elective course which is more advanced or specialized. (4 papers, each of 6 credit totaling 4×6=24 credit points)

III. Generic Elective Course (GEC):

An inter-disciplinary elective course to be opted from a discipline other than one's main discipline(s) of choice (e.g. a course in a discipline other than in which honours has been taken). (4 papers, each of 6 credit totaling 4×6=24 credit points)

IV. Ability Enhancement Compulsory Course (AECC):

These are compulsory courses. There are two of them. AECC-1 is Environmental Science & AECC-2 is Communicative English / Modern Indian Language (e.g.: Bengali, Arabic, Urdu, Hindi.) (2 papers, each of 4 credit totaling 2×4=8 credit points)

V. Skill Enhancement Course (SEC):

A discipline specific elective skill enhancement course. (2 papers, each of 4 credit totaling 2×4=8 credit points)

VI. Aliah University Compulsory Course (AUCC):

There will be Compulsory Course on "Arabic and Islamic Studies" having no credit points in Semester-II.

Overall credit points in the UG 6 semester courses=CC (14×6)+DSE (4×6)+GEC(4×6) +AECC(2×4)+SEC(2×4)=148

Overall marks in the UG 6 semester courses=CC(14×75)+ DSE(4×75)+GEC(4×75)+ AECC(2×50)+SEC(2×50)=1850

1.2 Distribution of Theory and Practical Marks

1.2.1 Scheme of Marks distribution for Lab based Papers having 75 Marks

I. **Theory- 50 Marks:** will comprise Written Examination of 40 Marks + Internal Assessment 10 Marks

II. **Practical- 25 Marks:** will comprise Practical Examination of 20 Marks + Internal Assessment 5 Marks

III. **Internal Assessment of total 15 Marks** shall comprise:

- Theoretical class Attendance: 05 Marks
- Class Test: 05 Marks (There will be 02 class tests with documentation)
- Quiz: 05 Marks

IV. **Practical Examination: 20 Marks** will comprise: Lab Note Book: 05 + Viva-voce: 05 + Experiment: 10

V. **Duration** for Written Examination of 40 Marks: 2 Hours

VI. **Duration** of Practical Examination of 20 Marks: 1 Hour 30 minutes.

VII. **Distribution of 05 Marks allotted for Theoretical class attendance:**

- 50% ≤ Attendance < 60% : 02 Marks
- 60% ≤ Attendance < 75%: 03 Marks
- 75% ≤ Attendance < 90%: 04 Marks
- Attendance ≥ 90%: 05 Marks

VIII. **Scheme of Question Paper setting for theoretical Papers of 40 Marks**

- To answer 05 questions out of 08 questions each carrying 02 marks 05×02=10
- To answer 02 questions out of 04 questions each carrying 05 marks=02×05=10
- To answer 02 questions out of 04 questions each carrying 10 marks=02×10=20

Note: Questions carrying 5 or 10 marks, need not necessarily be a single question

1.2.2. Scheme of Marks Distribution for Tutorial based Papers having 75 Marks

1. Class Attendance cum Internal Assessment: 20% of 75 marks=15 marks of which 5 marks be reserved for class attendance (both Theoretical + Tutorial) in the following manner:

- Attendance 50% & above but below 60% - 2 marks
- Attendance 60% & above but below 75% - 3 marks
- Attendance 75% & above but below 90% - 4 marks
- Attendance 90% & above – 5 marks

10 marks be reserved for class test/ assignment/ seminar (Theoretical-5 & Tutorial–5). Minimum 15 classes be allotted for tutorial portion.

2. In the Semester-end- Examination of each paper (Duration of Examination: 3 hours), Question Paper to be set for 60 marks.

3. Scheme of Question Paper setting for theoretical Papers of 60 Marks

- To answer 10 questions out of 15 questions each carrying 02 marks=10×02=20
- To answer 04 questions out of 06 questions each carrying 05 marks=04×05=20
- To answer 02 questions out of 04 questions each carrying 10 marks=02×10=20

Note: Questions carrying 5 or 10 marks, need not necessarily be a single question

1.2.3 For each SEC paper, distribution of 50 marks be as follows:

1. Internal Assessment 20% of 50 marks=10 marks be reserved for class test/assignment/ seminar.

2. 40 marks be allotted for Semester-end-Theoretical Examination of each paper (Duration of Examination: 2 hours) distribution of which may be as under:

3. Scheme of Question Paper setting for theoretical Papers of 40 Marks under SEC

- To answer 05 questions out of 08 questions each carrying 02 marks = 05×02 =10
- To answer 02 questions out of 04 questions each carrying 05 marks = 02×05=10
- To answer 02 questions out of 04 questions each carrying 10 marks = 02×10=20

Note: Questions carrying 5 or 10 marks, need not necessarily be a single question.

1.3 Semester wise Course distribution

Course Type	Semester I	Semester II	Semester III	Semester IV	Semester V	Semester VI
CC	CHMUGCC01 CHMUGCC02	CHMUGCC03 CHMUGCC04	CHMUGCC05 CHMUGCC06 CHMUGCC07	CHMUGCC08 CHMUGCC09 CHMUGCC10	CHMUGCC11 CHMUGCC12	CHMUGCC13 CHMUGCC14
DSE					CHMUGDS01/ CHMUGDS02 CHMUGDS03/ CHMUGDS04	CHMUGDS05/ CHMUGDS06 CHMUGDS07/ CHMUGDS08
GEC	MATUGGE01	PHYUGGE01	MATUGGE02	PHYUGGE02		
SEC			CHMUGSE01/ CHMUGSE02	CHMUGSE03/ CHMUGSE04		
AECC	CHMUGAE01	ENGUGAE02				
AUCC		ARBUGAU01				
Papers/Semester	4	5	5	5	4	4
CC	2×6=12	2×6=12	3×6=18	3×6 = 18	2×6 = 12	2×6 = 12
DSE	0×6 = 00	0×6 = 00	0×6 = 00	0×6 = 00	2×6 = 12	2×6 = 12
GEC	1×6 = 06	1×6 = 06	1×6 = 06	1×6 = 06	0×6 = 00	0×6 = 00
SEC	0×4 = 00	0×4 = 00	1×4 = 04	1×4 = 04	0×4 = 00	0×4 = 00
AECC	1×4 = 04	1×4 = 04	0×4 = 00	0×4 = 00	0×4 = 00	0×4 = 00
AUCC	0×0 = 00	1×0 = 00	0×0 = 00	0×0 = 00	0×0 = 00	0×0 = 00
Credits/Semester	22	22	28	28	24	24

Courses offered by the Department of Chemistry to allied Departments:

Course Type	Semester I	Semester II	Semester III	Semester IV	Semester V	Semester VI
GEC	CHMUGGE01	CHMUGGE01	CHMUGGE02	CHMUGGE02		
		CHMUGBS01 & CHMUGBS02				
Credits/Semester	6	6+6	6	6		

1.4 Semester wise course details

Semester	Course Type	Course Code	Course Name	Teaching Mode	Credit	Marks
I	**CC**	CHMUGCC01	Inorganic Chemistry-I	Theory Practical	4 2	50 25
	CC	CHMUGCC02	Physical Chemistry-I	Theory Practical	4 2	50 25
	GEC	CHMUGGE01	Subsidiary Chemistry-I	Theory Practical	4 2	50 25
	AECC	EVSUGAE01	Environmental Studies	Theory	4	50
II	**CC**	CHMUGCC03	Organic Chemistry-I	Theory Practical	4 2	50 25
	CC	CHMUGCC04	Physical Chemistry-II	Theory Practical	4 2	50 25
	GEC	to be opted from a discipline other than main discipline		Theory Practical	4 2	50 25
	AECC **(Any one)**	ENGUGAE02	Communicative English/ Bengali/ Urdu	Theory Theory Theory	4 4 4	50 50 50
	AUCC	ARBUGAU01	Arabic and Islamic Studies (Compulsory)	Theory	0	00

III	**CC**	CHMUGCC05	Inorganic Chemistry-II	Theory Practical	4 2	50 25
	CC	CHMUGCC06	Organic Chemistry-II	Theory Practical	4 2	50 25
	CC	CHMUGCC07	Physical Chemistry-III	Theory Practical	4 2	50 25
	GEC	CHMUGGE02	Subsidiary Chemistry-II	Theory Practical	4 2	50 25
	SEC-A (Any one)	CHMUGSE01	Analytical Clinical Biochemistry	Theory	4	50
		CHMUGSE02	Chemical Technology and Society	Theory	4	50
IV	**CC**	CHMUGCC08	Inorganic Chemistry-III	Theory Practical	4 2	50 25
	CC	CHMUGCC09	Organic Chemistry-III	Theory Practical	4 2	50 25
	CC	CHMUGCC10	Physical Chemistry-IV	Theory Practical	4 2	50 25
	GEC	to be opted from a discipline other than main discipline		Theory Practical	4 2	50 25
	SEC-B (Any one)	CHMUGSE03	Polymer Chemistry	Theory	4	50
		CHMUGSE04	Basic Analytical Chemistry	Theory	4	50
	CC	CHMUGCC11	Organic Chemistry-IV	Theory Practical	4 2	50 25
	CC	CHMUGCC12	Physical Chemistry-V	Theory Practical	4 2	50 25

V	**DSE-A1 (Any one)**	CHMUGDS01	Application of Computers in Chemistry	Theory Practical	4 2	50
		CHMUGDS02	Bioinorganic Chemistry	Theory Practical	4 2	50
	DSE-B1 (Any one)	CHMUGDS03	Research Methodology for Chemistry	Theory Tutorials	5 1	60 15
		CHMUGDS04	Mathematical Chemistry and Structural Activity Relationship	Theory practical	4 2	50 25
VI	**CC**	CHMUGCC13	Inorganic Chemistry-IV	Theory practical	4 2	50 25
	CC	CHMUGCC14	Organic Chemistry-V	Theory practical	4 2	50 25
	DSE-A2 (Any one)	CHMUGDS05	Analytical Methods in Chemistry	Theory Practical	4 2	50 25
		CHMUGDS06	Industrial Chemicals and Environment	Theory Practical	4 2	50 25
	DSE-B2 (Any one)	CHMUGDS07	Fundamentals of Medicinal Chemistry	Theory practical	4 2	50 25
		CHMUGDS08	Dissertation	Project work	6	75

1.5 Credit Structure

In CBCS, all courses have credits assigned to them. For any course, one of the following three modes teaching will be used:

1. Theory + Practical
2. Theory + Tutorial
3. Theory only

The credit structure is described below:

Course Type	Theory+Practical		Theory+Tutorials		Theory	Total Credit
	Theory	Practical	Theory	Tutorials	Theory Only	
CC	4	2	5	1		6
DSE	4	2	5	1		6
GEC	4	2	5	1		6
SEC					4	4
AECC					4	4
AUCC					0	0

Class Assignments

The class assignment for different course segments (Theory, Practical, and Tutorial) is as follows:

- Theory: 1 credit = 1 hour/week
- Practical: 1 credit = 2 hours/week
- Tutorial: 1 credit = 1 hour/week

Duration of the Semesters

The semesters will comprise 15 to 18 weeks of direct teaching.

Grading

The evaluation and final grading will also depend crucially on the credits of the papers.

A Grade Point Average system will be used. The weight factor (or importance) with which a particular paper will contribute to the final CGPA (Cumulative Grade Point Average) will depend on the credit of the course.

Please refer to the University Regulations for details.

1.6 Selection of DSE

- A student must choose total four DSE papers from his/her honours subject of which two papers in the 5^{th} semester and two papers in the 6^{th} semester.

- There are two groups of DSE papers, DSE-A and DSE-B. Each of these groups is further divided into two subgroups DSE-A1, DSE-A2, and DSE-B1, DSE-B2 respectively.

- In the 5th semester a student will have to choose two DSE papers of which one shall be DSE-A1 and other shall be DSE-B1.

- Similarly, in the 6th semester a student will have to choose two DSE papers of which one shall be DSE-A2 and other shall be DSE-B2.

1.7 Selection of SEC

- A student must choose two SEC papers from the honours discipline – one in the 3rd semester and one in the 4th semester.

