Curriculum

Name of the Degree Program	B.Sc. / B.Sc. (Honors) Chemistry
Discipline Core	Chemistry.
Total Credits for the Program	186

Starting year of implementation: 2021-22

Program Outcomes:

By the end of the program the students will be able to:

(Refer to literature on outcome-based education (OBE) for details on Program Outcomes)

1. **PO. 1:** To create enthusiasm among students for Analytical chemistry and its application in various fields of life.
2. **PO. 2:** To provide students with broad and balanced knowledge and understanding of key concepts in Analytical chemistry
3. **PO. 3:** To develop in students a range of practical skills so that they can understand and assess risks and work safely measures to be followed in the laboratory.
4. **PO. 4:** To develop in students the ability to apply standard methodology to the solution of problems in chemistry
5. **PO. 5:** To provide students with knowledge and skill towards employment or higher education in chemistry or multi-disciplinary areas involving chemistry.
6. **PO. 6:** To provide students with the ability to plan and carry out experiments independently and assess the significance of outcomes and to cater to the demands of chemical Industries of well-trained graduates
7. **PO. 7:** To develop in students the ability to adapt and apply methodology to the solution of unfamiliar types of problems.
8. **PO. 8:** To instil critical awareness of advances at the forefront of chemical sciences, to prepare students effectively for professional employment or research degrees in chemical sciences and to develop an independent and responsible work ethics.

Assessment: Weightage for assessments (in percentage)

Type of Course	**Formative Assessment / IA**	**Summative Assessment**
Theory	30	70
Practical	15	35
Projects	-	-
Experiential Learning (Internships etc.)	-	-

Curriculum Structure for the Undergraduate Degree Program

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

Sem ester	Title / Name of the course	Program outcomes that the course addresses (not more than 3 per course)	Pre-requisite course(s)	Pedagogy# #	Assessment$
1	DSC-1: Analytical, Inorganic and Organic Chemistry-I **Credits**-4	• The concepts of chemical analysis, accuracy, precision and statistical data treatment • Understand the preparation of alkanes, alkenes and alkynes, their reactions, etc. • The Bohr's theory of atomic structure and how it was developed • Quantum numbers and their necessity in explaining the atomic structure	P.U.C /12th standard/ or equivalent with Chemistry (With Maths in 10+2 Level)	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	DSClab-1: Analytical, Inorganic and organic Practical-I **Credits**-2	• 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: Analytical, Physical and Organic Chemistry-II **Credits**-4	• Know the concept of volumetric and gravimetric analysis • And handle toxic chemicals, concentrated acids and organic solvents and practice safety procedures. • The concept of unit cell, symmetry elements, Nernst distribution law. • Understand the preparation of alkenes and alkynes, their reactions, and the mechanism	-	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams

		of nucleophilic, electrophilic reactions.			
	DSC Lab -2: Inorganic, and Physical Practicals-II **Credits**-2	• To prepare standard solutions • Techniques like precipitation, filtration, drying and ignition • Various titrimetric techniques and gravimetric methods.		Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
3	DSC-3: **Credits**-4 DSC Lab-3 **Credits**-2		DSC-1 and DSC-2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
4	DSC-4: **Credits**-4 DSC Lab-4: **Credits**-2			Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
5.	DSC-5: **Credits**-3 DSC Lab-5: **Credits**-2 DSC-6: **Credits**-3 DSC Lab-6: **Credits**-2 DSE-A1: **Credits**-3	:	DSC-3 and DSC-4	MOOC, Problem solving	Internal tests, Assignments, Quiz
6.	DSC-7: **Credits**-3 DSC Lab-7: **Credits**-2. DSC-8: **Credits**-3 DSC Lab-8: **Credits**-2 DSE-A2: **Credits**-3			MOOC, Problem solving	Internal tests, Assignments, Quiz
7.	DSC-9: **Credits-3** DSC Lab-9: **Credits=2** DSC-10: **Credits**-3 DSC Lab-10 : **Credits** -2 DSC-11: **Credits**=4 DSE-A3: **Credits**-3 **And Research methodology Or DSE. Credits**-3		DSC-5 and DSC-6 DSE-A1: DSC-7 and DSC-8 DSE-A2:	MOOC, Problem solving	Internal tests, Assignments, Seminar, Debate, Quiz
8.	DSC-12: **Credits**=4 DSC-13:. **Credits**-4			Project work, Industrial Visit	Internal tests, Assignments, Seminar, Debate, Quiz

	DSC-14: **Credits**-3 DSE-A4: **Credits**=3 Research Project. **Credits**=6 **Or** Two Papers. **Credits**=3Each.				

Pedagogy for student engagement is predominantly lectures. However, other pedagogies enhancing better student engagement to be recommended for each course. The list includes active learning/ course projects/ problem or project-based learning/ case studies/self-study like seminar, term paper or MOOC

$ Every course needs to include assessment for higher order thinking skills (Applying/ Analyzing/ Evaluating/ Creating). However, this column may contain alternate assessment methods that help formative assessment (i.e. assessment for learning).

B.Sc. / B.Sc. (Honors) Chemistry. Semester 1

Course Title: DSC-1: Analytical/Inorganic and Organic Chemistry.	
Total Contact Hours: 56	Course Credits: 4
Formative Assessment Marks: 30	Duration of ESA/Exam: 3 hrs.
Model Syllabus Authors: BOS.	Summative Assessment Marks: 70

Course Pre-requisite(s):

PUC/12th standard/ or equivalent with Chemistry (With Maths in 10+2 Level)

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Explain basic laboratory practices like calibration of glassware, sampling, handling acids and safety precautions.
2. Prepare the solutions after calculating the required quantity of salts in preparing the reagents/solutions and dilution of stock solution.
3. Describe the limitations of Classical Mechanics which necessitated the development of Quantum Mechanics.
4. Solve the Schrodinger's equation to obtain wave function for a basic type of Potential in one dimension and predict the shapes of orbitals as well as probability Distributions
5. To justify the need for quantum mechanical structure of atoms
6. Describe the periodicity in physical and chemical properties. Of elements in the Periodic table.
7. Explain the nature of bonding in organic compounds using concepts such as Conjugation, resonance, etc.
8. Learn methods of syntheses of alkanes, alkenes and alkynes along with their

Reactions.

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. Explain basic laboratory practices like calibration of glassware, sampling, handling acids and safety precautions	X	X						
2. Prepare the solutions after calculating the required quantity of salts in preparing the reagents/solutions and dilution of stock solution	X	X		X				
3. Describe the limitations of Classical Mechanics which necessitated the development of Quantum Mechanics	X					X		
4. Solve the Schrodinger's equation to obtain wave function for a basic type of Potential in one dimension and predict the shapes of orbitals as well as probability distributions	X		X					
5. To justify the need for quantum mechanical structure of atoms	X			X				
6. Describe the periodicity in physical and chemical properties. Of elements in the Periodic table	X							X
7. Explain the nature of bonding in organic compounds using concepts such as Conjugation, resonance, etc.	X						X	
8. Learn methods of syntheses of alkanes, alkenes and alkynes along with their reactions	X							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.

