BANGALORE UNIVERSITY

III & IV Semester Chemistry Syllabus

for

B.Sc. / B.Sc. Honors Courses

Framed According to the National Educational Policy (NEP 2020)

(To be implemented from the academic year 2022-23)

DEPARTMENT OF CHEMISTRY
Bangalore University
Jnanabharathi
Bangalore-560056

AUGUST-2022

Preamble

The Board of studies in UG Chemistry headed by Prof G Krishnamurthy, the Chairman, Department of Studies in Chemistry, Jnanabharathi Campus, Bangalore University had the thorough discussions on the syllabus of III and IV semester Chemistry for BSc/ BSc Honors courses using the syllabus provided by the NEP Chemistry syllabus drafting Committee. This syllabus has to be accepted for the academic year 2022-23.

The Core committee consisting of the faculty members of different branches of Chemistry namely Analytical, Physical, Inorganic and Organic Chemistry which comprising the BOS and also additional faculty members from different UG Colleges of Bangalore University have made effective joint brain storming discussions and arrived at a Syllabus in Chemistry for **III and IV** semesters on **23.08.2022** and **24.08.2022**.

The final syllabus incorporating all the suggestions was finally approved by the members of the Board of Studies in Chemistry (UG) on **24.08.2022**. The following Faculty Members of the Core Committee were involved in the preparation of the Chemistry Syllabus.

Physical Chemistry Section

1. G. Krishnamurthy
2. K. Ramakrishna Reddy
3. P Nagegowda

Analytical and Inorganic Chemistry Section

1. M. Shubha
2. R. Nalini
3. B. M. Savitha
4. B M Sreenivas

Organic Chemistry Section

1. Renuka Manjunath
2. Vasudeva Reddy
3. Sumaiya Tabassum
4. Meenaakshi Srinivasan

Sd/-

PROF. G. KRISHNAMURTHY
CHAIRMAN
BOS in Chemistry (UG)
Bangalore University
Bangalore -560056

Proceedings of the meeting of the Board of Studies in Chemistry- UG held on 23rd & 24th August 2022 from 10.30 am to 6.30 pm in the Department of Chemistry, Bangalore University, Jnana Bharathi, Bengaluru-560 056

A meeting of the Board of Studies (UG) in Chemistry was held on 23rd & 24th August 2022 from 10.30 am to 6.30 pm in the Department of Chemistry, Bangalore University, Jnana Bharathi, Bangalore-56. The Chairman welcomed the members and placed before them the following agenda for deliberations.

Approval of B.Sc Chemistry Syllabus-NEP 2021-2022 batch: The syllabus of B.Sc Chemistry III and IV semesters for 2022-2023 was considered, discussed in detail, all suggestions incorporated and unanimously approved by the members.

Revision of B.Sc Chemistry syllabus (NEP-2020) I and II Semesters of 2022-2023 batch: The I and II semester syllabus was done without taking care of equal distribution of different branches of Chemistry such as Analytical, Organic, Inorganic and Physical Chemistry. It was very unfair for Chemistry learning students at I year (I/II semesters) level. So, all the board members unanimously decided to revise the syllabus. The syllabus was thus revised by thoroughly discussing in detail and the same has been unanimously approved by all the members.

The meeting ended with vote of thanks by the Chairman, Department of Chemistry, Bangalore University, Jnana Bharathi, Bangalore- 560 056.

MEMBERS OF THE BOS (UG)		**Signature**
1. Prof. G. Krishnamurthy	**Chairman**	
2. Prof. B. M. Sreenivasa	Member	B. M. Sreenivasa
3. Prof. M. Shubha	Member	
4. Dr. Nagegowda P	Member	
5. Dr. Renuka Manjunath	Member	
6. Dr. K. Ramakrishna Reddy	Member	
7. Dr. K. R. Muddukrishna	Member	Absent
8. Dr. Prasannakumar S G	Member (Coopted)	Absent
9. Dr. Sumaiya Tabassum	Member (Coopted)	Sumaiya-Z

Retired/Transferred to other University

1. Dr. Jisha S. P.
2. Dr. B. Vijaya Babu
3. Dr. Mallesh

24/8/2022

Prof. G. KRISHNAMURTHY
Chairman
Department of Chemistry
Bangalore University
Jnanabharathi Campus
Bangalore - 560 056.