- For each subject there will be two groups of SEC papers, SEC-A and SEC-B.

- The SEC paper in the 3rd semester must be chosen from Group A namely SEC-A and the SEC paper in the 4th semester must be chosen from Group B namely SEC-B.

1.8 Semester wise Courses

The number of different types of courses to be taken in the different semesters has been specialized in the table below:

Course Type	Semester I	Semester II	Semester III	Semester IV	Semester V	Semester VI	Total	Credits
CC	2	2	3	3	2	2	14	14×6 =84
DSE					2	2	4	4×6=24
GE	1	1	1	1			4	4×6=24
SEC			1	1			2	2×4=8
AECC	1	1					2	2×4=8
AUCC		1					1	1×0=0
Total	4	5	5	5	4	4	27	148

Special Note:

Across all courses (for both, Honours and General) out of 20% of the totalling marks (i.e. 20% of 75 marks=15 marks), 2/3 marks (i.e. 2/3 of 15 marks=10 marks) will be reserved for Internal Assessment and remaining 1/3 marks (i.e. 1/3 of 15 marks=5 marks) will be reserved for Attendance.

1.9 Syllabi for Core Courses (Honours)

- **Core Courses**

Semester	Course Type	Course code	Course Name	Teaching Mode	Credit	Marks
I	CC	CHMUGCC01	Inorganic Chemistry-I	Theory	4	50
				Practical	2	25
	CC	CHMUGCC02	Physical Chemistry-I	Theory	4	50
				Practical	2	25
II	CC	CHMUGCC03	Organic Chemistry-I	Theory	4	50
				Practical	2	25
	CC	CHMUGCC04	Physical Chemistry-II	Theory	4	50
				Practical	2	25
III	CC	CHMUGCC05	Inorganic Chemistry-II	Theory	4	50
				Practical	2	25
	CC	CHMUGCC06	Organic Chemistry-II	Theory	4	50
				Practical	2	25
	CC	CHMUGCC07	Physical Chemistry-III	Theory	4	50
				Practical	2	25
IV	CC	CHMUGCC08	Inorganic Chemistry-III	Theory	4	50
				Practical	2	25
	CC	CHMUGCC09	Organic Chemistry-III	Theory	4	50
				Practical	2	25
	CC	CHMUGCC010	Physical Chemistry-IV	Theory	4	50
				Practical	2	25
V	CC	CHMUGCC11	Organic Chemistry-IV	Theory	4	50
				Practical	2	25
	CC	CHMUGCC12	Physical Chemistry-V	Theory	4	50
				Practical	2	25
VI	CC	CHMUGCC13	Inorganic Chemistry-IV	Theory	4	50
				Practical	2	25
	CC	CHMUGCC14	Organic Chemistry-V	Theory	4	50
				Practical	2	25

- **Choices for DSE**

Semester	Course type-Group	Course Code	Course name	Teaching	Credit	Marks
V	DSE-A1 (Any one)	CHMUGDS01	Application of Computers in Chemistry	Theory Practical	4 2	50 25
		CHMUGDS02	Bioinorganic Chemistry	Theory Practical	4 2	50 25
	DSE-B1 (Any one)	CHMUGDS03	Research Methodology for Chemistry	Theory Tutorials	5 1	60 15
		CHMUGDS04	Mathematical Chemistry and Structural Activity Relationship	Theory Practical	4 2	50 25
VI	DSE-A2 (Any one)	CHMUGDS05	Analytical Methods in Chemistry	Theory Practical	4 2	50 25
		CHMUGDS06	Industrial Chemicals and Environment	Theory Practical	4 2	50 25
	DSE-B2 (Any one)	CHMUGDS07	Fundamentals of Medicinal Chemistry	Theory Practical	4 2	50 25
		CHMUGDS08	Dissertation	Project work	6	75

- **Choices for GE**

Semester	Course type-Group	Course code	Course name	Teaching	Credit	Marks
I	GE1	CHMUGGE01	Subsidiary Chemistry-I	Theory Practical	4 2	50 25
III	GE2 (Any one)	CHMUGGE02	Subsidiary Chemistry-II	Theory Practical	4 2	50 25

- **Choices for AECC**

Semester	Course type-Group	Course code	Course name	Teaching	Credit	Marks
I	AECC1	EVSUGAE01	Environmental Studies	Theory	4	50
II	AECC2 (Any one)	ENGUGAE02	Communicative English/ Urdu/Bengali	Theory	4	50

- **Choices for SEC**

Semester	Course Type-Group	Course Code	Course Name	Teaching Mode	Credit	Marks
III	SEC-A (Any one)	CHMUGSE01	Analytical Clinical Biochemistry	Theory	4	50
		CHMUGSE02	Chemical Technology and Society	Theory	4	50
IV	SEC-B (Any one)	CHMUGSE03	Polymer Chemistry	Theory	4	50
		CHMUGSE04	Basic Analytical Chemistry	Theory	4	50

- **Choices for AUCC**

Semester	Course Type-Group	Course Code	Course Name	Teaching Mode	Credit	Marks
III	AUCC	ARBUGAU01	Arabic and Islamic Studies	Theory	0	00

1.10 Table for credit and marks distribution against different courses

Type of Paper	Sub Category	Theory Papers	Practical Papers	Credits	Total Credits
Core Course (CC)	Core Course(CC)	14		4 each	56
	Core Course (CC)		14	2 each	28
Elective Course (EC)	Generic Elective (GE)	04		4 each	16
	Generic Elective (GE)		04	2 each	08
	Discipline Specific Elective (DS)	04		4 each	16
	Discipline Specific Elective (DS)		04	2 each	08
Ability Enhancement (AE)	Ability Enhancement Compulsory (AE)	02		4 each	08
Skill Enhancement (SE)	Skill Enhancement Course (SE)	02		4 each	08
Aliah University Non-credit compulsory course	Arabic and Islamic Studies (AU)	01		Non credit	0
Total					**148**

2. Detailed Syllabi

Semester I

2.1 Course Name: Inorganic Chemistry-I
Topic: Atomic Structure, Radioactivity & Chemical Periodicity-I
Course Code: CHMUGCC01

Course type: Core	Course Distribution: Theory: 4 Credit Practical: 2 Credit	Theory: 60 Lectures Practical: 60 Class Hours

Radioactivity (20 Lectures)

Nuclear stability and binding energy, Nuclear forces, meson theory, Nuclear models, Concept of nuclear quantum number, Magic numbers, Nuclear Reactions: fission, fusion and spallation, Nuclear energy and power generation, Separation and uses of isotopes. Natural radioactivity, Law of radioactive decay, Artificial radioactivity, radio carbon dating, hazards of radiation and safety measures.

Atomic Structure (20 Lectures)

Bohr's theory, spectrum of hydrogen atom, Sommerfeld's model, Quantum numbers, Concept of atomic orbitals; shapes, radial and angular probability diagrams of *s*, *p* and *d* orbitals, Schrödinger's equation, Many electron atoms and ions, Pauli's exclusion principle, Hund's rule, exchange energy, Aufbau principle and its limitation, Term symbols of atoms and ions.

Chemical periodicity I (20 Lectures)

Periodic table, group trends and periodic trends, Modern IUPAC Periodic table, General characteristic of s, p, d and f block elements. Position of hydrogen and noble gases, Effective nuclear charges, screening effects, Slater's rules, atomic radii, ionic radii (Pauling's univalent), covalent radii, Ionization potential, electron affinity and electro negativity and factors influencing these properties, Inert pair effect, Group trends and periodic trends in these properties in respect of s-, p- and d-block elements.

Reference Books	
I.	Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
II.	Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970.
III.	Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.

Practicals	
I. Systematic qualitative analysis of the following metals and non metal salts	
	Sulphide, suiphate, sulphite, thiosulphate, nitrite, nitrate, orthoborate, metaborate, fluoride, chloride, bromide, iodide, phosphate, Arsenate, arsenite, silicate, ferocyanide, fericyanide, thiocyanate.

Reference Books	
I.	Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.

2.2 Course Name: Physical Chemistry-I
Topic: Physical States of Matter
Course Code: CHMUGCC02

Course type: Core	Course Distribution: Theory: 4 Credit Practical: 2 Credit	Theory: 60 Lectures Practical: 60 Class Hours

Theory

Gaseous state (15 Lectures)

Gas laws, Postulates of Kinetic theory of gases, Pressure equation on the basis of the Kinetic theory, gas laws based on kinetic theory, Distribution of velocity of gas molecules-Maxwell's velocity distribution, Values of different types of average velocities of gas, Collision in a gas-mean free path, collision diameter, collision number, mean free path, deviation of gases from ideal behavior, compressibility factor, Andrew's and Amagat's plot Van der Waals equation , existence of critical state, critical constants in terms of Van der Waals constant, reduced equation of state, Principles of corresponding state.

Liquid state (15 Lectures)

Intermolecular forces in liquids, Dipole-dipole attractions, London forces, Hydrogen bonding, Vapour pressure, Effect of temperature on vapour pressure, Effect of vapour on boiling points, Surface tension, Units of surface tension, Spreading of liquid over other surface, Determination of surface tension by capillary rise method, Determination of surface tension by drop formation method, Influence of temperature on surface tension, Parachor and molar refraction of a liquid, Viscosity, Viscosity coefficient, Poiseuille's equation, Measurement of viscosity by Ostwald method, Effect of temperature on viscosity of a liquid, Liquid crystal, Smectic, Nematic and Cholestric Liquid Crystals.

Solid state (15 Lectures)

Classification of solids, Isotropy and anisotropy, crystal habits, Symmetry of crystal, Miller indices, Findings of miller indices, Crystal structures, Parameters of the unit cell, Cubic unit cell, Three types of cubic unit cell, Coordination number of a crystal lattices, X-ray crystallography, Bragg's equation, Measurement of diffraction angles, Ionic crystals, sodium chloride crystal, Cesium chloride crystal, Lattice energy of an ionic crystal, Molecular crystal, Metallic crystals, Hexagonal closed packed structure, Body centered cubic structure, Imperfection in crystal: point defects-Schottky and Frenkel defects, Metal alloys, Semiconductors, Solar cell, Liquid crystal, Application of liquid crystal.

Colloidal State (15 Lectures)

Definition of colloids, classification of colloids, Types of colloidal system, Preparation of sols: by mechanical dispersion method, by Bredig's Arc method, by Peptization, Purification of sols: dialysis, electrodialysis, ultrafiltration. Optical properties of sol: Tyndall effect, Kinetic properties of sol: Brownian motion, Electrical properties of sol, Electrical double layer, Helmholtz Double layer, Electrophoresis of sols, Electrro-osmososis, Protective colloids, Hardy- Schulze rule, Gold number, Stability of sols, Associated colloids, Micelles, Cleansing action of soap, Emulsions, Emulsification, De-emulsification, Gels, Preparations of gels, Artificial kidney machine, Macromolecules, Determination of molecular weights of macromolecules, Application of colloidal chemistry.

Reference Books	
I.	Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 13 (2006).
II.	Ball, D. W. Physical Chemistry Thomson Press, India (2007).
III.	Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
IV.	I. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).

Practical	
1.	Determination of viscosity co-efficient of a given solution with Ostwald's viscometer.
2.	To determine the percentage composition of the given mixture consisting of two components by viscosity measurement.
3.	To determine the surface tension of a given liquid at room temperature using Stalagmometer.
4.	To determine the solubility of benzoic acid at room temperature.
5.	Study the effect on Ph of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
6.	pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.

Reference Books	
I.	Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson
II.	Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books(2009)
III.	Physical Chemistry Practical: Saroj Kr Maity, Naba Kr Ghosh
IV.	Harris, D. C. Quantitative Chemical Analysis. 9th Ed., Freeman (2016)
V.	An Advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad
VI	Palit, S.R., De, S. K. Practical Physical Chemistry Science Book Agency
VII.	Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.