BSc Semester 1 – B.Sc. / B.Sc. (Honors) Chemistry

Title of the Course: DSC-1:

Number of Theory Credits	Number of lecture hours/ semester	Number of practical Credits	Number of practical hours/ semesters
4	56	2	56

Course Objectives:

- To strengthen the concepts of mole and stoichiometry
- To develop analytical skills of determination of analyte through titrimetric and gravimetric experiments
- To develop the ability to set-up apparatus, using the apparatus to collect data and analyze the data to determine the desired parameter or quantity.
- To impart skills of preparation of reagents/solutions from source materials
- Quantum numbers and their necessity in explaining the atomic structure
- Shapes of different atomic orbitals
- Historical development of periodic table.
- Periodic properties viz. atomic radii, ionization energy, electronegativity etc.
- To introduce the basic concepts of organic chemistry.

Course Specific Outcome:

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

- The concepts of chemical analysis, accuracy, precision and statistical data treatment
- Prepare the solutions after calculating the required quantity of salts in preparing the reagents/solutions and dilution of stock solution.
- Quantum numbers and their necessity in explaining the atomic structure
- Shapes of different atomic orbitals
- Historical development of periodic table
- Periodic properties viz. atomic radii, ionization energy, electronegativity etc.
- The Concept of aromaticity, resonance, hyper conjugation, etc.
- Understand the preparation of alkanes, alkenes and alkynes, their reactions, etc.
- Understand the mechanism of nucleophilic, electrophilic reactions
- Able to draw the energy profile diagrams
- Able to explain the factors affecting the orientation during aromatic substitution reactions.

Content of Theory Course 1	56 hrs.
Unit – 1 Basic laboratory practices, calibration of glassware (pipette, burette and volumetric flask), Sampling (solids and liquids), weighing, drying, dissolving, Acid treatment, Rules of work in analytical laboratory, General rule for performing quantitative determinations (volumetric and gravimetric), Safety in Chemical laboratory, Rules of fire prevention and accidents, First aid. Precautions to be taken while handling toxic chemicals, concentrated/fuming acids and organic solvents. **(4 hrs.)** **Language of analytical chemistry**: Definitions of analysis, determination, measurement, techniques and methods. Significant figures, Classification of analytical techniques. Choice of an analytical method. Errors and treatment of analytical data: Limitations of analytical methods – Errors: Determinate and indeterminate errors, some important terms replicate, outlier, Accuracy, precision, ways of expressing accuracy, absolute error, relative error, minimization of errors. Statistical treatment of random errors, mean, median, range, standard deviation and variance. External standard calibration. Numerical problems. **(6 hrs.)** Regression equation (least squares method), correlation coefficient (R2), limit of detection (LOD), limit of quantification (LOQ), linear dynamic range (working range), sensitivity, selectivity, method validation, figures of merit of analytical methods. **(4 hrs.)**	**14 hrs**
Unit - 2 **Limitations of classical mechanics**. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance. Quantum Mechanics-..Schrödinger's wave equation, derivation (time independent) significance of ψ and ψ^2. Eigen values and functions Applications of Schrödinger's wave equation - Particals in one-dimension box **(5hrs)** Quantum numbers and their significance. Quantum mechanical operators- (i) Hamiltonian operator; (ii) Laplacean operator Normalized and orthogonal wave functions. Sign of wave functions. Postulates of quantum mechanics Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams. (**6hrs**) Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations- Electronic configurations of the elements (Z=1-30), effective nuclear charge, shielding/screening effect, Slater's rules. Variation of effective nuclear charge in Periodic Table. (**3hrs**)	**14 hrs.**

Unit - 3	**14 hrs.**
s, p, d and f-block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s and p-block elements: (a) Atomic radii (van der Waals) (b) Ionic and crystal radii. (c) Covalent radii (d) Ionization enthalpy, successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy (e) Electron gain enthalpy; trends of electron gain enthalpy. (f) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. **(8 hrs)** Trends in the chemistry of the compounds of groups 13 to 17 (hydrides, carbides, oxides and halides) are to be discussed. **(6 hrs.)**	
Unit - 4	**14 hrs.**
Classification and nomenclature of organic compounds, hybridization, shapes of organic molecules, influence of hybridization on bond properties. **(2hrs)** **Nature of bonding in Organic molecules** Formation of covalent bond, types of chemical bonding,(Notations used to represent electron movements and directions of reactions- curly arrows, formal charges). localized and delocalized, conjugation and cross conjugation, with examples. Concept of resonance. Electronic displacements: Inductive effect, electrometric effect, resonance and hyper conjugation, aromaticity, Huckel rule, anti-aromaticity explanation with examples. **(4hrs)**	

Strengths of organic acid and bases: Comparative study with emphasis on factors effecting pKa values. Relative strength of aliphatic and aromatic carboxylic acids - acetic acid and chloroacetic acid, acetic acid and propionic acid, acetic acid and benzoic acid. Steric effect - relative stability of trans and *cis*-2-butene. Types of bond cleavages- homolytic and heterolytic cleavages Types of reagents - electrophiles, nucleophiles, nucleophilicity and basicity. Types of organic reactions - substitution, addition, elimination, and rearrangement explanation with examples. **(4hrs)** **Chemistry of Aliphatic hydrocarbons**, **carbon - carbon sigma bonds** Formation of alkanes: Wurtz reaction, free radical substitution, halogenation **Carbon-carbon pi bonds:** Formation of alkenes and alkynes by elimination reaction. Mechanism of E1, E2, reactions. Saytzeff and Hofmann eliminations. Addition of HBr to propene, free radical addition of HBr to propene. Addition of halogens to alkenes-carbocation and halonium ion mechanism. Ozonolysis - ozonolysis of propene, hydrogenation, hydration, hydroxylation and epoxidation of alkenes, explanation with examples, addition of hydrogen halides to alkynes. Conjugated Dienes - 1,2 and 1,4- addition reactions in conjugated dienes. Diels-Alder reaction. (**4 hrs.)**	

