

Model Curriculum

Name of the Degree Program: BSc (Honors) Chemistry with Analytical Specialization

Discipline Core: Chemistry Total Credits for the Program: 176

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 Analytical chemistry or multi-disciplinary areas involving Analytical 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 BSc (Honors) Chemistry with Analytical Specialization

Total Credits for the Program: 176

Starting year of implementation: 2021-22

Name of the Degree Program: B. Sc (Honors) Discipline/Subject: Chemistry

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 (not more than 3 per course)	Pre- requisite course(s)	Pedagogy##	Assessment\$
1	DSC-1: Analytical and Organic Chemistry-I	<ul style="list-style-type: none"> 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 	P.U.C with Chemistry	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	DSC lab-1: Analytical and Organic Practical's-I	<ul style="list-style-type: none"> 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. 	-	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams

		<ul style="list-style-type: none"> The students will be able to deduce the conversion factor based on stoichiometry and in turn use this value for calculation 			
2	DSC-2: Inorganic and Physical Chemistry-I	<ul style="list-style-type: none"> 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 Practical's-I	<ul style="list-style-type: none"> 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: Analytical and Organic Chemistry-II DSC Lab-3: Analytical and Organic Practical's-II		DSC-1 and DSC-2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
4	DSC-4: Inorganic and Physical Chemistry-II DSC Lab-4: Inorganic and Physical Practical's-II			Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams

5.	DSC-5: Selected topics in Inorganic Chemistry DSC Lab-5: Inorganic Chemistry Practical's DSC-6: selected topics in Organic Chemistry DSC Lab-6: Organic Chemistry Practical's		DSC-3 and DSC-4	MOOC, Problem solving	Internal tests, Assignments, Quiz
6.	DSC-7: Selected topics in Physical Chemistry DSC Lab-7: Physical Chemistry Practical's. DSC-8: Spectroscopy DSC Lab-8: Analytical and Industrial Chemistry Practical's			MOOC, Problem solving	Internal tests, Assignments, Quiz
7.	DSC-9 :Analytical Techniques-I DSC Lab-9: Analytical Chemistry. DSC-10:Applied Chemical Analysis. DSC Lab-10 :Analytical Chemistry. DSC-11: Enviornmental and Nanomaterial Chemistry.		DSC-5, DSC-6, DSC-7 and DSC-8	MOOC, Problem solving	Internal tests, Assignments, Seminar, Debate, Quiz
8.	DSC-12: Analytical Techniques-II DISIPLINE A13(4) DSC-13: Separation and Electroanalytical Techniques. DSC-14: Analysis of food and pharmaceuticals			Project work, Industrial Visit	Internal tests, Assignments, Seminar, Debate, Quiz

\$ 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).

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

PUC with Chemistry

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

1. The concepts of chemical analysis, accuracy, precision and statistical data treatment
2. Prepare the solutions after calculating the required quantity of salts in preparing the reagents/solutions and dilution of stock solution.
3. The concept of volumetric and gravimetric analysis and deducing the conversion factor for determination
4. Handling of toxic chemicals, concentrated acids and organic solvents and practice safety procedures.
5. The concepts of Organic reactions and techniques of writing the movement of electrons, bond breaking, bond forming
6. The Concept of aromaticity, resonance, hyper conjugation, etc.
7. Understand the preparation of alkanes, alkenes and alkynes, their reactions, etc.
8. Understand the mechanism of nucleophilic, electrophilic reactions

[illegible]

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.

BA/BSc/BCom/BBA/BCA

BSc Semester 1 – Chemistry (Hons) with specialization in Analytical Chemistry

Title of the Course: DSC-1: Analytical and Organic Chemistry – I

Number of Theory Credits	Number of lecture hours/ semester	Number of practical Credits	Number of practical hours/ semesters
4	56	2	56
Content of Theory Course 1			56Hrs
Unit – 1			14
Language of analytical chemistry: Definitions of analysis, determination, measurement, techniques and methods. Classification of analytical techniques. Choice of an analytical method - accuracy, precision, sensitivity, selectivity, method validation. Figures of merit of analytical methods and limit of detection (LOD), Limit of quantification (LOQ), linear dynamic range (working range).			
Errors and treatment of analytical data: Limitations of analytical methods – Errors: Determinate and indeterminate errors, absolute error, relative error, minimization of errors. Statistical treatment of finite samples -mean, median, range, standard deviation and variance. External standard calibration - regression equation (least squares method), correlation coefficient (R^2).			
Numerical problems			
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.			
Unit - 2			14
Titrimetric analysis: Basic principle of titrimetric analysis. Classification, Preparation and dilution of reagents/solutions. 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.			
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.			
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.			
Redox titrimetry: Balancing redox equations, calculation of the equilibrium constant of redox reactions,			