2.3 Subsidiary Chemistry-I (CHMUGGE01)

Course type: Generic Elective Course (Minor-Chemistry)	**Course Distribution: Theory: 4 Credit Practical: 2 Credit**	**Theory: 60 Lectures Practical: 60 Class Hours**

Theory

Atomic Structure and Chemical Bonding (20 Lectures)

Extra nuclear structure of atom: Bohr's theory for hydrogen atom, Bohr's model, Sommerfeld's model, Quantum numbers, Hund's rule, Pauli's exclusion principle, Aufbau principle. Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability.

Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment. Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Fundamentals of Organic Chemistry (20 Lectures)

Bonding and physical properties

Valence bond theory: concept of hybridisation, orbital pictures of compounds (sp^3, sp^2, sp: C-C, C-N & C-O system). Inductive effect, bond polarization and bond polarizability, steric effect, resonance, hyperconjugation, steric inhibition of resonance, acidity-basicity, tautomerism.

Concept of DBE: Prediction of probable structures from chemical formula.

Moleular Orbital Theory: sketch and energy levels of MOs of i) acyclic p orbital system (C=C, conjugated diene and allyl systems) Hückel's rules for aromaticity & antiaromaticity.

Physical properties: bond distance, bond angles, mp/bp & dipole moment.

Nucleophilic Substitution and Elimination Reactions

Nucleophilic substitutions: S_N1 and S_N2 reactions; eliminations: E1 and E2 reactions (elementary mechanistic aspects); Saytzeff and Hofmann eliminations.

Thermodynamics (20 Lectures)

Thermodynamic terms, types of thermodynamics system, properties, state of a system, thermodynamic processes, internal energy, first law of thermodynamics, enthalpy of system, molar heat capacities, work done by isothermal and adiabatic expansion of ideal gas, spontaneous process, Carnot cycle, thermodynamic potential and Maxwell's equation.

Reference Books	
I.	textbook of Organic Chemistry and Problem Analysis: K. L. Ghatak
II.	A Mechanism and Theory in Organic Chemistry- Sachin Kumar Ghosh
III.	I.L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
IV.	Physical Chemistry-P. C. Raxit
V.	Physical Chemistry-K. L. Kapoor
VI.	T. W. Graham Solomons: Organic Chemistry, John Wiley and Sons.
VII.	Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
VIII.	R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
IX.	Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
X.	G. M. Barrow: Physical Chemistry Tata McGraw---Hill (2007).
XI.	G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
XII.	J. C. Kotz, P. M. Treichel & J. R. Townsend: General Chemistry Cengage Lening India Pvt. Ltd., New Delhi (2009).
XIII.	B. H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
XIV.	R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).

Practical	
1.	**Systematic qualitative analysis of the following metals and non metal salts**
	Ag, Cu, Al, Fe, Cr, Co, Ni, Zn, Ca, Sr, Ba, Mg, Na, K; sulphide, sulphate, sulphite, nitrate, chloride, bromide, iodide, phosphate, ferrocyanide, ferricyanide, thiocyanate. Semi-micro and spot analysis method should be encouraged.

2.	**Qualitative analysis of single solid organic compounds**
	Detection of special elements (N, Cl, S) by Lassaigne's test Solubility and Classification (solvents: H_2O, 5% HCl, 5% $NaHCO_3$, 5% NaOH) Detection of the following functional groups by systematic chemical tests: Aromatic amino (-NH_2), aromatic nitro (-NO_2), Amido (-$CONH_2$, including imide), Phenolic –OH, Carboxylic acid (-COOH), Carbonyl (>C=O); only one test for each functional group is to be reported.
3.	**Physical methods of estimation**
	(a) Determination of surface tension of a given solution by drop weight method using a stalagmometer, considering aqueous solutions of NaCl, acetic acid, ethanol etc, as systems. (b) Determination of viscosity coefficient of a given solution with Ostwald's viscometer considering aqueous solutions of cane-sugar, glycerol, ethanol, etc.

Reference Books	
I.	Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
II.	Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
III.	Textbook of Practical Organic Chemistry, A.I. Vogel, Prentice Hall, 5th edition.
IV.	Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960.

Semester II

2.4 Course Name: Organic Chemistry-I
Topic: Bonding & Stereochemistry
Course Code: CHMUGCC03

Course type: Core	Course Distribution: Theory: 4 Credit Practical: 2 Credit	Theory: 60 Lectures Practical: 60 Class Hours

Theory

Chemical Bonding (30 Lectures)

Valence bond theory: concept of hybridisation, orbital pictures of compounds (sp^3, sp^2, sp: C-C, C-N & C-O system). Inductive effect, bond polarization and bond polarizability, steric effect, resonance, cross conjugation, hyperconjugation, steric inhibition of resonance, acidity-basicity.

Concept of DBE: Prediction of probable structures from chemical formula.

Moleular Orbital Theory: sketch and energy levels of Mos of i) acyclic p orbital system (C=C, conjugated diene and allyl systems) ii) cyclic p orbital system (neutral system: [4], [6] annulenes; charged system: 3,4,5-ring system); Fröst diagram, Hückel's rules for aromaticity & antiaromaticity; homoaromaticity, meso-ionic compounds, ylides.

Physical properties: bond distance, bond angles, mp/bp & dipole moment, intermolecular forces, heat of hydrogenation and heat of combustion.

Transition State Theory: elementary idea, Hammond's postulate.

Bonding weaker than covalent Hydrogen bonding, π-π interactions, addition compounds: electron donor-acceptor complex, crown ether complex, cryptates, inclusion compounds, cyclodextrins, catenanes, rotaxanes.

Application of thermodynamic principles in tautomeric equilibria [keto-enol, amine-enamine, nitro-acinitro, nitroso-oxime, composition of the equilibrium in different systems (simple carbonyl, 1,3 and 1,2- dicarbonyl systems, phenols and related system), substituent and solvent effect].

Stereochemistry (30 Lectures)

Representation of molecules in saw horse, Fischer, flying-wedge and Newman formulae and their inter translations, symmetry elements, molecular chirality.

Optical activity of chiral compounds: specific rotation, optical purity (enantiomeric excess)

Molecular chirality. Configuration: stereogenic units i) stereocentres: systems involving 1, 2, 3 centres, stereogenicity, absolute configuration, CIP rule, chirotopicity. Pseudoasymmetric (D/L and *R*/*S* descriptor, threo/erythro and syn/anti nomenclatures (for aldols) ii) stereoaxis: chiral axis in allenes & biphenyls, *R*/*S* descriptor; *cis*/*trans*, *syn/anti*, *E*/*Z* descriptors (for C=C, C=N). racemisation (through cationic and anionic and radical intermediates), resolution of acids, bases and alcohols via diastereomeric salt formation. Topicity of ligands and faces (elementary idea): Pro-*R*, Pro-*S* and *Re*/*Si* descriptors.

Conformation: Conformational nomenclature, eclipsed, staggered, gauche and anti; dihedral angle, torsion angle, energy barrier of rotation, relative stability of conformers on the basis of steric effect, dipole-dipole interaction, H-bonding; conformational analysis of ethane, propane, n-butane, haloethane, 1,2-haloethane, 1,2- glycol, 1,2-halohydrin; invertomerism of trialkylamines.

Reference Books	
I.	Organic Chemistry – Wade
II.	Organic Chemistry- Paula Y. Bruice
III.	Mechanism & Theory in Organic Chemistry , S.K. Ghosh
IV.	Organic Chemistry, Vol. I – Finar
V.	A guidebook to mechanics in organic chemistry-Sykes
VI.	Organic Chemistry – Solomons
VII.	Advanced Organic Chemistry-Jerry march
VIII.	Basic stereochemistry of organic molecules- Subrata Sen Gupta
IX.	Stereochemistry of organic compounds – Ernest L. Eliel
X.	Stereochemistry of Organic Compounds- Principles and Applications- D. Nasipuri

Practical	
Qualitative analysis of single solid organic compounds	
1.	Physical Characteristics and M. P. detection
2.	Preliminary Tests
3.	Solubility Classification (solvents: H_2O, 5% HCl, 5% $NaHCO_3$, 5% NaOH, c. H_2SO_4)

4.	Detection of special elements (N, S, halogen) by Lassaigne's test
5.	Detection of functional groups (Aromatic $-NH_2$ & $-NO_2$, anilido, amido, phenolic –OH, $-CO_2H$, carbonyl, ester/anhydride/lactone).
6.	Preparation, purification and M. P. determination of a crystalline derivative of the given compound.

Reference Books	
I.	Vogel's Textbook of Practical Organic Chemistry: A. I. Vogel, B. S. Furniss, P. W. Smith
II.	An advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad
III.	A Textbook On Chemistry Practical: Bidhan Chandra Ray, Satyanarayan Das

2.5 Course Name: Physical Chemistry-II
Topic: Chemical Thermodynamics, Chemical Equilibrium and Phase rule
Course Code: CHMUGCC04

Course type: Core	**Course Distribution: Theory: 4 Credit Practical: 2 Credit**	**Theory: 60 Lectures Practical: 60 Class Hours**

Theory

Thermodynamics-I (15 Lectures)

Importance and scope, thermodynamic terms: system, boundary, surrounding, types of systems: isolated, closed and open, extensive and intensive variables, partial derivatives and cyclic rule, state function and path function, equilibrium and non-equilibrium state, zeroth law of thermodynamics thermodynamic processes, concept of heat and work, work done during expansion and compression of an ideal gas, pressure-volume work, reversible and irreversible processes and work done, comparison of W_{rev} and W_{irrev}, internal energy, calculation of ΔU, ΔH. q and w, enthalpy of a system, heat capacity: heat capacities at constant volume and pressure and their relationship, Joule-Thomson effect, adiabatic expansion of an ideal gas, work done in adiabatic reversible expansion.

Thermochemistry (10 Lectures)

t equations, Methods of writing thermochemical equation, heat of reaction or enthalpy of reaction, laws of thermochemistry, heat of combustion, heat of solution, heat of neutralization, energy changes during transitions, heat of fusion, heat of vaporization, heat of sublimation, heat of transition, Hess's law of constant heat summation, application of Hess's law, bond energy, measurement of the heat of reaction.

Thermodynamics-II (15 Lectures)

Spontaneous process, criteria of spontaneity, second law thermodynamics, different statements of the law. Carnot cycle and its efficiency, Carnot theorem, Maxwell relations, thermodynamic scale of temperature, entropy: unit of entropy, numerical definition of entropy, standard entropy, standard entropy of formation, physical significance of entropy, entropy as a function of V and T, entropy as a

function of P and T, entropy change in ideal gases and mixing of gases, entropy change accompanying change of phase, free energy function and work function, variation of free energy with temperature and pressure, Gibb's Helmholtz equations, condition of equilibrium and criteria for a spontaneous process, Clapeyron equation, Clausius-Clapeyron equation. Maxwell relations; thermodynamic equation of state.

Chemical Equilibrium (10 Lectures)

Thermodynamic conditions for equilibrium, degree of advancement; variation of free energy with degree of advancement; equilibrium constant and standard Gibbs free energy change; definitions of K_p, K_c and K_x and relation among them; van't Hoff's reaction isotherm, isobar and isochore from different standard states; shifting of equilibrium due to change in external parameters e.g. temperature and pressure; variation of equilibrium constant with addition to inert gas; Le Chatelier's principle.

Phase Equilibrium (10 Lectures)

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

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

Three component systems, water-chloroform-acetic acid system, triangular plots.

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

Nernst distribution law: its derivation and applications.

Reference Books

I.	Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).
II.	Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
III.	Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012). McQuarrie, D. A. &
IV.	Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
V.	Physical Chemistry by P.C. Rakshitvi. Levine, I .N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010).
VI.	Metz, C.R. 2000 solved problems in chemistry, Schaum Series (2006).
VII.	Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).
VIII.	Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004). Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
IX.	McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.:New Delhi (2004).

Practical

1.	Partition coefficient of iodine between CCL_4 and water
2.	Equlibrium constant of $KI+I_2=KI_3$ by partition method
3.	To show that benzene dimerizes in benzene
4.	Study of the adsorption of acetic acid on charcoal-verification of Freunflich's Adsorption Isotherm
5.	To study the phase diagram of a binary system (Phenol + water) and the effect of impurities (e.g. NaCl)

Reference Books	
I.	Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson
II.	Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009)
III.	Physical Chemistry Practical: Saroj Kr Maity, Naba Kr Ghosh
IV.	Harris, D. C. Quantitative Chemical Analysis. 9th Ed., Freeman (2016)
V.	An Advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad
VI.	Palit, S.R., De, S. K. Practical Physical Chemistry Science Book Agency
VII.	Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.