Recommended Books/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. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8th edition, Saunders College Publishing, New York (2005).
3. Basic Inorganic Chemistry, F A Cotton, G Wilkinson and P. L. Gaus, 3rd Edition. Wiley. India December 1994
4. Analytical Chemistry, G.D. Christian, 6th edition, Wiley-India (2007).
5. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
6. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
7. Concise Inorganic Chemistry: J D Lee, 4thEdn, Wiley, (2021)
8. Fundamentals Concepts of Inorganic Chemistry, Vol 1 and 2, 2nd Edition, Asim K Das, CBS Publishers and Distributors, (2013)
9. Inorganic Chemistry, 2ndEdn. Catherine E. Housecroft and A.G. Sharpe, Pearson Prentice Hall (2005)
10. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education) (2010)

11. Finar, I. L. *Organic Chemistry (Volume I),* Dorling Kindersley (India) Pvt. Ltd. (Pearson Education) (2002)
12. McMurry, J. E. *Fundamentals of Organic Chemistry,* 7th Ed. Cengage Learning India Edition, 2013
13. Organic Reaction mechanism by V. K. AhIuwalia and K. Parashar Oxford, U.K. : Alpha Science International, 2011.
14. Organic Chemistry by S. M. Mukherji, S. P. Singh and R. K. Kapoor. New age publishers Publication Date.2 February 2017
15. A Guide book to mechanism in Organic Chemistry by Peter Sykes. Pearson. (January 2003)
16. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007)
17. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008).
18. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford University Press.
19. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher, (2000).

Pedagogy: ICT tools, Chalk & Talk, Models & Charts, MOOC

Formative Assessment	
Assessment Occasion/ type	**Weightage in Marks**
Internal Test	30
Sem End Exam	70
Total	100

Scheme of Internal Assessment Marks:

	Theory		**Practicals:**	
Sl. No.	**Particulars**	**IA Marks**	**Particulars**	**IA Marks**
1	Attendance	05		
2	Internal Tests (Minimum of Two)	15	Practical Test	10
3	Assignments /Seminar	10	Attendance and Active participation in practical classes	05
TOTAL Theory/Practicals IA Marks		**30**		**15**

PRACTICALS (SEMESTER I)

Course outcome:

At the end of this course, student should be able to:

- Calibrate common laboratory glassware like pipette, burette and volumetric flask.
- Conduct a variety of volumetric estimations such as acid-base, redox and iodometric titrations.
- Purify/crystallize organic compounds by proper selection of suitable solvents.
- Synthesize different organic compounds such as *p*-nitro acetanilide, *m*-nitrobenzoic acid, tribromophenol, dibenzalacetone, etc., using conventional/green methods.

PART- A Analytical Chemistry

Course objectives:

- To prepare the standard/working solutions from source materials
- To standardize the reagents and determination of analytes
- To familiarize the student about filtration, drying, incineration and ignition of the precipitates

Course specific outcome:

- 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

List of Experiments:

1. Calibration of glassware, pipette, burette and volumetric flask.
2. Estimation of sodium carbonate and sodium bicarbonate in a mixture.
3. Estimation of alkali present in soaps/detergents.
4. Estimation of iron(II) using potassium dichromate.
5. Estimation of oxalic acid using potassium permanganate solution.
6. Estimation of chlorine in bleaching powder using iodometric method.
7. Estimation of alkali content in antacids.
8. Standardization of silver nitrate and determination of chloride in a water sample.

PART- B Organic Chemistry

Course objective:

- To get training on how to plan and execute single step synthesis of small organic molecules.
- To learn and get trained on how to purify a compound and to learn the crystallization techniques.
- To learn how to calculate percentage yield and to record physical constant
- To understand the mechanism involved in the transformation

Course specific outcome:

- Students gain the basic knowledge as how to select a solvent for crystallization of organic compounds and get trained as how to purify a compound.
- Students would understand the mechanism behind the reaction and role of catalysts in enhancing reaction rate and yield.
- Students would learn the importance of green methods over conventional methods.
- The students would be exposed to the safety measures to be taken to conduct reactions in the laboratory. and also learn how to manage by products and disposal of waste.

List of Experiments:

1. Selection of suitable solvents for purification/crystallization of organic compounds.
2. Preparation of acetanilide from aniline using Zn/acetic acid (green method).
3. Synthesis of *p*-nitro acetanilide from acetanilide using nitrating mixture.
4. Bromination of acetanilide (i) Conventional method and/or (ii) With ceric ammonium nitrate and potassium bromide (green method).
5. Preparation of methyl *m*-nitro benzoate from methyl benzoate by nitration method.
6. Hydrolysis of methyl *m*-nitro benzoate to *m*-nitro benzoic acid (conventional method).
7. Bromination - preparation of tribromophenol from phenol.
8. Preparation of dibenzalacetone (green method).

Note: Questions from both sections should be given in each batch.

1. In the first 20 minutes the Teacher should discuss in detail the theory, principle, procedure and calculations.
2. Instructions to be given for operating instruments, weighing chemicals and precautions while handling chemical.

Recommended Books/References:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis Sixth Edition, Pearson, 2009.
2. Practical Volumetric Analysis, Peter A C McPherson, Royal Society of Chemistry, Cambridge, UK (2015).
3. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
4. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)

BSc Semester I.

OPEN ELECTIVE-1

Title of the Course: OE-1:	CHEMISTRY IN DAILY LIFE
Number of Theory Credits	3
Number of lecture hours/ semester	42hrs.

Course outcomes:

At the end of this course, student should be able to:

1. Describe the analysis of important constituents in food items such as fat content in dairy products, caffeine in coffee/tea, methanol in alcoholic beverages, etc.
2. Give details of possible food additives, preservatives, colorants and adulterants commonly used in processed food.
3. Explain the nutritional aspects of macro and micronutrients, namely oils/fats and vitamins respectively.
4. Explain the chemistry of daily used products like soaps/detergents, batteries/fuel cells and polymers.

Course Objective:

The objective of this paper is to equip the non-chemistry students with knowledge about chemistry of some of the products which are commonly used in daily life.

Course specific outcome:

After studying this paper the student would be able to:

1. Describe the composition of the milk and dairy products.
2. Detect/determine the amount of caffeine, chicory in coffee and chloral hydrate in toddy.
3. Explain the preservatives used in food products and their effects and possible adulterants.
4. Acquire detailed information about the colorants used in food products.
5. Differentiate various vitamins, their sources and deficiencies.
6. Examine purity of the oils.
7. Explain how electrical energy is stored in batteries.
8. Classify commonly used polymers in our daily lives.