PROGRAMME STRUCTURE

Sem.	Discipline Core (DSC) (L+T+P)	Discipline Elective(DSE)/ Open Elective (OE)	Ability Enhancement Compulsory Courses (AECC), Languages (L+T+P)		Skill Enhancement Courses (SEC)		Total Credits
					Skill based (L+T+P)	Value based (L+T+P)	
I	DISCIPLINE A1 (4 + 2) DSC-1:Analytical and Organic Chemistry-I DSC lab-1:Analytical and Organic Practicals-I DISCIPLINE-B1(4+2)	OE – 1 (3 CREDITS) Chemistry in Daily Life	L1-1 (3), L2-1(3)		SEC-1: Digital Fluency (2)		23
II	DISCIPLINE A2(4 + 2) DSC-2:Inorganic and Physical Chemistry-I DSC Lab -2:Inorganic and Physical Practicals-I DISCIPLINE-B2(4+2)	OE – 2 (3 CREDITS) Molecules of Life	L1-2(3), L2-2 (3) (3+1+0 each)	Environmental Studies (2)		Health and Wellness/ Social & Emotional Learning (2)	25
Exit option with Certificate (48 credits)							
III	DISCIPLINE A3(4 + 2) DSC-3:Analytical and Organic Chemistry-II DSC Lab-3: Analytical and Organic Practicals-II DISCIPLINE-B3(4+2)	OE – 3 (3 CREDITS)	L1-3 (3), L2-3(3) (3+1+0 each)		SEC-2: (2)		23
IV	DISCIPLINE A4(4 + 2) DSC-4: Inorganic and Physical Chemistry-II DSC Lab-4:Inorganic and Physical Practicals=II DISCIPLINE-B4(4+2)	OE – 4 (3 CREDITS)	L1-4 (3), L2-4(3) (3+1+0 each)	Constitution of India (2)		Sports/NCC/NSS etc	25
Exit option with Diploma (96 credits)							
Choose any one Discipline as Major, the other as the Minor							
V	DISCIPLINE A5 (3 + 2) DSC-5: DSC Lab-5 DISCIPLINE A6 (3 + 2) DSC-6: DSC Lab-6: DISCIPLINE B5 (3 + 2)	DSE A1 (3 CREDITS)			SEC-3: (2)	Ethics & Self Awareness (2) (1+0+2)	20
VI	DISCIPLINE A7 (3 + 2) DSC-7 DSC Lab-7 DISCIPLINE A8 (3 + 2) DSC-8 DSC Lab-8 DISCIPLINE B6 (3 + 2)	DSE A2 (3 CREDITS)			SEC-4: (2)		20
Exit option with B. Sc. Basic Degree (136 credits)							
VII	DISCIPLINE A9 (3 + 2) DSC-9 DSC Lab-9 DISCIPLINE A10 (3 + 2) DSC-10 DSC Lab-10: DISCIPLINE A11 (4) DSC-11	DSE A3 (3 CREDITS) RESEARCH METHODOLOGY (3 CREDITS)					20

VIII	**DISCIPLINE A12 (4)** **DSC-12** **DISCIPLINE A13 (4)** **DSC-13** **DISCIPLINE A14 (3)** **DSC-14**	**DSE A4** **(3 CREDITS)** **RESEARCH PROJECT** **(6 CREDITS)**					**20**
Award of B.Sc. CHEMISTRY (Hons) degree (176 credits)							

***In lieu of the research Project, two additional elective papers/ Internship may be offered.**

Sl. No.	**Semester**	**Title of the Paper**	**Teaching Hours**	**Hours / week**		**Examination Pattern Max. & Min. Marks /Paper**						**Duration of Exam (hours)**		**Total Marks / paper**	**Credits**	
				Theory	**Practical**	**ESE**		**IA**	**Practical**			**Theory**	**Practical**		**Theory**	**Practical**
						Max.	**Min.**		**Max.**	**Min.**	**IA**					
1	**I**	**DSC-3: Analytical and Organic Chemistry-II**	**56**	**4**	**-**	**60**	**22**	**40**	**-**	**-**	**-**	**3**	**-**	**150**	**4**	**-**
		DSC LAB-3: Analytical and Organic Chemistry-II	**56**	**-**	**4**	**-**	**-**	**-**	**25**	**9**	**25**	**-**	**4**	**50**	**-**	**2**
		Chemistry-OE-3: Chemistry in Daily life	**42**	**3**	**-**	**60**	**22**	**40**	**-**	**-**	**-**	**3**	**-**	**100**	**3**	**-**
2	**II**	**DSC-4: Inorganic and Physical Chemistry-II**	**56**	**4**	**-**	**60**	**22**	**40**	**-**	**-**	**-**	**3**	**4**	**150**	**4**	**-**
		DSC LAB-2: Inorganic and Physical Chemistry-II	**56**	**-**	**4**	**-**	**-**	**-**	**25**	**9**	**25**	**-**	**4**	**50**	**-**	**2**
		Chemistry-OE-4:- Industrial Applications in Chemistry	**42**	**3**	**-**	**60**	**22**	**40**	**-**	**-**	**-**	**3**	**-**	**100**	**3**	**-**

ASSESSMENT: WEIGHTAGE FOR ASSESSMENT
Common for both III and IV semesters

TYPE OF ASSESSMENT	SUMMATIVE (MARKS)	FORMATIVE (MARKS)
THEORY	**60**	**40**
PRACTICAL	**25**	**25**

SCHEME OF INTERNAL ASSESSMENT MARKS:
THEORY PAPERS
Common for both III and IV semesters

Sl N	PARTICULARS	MARKS
1	**Attendance**	**10**
2	**Assignments/ Seminars**	**10**
3	**Internal Tests (Average of two tests)**	**20**
TOTAL		**40**

PRACTICALS
Common for both III and IV semesters

SL NO	PARTICULARS	MARKS
1	**Attendance**	**05**
2	**Record writing**	**05**
3	**Internal Tests (Average of two tests)**	**15**
TOTAL		**25**

Program Articulation Matrix:
This matrix lists only the core courses. Core courses are essential to earn the degree in that discipline/subject. They include courses such as theory, laboratory, project, internships etc. Elective courses may be listed separately

Semester	Title /Name Of the course	Program outcomes that the course addresses	Pre-requisite course(s)	Pedagogy	Assessment
1	**DSC-1: Analytical and Organic Chemistry-I**	● The concepts of chemical analysis, accuracy, precision and statistical data treatment ● Understand the preparation of alkanes, alkenes and alkynes, their	P.U.C with Chemistry	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams

		reactions, etc. ● Understand the mechanism of nucleophilic, electrophilic reactions			
	DSC lab-1: Analytical and Organic Practicals-I	● The students will be able to learn how to handle the glassware, prepare and dilute solutions and perform the experiments with prepared reagents ● The students will be able to determine the analyte through volumetric and gravimetric analysis and understand the chemistry involved in each method of analysis. ● The students will be able to deduce the conversion factor based on stoichiometry and in turn use this value for calculation	-	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
2	**DSC-2: Inorganic and Physical Chemistry-I**	● The Bohr's theory of atomic structure and how it was developed ● Quantum numbers and their necessity in explaining the atomic structure ● The concept of unit cell, symmetry elements, Nernst distribution law.	-	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	DSC Lab -2: Inorganic and Physical Practicals-I	● Techniques like precipitation, filtration, drying and ignition ● Various titrimetric		Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams

		techniques and gravimetric methods ● To determine the physical constants of organic liquids and molecular weight of non-volatile solute.			
3	**DSC-3: Analytical and Organic Chemistry-II**	● The concepts of chemical analysis, accuracy, precision and statistical data treatment ● Understand the preparation of alkanes, alkenes and alkynes, their reactions, etc. ● Understand the mechanism of nucleophilic, electrophilic reactions	DSC-1 and DSC-2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	DSC Lab-3: Analytical and Organic Practicals-II	● The students will be able to learn how to handle the glassware, prepare and dilute solutions and perform the experiments with prepared reagents ● The students will be able to determine the analyte through volumetric and gravimetric analysis and understand the chemistry involved in each method of analysis. ● The students will be able to deduce the conversion factor based on stoichiometry and in turn use this value for			

		calculation			
4	**DSC-4: Inorganic and Physical Chemistry-II**	● The Bohr's theory of atomic structure and how it was developed ● Quantum numbers and their necessity in explaining the atomic structure ● The concept of unit cell, symmetry elements, Nernst distribution law.		Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	DSC Lab-4: Inorganic and Physical Practicals-II	● Techniques like precipitation, filtration, drying and ignition ● Various titrimetric techniques and gravimetric methods ● To determine the physical constants of organic liquids and molecular weight of non-volatile solute.			
5.	**DSC-5:** **DSC Lab-5:** **DSC-6:** **DSC Lab-6:**		DSC-3 and DSC-4	MOOC, Problem solving	Internal tests, Assignments, Quiz
6.	**DSC-7:** **DSC Lab-7:** **DSC-8:** **DSC Lab-8:**			MOOC, Problem solving	Internal tests, Assignments, Quiz
7.	**DSC-9 :** **DSC Lab-9:** **DSC-10:** **DSC Lab-10 :** **DSC-11:**		DSC-5, DSC-6, DSC-7 and DSC-8	MOOC, Problem solving	Internal tests, Assignments, Seminar, Debate, Quiz
8.	**DSC-12:** **DSC Lab-12** **DSC-13:** **DSC Lab-13** **DSC-14:**			Project work, Industrial Visit	Internal tests, Assignments, Seminar, Debate, Quiz

CHEMISTRY
DSC-3: Analytical and Organic Chemistry-II
Contact Hours: 56 **Work load: 4 Hours/Week.**

Credit Points :4

Evaluation: Continuous Internal Assesment-40 Marks

Semester End Examination -60 Marks

Course Objectives:

1) Interrelationship among frequency, wavelength and wave number and importance of validation parameters of an instrumental method will be taught
2) Principle, instrumentation and applications of spectrophotometry, nephelometry and turbidometry will be taught
3) Fundamentals of separation methods and principles of paper, thin layer and column chromatography will be taught
4) Principle, types and applications of solvent extraction will be taught
5) Principle and mechanism of ion-exchange, types of resins and domestic andindustrial applications of ion-exchange chromatography will be taught
6) The concept of mechanism and its importance will be taught to the student
7) Concept and importance of intermediates in organic chemistry will be taught taking proper examples
8) The various techniques for identification of reaction mechanism will be taught to the student taking proper examples
9) Concept of stereochemistry and its importance will be taught.
10) The various projection formulae and the techniques of designating the moleculesinto R, S, D, L will be taught taking proper examples
11) The theory and concept of Cis-, Trans- isomerism and its importance and thetechniques to differentiate between them will be taught taking examples

Course Specific Outcomes

After the completion of this course, the student would be able to

1) Understand the importance of fundamental law and validation parameters in chemical analysis
2) Know how different analytes in different matrices (water and real samples) can be determined by spectrophotometric, nephelometric and turbidometric methods.
3) Understand the requirement for chemical analysis by paper, thin layer and column chromatography.
4) Apply solvent extraction method for quantitative determination of metal ions in different samples
5) Utilize the ion-exchange chromatography for domestic and industrial applications
6) Explain mechanism for a given reaction.
7) Predict the probable mechanism for a reaction. Explain the importance of reaction intermediates, its role and techniques of generating such intermediates

8) Explain the importance of Stereochemistry in predicting the structure and property of organic molecules.
9) Predict the configuration of an organic molecule and able to designate it.
10) Identify the chiral molecules and predict its actual configuration.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-12)

Course Outcomes (COs) / Program Outcomes (POs)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	X							
2	X							
3	X							
4	X							
5	X							
6	X							
7	X							
8	X							

Course Articulation Matrix relates course outcomes of course with the corresponding program outcomes whose attainment is attempted in this course. Mark 'X' in the intersection cell if a course outcome addresses a particular program outcome.

DSC-3: Analytical and Organic Chemistry-II

Contact Hours: 56 **Work load: 4 Hours/Week.**

Unit-I

Quantitative Analysis-Instrumental methods

Electromagnetic spectrum, absorption of electromagnetic radiation, Definition and unitsof frequency, wavelength, wave number, Beer's law, Beer-Lambert law derivation,deviations from Beer's law, limitations, construction of calibration graph (Plot of absorbance versus concentration), Evaluation Procedures- standard addition, Internal standard addition, validation parameters-detection limits, sensitivity, dynamic/linearity range, Instrumentation, single beam and double beam spectrophotometers, quantitativeapplications of colorimetry (determination of Fe, Mo, Cu, Ti and $PO4^{3-}$) and numericalproblems on application of Beer's law. **10 hrs**

Nephelometry and Turbidimetry: Introduction, principle, instrumentations of nephelometry and turbidimetry; effects of concentration, particle size and wavelength on scattering; choice between nephelometry, applications of nephelometry and turbidimetry (determination of $S04^{2-}$ and $PO4^{3-}$). **4 hrs**

Unit-II

Separation methods

Solvent Extraction: Definition of solvent extraction, Types- batch, continuous, efficiency, selectivity, Nernst distribution law, derivation, distribution coefficient, factors affecting the partition, relationship between % extraction and volume fraction, Numerical problems on solvent extraction. Solvent extraction of iron and copper. **4hrs**

Fundamentals of chromatography: General description, definition, terms and parameters used in chromatography, classification of chromatographic methods, criteria for selection of stationary and mobile phase and nature of adsorbents. Principles of paper, thin layer, column chromatography. Column efficiency, factors affecting the column efficiency, van Deemter's equation and its modern version. **3hrs**

Paper chromatography: Theory and applications.