2.6 Course Name: Inorganic Chemistry-II
Topic: Chemical Bonding-I, Chemical Periodicity-II & Acid-Base Concept
Course Code: CHMUGCC05

Course type: Core	**Course Distribution: Theory: 4 Credit Practical: 2 Credit**	**Theory: 60 Lectures Practical: 60 Class Hours**

Theory

Chemical Bonding-I (15 Lectures)

Lewis structures, formal charge. Valence Bond Theory, directional character, hybridizations, equivalent and non-equivalent hybrid orbitals, Bent's rule, VSEPR theory, shapes of molecules and ions, Partial ionic Character, bond moment, dipole moment, Concept of resonance, resonance energy and resonance structures.

Chemical Periodicity II (25 Lectures)

General trends of variation of electronic configuration, elemental forms, metallic nature, magnetic properties (if any), catenation and catalytic properties (if any), oxidation states, inert pair effect (if any), aqueous and redox chemistry in common oxidation states, properties and reactions of important compounds such hydrides, halides, oxides, oxyacids (if any), complex chemistry (if any) in respect of s-block and p-block elements.

Structure, bonding and reactivity of B_2H_6; $(SN)_x$ with x= 2,4; phosphazines; interhalogens. Structure of borates, silicates, polyphosphates, borazole, boron nitride, silicones, thionic acids. Reactivity of polyhalides, pseudo halides, fluorocarbons, freons and NO_x with environmental effects. Chemistry of hydrazine, hydroxylamine, N_3^-, thio- and per-sulphates.
Noble gases from air; oxides, fluorides and oxofluorides of xenon, chemical and photochemical reactions of ozone.

Acid-Base Concept (20 Lectures)

Acid-Base concept: Arrhenius concept, theory of solvent system, Bronsted-Lowry's concept, relative strength of acids, Pauling rules, Amphoterism, Lux-Flood concept, Lewis concept, Superacids, HSAB principle. Acid-base equilibria in aqueous solution and pH scale, Acid-base neutralisation curves, indicator, choice of indicators.

SN	Reference Books
I.	Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
II.	Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970.
III.	Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.

SN	Practical
I.	**Systematic qualitative analysis of the following metal salts** Hg(I), Hg (II), Pb, Ag, Cu, Bi, Cd, As, Sb, Sn, Al, Fe, Cr, Co, Ni, Zn, Ca, Sr, Ba, Mg, Na, K, NH_4. Semi micro and spot analysis method should be encouraged.

Reference Books	
I.	G. Svehla, Vogel's Qualitative Inorganic Analysis, 7^{th} Edn.

2.7 Course Name: Engineering Chemistry
Course Code: CHMUGBS01

Course type: Engineering	Course Distribution: Theory: 3 Credit	Theory: 75 Lectures

Thermodynamics (15 Lectures)

Importance and scope, definitions of system and surroundings; type of systems; Extensive and intensive properties; Steady state and equilibrium; Zeroth law of thermodynamics; First law of thermodynamics, internal energy and Enthalpy as a state function; Second law of thermodynamics; Kelvin, Planck and Clausius statements; Carnot cycle and refrigerator; Carnot's theorem; Physical concept of entropy.

Non-Conventional Energy Resources (15 Lectures)

Nuclear Energy; Solar Energy; Wind Energy; Biomass and Bio fuels, Hydrogen Energy.

Water and its Treatmen (15 Lectures)

Sources of water, Impurities in water, Hardness of water, Determination of hardness of water, Water quality parameter, Treatment of water for domestic purpose, Waste water.

Polymers (15 Lectures)

Terminology, Classification of polymers, Polymerization techniques, Molecular weight of polymers, Plastics, Rubbers, Fibers, Conducting and semiconducting polymers, Natural polymers.

Green Chemistry (15 Lectures)

Definition and concept of green chemistry, Emergence of green chemistry, Alternative solvents, Design of safer chemicals, Microwave radiation of green synthesis, Green laboratory Technology.

Reference Books	
I.	Wiley Engineering Chemistry, Wiley, 2nd Edn., 2014.
II.	K. S. Maheswaramma and M. Chugh, Engineering Chemsitry, Pearson, 2016.

2.8 Course Name: Engineering Chemistry Lab; Course Code: CHMUGBS02

Course type: Engineering	**Course Distribution: Theory: 3 Credit**	**Theory: 75 Lectures**

Practical	
1.	Acidimetric estimation of Sodium Carbonate and Sodium bi-Carbonate in their mixture.
2.	Estimation of Total Hardness of water by Complexometric method.
3.	Estimation of Fe^{II} in Mohr's Salt by Permanganometric Titration.
4.	Qualitative analysis of single solid organic compounds.

Reference Books	
I.	In house laboratory manual by the Department of Chemistry, Aliah University.

Semester III		
2.9 Course Name: Organic Chemistry-II Topic: Organic Reactions & Mechanisms Course Code: CHMUGCC06		
Course type: Core	**Course Distribution: Theory: 4 Credit Practical: 2 Credit**	**Theory: 60 Lectures Practical: 60 Class Hours**

Theory

General concept of organic reaction (10 Lectures)

Mechanistic classification: ionic, radical and pericyclic; heterolytic bond cleavage and heterogenic bond formation, homolytic bond cleavage and homogenic bond formation; representation of mechanistic steps using arrow formalism.
Reactive intermediates: carbocations (cabenium and carbonium ions), carbanions, carbon radicals, carbenes –Concept of acids and bases: effect of structure, substituent and solvent on acidity and basicity.
Kinetic Isotopic effect: Theory of isotope effects, primary and secondary kinetic isotope effects, heavy atom isotope effects, tunneling effect, solvent effects.

Nucleophilic substitution reactions (10 Lectures)

Substitution at sp^3 centre – Mechanism: S_N^1, S_N^2, $S_N^{2'}$, S_N^i mechanisms, effect of solvent, substrate structure, leaving group, nucleophiles including ambident nucleophiles (cyanide & nitrite) substitution involving NGP; relative rate & stereochemical features [systems: alkyl halides, allyl halides, alcohols, ethers, epoxides].
Substitution at sp^2 carbon (carbonyl system) – Mechanism: B_{AC}^2, A_{AC}^2, A_{AC}^1, A_{AL}^1 (in connection to acid and ester). Systems: amides, anhydrides & acyl halides [formation and hydrolysis]

Addition reactions (20 Lectures)

Electrophilic addition to C=C: Mechanism, reactivity, regioselectivity and stereoselectivity. Reactions: halogenations, hydrohalogenation, hydration, hydrogenation, epoxidation, hydroxylation, ozonolysis, electrophiilic addition to diene (conjugated dienes and allenes). Radical addition: HBr addition. Dissolving metal reduction of alkynes and bezenoid aromatics (Birch). Pericyclic addition: Diels-Alder reaction. Addition of singlet and triplet carbenes.
Nucleophilic addition to C=O: Mechanism, reactivity, equilibrium and kinetic control. Reactions with alcohols, amines, thiols, HCN, bisulfite, Wittig reaction.
Carbonyl Reduction: hydride addition, Wolff-Kishner reduction, dissolving metal (Bouveault-Blanc reduction, Clemmensen Reduction); Cannizzaro reaction, Tischenko reaction, aldol condensation, benzoin condensation.
Nucleophilic addition to α,β-unsaturated carbonyl system (general principles).

Elimination and aromatic substitution (20 Lectures)

Elimination – Mechanisms: E1, E2 and E1Cb; reactivity, orientation (Saytzeff/ Hofmann) and stereoselectivity; substitution vs elimination,
Electrophilic aromatic substitution: Mechanisms, orientation and reactivity. Reactions: nitration,

nitrosation, sulfonation, halogenation , Friedel-Crafts reactions, one carbon electrophiles (reactions: chloromethylation, Gatterman-Koch, Gatterman, Hoesch, Vilsmeier-Haack reaction, Reimer-Tiemann, Kolbe-Schmidt).
Nucleophilic aromatic substitution: Addition-elimination mechanism, S_N^1 mechanism, benzyne intermediate.

Reference books	
I.	Mechanism & Theory in Organic Chemistry-S.K. Ghosh I. Organic Chemistry, Vol. I – Finar
II.	A guidebook to mechanics in organic chemistry- Peter Sykes
III.	Advanced Organic Chemistry-Jerry march
IV.	An advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad

Practical	
Quantitative Estimation of organic compounds	
1.	Estimation of glucose solution by Fehling's solution
2.	Estimation of sucrose solution by Fehling's solution
3.	Estimation of phenol/aniline by bromination
4.	Estimation of formaldehyde
5.	Estimation of acetone
6.	Estimation of Vitamin-C
7.	Estimation of amino acids
8.	Estimation of chemical oxygen demand (COD) of water
9.	Estimation of calcium in milk

Reference books	
I.	Vogel's Textbook of Practical Organic Chemistry: A. I. Vogel, B. S. Furniss, P. W. Smith
II.	AA Textbook On Chemistry Practical: Bidhan Chandra Ray, Satyanarayan Das

2.10 Course Name: Physical Chemistry-III
Topic: Chemical kinetics, Adsorption and catalysis
Course Code: CHMUGCC07

Course type: Core	**Course Distribution:** **Theory: 4 Credit** **Practical: 2 Credit**	**Theory: 60 Lectures** **Practical: 60 Class Hours**

Theory

Chemical kinetics (30 Lectures)

Chemical kinetics and its scope, Rate of a reaction, Average rate of reaction, Instantaneous rate of reaction, Rate laws, Order of a reaction, Zero order reaction, Molecularity, Molecularity of a elementary reaction, Molecularity a complex reaction, Molecularity vs order of a reaction, Pseudo

order reactions, Mathematical characteristics of simple chemical reactions – zero order, first order, second order, third order, Rate constant, Half life of a reaction, Determination of order of a reaction by: integrated rate equations, graphical method, half-life method, differential method, Concentration and temperature dependence of rates Collision theory of reaction rates, Arrhenius equation, concept of activation energy. Simultaneous reactions: consecutive reaction, parallel reactions, opposing reactions, Limitation of collision theory, transition state theory, concept of activation energy, Lindeman's theory of unimolecular reactions.

Adsorption and catalysis (30 Lectures)

Adsorption phenomenon, Mechanism of adsorption, Types of adsorptions, Adsorption of gases by solids, Adsorption isotherm: Freundlich adsorption isotherm, Langmuir adsorption isotherm, Derivation of Langmuir Adsorption Isotherm, Adsorption of solutes from solutions, Application of adsorption, Ion exchange adsorption. Catalysts, Classification of catalysis: homogenous and heterogenous, Characetristics of catalytic reaction, Promoters, Catalytic poisoning, Autocatalysis, Negative catalysis, Activation energy and catalysis, Intermediate compound formation theory, The adsorption theory, Hydrogenation of ethyne in presence of nickel, Active centres,

Acid-base catalysis, Enzyne catalysis, Enzyme catalysis, Mechanism of enzyme catalysis, Michaelis-menten equation, Uses of catalysts in industry.

Reference books	
I.	Peter Atkins & Julio De Paula, Physical Chemistry 9th Ed., Oxford University Press (2010).
II.	Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004).
III.	McQuarrie, D. A. & Simon, J. D., Molecular Thermodynamics, Viva Books Pvt. Ltd.: New Delhi (2004). Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
IV.	Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
V.	Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).