Content of Theory Course 1	42 Hrs
Unit – 1 **Dairy Products**: Composition of milk and milk products. Analysis of fat content, minerals in milk and butter. Estimation of added water in milk. Beverages: Analysis of caffeine in coffee and tea, detection of chicory in coffee, chloral hydrate in toddy, determination of methyl alcohol in alcoholic beverages. **(06hrs)** **Food additives, adulterants, and contaminants** - Food preservatives like benzoates, propionates, sorbates, and disulphites. Artificial sweeteners: aspartame, saccharin, dulcin, sucralose, and sodium cyclamate. Flavors: vanillin, alkyl esters (fruit flavors), and monosodium glutamate**.** **(06hrs)** **Artificial food colorants:** Coal tar dyes and non-permitted colors and metallic salts. Analysis of pesticide residues in food. **(02hrs).**	**14 hrs.**
Unit - 2 **Vitamins:** Classification and nomenclature. Sources, deficiency diseases, and structures of vitamin A1, vitamin B1, vitamin C, vitamin D, vitamin E & vitamin K1. **(06hrs).** **Oils and fats**: Composition of edible oils, detection of purity, rancidity of fats and oil. Tests for adulterants like argemone oil and mineral oils. Halphen test. **(05hrs).** **Soaps & Detergents**: Definition, classification, manufacturing of soaps and detergents, composition and uses **(03hrs)**	**14 hrs.**
Unit - 3 Chemical and renewable energy sources: principles and applications of primary & secondary batteries and fuel cells. Basics of solar energy, future energy storer. (**06hrs).** Polymers: basic concept of polymers, classification and characteristics of polymers. Applications of polymers as plastics in electronic, automobile components, medical fields, and aerospace materials. Problems of plastic waste management. Strategies for the development of environment-friendly polymers. **(08hrs).**	**14 hrs.**

Recommended Books/References:

1. B. K. Sharma: Introduction to Industrial Chemistry, Goel Publishing, Meerut (1998)
2. The chemical analysis of foods. . Pearson, David, 1919-1977. Cox and Pearson. 7th ed. Published Edinburgh; New York: Churchill Livingstone, 1976.
3. Foods: Facts and Principles. N. Shakuntala Many and S. Swamy, 4thed. New Age International (1998)
4. Odian; George, Principles of Polymerization, McGraw-Hill Book Co., New York (1970).
5. W. Billmeyer, Text book of polymer science, 3rd Edn., 2007, Wiley.
6. Foods: Facts and Principles. N. Shakuntala Many and S. Swamy, 4thed. New Age International (1998)
7. Subalakshmi, G and Udipi, SA (2006):Food processing and preservation, 1st Ed. New Age International (P)Ltd.
8. SrilakshmiB (2018): Food Science, 7th Colour Ed. New Age International (P) Ltd
9. Potter NN and Hotchkiss JH(1999): Food science,5th Ed , Spinger.
10. M.P. Stevens, Polymer Chemistry: An Introduction 3rd ed. Oxford University Press (2005).

Pedagogy: ICT tools, Chalk & Talk, Models & Charts, MOOC

Formative Assessment	
Assessment Occasion/ type	**Weightage in Marks**
Internal Test	30
Sem End Exam	70
Total	100

Scheme of Internal Assessment Marks:

	Theory	
Sl. No.	**Particulars**	**IA Marks**
1	Attendance	05
2	Internal Tests (Minimum of Two)	15
3	Assignments /Seminar	10
TOTAL Theory/Practicals IA Marks		**30**

B.Sc. / B.Sc. (Honors) Chemistry Semester II

Course Title: DSC-2: Analytical/Physical and Organic Chemistry.	
Total Contact Hours: 56	Course Credits: 4
Formative Assessment Marks: 30	Duration of ESA/Exam: 3 hrs.
Model Syllabus Authors: BOS	Summative Assessment Marks: 70

Course Outcomes (COs): At the end of the course the student should be able to:

1. Explain the principles and concepts related to titrimetric analysis with reference to acid-base, precipitation and complexometric titrations.
2. Handling of toxic chemicals, concentrated acids and organic solvents and practice safety procedures.
3. Write the mechanisms of S_N1 and S_N2 reactions taking suitable examples.
4. Illustrate types of aromatic electrophilic and nucleophilic substitution reactions with examples.
5. Give a comprehensive description of the gaseous state in terms of molecular velocity, their distribution based on Maxwell-Boltzmann law, types of molecular velocities, molecular collision parameters, critical phenomena and liquefaction of gases.
6. Explain important properties of liquid state such as viscosity, surface tension, refraction and parachor by defining them and elaborating on their experimental determination.
7. Learn methods of determining molecular weights of solutes by measuring colligative properties and the concept of distribution law along with its applications.
8. Describe the crystalline state in detail using the terms unit cell, Bravias lattices, Miller indices, Crystal systems, symmetry elements and lattice planes.

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. Explain the principles and concepts related to titrimetric analysis with reference to acid-base, precipitation and complexometric titrations.	X	X						
2. Handling of toxic chemicals, concentrated acids and organic solvents and practice safety procedures	X	X		X				
3. Write the mechanisms of S_N1 and S_N2 reactions taking suitable examples	X					X		
4. Illustrate types of aromatic electrophilic and nucleophilic substitution reactions with examples	X		X					

5. Give a comprehensive description of the gaseous state in terms of molecular velocity, their distribution based on Maxwell-Boltzmann law, types of molecular velocities, molecular collision parameters, critical phenomena and liquefaction of gases	X			X				
6. Explain important properties of liquid state such as viscosity, surface tension, refraction and parachor by defining them and elaborating on their experimental determination	X							X
7. Learn methods of determining molecular weights of solutes by measuring colligative properties and the concept of distribution law along with its applications	X						X	
8. Describe the crystalline state in detail using the terms unit cell, Bravias lattices, Miller indices, Crystal systems, symmetry elements and lattice planes	X							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.

BSc Semester II – B.Sc. / B.Sc. (Honors) Chemistry

Title of the Course: DSC – 2:

Number of Theory Credits	Number of lecture hours/semester	Number of practical Credits	Number of practical hours/ semesters
4	56	2	56

Course Objectives:

- The concept of volumetric and gravimetric analysis and deducing the conversion factor for determination.
- Handling of toxic chemicals, concentrated acids and organic solvents and practice safety procedures.
- To make him familiarize with various states of matter.
- To learn the calculation of lattice parameters.
- To learn various theories of physical chemistry.
- To understand how liquid state and its physical properties are related to temperature and pressure variation.

- To develop the concept of solids, lattice parameters – its calculation, application of symmetry and solid characteristics of simple salts.
- Understand the mechanism of nucleophilic, electrophilic reactions.
- To understand the concept of aromaticity and Huckel rule.
- To familiarize the student with nucleophilic and electrophilic substitution reactions in aliphatic and aromatic compounds.