Thin layer chromatography (TLC): Mechanism, Rf value, efficiency of TLC plates, methodology–selection of stationary and mobile phases, development, spray reagents, identification and detection, qualitative applications. **4 hrs**

Ion exchange chromatography: resins, types with examples- cation exchange and anion exchange resins, mechanism of cation and anion exchange process and applications of ion-exchange chromatography (softening of hard water, separation of lanthanides, industrial applications). **3hrs**

Unit-III

Reaction Intermediates: Generation, Stability and Reactions of,

i) Carbocations: Dienone-phenol; and Pinacol-Pinacolone Rearrangement.
ii) Carbanions : Perkin Reaction, Aldol condensation, Claisen-Schmith condensation.
iii) Free Radicals: Sandmeyer Reaction

iv) Carbenes and Nitrenes: Singlet and Triplet states, their relative stability andreactions

v) Arynes: Formation and detection **8 hrs**

Methods for identifying reaction mechanism:

Product analysis, Isolation and Identification of Intermediates, Stereochemical Evidences, Effect of Catalyst, crossover Experiments, Isotopic studies, Kinetic Studies.

6 hrs

Unit-IV

Stereochemistry of Organic Compounds:

Fischer projection, Newmann and Sawhorse projection formulae and their interconversions. Geometrical isomerism: Cis-trans and syn-anti isomerism, E/Z notations with C.I.P rules. Optical Isomerism: Optical activity, Specific rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral centres, Diasteroisomers, meso structures, Racemic mixtures and Resolution, Relative and absolute configuration, D/L and R/S designations

14 hrs

References:

1) Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8th edition, Saunders College Publishing, New York (2005).
2) Analytical Chemistry, G.D. Christian, 6th edition, Wiley-India (2007).
3) Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, PHI Learning PvtLtd. New Delhi (2009).
4) Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M. J. K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt Ltd. (2007).
5) Organic Reaction Mechanism, V. K. Ahluwalia and R. K. Parashar, Narosa Publishers, (2007).
6) Organic Chemistry, S. M Mukherji, S. P Singh and R. K Kapoor (Volume II), International Pvt Ltd. Narosa Publishers, (2003).
7) Organic Chemistry, R.N Morrison and R.N Boyd, DarlingKindersley (India) Pvt. Ltd. Pearson Education, (2016).
8) Organic Chemistry: Stereochemistry and the Chemistry of Natural Products, I. L Finar (Volume I), I. L Finar, (Volume II), Dorling Kindersley India Pvt Ltd. Pearson Education, (2002).
9) Stereochemistry, Conformation and Mechanism, P.S Kalsi, New age International, (2005).
10) Stereochemistry of Organic Compounds, Wiley, E.L Eliel and S.H Wilen, (London), (2020).

PRACTICALS

Credit Points: 2 **Teaching Hours:4 hrs**

Evaluation: Continuous Internal Assessment-20 marks

Semester End Examination :30 marks

Course Objectives

1) To impart skills related to preparation of stock and working solutions and handling of instrumental methods
2) To know the principle of colorimetric analysis and construction of calibration plot
3) To understand the chemistry involved in colorimetric determination of metal ions andanions
4) To determine Rf values of different metal ions present in a mixture
5) To impart knowledge on the importance of functional groups in organic compounds.
6) Techniques to identify the functional groups in a compound by performing physical and chemical tests
7) To record its melting point/boiling point.
8) To prepare suitable derivative for that compound and to characterize it.

Course Specific outcomes

After the completion of this course, the student would be able to

1) Understand the importance of instrumental methods for quantitative applications
2) Apply colorimetric methods for accurate determination of metal ions and anions in water or real samples
3) Understand how functional groups in a compound is responsible for its characteristic property
4) Learn the importance of qualitative tests in identifying functional groups.
5) Learn how to prepare a derivative for particular functional groups and how to purify it.

PART-A (Analytical Chemistry)

1) Colorimetric determination of copper using ammonia solution
2) Colorimetric determination of iron using thiocyanate solution
3) Colorimetric determination of nickel using DMG solution
4) Colorimetric determination of titanium using hydrogen peroxide
5) Colorimetric determination of nitrite in a water sample (diazo coupling Reaction/Griess reagent
6) Colorimetric determination of phosphate as ammonium phosphomolybdate
7) Determination of Rf values of two or three component systems by TLC
8) Separation of different metal ions by paper chromatography/ Solvent extraction of ironusing oxine solution **(demonstration)**

PART-B(Organic Chemistry)

Qualitative analysis of bifunctional Organic compounds such as:

1)Salycilic acid , p-Nitro benzoic acid, Antranilicacid, p-Chloro benzoic acid

2) o-Cresol, p-Cresol, Resorcinol,o- Nitrophenol, p-nitophenol

3)o-Nitro aniline, p-Nitroaniline, p-Toluidine, p-Chloroaniline, p- Bromoaniline,

4)Ethyl Salicylate, Salicylaldehyde, Actophenone, p-Dichlorobenzene, p-Nitro toluene,,Benzamide etc.(Atleast 6-8 compounds to be analysed in a semester)

References

1)Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D.Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt Ltd (2007).