Practical	
1.	Study of kinetics of acid hydrolysis of ester
2.	Determination of rate constant of inversion of sucrose by polarimeter
3.	Kinetic study of decomposition of hydrogen peroxide in presence of I-ion
4.	Adsorption of acetic acid on charcoal
5.	Study of reaction between $K_2S_2O_8$ and KI
6.	Determination of rate constant of decomposition of H_2O_2 by acidified KI solution using clock reactions.
7.	Studies on kinetics of acid catalyzed hydrolysis of methyl acetate/ ethyl acetate: (i) Determination of rate constants (ii) Determination of catalytic co-efficient
8.	To study the phase diagram of a binary system (Phenol + water) and the effect of impurities (e.g. NaCl)
9.	To show that benzoic acid dimerises in benzene

Reference books	
I.	Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson
II.	Viswanathan, B., Raghavan, P.S. *Practical Physical Chemistry* Viva Books (2009)
III.	Physical Chemistry Practical: Saroj Kr Maity, Naba Kr Ghosh
IV.	An Advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad
V.	Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
VI.	Palit, S.R., De, S. K. *Practical Physical Chemistry* Science Book Agency
VII.	Levitt, B. P. edited *Findlay's Practical Physical Chemistry* Longman Group Ltd.

2.11 Course Name: Subsidiary Chemistry-II
Course Code: CHMUGGE02

Course type: Generic Elective Papers (GE) (Minor-Chemistry)	Course Distribution: Theory: 4 Credit Practical: 2 Credit	Theory: 60 Lectures Practical: 60 Class Hours

Theory

Chemical periodicity and compounds of *s*- and *p*- block elements (20 Lectures)

General characteristics of s, p, d and f block elements, position of hydrogen and noble gases, atomic and ionic radii, ionization potential, electron affinity and electro negativity; periodic and group wise variations.
Hydrides and their classification (ionic, covalent and interstitial), structure and properties with respect to stability of hydrides of p- block elements.
Concept of multicentre bonding (diborane).
Structure, bonding and their important properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial, organic and environmental chemistry.
Hydrides of nitrogen (NH_3, N_2H_4, N_3H, NH_2OH)
Oxoacids of P, S and Cl.
Halides and oxohalides: PCl_3, PCl_5, $SOCl_2$ and SO_2Cl_2

Stereochemistry and Reaction mechanism (20 Lectures)

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis – trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).
Reaction mechanism –Mechanistic classification: ionic, radical and pericyclic; heterolytic bond cleavage and heterogenic bond formation, homolytic bond cleavage and homogenic bond formation; representation of mechanistic steps using arrow formalism.
Substitution at sp^3 centre – Mechanism: S_N^1 and S_N^2 mechanisms, effect of solvent, substrate structure, leaving group, nucleophiles including ambident nucleophiles (cyanide & nitrite) substitution involving NGP; relative rate & stereochemical features.

Electrochemistry and Chemical Kinetics (20 Lectures)

Electrolysis, Laws of electrolysis, factor affecting electrolytic conduction, equivalent conductivity, molar conductivity, conductance behavior of of weak and strong electrolyte, Kohlrausch's Law of independence migration of ions, conductmetric titration, electrochemical cells. Types of electrode, concentration cell, potentiometric titrations, electrochemical sensor, batteries.
Chemical kinetics: Order and molecularity of reaction, rate laws and rate equations of first order and second order reaction, zero order reaction, temperature dependence of reaction rate, half life.

Reference books	
I.	Physical Chemistry by P. C. Raxit
II.	Physical Chemistry by K. L. Kapoor
III.	Study guide to Organic Chemistry by Chandan Saha
IV.	General and Inorganic Chemistry-R. Sarkar
V.	D. F. Shriver and P. W. Atkins: Inorganic Chemistry, Oxford University Press.

Practical	
Quantitative analysis of inorganic salts	
1.	Estimation of Mohr salt solution by permanganometric titration.
2.	Estimation of total hardness of water by complexometric titration.
3.	Detection of the following functional groups by systematic chemical tests.
4.	Aromatic amino ($-NH_2$), aromatic nitro ($-NO_2$), Amido ($-CONH_2$, including imide), Phenolic –OH, Carboxylic acid (-COOH), Carbonyl (>C=O); only one test for each functional group is to be reported..
5.	Acidimetric estimation of sodium carbonate and sodium bi-carbonate in their mixture.
6.	Study the kinetics of Iodide-persulphate reaction.

Reference books	
I.	A. I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7^{th} Edn.

2.12 Course Name: Analytical Clinical Biochemistry
Course Code: CHMUGSE01

Course type: Skill Enhancement Courses	Course Distribution: Theory: 4 Credit	Theory: 60 Lectures

Theory

Basic understanding of the structures, properties and functions of carbohydrates, lipids and proteins: (30 Lectures)

Carbohydrates: Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle.
Isolation and characterization of polysachharides.
Proteins: Classification, biological importance; Primary and secondary and tertiary structures of proteins: α-helix and β- pleated sheets, Isolation, characterization, denaturation of proteins.

Enzymes: Nomenclature, Characteristics (mention of Ribozymes), Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes, Coenzymes and cofactors, Enzyme inhibitors, Introduction to Biocatalysis: Importance in "Green Chemistry" and Chemical Industry.
Lipids: Classification. Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications.
Lipoproteins: Properties, functions and biochemical functions of steroid hormones.
Biochemistry of peptide hormones: Structure of DNA (Watson-Crick model) and RNA, Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation, Introduction to Gene therapy.
Enzymes: Nomenclature, classification, effect of Ph, temperature on enzyme activity, enzyme inhibition.

Biochemistry of disease: A diagnostic approach by blood/ urine analysis. (30 Lectures)

Blood: Composition and functions of blood, blood coagulation. Blood collection and preservation of samples. Anaemia, Regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol and bilirubin.
Urine: Collection and preservation of samples, formation of urine, composition and estimation of constituents of normal and pathological urine.

Practical	
Identification and estimation of the following	
1.	Carbohydrates – qualitative and quantitative.
2.	Lipids – qualitative.
3.	Determination of the iodine number of oil.
4.	Determination of the saponification number of oil.
6.	Proteins – qualitative.
7.	Isolation of protein.
8.	Determination of protein by the Biuret reaction.

Reference Books	
I.	T.G. Cooper: Tool of Biochemistry.
II.	Keith Wilson and John Walker: Practical Biochemistry.
III.	Alan H Gowenlock: Varley's Practical Clinical Biochemistry.
IV.	Thomas M. Devlin: Textbook of Biochemistry.
V.	Jeremy M. Berg, John L Tymoczko, Lubert Stryer: Biochemistry.
VI.	G. P. Talwar and M Srivastava: Textbook of Biochemistry and Human Biology.
VII.	A. L. Lehninger: Biochemistry.
VIII.	O. Mikes, R.A. Chalmers: Laboratory Handbook of Chromatographic Methods

2.13 Course Name: Chemical Technology and Society Course Code: CHMUGSE02		
Course type: Skill Enhancement Courses	**Course Distribution: Theory: 4 Credit**	**Theory: 60 Lectures**

Theory

Chemical Technology (30 Lectures)

Basic principles of distillation, solvent extraction, solid-liquid leaching and liquid-liquid extraction, separation by absorption and adsorption. An introduction into the scope of different types of equipment needed in chemical technology, including reactors, distillation columns, extruders, pumps, mills, emulgators. Scaling up operations in chemical industry.
Introduction to clean technology.

Society (30 Lectures)

Exploration of societal and technological issues from a chemical perspective. Chemical and scientific literacy as a means to better understand topics like air and water (and the trace materials found in them that are referred to as pollutants); energy from natural sources (i.e. solar and renewable forms), from fossil fuels and from nuclear fission; materials like plastics and polymers and their natural analogues, proteins and nucleic acids, and molecular reactivity and interconversions from simple examples like combustion to complex instances like genetic engineering and the manufacture of drugs.

Reference Book	
I.	John W. Hill, Terry W. McCreary & Doris K. Kolb, *Chemistry for changing times* 13th Ed.

Semester IV

2.14 Course Name: Inorganic Chemistry-III: Chemical Bonding-II & Redox Reactions Course Code: CHMUGCC08		
Course type: Core	**Course Distribution: Theory: 4 Credit Practical: 2 Credit**	**Theory: 60 Lectures Practical: 60 Class Hours**

Theory: 60 Lectures

Chemical Bonding-II (30 Lectures)

Ionic bonding: Size effects, radius ratio rules and their limitations. Packing of ions in crystals, lattice energy, Born-lande equation, Born-Haber cycle and its applications. Salvation energy, polarizing power and polarizibility, ionic potential, Fazan's rules. Defects in solids.
Molecular orbital concept of bonding: sigma and pi-bonds, multiple bonding, MO diagrams of H_2, F_2,

O_2, C_2, B_2, CO, NO, CN^-, HF and H_2O; bond orders, bond lengths, Walsh Diagram. Hydrogen bonding and its effects. *Metallic bonding:* qualitative idea of band theory, conducting, semi conducting and insulating properties with examples.
Coordinate bonding: Lewis acid-base adducts, double salts and complex salts, Werner theory of coordination compounds. Ambidentate and polydentate ligands, chelate complexes. IUPAC nomenclature of coordination compounds. Coordination numbers, constitutional isomerism. Stereoisomerism in square planar and octahedral complexes.

Redox Reactions (30 Lectures)

Solubility product principle, common ion effect and their applications to the precipitation and separation of common metallic ions as hydroxides, sulfides, phosphates, carbonates, sulfates and halides. Ion-electron method of balancing equation of redox reaction. Elementary idea on standard redox potentials with sign conventions, Nernst equation (without derivation). Influence of complex formation, precipitation and change of pH on redox potentials; formal potential. Feasibility of a redox titration, redox potential at the equivalence point, redox indicators. Redox potential diagram (Latimer and Frost diagrams) of common elements and their applications. Disproportionation and comproportionation reactions (typical examples).

Reference Books	
I.	J. D. Lee: A New Concise Inorganic Chemistry, E.L.B.S
II.	F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry,* John Wiley
III.	D. F. Shriver and P. W. Atkins: *Inorganic Chemistry,* Oxford University Press.

Practical	
1.	**Redox titration Estimation**
	Estimation of Mohr salt solution by permanganometry and dichromometry, Fe^{+2}/ Fe^{3+} by permanganometry and dichromometry, iron-copper mixture, estimation of the strength of hydrogen peroxide, estimation of Cu in brass, estimation of available chorine in bleaching powder.

Reference books:

SN.	
I.	Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6^{th} Edition.

2.15 Course Name: Organic Chemistry-III Topic: Important Compounds & Rearrangements Course code: CHMUGCC09		
Course type: Core	**Course Distribution: Theory: 4 Credit Practical: 2 Credit**	**Theory: 60 Lectures Practical: 60 Class Hours**

Theory

Nitrogen compounds (10 Lectures)

Nitrogen compounds: amines (aliphatic & aromatic) [preparation, separation and identification of primary, secondary and tertiary amines], E. Clarke reaction, enamines, Mannich reaction, diazomethane, diazoacetic ester, nitrile and isonitrile.

Carbocycles and Heterocycles (20 Lectures)

Polynuclear hydrocarbons: syntheses and reactions of naphthalene, anthracene and phenanthrene.

Heterocyclic compounds: reactivity, orientation and important reactions of furan, pyrrole, thiophene, pyridine, indole, synthesis (including retrosynthetic approach) pyrrole: Knorr pyrrole synthesis and Hantzsch synthesis. Hantzsch pyridine synthesis. Indole: Fischer, Madelung and Reissert synthesis, Skraup quinoline and Bischler-Napieralski Synthesis of isoquinoline.

General Reagents (10 Lectures)

DCC I, 1,3-dithianes, Polyphosphoric acid, diazomethane, ethyldiazoacetate, Boron Trifluoride, Trifluoro acetic acid, cuprous chloride, N-bromosuccinamide, Mont- K-10, and KSF (clays). Phase Transfer catalysts.

Organometallics: preparation of Grignard reagent and organo lithium. Reactions: addition of Grignard and organo lithium to carbonyl compounds, substitution on –COX, conjugate addition by Gilman cuprates, Reformatsky reaction.

Rearrangements (20 Lectures)

1,2-shift: Rearrangement to electron-deficient carbon (Wagner-Meerwein rearrangement, pinacol rearrangement, dienone-phenol; Wolff rearrangement in Arndt- Eistert synthesis, benzil-benzilic acid rearrangement.