Course specific outcome:

On completion of the course the students will learn and able to explain

- The concept of volumetric and gravimetric analysis and deducing the conversion factor for determination.
- Handling of toxic chemicals, concentrated acids and organic solvents and practice safety procedures.
- The concepts of organic reactions and techniques of writing the movement of electrons, bond breaking, bond forming.
- .Various theories of gases and their significance.
- The concept of surface tension, viscosity, refraction and its significance.
- Different types of liquid crystals and their applications.
- The concept of unit cell, symmetry elements, Nernst distribution law.

Content of Theory Course 2	**56Hrs**
Unit – 1	
Titrimetric analysis: Basic principle of titrimetric analysis. Classification, preparation and dilution of reagents/solutions. Equivalent masses of compounds Normality, Molarity and Mole fraction. Use of $N_1V_1 = N_2V_2$ formula, preparation of ppm level solutions from source materials (salts), conversion factors. Numerical problems. (**2hrs)** Acid-base titrimetry: Titration curves for strong acid vs. strong base, weak acid vs. strong base and weak base vs. strong acid titrations. Titration curves, quantitative applications – selecting and standardizing a titrant, inorganic analysis - alkalinity, acidity. **(2hrs)** Complexometric titrimetry: Indicators for EDTA titrations - theory of metal ion indicators, titration methods employing EDTA - direct, back, displacement and indirect determinations, Application-determination of hardness of water. **. (3hrs)** Precipitation titrimetry: Titration curves, titrants and standards, indicators for precipitation titrations involving silver nitrate - Volhard's and Mohr's methods and their differences. **(2hrs)**	**14hrs**

Gravimetric Analysis: Requisites of precipitation, mechanism of precipitation, factors influencing precipitation, co-precipitation, post-precipitation. Advantages of organic reagents over inorganic reagents, reagents used in gravimetry : 8-hydroxy quinoline (oxine) and dimethyl glyoxime (DMG). . **(5hrs)**	
Unit – 2	**14hrs**
Nucleophilic substitution at saturated carbon. Mechanism of S_N1 and S_N2 reactions with suitable examples. Energy profile diagrams, stereochemistry and factors effecting S_N1 and S_N2 reactions. **(4hrs)** Aromatic electrophilic substitution reactions, mechanisms, σ and π complexes, halogenation, nitration, sulphonation, Friedal Crafts alkylation and acylation with their mechanism. Activating and deactivating groups. Orientation influence, ortho - Para ratio (Cl, NO_2, CH_3, NH_2, OH). **(5hrs)** Aromatic nucleophilic substitution reaction: S_NAr mechanism, *ipso* substitution. Example -- conversion of 2,4-dinitrochlorobenzene to 2,4-dinitrophenyl hydrazine. Introduction to benzyne. Stability based on Huckel rule of aromaticity. Generation of benzyne with mechanism**.** **(5hrs)**	
Unit – 3	**14hrs**
Gaseous state: Molecular velocity, collision frequency, collision diameter, collision cross section, collision number and mean free path and coefficient of viscosity, calculation of σ and η, variation of viscosity with temperature and pressure. Maxwell-Boltzmann distribution law of molecular velocities (most probable, average and root mean square velocities). Relation between RMS, average and most probable velocity and average kinetic energies. (mathematical derivation not required), law of equipartition of energy. Behaviour of real gases: Deviation from ideal gas behaviour. Compressibility factor (Z) and its variation with pressure for different gases. Causes of deviation from ideal behaviour, vander Waals equation of stat (No derivation) and application in explaining real gas behaviour. Critical phenomena - Andrews isotherms of CO_2, critical constants and their derivation from van der Waals equation, Experimental determination of critical constants. Continuity of states, Law of corresponding states. Joule Thomson effect. Inversion temperature, application of J-T effect, liquefaction of air by Linde's process. Numerical problems. (**8hrs)** **Liquid state**	

Surface tension: Definition and its determination using stalagmometer, effect of temperature and solute on surface tension. **Viscosity**: Definition, coefficient of viscosity. Determination of viscosity of a liquid using Oswald viscometer. Effect of temperature, size, weight, shape of molecules and intermolecular forces. **Refraction**: Specific and molar refraction- definition and advantages. Determination of refractive index by Abbes Refractometer. Additive and constitutive properties. **Parachor:** Definition, atomic and structure parachor, elucidation of structure of benzene and benzoquinone. Viscosity and molecular structure. Molar refraction and chemical constitution. Numerical problems. **(6hrs)**	
Unit - 4 Dilute solutions. Review of colligative properties. Experimental determination of molar mass of solute by: 1.Berkely-Hertely method 2. Beckmann method 3. Landsberger method and Numerical problems **(3hrs)** Distribution Law: Nernst distribution law - Statement. Distribution coefficient, factors affecting distribution coefficient, validity of distribution law, modification of distribution law when molecules undergo a) association b) dissociation. Application of distribution law in Solvent extraction. Derivation for simple and multiple extractions. Principles of distribution law in Parke's process of desilverisation of lead. Numerical problems**.** **(4hrs)** **Solids:** Forms of solids**:** Unit cell and space lattice, anisotropy of crystals, size and shape of crystals. Laws of Crystallography: Law of constancy of interfacial angles, law of rational indices, law of symmetry (symmetry elements), crystal systems, Bravais lattice types and identification of lattice planes. Miller indices and its calculation, X–Ray diffraction by crystals: Bragg's law and derivation of Bragg's equation, single crystal and powder diffraction methods. Defects in crystals, glasses and liquid crystals. Numerical problems. **(7hrs)**	**14hrs**

Recommended Text books/references:

1. Fundamentals 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. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press (2006).
4. Physical Chemistry by Samuel Glasstone, ELBS (1982).
5. Ball, D. W. Physical Chemistry Thomson Press, India (2007).

6. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
7. A Text book of Physical Chemistry, A S Negi& S C Anand, New Age International Publishers (2007).
8. Principles of Physical Chemistry, Puri, Sharma &Pathania, Vishal Publishing Co.
9. A Text Book of Physical Chemistry P.L.Soni , O.P. Dharmarhaand and U.N.Dash, Sultan Chand and Sons.
10. Advanced Physical Chemistry, Gurdeep Raj, Goel Publishing House (2018)
11. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)
12. Finar, I. L. Organic Chemistry (Volume I), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)

Pedagogy:

ICT tools, Chalk & Talk, Models & Charts, MOOC

Formative Assessment	
Assessment Occasion/ type	**Weightage in Marks**
Internal Test	30
Sem End Exam	70
Total	100

Scheme of Internal Assessment Marks:

	Theory		**Practicals:**	
Sl. No.	**Particulars**	**IA Marks**	**Particulars**	**IA Marks**
1	Attendance	05		
2	Internal Tests (Minimum of Two)	15	Practical Test	10
3	Assignments /Seminar	10	Attendance and Active participation in practical classes	05
TOTAL Theory/Practicals IA Marks		**30**		**15**

PRACTICALS-(SEMESTER II)

Course Outcome

At the end of this course, student should be able to:

1. Estimate components in a mixture, nitrite in a water sample and hardness of water by volumetry.
2. Estimate presence of nickel, barium and copper in solutions by gravimetry.
3. Measure physical properties of a liquid such as density, viscosity, surface tension and refraction using specific instruments.
4. Study the distribution phenomena of different systems and evaluate the Corresponding distribution coefficient

PART-A (Inorganic Chemistry)

Course Objectives:

- To strengthen the concepts of mole and stoichiometry.
- To develop analytical skills of determination through titrimetry and Gravimetry.