2) Vogels Text Book of Qualitative Chemical Analysis, ELBS (1989).

OE1: For Science students

Title of the Course: Open Elective-3: ATOMIC STRUCTURE, BONDING AND CONCEPTS IN ORGANIC CHEMISTRY

Contact Hours: 42 **Workload: 3 hours per week**

Credit Points: 3

Evaluation: Continuous Internal Assessment - 40 marks

Semester End Examination - 60 marks

Course Objectives:

1) To develop an understanding of principles of Atomic structure
2) To know the importance of quantum numbers, writing of electronic configurations and represention of orbitals
3) To develop an understanding of the periodic trends
4) To understand the nature of bonding and to predict the shapes of molecules
5) To construct MO energy level diagrams and predict the properties of molecules
6) To understand the formation of sigma and pi bonds and the bond strength.
7) To study the classification of organic reactions
8) To learn nomenclature preparation and reactions of alkanes, alkenes, alkynes and stability of alicyclic compounds

COURSE CONTENT

Unit I: Atomic Structure and Periodic Properties

History of an atom. Idea of de Broglie matter waves. Heisenberg uncertainty principle. Schrödinger wave equation, significance of wave functions, Bohr's model of hydrogen atom and its limitations. Quantum numbers and their importance, atomic orbitals and shapes of s, p, d orbitals, Multi-electron atoms, Aufbau and Pauli exclusion principle and Hund's multiplicity rule- Electronic configurations of the elements (atomic no. up to 30), effective nuclear charge and shielding. **8 hrs**

Periodic Properties

Atomic radius, Covalent, ionic and van der Waal radii-explanation with examples. Definition and periodicity of the following properties - ionic radii, ionisation potential, electron affinity and electronegativity, methods of determination of electronegativity. Factors affecting the values of ionisation energy. **6 hrs**

Unit II: Chemical Bonding

Ionic Solids– Ionic structures (NaCl, CsCl, TiO_2, ZnS), radius ratio rule and coordination number, limitation of radius ratio rule, lattice energy and Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarisability of ions, Fajan's rule and their consequences. **4 hrs**

Covalent Bond – Valence bond theory and its limitations, directional characteristics of covalent

bond, various types of hybridization with examples and shapes of simple inorganic molecules and ions. Shapes of NH_3, I_3^+, I_3^-, SF_4, CIF_3, IF_5, ICl_2^- and H_2O using valence shell electron pair repulsion (VSEPR) theory, linear combination of atomic orbitals (LCAO), bonding, nonbonding and antibonding molecular orbitals, physical picture of bonding and antibonding wave functions. Applications of MO theory to explain the stability of homo dinuclear (He_2, N_2, O_2, F_2, C_2) and hetero dinuclear (NO and CO) molecules. Comparison of M.O. and V.B. Models.

7 hrs

Metallic bond-free electron, Band theory-electrical properties of metals, semiconductors and insulators.

Weak interactions – Hydrogen bonding and its consequences, van der Waals forces. **3 hrs**

Unit III: Bonding and molecular structure and hydrocarbons

Bonding and molecular structure: Introduction to organic chemistry, atomic orbitals, sigma and pi bond formation-molecular orbital [MO] method, sp, $sp^2$and sp^3 hybridization, bond length, bond dissociation energies and bond angles (open chain and cyclic compounds). Electronegativity and polarity of the bonds. Classification and reactions of organic compounds (with examples). **7 hrs**

Alkanes, Alkenes and Alkynes

Definition, Nomenclature, preparations (any two methods)

Reactions: Electrophilic, nucleophilic and free radical addition reactions

Alicyclic compounds:

Nomenclature, preparation and stability of cyclopropane, cyclobutane, cyclopentane and cyclohexane. **7 hrs**

Reference Books:

1. Concise Inorganic Chemistry, J. D. Lee, ELBS. (1996)
2. Fundamental Concepts of Inorganic Chemistry, A. K. Das, 3rd edition, Vol 1. (2020)
3. Inorganic Chemistry: Principles of Structure and Reactivity, J. E Huheey, E. A Keiter, R. L Keiter & O. K Medhi, Pearson Education India, (2006)
4. Inorganic Chemistry, D.F Shriver & P. W Atkins, Oxford University Press. (2009)
5. Schaum's Outline Series Theory and Problems of Organic Chemistry. SI (metric) edition Herbert Meislich, Howard Nechamkin and Jacob Sharefkin. (2013)
6. Organic chemistry. Robert T. Morrison and Robert N. Boyd, 6th Edition. (1992)
7. Organic Chemistry, I. L.Finar (Volume I). (2002)

COURSE OUTCOME:

On completion of the course the student will learn and be able to understand/explain

1) the concept of atomic structure, significance of quantum numbers, filling of electrons of atoms/ions in various orbitals as per rules
2) the trends in periodic properties
3) the structures of ionic solids, applications of B-H cycle, solubility of compounds and consequences of polarization of ions
4) the shapes of molecules/ions based on VSEPR theory

5) the construction of MO energy level diagrams and prediction of properties of molecules/ions like bond order, bond energies, bond lengths and magnetic properties.
6) the formation of sigma and pi bonds and the bond strength
7) the classification of organic reactions
8) nomenclature preparation, and reactions of alkanes, alkenes, alkynes and stability of alicyclic compounds.