Electron-deficient nitrogen (Beckmann rearrangement, Schmidt rearrangement, Hofmann rearrangement, Lössen rearrangement, Curtius rearrangement).

Electron-deficient oxygen (Baeyer-Villiger oxidation, hydroperoxide rearrangement, cumene hydroperoxide-phenol rearrangement), Dakin reaction.

Aromatic rearrangements [migration from oxygen to ring carbon (Fries rearrangement, Claisen rearrangement), migration from nitrogen to ring carbon (Hofmann-Martius rearrangement**,** Fischer-

Hepp rearrangement, N-azo to C-azo rearrangement, Bamberger rearrangement, Orton rearrangement, benzidine rearrangement.

Reference books	
I.	Organic Chemistry – Marc Loudon
II.	Organic Chemistry – Bruice
III.	Organic Chemistry, Vol. I and II – Finar
IV.	Organic Chemistry – Solomons
V.	Organic Chemistry- Clayden, Greeves, Warren
VI.	Organic Chemistry–Morrison, Boyd & Bhattacharjee
VII.	Heterocyclic Chemistry, T.L. Gilchrist
VIII.	Heterocyclic Chemistry, J.A. Joule, K. Mills and G.F. Smith
IX.	Mechanism & Theory in Organic Chemistry–S.K. Ghosh
X.	Organic Chemistry, Vol. I – Finar
XI.	A guidebook to mechanics in organic chemistry– Peter Sykes
XII.	Advanced Organic Chemistry–Jerry march

Practical	
Qualitative Analysis of liquid compounds	
1.	Qualitative analysis of liquid compounds. Determination of boiling point.
2.	Preparation of derivatives
Quantitative Analysis	
1.	Estimation of acid value (analysis of an oil)
2.	Estimation of methoxy group by Zeisel's method
3.	Estimation of nitrogen by kjeldahl's method

2.16 Course Name: Physical Chemistry-IV
Topic: Colligative Properties, Ionic Equilibrium and Electrochemistry
Course Code: CHMUGCC10

Course type: Core	**Course Distribution:** **Theory: 4 Credit** **Practical: 2 Credit**	**Theory: 60 Lectures** **Practical: 60 Class Hours**

Colligative properties, Ionic equilibrium, and Electrochemistry

Colligative properties (15 Lectures)
Ways of expressing concentration, Solutions of gases in gases, Henry's law, Solutions of liquids in liquids, Solubility of completely miscible liquids, Solubility of partially miscible liquids, Phenol-water system, Trimethylamine-water system, Azeootropes, Theory of fractional distillation, Steam distillation, Solution of solids in liquid, Determination of solubility, Solubility of solids in solids.

Ionic equilibria-solubility product (15 Lectures)

Ostwald's dilution law, Experimetal verification of Ostwald's law, Limitation of Ostwald's law, Theory of strong electrolytes, Ghosh's formula, Debye-Huckel theory, Degree of dissociation, The common ion effect, Factors influencing the degree of dissociation, solubility equilibria and the solubility product, application of solubility product principle in qualitative analysis, selective precipitation, separation of the basic inos into groups

Electrochemistry (15 Lectures)

Mechanism of electrolysis, Faraday's laws of electrolysis, specific conductance, equivalent conductance, strong electrolytes, weak electrolytes, determination of cell constant, Arhenius theory of ionization, transport number, determination of transport number, Kohlrausch's law, Conductometric titrations, Electrochemical cells, EMF, measurement of EMF, Nerst equation, electrodes, potentiometric titration, acid base titration, redox titration, overvoltage, Arhenius theory of ioniozation, Migration of ions, transport number, determination of transport number, Hittorf's method, Moving boundary method, Kohlrausch's law, application of Kohlrausch's law, conductometric titrations, difference between conductometric and volumetric titration, half reaction.

Electrochemical cells (15 Lectures)

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell.
Nernst equation and its importance. Types of electrodes. Standard electrode potential.
Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. Ph determination using hydrogen electrode and quinhydrone electrode.

Reference books	
I.	Physical Chemistry, G.M. Barrow, Int. Students Edition, McGraw Hill
II.	Physical Chemistry, R.A. Alberty, Wiley Eastern Ltd.
III.	Physical Chemistry, P.W. Atkins, Oxford University Press.
IV.	Principles of Physical Chemistry, B.R. Puri & L.R. Sharma, Shoban Lal Nagin Chand & Co.

Practical	
1.	To determine the equivalent conductance at infinite dilution of a strong electrolyte (KCL)
2.	To determine the equivalent conductance of weak electrolyte at infinite dilution by Kohlrausch's law of independent migration of ions and verification of Ostwald's dilution law.
3.	To determine the ionization constant of a weak electrolyte (say CH_3COOH).
4.	To determine the solubility product of a sparingly soluble salt by conductance measurement.
5.	Conduct metric titration of oxalic acid by a standard NaOH solution.

Reference books	
I.	Vogel's Textbook of Practical Organic Chemistry: A. I. Vogel, B. S. Furniss, P. W. Smith
II.	An advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad
III.	A Textbook On Chemistry Practical: Bidhan Chandra Ray, Satyanarayan Das
IV.	B. Sc. Honours Practical Chemistry: Sachin Dutta

2.17 Course Name: Polymer Chemistry
Course Code: CHMUGSE03

Course type: Skill Enhancement Courses	Course Distribution: Theory: 4 Credit	Theory: 60 Lectures

Theory: 60 Lectures

Introduction **(20 Lectures)**

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

Properties of Polymers (Physical, thermal, Flow & Mechanical Properties) **(40 Lectures)**.

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes,
Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

Reference Books	
I.	Seymour's Polymer Chemistry, Marcel Dekker, Inc.
II.	G. Odian: Principles of Polymerization, John Wiley.
III.	F.W. Billmeyer: Text Book of Polymer Science, John Wiley.
IV.	P. Ghosh: Polymer Science & Technology, Tata Mcgraw-Hill.
V.	R.W. Lenz: Organic Chemistry of Synthetic High Polymers.

2.18 Course Name: Basic Analytical Chemistry; Course Code: CHMUGSE04

Course type: Skill Enhancement Courses	Course Distribution: Theory: 4 Credit	Theory: 60 Lectures

Theory

Introduction

Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

Analysis of soil

Composition of soil, Concept of Ph and Ph measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators
a. Determination of Ph of soil samples.
b. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

Analysis of water

Definition of pure water, sources responsible for contaminating water,
water sampling methods, water purification methods.
a. Determination of Ph, acidity and alkalinity of a water sample.
b. Determination of dissolved oxygen (DO) of a water sample.

Analysis of food products

Nutritional value of foods, idea about food processing and food preservations and adulteration.

a. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.
b. Analysis of preservatives and colouring matter.

Chromatography

Definition, general introduction on principles of chromatography, paper
chromatography, TLC etc.
a. Paper chromatographic separation of mixture of metal ion (Fe3+ and Al3+).
b. To compare paint samples by TLC method.

Analysis of cosmetics

Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc
oxide and Calcium carbonate by complexometric titration.

Instrumental demonstrations
a. Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:
i. Ni (II) and Co (II)
ii. Fe (III) and Al (III)
b. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.
c. Spectrophotometric Determination of Caffeine and Benzoic Acid in Soft Drink.

Reference Books

I.	Skoog & Lerry. Instrumental Methods of Analysis, Saunders College Publications, New York.
II.	Skoog, D.A.; West, D.M. & Holler, F.J. Fundamentals of Analytical Chemistry 6th Ed., Saunders College Publishing, Fort Worth (1992).
III.	Harris, D. C. Quantitative Chemical Analysis, W. H. Freeman.
IV.	Dean, J. A. Analytical Chemistry Notebook, McGraw Hill.
V.	R.W. Lenz: Organic Chemistry of Synthetic High Polymers.
VI.	Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India.
VII.	Freifelder, D. Physical Biochemistry 2nd Ed., W.H. Freeman and Co., N.Y. USA (1982).
VIII.	Cooper, T.G. The Tools of Biochemistry, John Wiley and Sons, N.Y. USA. 16 (1977).
IX.	Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall.
X.	Vogel, A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Prentice Hall.
XI.	Robinson, J.W. Undergraduate Instrumental Analysis 5th Ed., Marcel Dekker, Inc., New York (1995).

Semester V

2.19 Course Name: Organic Chemistry-IV
Topic: Synthetic Strategies & Cyclic Stereochemistry
Course Code: CHMUGCC11

Course type: Core	**Course Distribution:** **Theory: 4 Credit** **Practical: 2 Credit**	**Theory: 60 Lectures** **Practical: 60 Class Hours**

Theory

Carbanion chemistry (10 Lectures)

Carbanions: formation of enols and enolates (metal), alkylation of enolates, reactions of enolates with carbonyls (aldehydes, ketones and esters), conjugate addition of enolates.

Synthetic strategies (15 Lectures)

Retrosynthetic analysis: disconnections, synthons, donor and acceptor synthons, functional group interconversion, C-C disconnections and synthesis [one group and two group (1,2 to 1,6-dioxygenated], reconnection (1,6-di carbonyl), natural reactivity and umpolung.
Protecting group chemistry: protection-deprotection strategy [alcohol, amine, carbonyl, acid]

Strategy of ring synthesis (8 Lectures)

Thermodynamic factor, synthesis through enolate anion chemistry and carbonyl condensation reactions (including acetoaceticester & malonic ester synthesis), synthesis through rearrangement (including pinacol, Favorski), synthesis of large rings, high dilution technique and acyloin reaction, Stobbe condensation, Pauson Khand reaction, Bergman cyclization, Nazarov cyclization.

Asymmetric Synthesis (5 Lectures)

Stereoselective and stereospecific reactions: Definition and examples. Diastereoselectivity and enantioselectivity, diastereoselective addition of nucleophiles to C=O, Cram's rule, Felkin-Anh model.

Cyclic stereochemistry (22 Lectures)

Baeyer strain theory. Conformational analysis: small ring, cyclopentane, cyclohexane, mono and disubstituted cyclohexane, symmetry properties and optical activity.
Conformation & reactivity in cyclohexane system: elimination (E2), rearrangement, nucleophilic substitution (S_N^1, S_N^2, NGP), oxidation of cyclohexanol, esterification, saponification, lactonisation.

Reference books	
I.	Organic Chemistry-Wade
II.	Organic Chemistry- Marc Loudon
III.	Organic Chemistry- Bruice
IV.	Organic Chemistry, Vol. I and II – Finar

V.	Organic Chemistry – Solomons
VI.	Organic Chemistry- Clayden, Greeves, Warren
VII.	Organic Chemistry- Morrison, Boyd & Bhattacharjee
VIII.	Basic stereochemistry of organic molecules- Sengupta
IX.	Stereochemistry of organic compounds – ELIEL
X.	Stereochemistry of Organic Compounds- Principles and Applications- D. Nasipuri
XI.	Organic Synthesis: The Disconnection Approach- Warren
XII.	Modern Methods of Organic Synthesis- W. Carruthers

Practical	
Preparation of organic compounds involving single/two step process (minimum six)	
1.	*p*-Nitroacetanilide from acetanilide
2.	*p*-Bromoaniline from acetanilide
3.	Benzil from benzoin
4.	Benzilic acid from benzil
5.	Iodoform
6	Phthalimide from phthalic anhydride
7	Benzoic acid from benzamide
8	Dibenzylideneacetone
9	Benzanilide from aniline
10	Methyl Orange
11	1,1'-bi-2-naphthol

Reference books	
I.	Vogel's Textbook of Practical Organic Chemistry: A. I. Vogel, B. S. Furniss, P. W. Smith
II.	An advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad
III.	A Textbook On Chemistry Practical: Bidhan Chandra Ray, Satyanarayan Das
IV.	B. Sc. Honours Practical Chemistry: Sachin dutta

I.

2.20 Course Name: Physical Chemistry-V
Topic: Quantum Chemistry and Physical Spectroscopy
Course Code: CHMUGCC12

Course type: Core	**Course Distribution:** **Theory: 4 Credit** **Practical: 2 Credit**	**Theory: 60 Lectures** **Practical: 60 Class Hours**

Theory: 60 Lectures

Quantum Chemistry-I

Origin of quantum theory, Blackbody radiation, Planck's radiation law, photoelectric effect, Compton effect, de Broglie's hypothesis, Heisenberg's uncertainty principle. Postulates of quantum mechanics. Concept of operator, Schrodinger wave equation and its application to a particle in a box, energy levels, wave functions and probability densities.