Course specific outcome:

The student will learn

- To prepare standard solutions.
- Techniques like precipitation, filtration, drying and ignition.
- Various titrimetric techniques and gravimetric methods.
- Calculation on basis of mole concept and stoichiometry.

LIST OF EXPERIMENTS:

a) TITRIMETRY

1. Estimation of carbonate and hydroxide present in a mixture.
2. Estimation of oxalic acid and sodium oxalate in a given mixture using standard $KMnO_4$/NaOH solution.
3. Standardization of potassium permanganate solution and estimation of nitrite in a water sample.
4. Standardization of EDTA solution and estimation of hardness of water.

b) GRAVIMETRY

1. Determination of Ba^{2+} as $BaSO_4$.
2. Estimation of Ni^{2+} as $Ni(DMG)_2$ complex.
3. Determination of Cu^{2+} as CuSCN.
4. Estimation of Fe^{2+} as Fe_2O_3.

PART -B (Physical Chemistry)

Course Objectives:

- To learn various techniques for the measurement of viscosity, surface tension and refractive index
- To study the effect of concentration on viscosity and surface tension
- To determine the composition of a liquid mixture by Refractometry
- To calibrate and operate Abbe's Refractometer
- To understand the concept of distribution coefficient and Nernst Distribution law

Course specific outcome:

The student will able to

- Determine the density of liquids
- Understand how viscosity and surface tension of liquids vary with concentrations
- Determine the percentage composition of liquid mixtures using Abbe's Refractometer.
- Explain the concept of distribution coefficient, and dissociation in a layer.
- Describe the conditions required for liquefaction of gases
- Understand cooling effect of gas on adiabatic expansion
- Explain properties of liquids in terms of intermolecular attraction

LIST OF EXPERIMENTS:

1. Safety practices in the chemistry laboratory, knowledge about common toxic chemicals and safety measures in their handling, cleaning and drying of glasswares.
2. Determination of density using specific gravity bottle and viscosity of liquids using Ostwald's viscometer (ethyl acetate, toluene, chlorobenzene or any other non-hazardous liquids).
3. Study of the variation of viscosity of sucrose solution with the concentration of a solute
4. Determination of the density using specific gravity bottle and surface tension of liquids using Stalagmometer (ethyl acetate, toluene, chlorobenzene or any other non-hazardous liquids).
5. Determination of molar mass of non-electrolyte by Walker-Lumsden method.
6. Determination of specific and molar refraction by Abbes Refractometer (ethyl acetate, methyl acetate, ethylene chloride).
7. Determination of the composition of liquid mixture by refractometry (toluene & alcohol, water & sucrose).
8. Determination of partition/distribution coefficient - i) Acetic acid in water and cyclohexane. ii) Acetic acid in water and butanol iii) Benzoic acid in water and toluene.

Note:

1. Questions from both sections should be given in each batch.

2. In the first 20 minutes the Teacher should discuss in detail the theory, principle, procedure and calculations.

3. Instructions to be given for operating instruments, weighing chemicals and precautions while handling chemical.

Recommended Books/References

1. Practical Volumetric Analysis, Peter A C McPherson, Royal Society of Chemistry, Cambridge, UK (2015).
2. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
4. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).
5. Athawale V. D. amd Mathur P. Experimental Physical Chemistry, New Age International (2001)

BSc Semester II
OPEN ELECTIVE - 2

Title of the Course: OE-2:	MOLECULES OF LIFE
Number of Theory Credits	3
Number of lecture hours/ semester	42hrs.

Course Outcomes:

At the end of this course, student should be able to:

1. Describe the biomolecules, namely carbohydrates, amino acids, lipids and nucleic acids on the basis of their classification and structure.
2. Explain enzyme action, factors influencing enzyme action, co-enzymes and enzyme specificity.
3. Depict the action of drugs in biological systems based on Receptor theory, SAR studies and binding action of various groups.
4. Study the energy dynamics of biological systems in terms of calorific values of macronutrients, their metabolic pathways and ATP as energy currency.

Course Objective:

To make the non-chemistry students aware of various biochemicals/biomolecules involved in various biological processes.

Course specific outcome:

After studying this paper, the student would be able to:

1. Acquire knowledge about different types of sugars and their chemical structures
2. Identify different types of amino acids and determine the structure of peptides.
3. Explain the actions of enzymes in our body and interpret enzyme inhibition..
4. Depict the importance of lipids in the metabolism.
5. Differentiate RNA and DNA and their replication..
6. Explain production of energy in our body.

Content of Theory Course 2	**42 hrs.**
Unit – 1	**14 hrs.**
Carbohydrates Classification of carbohydrates, reducing and non-reducing sugars, general properties of glucose and fructose, their open chain structures. Epimers, mutarotation and anomers. Linkage between monosaccharides, structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation. **(8hrs)** **Amino acids, peptides and proteins** Classification of amino acids, Zwitter ion structure and isoelectric point. Overview of primary, secondary, tertiary and quaternary structure of proteins. Determination of primary structure of peptides. **(6hrs)**	
Unit – 2. **Enzymes and correlation with drug action.** Mechanism of enzyme action, factors affecting enzyme action, co-enzymes and cofactors and their role in biological reactions, Specificity of enzyme action (including stereospecificity). Enzyme inhibitors and their importance, phenomenon of inhibition (competitive and non-competitive inhibition including allosteric inhibition). **(10hrs)** **Drug action** - receptor theory. Structure–activity relationships of drug molecules, binding role of –OH group, -NH_2 group, double bond and aromatic ring. **(2hrs)** **Lipids.** Introduction to lipids, classification. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol) **(2hrs)**	**14 hrs.**
Unit - 3	