OE 2 : For Other than Science Students

CHEMISTRY

DSC-4: Inorganic and Physical Chemistry-II

Contact Hours: 56 **Work load: 4 Hours/Week.**

Credit Points :4

Evaluation: Continuous Internal Assesment-40 MarksSemester End Examination -60 Marks

Course Objectives:

Students learn about

1) Different types of bonding in molecules/compounds/ions
2) The structures of molecules/compounds/ions based on different models/theories
3) Properties of compounds based on bonding and structure
4) The fundamentals of thermodynamics including the laws, the concept of entropy and free energy functions and their applications.
5) The concepts of surface chemistry, catalysis and their applications.
6) The theoretical and experimental aspects of chemical kinetics including basic theories of reaction rates and methods of determining order.
7) Electrochemistry dealing with electrolytes in solution. Conductance measurements and applications. Concept of ionic mobility and their determination.

Course outcomes:

After the completion of this course, the student would be able to

1) Predict the nature of the bond formed between different elements
2) Identify the possible type of arrangements of ions in ionic compounds
3) Write Born - Haber cycle for different ionic compounds
4) Relate different energy parameters like, lattice energy, entropy, enthalpy and solvation energy in the dissolution of ionic solids
5) Explain covalent nature in ionic compounds
6) Write the M.O. energy diagrams for simple molecules
7) Differentiate bonding in metals from their compounds
8) Learn important laws of thermodynamics and their applications to various thermodynamic systems
9) Understand adsorption processes and their mechanisms and the function and purpose of a catalyst
10) Apply adsorption as a versatile method for waste water purification.
11) Understand the concept of rate of a chemical reaction, integrated rate equations, energy of activation and determination of order of a reaction based on experimental data
12) Know different types of electrolytes, usefulness of conductance and ionic mobility measurements
13) Determine the transport numbers

DSC-4: Inorganic and Physical Chemistry-II

Contact Hours: 56 **Work load: 4 Hours/Week.**

Unit - I

Structure and Bonding -I

The ionic bond: Structures of ionic solids

Radius ratio rules, Calculation of some limiting radius ratio values, Coordinationnumber 3

(planar triangle), Coordination number 4 (tetrahedral and square planar), Coordination number 6 (octahedral), Close packing. **3hrs**

Classification of ionic structures:

Ionic compounds of the type AX (ZnS, NaCl, CsCI)

Ionic compounds of the type AX_2 (Calcium fluoride (fluorite) and Rutile structure Layer structures CdI_2 , Cadmium iodide structure

Limitations of radius ratio concept **2 hrs**

Lattice energy and Born-Haber cycle, Derivation of Born-Lande equation and its drawbacks, Kapustinskii equation, solvation energy and solubility of ionic solids, polarizing power and polarizability, Fajan's rules with applications.

Numerical problems **5 hrs**

Covalent bond: Valence bond theory, The Lewis theory, The octet rule, Exceptions to the octet rule, Sidgwick- Powell theory. Valence shell electron pair repulsion (VSEPR) theory, Effect of lone pairs, electronegativity, isoelectronic principle, Examples using VSEPR theory: BF_3 and BF_4^-, NH_3 and NH_4^+, H_2O, PCl_5, CIF_3, SF_4, I_3^- and I_3^+, SF_6, and IF_7.

Limitations of VSEPR. **4 hrs**

Unit - II

Structure and Bonding -II

Concept of resonance, resonance energy, hybridisation, types of hybridization, sp, sp^2, sp^3 dsp^2 dsp^3, d^2sp^3, sp^3d^2 with one example each, and energetics of hybridization. Bent's rule, Limitations of Valence Bond Theory. **3 hrs**

Molecular Orbital theory:

LCAO concept: s-s, s-p, p-p, p-d and d-d combinations of orbitals, bonding, nonbonding and antibonding molecular orbitals, non-bonding combinations of orbitals, Rules for linear combination of atomic orbitals

Examples of molecular orbital treatment for homonuclear diatomic molecules, H_2 molecule, H^+ He_2 molecule, He^{+2} molecule ion, Li_2 molecule, Be_2 molecule, B_2 molecule, C_2 molecule, N_2 molecule, N_2^+, O_2 molecule, O^- and O_2^{2-} M.O. energy diagrams of heteronuclear diatomic molecules with examples (NO, NO^+, CO and HCl). Calculation of bond order, relationship between bond order, bond energy and bond length, magnetic properties based on MOT. **7 hrs**

Metallic Bonding:

General properties of metals: Conductivity, Lustre, Malleability and cohesive force Crystal structures of metals and Bond lengths

Theories of bonding in metals:

Free electron theory, Valence bond theory, Molecular orbital or band theory of solids Prediction of conducting properties of conductors. insulators and semiconductors, extrinsic and intrinsic semiconductors using M.O. theory. **4 hrs**

UNIT III

First Law of Thermodynamics

Thermodynamic Processes, Reversible and Irreversible Processes, Nature of Heat and Work,Internal Energy, First Law of Thermodynamics, Enthalpy of a System,Work done in isothermal and adiabatic expansion of an ideal gas, Numerical problems, Joule -Thomson Expansion, Relation between Joule-Thomson coefficient and other thermodynamic parameters.

Second law of Thermodynamics

Concept of entropy, thermodynamic scale of temperature, Statements of the Second Law of Thermodynamics, molecular and statistical interpretation of entropy, Calculation of entropy change for reversible and irreversible processes, Free Energy Functions: Gibbs and Helmholtz energy, Variation of S, G, A with T, V and P, Numerical problems, Free energy change and spontaneity, Gibbs-Helmholtz equation.

Third Law of Thermodynamics

Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules. **9 Hrs**

Surface Chemistry

Adsorption: Types of adsorption isotherms. Freundlich adsorption isotherm (only equation), its limitations. Langmuir adsorption isotherm (derivation to be done) and BET equation (derivation not included).