Quantum Chemistry-II

Simple Harmonic Oscillator: setting up of the Schrodinger stationary equation, energy expression (without derivation), expression of wave function for n = 0 and n = 1 (without derivation) and their characteristic featuresStationary Schrodinger equation for the H-atom in polar coordinates, separation of radial and angular (θ, φ) parts. Solution of φ-part and emergence of quantum number 'm'; energy expression (without derivation), degeneracy. Hydrogenic wave functions up to n = 2 (expression only); real wave function. Concept of orbitals and shapes of s and p orbitals.

Spectroscopy

Introduction: electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born-Oppenheimer approximation, degrees of freedom.

Rotational Spectrum

Diatomic molecules, Energy of a rigid rotor (semi-classical principles), selection rules, spectral intesity, distribution using population distribution (Maxwell-Boltzmann distribution), determination of bond length, qualitative description of non-rigid rotor, isotope effect.

Vibrational Spectrum

Infrared spectrum: Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different funcitonal groups.

Raman Spectrum

Concept of polarizability, pure rotational and pure vibrational Raman spectra of diatomic molecules, selection rules.

Electronic Spectrum

Concept of potential energy curves for bonding and antibonding molecular orbitals, qualitative description of selection rules and Franck-Condon principle.

Reference books	
I.	Physical Chemistry, G.M. Barrow, Int. Students Edition, McGraw Hill.
II.	Physical Chemistry, R.A. Alberty, Wiley Eastern Ltd.
III.	Physical Chemistry, P.W. Atkins, Oxford University Press.
IV.	Physical Chemistry, Maron & Lando.
V.	Quantum Chemistry, R.K. Prasad, New Age.
VI.	Physical Chemistry, Vol. 04, K.L. Kapoor, Macmillan
VII.	Fundamentals of Molecular Spectroscopy, Colin N Banwell, McGraw Hill.

Practical	
1.	Elements of FORTRAN Language.
2.	FORTRAN Keywords and commands.
3.	Logical and Relational Operators, iteration, Array variables.

4.	Matrix addition and multiplication.
5.	Function and Subroutine.
	OR
1	Determination of rate constant of decomposition of H_2O_2 by acidified KI solution using clock reactions.
2	Determination of strengths of hydrocholoric acid and acetic acid in their mixture pH metrically.
3	Determination of concentration of HCl conductometrically using standard NaOH solution.
4	To study the phase diagram of a binary system (Phenol + water) and the effect of impurities (e.g. NaCl).

Reference books:

1. A. I. Vogel, B. S. Furniss, P. W. Smith, Vogel's Textbook of Practical Organic Chemistry
2. G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edn.
3. A. I. Vogel, J.Mendham, Vogel's Textbook of Quantitative Chemical Analysis, Prentice Hall, 2000.
4. Ghoshal, Mahapatra, Nad, An advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd.

2.21 Course Name: Application of Computers in Chemistry
Course Code: CHMUGDS01

Course type: Discipline Specific Elective (DSE-A1)	**Course Distribution: Theory: 4 Credit Practical: 2 Credit**	**Theory: 60 Lectures Practical: 60 Class Hours**

Theory

Basics: (20 Lectures)

Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Elements of the BASIC language. BASIC keywords and commands. Logical and relative operators. Strings and graphics. Compiled versus interpreted languages. Debugging. Simple programs using these concepts. Matrix addition and multiplication. Statistical analysis.

Numerical methods: (20 Lectures)

Roots of equations: Numerical methods for roots of equations: Quadratic formula, iterative method, Newton-Raphson method, Binary bisection and Regula-Falsi.
Differential calculus: Numerical differentiation. Integral calculus: Numerical integration (Trapezoidal and Simpson's rule), probability distributions and mean values.

Simultaneous equations: (20 Lectures)

Matrix manipulation: addition, multiplication. Gauss-Siedal method. Interpolation, extrapolation and curve fitting: Handling of experimental data. Conceptual background of molecular modelling: Potential energy surfaces. Elementary ideas of molecular mechanics and practical MO methods.

Reference Books	
I.	Harris, D. C. *Quantitative Chemical Analysis*. 6th Ed., Freeman (2007) Chapters 3-5.
II.	Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis*, Cambridge Univ. Press (2001) 487 pages.
III.	Noggle, J. H. *Physical chemistry on a Microcomputer*. Little Brown & Co. (1985).

Practical	
Computer programs based on numerical methods for	
1.	Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weak acid).
2.	Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).
3.	Numerical integration (e.g. entropy/ enthalpy change from heat capacity data), probability distributions (gas kinetic theory) and mean values.
4.	Matrix operations. Application of Gauss-Siedel method in colourimetry.
5.	Simple exercises using molecular visualization software.

Reference Books	
I.	McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books(2008).
II.	Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
III.	Steiner, E. The Chemical Maths Book Oxford University Press (1996).
IV.	Yates, P. Chemical Calculations. 2nd Ed. CRC Press (2007).

2.22 Course Name: Bioinorganic Chemistry
Course Code: CHMUGDS02

Course type: Discipline Specific Elective (DSE-A1)	**Course Distribution: Theory: 4 Credit Practical: 2 Credit**	**Theory: 60 Lectures Practical: 60 Class Hours**

Theory

Elements of life (30 Lectures)

Essential major, trace and ultratrace elements. Basic chemical reactions in the biological systems and the role of metal ions (specially Na^{+}, K^{+}, Mg^{2+}, Ca^{2+}, $Fe^{3+/2+}$, $Cu^{2+/+}$ and Zn^{2+}). Metal ion transport across biological membrane Na+-ion pump, ionophores. Biological functions of hemoglobin and myoglobin, cytochromes and ferredoxins, carbonate bicarbonate buffering system and carbonicanhydrase. Biological nitrogen fixation, Photosynthesis: Photosystem-I and Photosystem-II.

Toxicity of metal ions (15 Lectures)

Toxic metal ions (Hg, Pb, Cd and As) and their effects, reasons for toxicity, chelation therapy,

Metal ions in medicine (15 Lectures)

Pt and Au complexes as drugs, metal dependent diseases. Use of chelating agents in medicine.

Reference Books	
I.	Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.

Practical	
Quantitative estimation of ions	
I.	a) Gravimetric estimation of Ni^{2+} **b)** Estimation of Calcium in milk.

Reference Book	
I.	1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.

2.23 Course Name: Research Methodology for Chemistry; Course Code: CHMUGDS03

Course type: Discipline Specific Elective (DSE-B1)	**Course Distribution: Theory: 4 Credit Practical**	**Theory: 60 Lectures Practical: 60 Class Hours**

Literature Survey: (20 Lectures)

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital

Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, Chem Industry, Wiki- Databases, ChemSpider, Science Direct, SciFinder, Scopus.

Information Technology and Library Resources

The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.

Methods of Scientific Research and Writing Scientific Papers: (20 Lectures)

Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. Writing scientific papers – justification for scientific

contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism.

Chemical Safety and Ethical Handling of Chemicals (10 Lectures)

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

Data Analysis (10 Lectures)

The Investigative Approach: Making and Recording Measurements. SI Units and their use. Scientific method and design of experiments.
Analysis and Presentation of Data: Descriptive statistics. Choosing and using statistical tests. Chemometrics. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, *r* and its abuse. Basic aspects of multiple linear regression analysis.

Reference Books

I.	Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011)
II.	*Practical skills in chemistry*. 2nd Ed. Prentice-Hall, Harlow.
III.	Hibbert, D. B. & Gooding, J. J. (2006) *Data analysis for chemistry*. Oxford University Press.
IV.	Topping, J. (1984) *Errors of observation and their treatment.* Fourth Ed., Chapman Hall, London.
V.	Harris, D. C. *Quantitative chemical analysis*. 6th Ed., Freeman (2007) Chapters 3-5.

2.24 Course Name: Mathematical Chemistry and Structural Activity Relationship
Course Code: CHMUGDS04

Course type: Discipline Specific Elective (DSE-A1)	**Course Distribution:** **Theory: 4 Credit** **Practical: 2 Credit**	**Theory: 60 Lectures** **Practical: 60 Class Hours**

Unit-I

Concept of mathematical modeling, application of mathematics in chemistry, Graph invariants and computation of graph theoretic indices, topology of molecules.

Unit-II

Interrelation between structure and property / activity / function, structure as an encoded source of information, History of QSAR, Application of QSAR, Hammett equation, non linearity of Hammett equation, refinement of Hammett equation: Swain-Lupton equation, Taft equation, Grunwald-Weinstein equation, Yukawa-Tsuno equation.

Unit-III

Information theory and computation of information theoretic topological indices, Classification of molecular indices and their applications, Classical QSAR and its limitations.

Unit-IV

Basic concept of computer programming, Fortran language and programming using Fortran language.

Mathematical Chemistry and structure activity relationship Lab:

i. Programming using fortran language.
ii. Determination of topological indices of different alkane using suitable software
iii. Plotting of melting and boiling point *vs* molecular indices of different alkane and determination of melting and boiling point unknown alkane.

Reference Books

1) An introduction to mathematical modeling Book by Edward A. Bender
2) Mathematical Modeling: Models, Analysis and Applications Book by Sandip Banerjee
3) Topics in mathematical modeling Book by K. K. Tung
4) Introduction to programming with Fortran Book by I. D. Chivers
5) Guide to Fortran 2008 Programming Book by Walter S. Brainerd
6) Modern Fortran in Practice Book by Arjen Markus
7) Understanding the Basics of QSAR for Applications in Pharmaceutical Sciences and Risk Assessment Book by Kunal Roy, Rudra Narayan Das, and Supratik Kar
8) Statistical Modelling of Molecular Descriptors in QSAR/QSPR Matthias Dehmer, Kurt Varmuza, Frank Emmert-Streib, Danail Bonchev

Semester VI

2.25 Course Name: Inorganic Chemistry-IV
Topic: Coordination Chemistry & Organometallic Compounds
Course Code: CHMUGCC13

Course type: Core	**Course Distribution:** **Theory: 4 Credit** **Practical: 2 Credit**	**Theory: 60 Lectures** **Practical: 60 Class Hours**

Theory

Coordination Chemistry (30 Lectures)

Structure and bonding: VB description and its limitations. Crystal Field Theory: splitting of d^n configurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy in weak and strong fields; pairing energy. Jahn- Teller distortion. Metal-ligand bonding (MO concept).

Magnetism and Colour: Orbital and spin magnetic moments, spin only moments of d^n ions; quenching of magnetic moment: super exchange and antiferromagnetic interactions; d-d transitions; L-S coupling; qualitative Orgel diagrams for $3d^1$-$3d^9$ ions and their spectroscopic ground states; selection rules for electronic spectral transitions; spectrochemical series of ligands; charge transfer spectra. Isomerism, reactivity and stability: *cis*- and *trans*- isomers, Labile and inert complexes, substitution reaction on square planer complexes, trans effect, Stability constants of coordination compounds.

Chemistry of d- and f- block elements (10 Lectures)

d-block elements: electronic configuration, elemental forms, metallic nature, atomization energy, oxidation states, redox properties, coordination chemistry, spectral and magnetic properties.
f-block elements: electronic configuration, ionization energies, oxidation states, variation in atomic and ionic (3+) radii, magnetic and spectral properties of lanthanides, comparison between lanthanide and actinides, separation of lanthanides (by ion-exchange method).

Organometallic Compounds (20 Lectures)

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. □-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.
Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

Study of the following industrial processes and their mechanism: 30 Lectures

1. Alkene hydrogenation (Wilkinsons Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)
5. Synthesis gas by metal carbonyl complexes.