Nucleic acids. Components of nucleic acids: Adenine, guanine, thymine and cytosine (structure only), other components of nucleic acids, nucleosides and nucleotides (nomenclature), structure of polynucleotides: structure of DNA (Watson-Crick model) and RNA (types of RNA), Genetic code, biological roles of DNA and RNA: replication, transcription and translation. **(6hrs)** **Concept of energy in bio systems.** Calorific value of food. Standard caloric content of carbohydrates, proteins and fats. Oxidation of foodstuff (organic molecules) as a source of energy for cells. Introduction to metabolism (catabolism, anabolism), ATP: the universal currency of cellular energy, ATP hydrolysis and free energy change. Conversion of food into energy. Outline of catabolic pathways of carbohydrate - Glycolysis, fermentation, Krebs cycle. Overview of catabolic pathways of fats and proteins. Interrelationships in the metabolic pathways of Proteins, fats and carbohydrates. **(8hrs)**	**14 hrs.**

Recommended Books/References

1. W. H. Freeman. Berg, J.M., Tymoczko, J. L. &Stryer, L. Biochemistry, 2002.
2. Morrison R. T. and Boyd R. N. Organic Chemistry, Sixth Edition Prentice Hall India, 2003.
3. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VI the Edition. W.H. Freeman and Co.
4. Nelson, D. L., Cox, M. M. and Lehninger, A. L. (2009) principles of Biochemistry.IV Edition. W.H. Freeman and Co.
5. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange medical Books/ McGraw-Hill *Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Crichton R. H. Biological Inorganic Chemistry – An Introduction, Elsevier, 2008.
7. Berg J. M., Tymoczeko J. L., Stryer l. Biochemistry, W. H. Freeman, 2008.
8. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed. 2006.

Pedagogy: ICT tools, Chalk & Talk, Models & Charts, and MOOC.

Formative Assessment	
Assessment Occasion/ type	**Weightage in Marks**
Internal Test	30
Sem End Exam	70
Total	100

I Semester B.Sc. Examination
QUESTION PAPER PATTERN
(2021-22 & onwards) (NEP-CBCS SCHEME)
Paper-I-CHEMISTRY

Time: 3 Hours **Max. Marks: 70**

Instructions:

1. Question paper has three Parts. Answer all the Parts

2. Write chemical equations and diagrams wherever necessary.

PART– A.

Answer any **FIVE** of the following questions. Each question carries **TWO** marks**:**

(5 x 2 =10).

1.
2.
3.
4.
5.
6.
7.

PART– B.

Answer any **FOUR** of the following questions. Each question carries **FIVE** marks:

(4 x 5 = 20).

8.
9.
10.
11.
12.
13.

PART– C.

Answer all the following questions. Each question carries **TEN** marks:

(4 x 10 = 40).

14. UNIT – 1 (TWO questions to be given for choice)
15. UNIT – 2 (TWO questions to be given for choice)
16. UNIT – 3 (TWO questions to be given for choice)
17. UNIT – 4 (TWO questions to be given for choice)

BENGALURU CITY UNIVERSITY

I Semester B.Sc. Examination,
QUESTION PAPER PATTERN
(2021-22 & onwards) (NEP-CBCS SCHEME)
CHEMISTRY
(OPEN ELECTIVE)

Time: 3 Hours **Max. Marks: 70**

Instructions:

1. Question paper has three Parts. Answer all the Parts

2. Write chemical equations and diagrams wherever necessary.

PART– A.

Answer any **FIVE** of the following questions. Each question carries **TWO** marks**:**

(5 x 2 =10).

1.
2.
3.
4.
5.
6.
7.

PART– B.

Answer any **FIVE** of the following questions. Each question carries **SIX** marks:

(5 x 6 = 30).

8.
9.
10.
11.
12.
13.
14.

PART– C.

Answer all the following questions. Each question carries **TEN** marks:

(3 x 10 = 30).

15. UNIT – 1 (TWO questions to be given for choice)
16. UNIT – 2 (TWO questions to be given for choice)
17. UNIT – 3 (TWO questions to be given for choice)

CHEMISTRY

DSC-3: Analytical and Organic Chemistry-II

Contact Hours: 56 **Workload: 4 Hours/Week.**

Credit Points:4

Evaluation: Continuous Internal Assessment - 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, nephelometryand 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 and industrial 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 molecules into R, S, D, L will be taught taking proper examples
11) The theory and concept of Cis-, Trans- isomerism and its importance and the techniques 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 reactive intermediates its role and techniques of generating such intermediates
8) Explain the importance of Stereochemistry in predicting the structure and propertyof 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

Unit-I

Quantitative Analysis-Instrumental methods

Electromagnetic spectrum, absorption of electromagnetic radiation, Definition and unitsof frequency, wavelength, wave number,

Beer-Lambert law and its derivation,deviations, limitations, construction of calibration graph (Plot of absorbance vs concentration). Evaluation Procedures- standard addition, Internal standard addition, validation parameters-detection limits, sensitivity, linearity, Instrumentation, single beam and double beam spectrophotometers, quantitativeapplications of colorimetry (determination of Fe, Cu, Ti and PO_4^{3-}). Numerical problems **10 hrs**.

Nephelometry and Turbidometry: Introduction, principle, instrumentation of nephelometry and turbidometry; effects of concentration, particle size and wavelength on scattering, choice

between nephelometry and turbidometry, Applications of nephelometry and turbidometry (determination of SO_4^{2-} and PO_4^{3-}) **4 hrs**

Unit-II

Separation methods

Fundamentals of chromatography: General description, definition, terms and parameters used in chromatography, classification of chromatographic methods, criteria for selection of stationary and mobile phases and nature of adsorbents.

Column chromatography. Principle- Column efficiency, factors affecting the column efficiency, van Deemter's equation and its modern version. **3hrs**

Paper chromatography: Principle and applications

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

Ion exchange chromatography: Principle 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**

Solvent Extraction: Principal Types- batch, continuous, efficiency, selectivity, distribution coefficient, Nernst distribution law, derivation, factors affecting the partition, relationship between % extraction and volume fraction, Numerical problems.

Solvent extraction of lanthanides, iron and copper.

4hrs

Unit III

Reactive Intermediates: Generation, Stability and Reactions of,

i) Carbocations ii) Carbanions iii) Free Radicals iv) Carbenes and Nitrenes v) Arynes.

Applications:

i) Carbocations: Dienone-phenol; and Pinacol-Pinacolone Rearrangement.

ii) Carbanions: Perkin Reaction, Aldol condensation, Claisen-Schmidth condensation.

iii) Free Radicals: Sand Meyer Reaction

iv) Carbenes and Nitrenes: Singlet and Triplet states, relative stability and reactions: addition to C-C double bond.

v) Arynes: Formation, Diels-alder reaction to dienes **8 hrs**

Methods for Identifying Reaction Mechanisms:

Product analysis--- Isolation and Identification of Intermediates, Stereo chemical 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. Optical Isomerism: Optical activity, Specific rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral centers, Diastereoisomers, meso structures, Racemic mixtures and Resolution, Relative and absolute configuration, D/L and R/S designations (for single carbon stereo centers) with C.I.P rules

14 hrs

References:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch Ninth edition. Saunders College Publishing, New York (2014).