Catalysis: Types of Catalysis and theories with examples (intermediate compound theory and adsorption theory), Theory of acid base catalysis, Michaelis-Menten mechanism. Heterogeneous catalysis: surface reactions, unimolecular, bimolecular surface reactions. Autocatalysis with examples. Applications: Design process to removal of toxic compounds from industrial wastewater and treatment of portable water requirements. **5 Hrs**

UNIT IV

Chemical Kinetics

Differential and integrated form of rate expressions up to second order reactions, Derivation of expression of rate constant of second order reaction (a=b and a ≠ b), Problems on rate constant (a=b), Methods of determination of order of a reaction, temperature dependence of reaction rates; Arrhenius equation, activation energy, Numerical problems on Arrhenius equation in calculating energy of activation and rate constants. Collision theory of reaction rates, Lindemann's mechanism, qualitative treatment of the theory of absolute reaction rates. Experimental determination of kinetics of (i) inversion of cane sugar by polarimetric method (ii) spectrophotometric method for the reaction between potassium persulphate and potassium iodide. **7 Hrs**

Electrochemistry – I

Arrhenius theory of electrolytic dissociation. Merits and Demerits, Conductance, Specific conductance, equivalent and molar conductivity and their variation with dilution. Molar conductivity at infinite dilution. Numerical problems.

Kohlrausch's law of independent migration of ions and its applications, Debye-Hückel-Onsager equation. Ionic mobilities and their determinations, transference numbers and their relation to ionic mobility's, determination of transference numbers using Hittorf and Moving Boundary methods.

Applications of conductance measurement: (i) degree of dissociation of weak electrolytes (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts (iv) conductometric titrations (acid base titrations only) and (v) Hydrolysis constants of salts. Numerical problems. **7 Hrs**

Reference Books

1. Physical Chemistry, Peter Atkins & Julio De Paula, 9th Edition, Oxford University Press, (2010)
2. Physical Chemistry, G. W Castellan, 4th Edition, Narosa publishers, (2004)
3. Physical Chemistry, R. G Mortimer, 3rd Edition, Elsevier: Noida, UP (2009)
4. Principal of Physical Chemistry, B. R Puri, L. R Sharma and M. S Pathania, Vishal Publishing Co. (2008)
5. Essentials of Physical chemistry, B. S Bahl, G. D Tuli and Arun Bahl, S Chand & Company Ltd. (1994)
6. A textbook of Physical Chemistry, A. S Negi and S. C Anand, New Age International Publishers, (2022)
7. Advanced Physical chemistry, B. N Bajpai, S Chand and Company Ltd, (2012)
8. Chemistry for Degree Students, R. L Madan, Semester I, II, III and IV, S. Chand and Company Ltd.
9. Textbook of Physical Chemistry, P. L Soni, O. P Dharmarha and U N Dash, Sultan Chand and Sons (2021)

PRACTICALS

Credit Points: 2 **Teaching Hours:4Hrs**

Evaluation: Continuous Internal Assessment-20 marks

Semester End Examination: 30 marks

Course objective:

To attain practical knowledge about:

1) Analytical skills in detecting the constituents present in unknown samples bysystematically carrying out thequalitative analysis.
2) The methods of determining rates of chemical reactions.
3) Designing electrochemical cells and making measurements related to it.
4) Determination of physical characteristics of electrolytes using conductivitymeasurements in solution.
5) Adsorption phenomenon, mechanism and basic models to explain adsorption.
6) Simple techniques like conductometry to obtain physicochemical parameters ofelectrolytes.

Course outcomes: At the end of the course student would be able to

1) Understand the chemical reactions involved in the detection of cations and anions.
2) Explain basic principles involved in classification of ions into groups in semi-micro qualitative analysis of salt mixture
3) Carryout the separation of cations into groups and understand the concept of commonion effect.
4) Understand the choice of group reagents used in the analysis.
5) Analyse a simple inorganic salt mixture containing two anions and cations
6) Use instruments like a conductivity meter to obtain various physicochemical parameters.
7) Apply the theory about chemical kinetics and determine the velocity constants ofvarious reactions.
8) Learn about the reaction mechanisms.
9) Interpret the behavior of interfaces, the phenomena of physisorption andchemisorption and their applications in chemical and industrial processes.
10) Learn to fit experimental data with theoretical models and interpret the data

Part A- Inorganic Chemistry Practicals

Qualitative semi-micro analysis of mixtures containing 2 anions and 2 cations.Emphasis should be given to the understanding of different reactions.

The following cations and anions are suggested.

Cations: $NH4^{+}$, Pb^{2+}, Bi^{3+}, Cu^{2+}, Al^{3+}, Fe^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Zn^{2+}, Mn^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Mg^{2+}, Na^{+}, K^{+} and Li^{+}.

Anions: CO_3^{2-}, CH_3COO^{-}, Cl^{-}, Br^{-}, I^{-}, NO_3^{-}, BO_3^{3-}, SO_4^{2-}, $C_2O_4^{2-}$ and PO_4^{3-}

Spot tests and flame tests to be carried out wherever possible.

Part B- Physical Chemistry Practicals

1. Determination of the enthalpy of neutralization of a strong acid with strong base.
2. The study of kinetics of potassium persulphate and potassium iodide volumetrically.

3. Determination of velocity constant for acid catalyzed hydrolysis of methyl acetate.
4. Determination of equivalent conductivity of strong electrolyte and verification ofDHO equation.
5. Determination of dissociation constant of weak acid by conductivity method.
6. Conductometric titration of strong acid and strong base.
7. Conductometric titration of weak acid and strong base.
8. Determination of solubility product of sparingly soluble salt conductometrically.