Reference books

I.	Cotton, F.A. G.; Wilkinson & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.;*Wiley India
II.	Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed.,* Harper Collins 1993, Pearson, 2006.
III.	Sharpe, A.G. *Inorganic Chemistry,* 4th Indian Reprint (Pearson Education) 2005
IV.	Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry3rd Ed.,* John Wiley and Sons, NY, 1994. Greenwood, N.N. & Earnshaw, A. Chemistry of the Elements, Elsevier 2nd Ed, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).

V.	Lee, J.D. *Concise Inorganic Chemistry 5th Ed.,* John Wiley and sons 2008.
VI.	Powell, P. *Principles of Organometallic Chemistry*, Chapman and Hall, 1988.
VII.	Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.,* Oxford University Press, 1994.

	Practical
1.	**Complexometric titration**
	Determination of Hardness of water, Determination of Calcium and Magnesium in mixture Ca in chalk, iron-calcium mixture, Zinc-Magnesium mixture.
2.	**Colorimetric estimation**
	Colorimetric estimation of Mn in commercial H_3PO_4, colorimetric estimation of Fe in thiocyanate complex.
	Reference books
I.	Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.

2.26 Course Name: Organic Chemistry-V
Topic: Spectroscopy & Biomolecules
Course Code: CHMUGCC14

Course type: Core	**Course Distribution:** **Theory: 4 Credit** **Practical: 2 Credit**	**Theory: 60 Lectures** **Practical: 60 Class Hours**

Spectroscopy UV, IR, ^{1}H NMR

UV Spectra (7 Lectures)

Electronic excitations, origin of UV band structure, principle of absorption spectroscopy, instrumentation, presentation of spectra, solvent effect, chromophore, steric effect, effect of conjugation, Woodward-Fieser rules, red shift (bathochromic shift), blue shift (hypsochromic shift), hyperchromic effect, hypochromic effect (typical examples).

IR Spectra (8 Lectures)

Infrared absorption process, uses of IR spectrum, modes of stretching and bending, application of Hooke's law, bond properties and absorption trends, characteristic stretching frequencies of O-H, N-H, C-H, C-D, C=C, C=N, C=O functions; factors effecting stretching frequencies (H-bonding, mass effect, electronic factors, bond multiplicity, ring size), Infrared Spectrometer, preparation of samples, analysis of IR spectra.

^{1}HMR Spectra (15 Lectures)

Nuclear spin, nuclear magnetic moments, NMR active nuclei, principle of proton magnetic resonance, equivalent and non-equivalent protons, chemical shift (δ), shielding/deshielding of protons, up-field and down-field shifts. NMR peak area (integration), diamagnetic anisotropy, relative peak positions of

different kinds of protons (alkyl halides, olefins, alkynes, aldehyde H), substituted benzenes (toluene, anisole, nitrobenzene, halobenzene, dinitrobenzenes, chloronitrobenzene), first order coupling (splitting of the signals: ordinary ethanol, bromoehane, dibromoehanes), spin-spin splitting, (n+1) rule, Pascal's triangle, coupling constant.

Carbohydrate chemistry (18 Lectures)

Monosaccharides: Aldoses upto 6 carbons, structure of D-glucose & D-fructose (configuration & conformation), anomeric effect, mutarotation. Reactions: osazone formation, oxidation, reduction, reaction with acid and base, stepping–up (Kiliani-Fischer method) and stepping–down (Ruff's & Wohl's method) of aldoses.
Disaccharides: Structure of sucrose, maltose.

Amino acids, peptides, proteins and nucleic acids (12 Lectures)

Amino acids: Synthesis: (Strecker, Gabriel, acetamido malonic ester, azlactone); isoelectric point, ninhydrin reaction.
Peptides: peptide linkage, syntheses of peptides using N-protection & C-protection, solid phase synthesis; peptide sequence: C–terminal and N–terminal unit determination (Edmann, Sanger & dansyl chloride).
Nucleic acids: pyrimidine & purine bases (only structure & nomenclature), nucleosides and nucleotides, DNA: Watson-Crick model, complimentary base –pairing in DNA, Structure of RNA.

Reference books	
I.	Spectrometric identification of organic compounds- Silverstein
II.	Organic spectroscopy-Kemp
III.	Introduction To Spectroscopy- Pavia, lampman, Kriz, Vyvyan
IV.	Organic Chemistry, Vol. I and II - Finar
V.	Organic Chemistry- Marc Loudon
VI.	Organic Chemistry-Morrison, Boyd & Bhattacharjee

Practical	
1.	Assignment of labeled peaks in the IR spectrum of the same compound. (C-H, O-H, NH, C=C, C=O, NO_2 stretching frequencies) At least three compounds from among the list given below are to be chosen: (i) *p*-Bromoacetanilide (ii) *p*-Methyl-*α*-bromoacetophenone (iii) Vanillin (iv) Cinnamic acid (v) *p*-Aminobenzoic acid (vi) *o*-Hydroxybenzaldehyde (vii) *p*-Nitroaniline
2.	Separation techniques by chromatography: (a) Separation of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values. (b) Separation of mixture of amino acids by paper chromatography and identify them on the basis of their R_f values.
3.	Application of green chemistry in organic synthesis: (a) Acetylation of primary amine (preparation of acetanilide). (b) Preparation of benzilic acid in solid state under solvent-free condition. (c) Green approach for nitration of salicylic acid. (d) Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

	(e) Transesterification reaction (synthesis of biodiesel). (f) Three component coupling (synthesis of dihydropyrimidinone). (g) Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).

Reference books	
I.	Spectrometric identification of organic compounds- Silverstein
II.	Organic spectroscopy-Kemp
III.	Introduction To Spectroscopy- Pavia, lampman, Kriz, Vyvyan
IV.	Mikes, O. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
V.	Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York, 1974
VI.	Lancaster, M. Green Chemistry: An Introductory Text RSC Publishing, 2nd Edition, 2010.
VII.	Pavia, D.L., Lampman, G.M., Kriz, G.S. & Engel, R.G. Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach, W.B.Saunders, 1995.
VIII	Asif & al. / Mor. J. Chem. 4 N°1 (2016) 164-176

2.27 Course Name: Analytical Methods in Chemistry
Course Code: CHMUGDS05

Course type: Discipline Specific Course (DSE-A2)	**Course Distribution:** **Theory: 4 Credit** **Practical: 2 Credit**	**Theory: 60 Lectures** **Practical: 60 Class Hours**

Qualitative and quantitative aspects of analysis: (5 Lectures)

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

Optical methods of analysis: (25 Lectures)

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

UV-Visible Spectrometry:

Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument;

Basic principles of quantitative analysis

Estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Infrared Spectrometry

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

Flame Atomic Absorption and Emission Spectrometry

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

Thermal methods of analysis:(5 Lectures)

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

Electroanalytical methods: (10 Lectures)

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

Separation techniques: (15 Lectures)

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media. Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC. Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC). Role of computers in instrumental methods of analysis.

Reference books

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

VII.	Mikes, O. & Chalmes, R.A. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
VIII.	Ditts, R.V. Analytical Chemistry – Methods of separation.

Practical

1. Separation Techniques

1. Chromatography:
(a) Separation of mixtures
Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.
(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.
(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. Solvent Extractions

(i) To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni2+-DMG complex in chloroform, and determine its concentration by spectrophotometry.
(ii) Solvent extraction of zisconium with amberliti LA-1, separation from a mixture of irons and gallium.
3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.
4. Determination of Na, Ca, Li in cola drinks and fruit juices using fame photometric techniques.

5. Analysis of soil:
(i) Determination of pH of soil.
(ii) Total soluble salt
(iii) Estimation of calcium, magnesium, phosphate, nitrate
6. Ion exchange:
(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.
(ii) Separation of metal ions from their binary mixture.
(iii) Separation of amino acids from organic acids by ion exchange chromatography.

III Spectrophotometry
1. Determination of pKa values of indicator using spectrophotometry.
2 Structural characterization of compounds by infrared spectroscopy.
3 Determination of dissolved oxygen in water.
4 Determination of chemical oxygen demand (COD).
5 Determination of Biological oxygen demand (BOD).
6 Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Reference Books

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

V.	Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
VI.	Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore
VII.	Mikes, O. & Chalmes, R.A. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
VIII.	Ditts, R.V. Analytical Chemistry – Methods of separation.

2.28 Course Name: Industrial Chemicals and Environment
Course Code: CHMUGDS06

Course type: Discipline Specific Course (DSE-A2)	**Course Distribution: Theory: 4 Credit Practical: 2 Credit**	**Theory: 60 Lectures Practical: 60 Class Hours**

Industrial Gases and Inorganic Chemicals (10 Lectures)

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.
Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

Industrial Metallurgy (4 Lectures)

Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

Environment and its segments (30 Lectures)

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur. Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution.
Pollution by SO_2, CO_2, CO, NO_x, H_2S and other foul smelling gases. Methods of estimation of CO, NO_x, SO_x and control procedures.
Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

Water Pollution

Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems.
Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal.
Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

Energy & Environment (10 Lectures)

Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc.
Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

Biocatalysis (6 Lectures)

Introduction to biocatalysis: Importance in "Green Chemistry" and Chemical Industry.

Reference Books:

SN.	
I.	E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
II.	R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
III.	J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
IV.	S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
V.	K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
VI.	S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
VII.	S.E. Manahan, Environmental Chemistry, CRC Press (2005).
VIII.	G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
IX.	A. Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

Practicals

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method (AgNO3 and potassium chromate).
6. Estimation of total alkalinity of water samples (CO2-, HCO3-) using double titration method.
7. Measurement of dissolved CO2.
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples.
10. Preparation of borax/ boric acid.

Reference Books:

SN.	
I.	E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
II.	R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
III.	J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
IV.	S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
V.	I. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
VI.	S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.

2.29 Course Name: Fundamentals of Medicinal Chemistry
Course Code: CHMUGDS07

Course type: Discipline Specific Course (DSE-B2)	**Course Distribution: Theory: 4 Credit Practical: 2 Credit**	**Theory: 60 Lectures Practical: 60 Class Hours**

Theory

Clinical Health and Biochemical Analysis

Definition of Health, WHO standard, Concepts of immunity system, basic concepts of Human Anatomy. Biochemical analyses of urine and blood serum.

Common drugs:
Antibiotics, Antipyretics, Analgesics, Anti-inflammatory, Antihistamines, Hypnotics and Antidepressant drugs - Definition, Examples, uses and side effects.

Vital ailment and treatment:
Blood pressure - hypertension and hypotension, Diabetes, Cancer, AIDS - Causes, symptoms and medicines.

Indian Medicinal Plants
Neem, Turmeric, Vallarai, Thumbai, Hibiscus, Adadodai, Thoothuvalai, Nochi, Thulasi, Aloe vera - Chemical constituents and medicinal uses.

First Aid and safety: Treatment of shock, haemorrage, Snake bites, cuts and wounds. Burns - classification and first aid. Asbestos, silica, lead paints, cement, welding fumes and gases - Hazard alert and precautions for safety.

Reference Books :

I. Jayashree Ghosh - Applied Chemistry - S. Chand and Company Ltd., 2006
II. S.C Rastogi, Biochemistry, Tata McGraw Hill Publishing Co., 1993.
III. Rasheeduz Zafar - Medicinal Plants of India - CBs Publishers and Distributors, 2000.
IV. B.L Oser, Hawk's Physiological Chemistry, Tata-McGraw - Hill Publishing Co. Ltd.
V. A.H Beckett and J.B Stenlake - Practical Pharmaceutical Chemistry, Vol.I - CBS Publishers and Distributors, 2000.

Practical

1. Synthesis of paracetamol
2. Synthesis of aspirin
3. Synthesis of coumarin-3-carboxylic acid
4. Synthesis of Metamfepramone
5. Synthesis of di-methyl-p-phenylenediamine
6. Synthesis of gramine
7. Detection of Alkaloid, Volatile oil and active compounds in medicinal plant.
8. Prepatation of detols, phenyls ointments.
9. iHand on practical of FIRST AID.

Reference Books :

I. Advanced Practical Medicinal Chemistry-Asutosh Kar
II. Vogel's Textbook of Practical Organic Chemistry

2.30 Course Name: Dissertation
Course Code: CHMUGDS08

Course type: Discipline Specific Course (DSE-B2)	**Course Distribution: Theory: 6 Credit**	**Project Work**