2. Analytical Chemistry, G.D. Christian, 6th edition, John Wiley & Sons, (2007)

3. Analytical Chemistry, 7th Edition: Seventh Edition Gary D. Christian, Purnendu (Sandy) Dasgupta, Kevin Schug Wiley Global Education, (2013)

4 Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, PHI Learning Pvt Ltd. New Delhi (2015).

5 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).

6. Organic Reaction Mechanism by V.K. Ahluwalia and R.K. Parashar (Narosa Publishers) [2002], Organic Chemistry by S.M. Mukherji, S.P. Singh and R.K. Kapoor New age publishers (Feb 2017)

7. Organic Chemistry by Robert T. Morrison, Robert N. Boyd Dorling Kindersley (India) Pvt Ltd. Pearson Education India; 7th edition (1 January 2010)

8. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008)

9. Organic Chemistry by FINAR (Vol I and II) Pearson Education India; 6th edition (1 January 2002)

10. Introduction to Organic Chemistry by John E. McMurry CENGAGE LEARNING (RS); 1st edition (1 January 2008)

11. Stereochemistry of Organic Compounds Ernest L. Eliel, Samuel H. Wilen. Wiley publishers; 1st edition (1 January 2008)

12. P Sykes, A Guide Book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman, New Delhi.

13. Solomons, T.W G., Fryhle, B. Craig. Organic Chemistry, John Wiley & Sons, Inc (2009).

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 and anions
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 an 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 an 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 ammonium hydroxide.
2) Colorimetric determination of iron using thiocyanate
3) Colorimetric determination of nickel using DMG
4) Colorimetric determination of titanium using hydrogen peroxide
5) Colorimetric determination of nitrite in water sample (diazo coupling Reaction using Griessreagent
6) Colorimetric determination of phosphate as ammonium phosphomolybdate
7) Measurement of Rf values of two component systems by TLC (ortho and para nitro anilines)
8) Separation of different metal ions by paper chromatography (Co, Ni, and Cu) or Solvent extraction of iron using oxine (demonstration)

PART-B (Organic Chemistry)

Qualitative analysis of Organic compounds.

1) Salicylic acid,2) Glucose 3) Methyl salicylate

4)p-Amino benzoic acid, 5) p-Chloro benzoic acid 6) Salicylaldehyde,

7)Acetophenone, 8) Benzoic acid 9) Salicylamide 10) Benzamide etc.

(Atleast 6-8 compounds to be analyzed in a semester)

References

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

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

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

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

5) Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000)

CHEMISTRY

DSC-4: Inorganic and Physical Chemistry-II

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

Credit Points :4

Evaluation: Continuous Internal Assessment -40 Marks

Semester 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

Unit - I

Structure and Bonding -I

The ionic bond:

Structures of ionic solids Radius ratio rules and its Limitations: Calculation of some limiting radius ratio, 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,

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 **4 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, ClF_3, SF_4, SF_6, and IF_7.

Limitations of VSEPR theory. **5 hrs.**

Unit - II

Structure and Bonding -II

Concept of resonance, resonance energy, hybridization, 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 and ions.

H_2 and H^+_2, He_2 and He^+_2, Li_2, Be_2, B_2, C_2, N_2, and N_2^+, O_2, O_2^- 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, bondenergy 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. **09 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-Huckel-Onsager equation. Ionic mobilities and their determinations, transference numbers and theirrelation to ionic mobility's, determination of transference numbers using Hittorf and MovingBoundary 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. Peter Atkins & Julio De Paula, Physical Chemistry, 9th Ed., Oxford university Press(2010)
2. G W Castellan, Physical Chemistry, 4th Ed., Narosa (2004)
3. R G Mortimer, Physical Chemistry 3rd Ed., Elsevier: Noida, UP (2009)
4. B R Puri, L R Sharma and M S Pathania, Principal of Physical Chemistry, Vishal Publishing Co.48 edition (2021)
5. B S Bahl, G D Tuli and Arun Bahl, Essentials of Physical chemistry, S Chand Publishing; Twenty-eight edition (1 January 2020)
6. A S Negi and S C Anand, A textbook of Physical Chemistry, New Age International Publishers. 3rd Edition (2021)
7. B N Bajpai, Advanced Physical chemistry, S Chand and Company ltd. (2001)
8. R L Madan, Chemistry for Degree Students, Semester I, II, III and IV, S Chand and company Ltd. (2020)
9. P L Soni, O P Dharmarha and U N Dash, Textbook of Physical Chemistry, Sultan Chand and Sons. (2007)
10. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
11. Physical chemistry by Samuel Glasstone East-West Press (Pvt.) Ltd. (2006)

12. J.D. Lee Concise Inorganic Chemistry Wiley India Pvt Ltd. (2022)
13. Huheey James E. Inorganic Chemistry: Principles of Structure and Reactivity- Pearson Education India; 4th edition (2006)
14. Cotton Wilkinson =Advanced Inorganic Chemistry Wiley; 6th edition (1999)

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 by systematically carrying out the qualitative 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 conductivity measurements in solution.
5. Adsorption phenomenon, mechanism and basic models to explain adsorption.
6. Simple techniques like conductometry to obtain physicochemical parameters of electrolytes.

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 conductivity meter to obtain various physicochemical parameters.
7. Apply the theory about chemical kinetics and determine the velocity constants of

various reactions.

8. Learn about the reaction mechanisms.
9. Interpret the behaviour of interfaces, the phenomena of physisorption and chemisorptions 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. Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.
3. The study of kinetics of potassium persulphate and potassium iodide volumetrically.
4. Determination of velocity constant for acid catalyzed hydrolysis of methyl acetate.
5. Determination of velocity constant for the saponification of ethyl acetate ($a = b$) volumetrically.
6. Determination of equivalent conductivity of strong electrolyte and verification of DHO equation.
7. Determination of dissociation constant of weak acid by conductivity method.
8. Conductometric titration of strong acid and strong base.
9. Conductometric titration of weak acid and strong base.
10. Determination of the hydrolysis constant of aniline hydrochloride conductometrically.
11. Determination of solubility product of sparingly soluble salt conductometrically.

References

1. Vogel's Qualitative analysis, Revised by G. Svehla, Pearson education, 2002
2. J B Yadav, Advanced Physical Chemistry, Krishna Prakashan Media (P) Ltd,Meerut. (2015)
3. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R.Chand & Co.: New Delhi (2011).
4. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
5. Halpern, A. M. &McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H.Freeman & Co.: New York (2003)
6. Athawale V. D. and Mathur P. Experimental Physical Chemistry, New Age International (2001)