References

1. Vogel's Qualitative analysis, Revised by G. Svehla, Pearson education, (2002)
2. Advanced Physical Chemistry, J. B Yadav, Krishna Prakashan Media (P) Ltd,Meerut (2014)
3. Senior Practical Physical Chemistry, B. D Khosla, V. C Garg, & A. R Gulati, Chand & Co. New Delhi (2011)
4. Experiments in Physical Chemistry,C. W Garland, J. W Nibler & D. P Shoemaker, 8th Edition McGraw-Hill: New York (2003)
5. Experimental Physical Chemistry, A. M Halpern & G. C McBane, W.H Freeman & Co, New York (2003)

Semester 4
B Sc / B Sc (Honors)

Title of the Course: Open Elective: Applications of Chemistry in Industries

Number of Theory Credits	Number of lecture hours/semester
3	42

Evaluation Scheme for Theory:
Continuous Internal Assessment (CIA): 40 MarksSemester End Examination (SEE): 60 marks

This course provides a broad introduction to the fundamental principles of Electrochemistry, Corrosion and Metallurgy. The student will gain an understanding of basic and practical applications in various fields of Electrochemistry, Corrosion and Metals and Alloy behaviour andmanufacturing processes. This course is a valuable prerequisite for taking more technically challenging courses that will be required for career development.

Course Objectives

This course will deal with

1) Types of conductance, concept of electrolytes, electrolysis, redox reactions and EMF
2) Concept of different types of electrochemical cells, Types of electrodes and electrode potential. Application of electrochemical series.
3) Basic principles and applications of conductometric, potentiometric and pH titrations.
4) Different types of Batteries their principle construction and working - lead-acid storage

and lithium ion battery. Study of Fuels cells.

5) Concept of corrosion, types of corrosion and its prevention by different methods.Introduction to electroplating.
6) Introduction to ores and minerals, extraction of metals from their ores, and purification. Eg., Manganese, Titanium and Uranium.
7) Study of alloys, classification, production and uses of alloys.

Expected Course Outcomes

Upon completion of the course students will be able to

1) Understand the concept of conductance in electrolytic solutions, electrolysis and redox reactions involved in electrode reactions.

2) Learn the different types of electrochemical cells, their symbolical representation and application of electrochemical series.
3) Apply conductometric, potentiometric and pH titrations
4) Know the principle, construction and working of batteries
5) Understand different types of corrosion and its prevention by different methods
6) Learn the methods of extraction of metals from their ores and purification

UNIT I

Electrochemical Energy Sources

Batteries:Definition of a Cell and a Battery, Examples to each, Daniel cell, dry Cells - electrolytic and Galvanic cell, Representation of a cell. Standard electrode potential, Nernst equation (No derivation) and its application to chemical cell,

Oxidation -reduction reactions, electrode potential, EMF of an electrochemical cell, Electrochemical series and its importance.

Primary and Secondary batteries, Battery components and their role. Working of thefollowing Batteries- Lead acid, Lithium Storage, Batteries, Fuel cells. **12 hrs**

Types of Electrodes- Hydrogen, Calomel and Glass electrodes. Determination of pH using glass electrode. **2 hrs**

UNIT II

Corrosion: Introduction, definition, damages of corrosion, reasons for corrosion to occur, Types of Corrosion, Corrosion rate, Factors affecting corrosion rate, Metallic factor-purity, electrode potential of metal, hydrogen over voltage,nature of corrosion product. Environmental Factors-Temperature, pH of the medium, humidity, presence of impurities, electrical conductivity of the medium, velocity of the medium, concentration of the medium.

5hrs

Prevention of Corrosion: Material selection - Metals and alloys, metal purification, non-metallic, Alteration of environment - Changing media, inhibitors, Design-wall thickness, design rules, Coating-Metallic and other inorganic coatings, organic coating. **5 hrs**

Electroplating: Introduction, Electroplating of chromium (hard and decorative). Electro less

plating: Introduction, distinction between electroplating and electroless plating processes. Electroless plating of copper. **4 hrs**

UNIT III

Metallurgy

Introduction: Ore, minerals, important ores of some common elements in India, General Principles of pyrometallurgy, roasting, Calcination, Gangue, Smelting, Flux, Gravity separation, Froth flotation process, leaching. Techniques employed for Purification of metal (Distillation process, Bessemerization, Electro-refining, Van Arkel and De Boer's Filament. **6 hrs**

Extraction of metals: Extraction of Manganese (Pyrolusite), Titanium (Ilmanite) and Uranium. **4 hrs**

Alloys: Introduction, Classification of alloys, commercially important alloys, gold karats, Production of Ferro alloys; Ferrochrome, Ferro Manganese, Uses of alloys. **4 hrs**

Reference Books

1) Physical Chemistry, Barrow. G.M, Tata McGraw-Hill, (2007)
2) An introduction to Electrochemistry, Samuel Glasstone, East-West edition New Delhi, (1942)
3) Text book of Physical chemistry, Samuel Glasstone, 2nd Edition, Mac Millan India Ltd, (1991)
4) Principles and applications of Electrochemistry, D. R. Crow, 3rd edition, Chapmanhall London, (1988)
5) Fundamentals of Electrochemical deposition, Milan Paunovic and Mordechay Schlesinger, Wiley Interscience Publications, New York, (1998)
6) Engineering Chemistry, V R Kulkarni and K Ramakrishna Reddy, New Age International, (2015)
7) Electrochemistry and Corrosion Science, Nestor Perez, Springer (India) Pvt. Ltd, (2004)
8) Principles and Prevention of Corrosion, D. A. Jones, Macmillan Publ. Co, (1996)
9) Essential of Materials Science and Engineering, Donald R. Askeland, Thomson Learning, 5th Edition, (2006)
10) Introduction to Engineering Materials, B. K. Agarwal, Tata McGraw Hill, 1st Edition (1988)
11) Material Science and Engineering, V. Raghavan, PHI Learning, 5th Edition (2009)
12) Engineering Materials and Metallurgy, R. K. Rajput, S. Chand - 1st Edition, (2011)