<p>titration curves, Theory of redox indicators, calculation of standard potentials using Nernst equation. Applications.</p> <p>Precipitation titrimetry: Titration curves, titrants and standards, indicators for precipitation titrations involving silver nitrate- Volhard's and Mohr's methods and their differences.</p> <p>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)).</p> <p>Numerical problems on all the above aspects.</p>	
Unit - 3	14
<p>Classification and nomenclature of organic compounds, Hybridization, Shapes of organic molecules, Influence of hybridization on bond properties.</p> <p>Nature of bonding in Organic molecules</p> <p>Formation of Covalent bond, Types of chemical bonding, localized and delocalized, conjugation and cross conjugation, concept of resonance, electronic displacements: Inductive effect, Electromeric effect, Resonance and Hyper conjugation, cross conjugation explanation with examples. Concept of resonance, aromaticity, Huckel rule, anti-aromaticity explanation with examples. Strengths of Organic acid and bases: Comparative study with emphasis on factors effecting pK 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.</p> <p>Mechanisms of Organic Reactions</p> <p>Notations used to represent electron movements and directions of reactions- curly arrows, formal charges. Types of bonds breaking- homolytic and heterolytic. Types of reagents-Electrophiles, nucleophiles, nucleophilicity and basicity. Types of organic reactions- substitution, addition, elimination, rearrangement and pericyclic reactions, explanation with examples.</p> <p>Chemistry of Aliphatic hydrocarbons, Carbon-Carbon Sigma bonds</p> <p>Chemistry of alkanes: Formation of alkanes, Wurtz reaction, Wurtz-Fittig reaction, Free radical substitution, Halogenation- relative reactivity and selectivity</p> <p>Carbon-carbon pi bonds</p> <p>Formation of alkenes and alkynes by elimination reaction. Mechanism of E1, E2, E1cb reaction. 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. Stereospecificity of halogen addition. Ozonolysis mechanism - ozonolysis of propene. Addition of hydrogen halides to alkenes, mechanism, regioselectivity and relative rates of addition. Hydrogenation, hydration, hydroxylation and epoxidation of alkenes, explanation with examples, 1,2 and 1,4- addition reactions in conjugated dienes. Diels-Alder reaction, Allylic and benzylic bromination and mechanism in propene, 1-butene, 1-toluene and ethylbenzene.</p>	
Unit - 4	14
<p>Nucleophilic substitution at saturated carbon. Mechanism of S_N^1 and S_N^2 reactions with suitable examples. Energy profile diagrams, Stereochemistry and factors effecting S_N^1 and S_N^2 reactions.</p> <p>Aromatic Electrophilic substitution reactions, Mechanisms, σ and π complexes, Halogenation, Nitration, Sulphonation, Friedel Crafts alkylation and acylation with their mechanism. Activating and deactivating groups. Orientation influence, Ortho-para ratio.</p> <p>Aromatic nucleophilic substitution reaction: S_N^{Ar} and Benzyne mechanism with suitable examples</p>	

Text Books

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. Analytical Chemistry, G.D. Christian, 6th edition, Wiley-India (2007).
4. Practical Volumetric Analysis, Peter A C McPherson, Royal Society of Chemistry, Cambridge, UK (2015).
5. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)
6. Finar, I. L. *Organic Chemistry (Volume I)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)
7. McMurry, J. E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013

- Organic Reaction mechanism by V. K. Ahluwalia and K. Parashar (Narosa Publishers).
- Organic Chemistry by S. M. Mukherji, S. P. Singh and R. K. Kapoor. (Narosa Publishers)
- A Guide book to mechanism in Organic Chemistry by Peter sykes. Pearson.

References

Pedagogy

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

Date

Course Co-ordinator

Subject Committee Chairperson

Content of Practical Course 1: List of Experiments to be conducted

PART-A Analytical Chemistry

- Calibration of glassware, pipette, burette and volumetric flask.
- Determination of sodium carbonate and sodium bicarbonate in a mixture.
- Determination of alkali present in soaps/detergents
- Determination of iron(II) using potassium dichromate
- Determination of oxalic acid using potassium permanganate solution
- Standardization of EDTA solution and determination of hardness of water
- Determination of Fe^{2+} as Fe_2O_3
- Determination of Ni^{2+} as $\text{Ni}(\text{DMG})_2$ complex.

PART-B Organic Chemistry

- Selection of suitable solvents for Purification/Crystallization of organic compounds.
- Preparation of acetanilide from aniline using Zn/acetic acid (Green method).
- Synthesis of p-nitro acetanilide from acetanilide using nitrating mixture.
- Bromination of acetanilide (i) Conventional method and/or (ii) with ceric ammonium nitrate and potassium bromide (Green method).
- Hydrolysis of methyl m-nitrobenzoate to m-nitrobenzoic acid (Conventional method)
- Synthesis of diazoaminobenzene from aniline (conventional method).
- Preparation of dibenzalacetone (Green method).
- Diels Alder reaction between furan and maleic acid (Green method).

BSc Semester 1 – Chemistry (Hons) with specialization in Analytical Chemistry

Title of the Course: OE-1: CHEMISTRY IN DAILY LIFE

Number of Theory Credits	Number of lecture hours/ semester	Number of practical Credits	Number of practical hours/ semesters
3	42	-	42
Content of Theory Course 1			42 Hrs
Unit – 1			14
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. Food additives, adulterants, and contaminants- Food preservatives like benzoates, propionates, sorbates, disulphites. Artificial sweeteners: Aspartame, saccharin, dulcin, sucralose, and sodium cyclamate. Flavors: Vanillin, alkyl esters (fruit flavors), and monosodium glutamate. Artificial food colorants: Coal tar dyes and non-permitted colors and metallic salts. Analysis of pesticide residues in food.			
Unit - 2			14
Vitamins: Classification and Nomenclature. Sources, deficiency diseases, and structures of Vitamin A1, Vitamin B1, Vitamin C, Vitamin D, Vitamin E & Vitamin K1. 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. Soaps & Detergents: Definition, classification, manufacturing of soaps and detergents, composition and uses			
Unit - 3			14
Chemical and Renewable Energy Sources: principles and applications of primary & secondary batteries and fuel cells. Basics of solar energy, future energy storer. 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.			

Text Books

1. B. K. Sharma: Introduction to Industrial Chemistry, Goel Publishing, Meerut (1998)
2. Medicinal Chemistry- Ashtoush Kar.
3. Analysis of Foods – H.E. Cox: 13.
4. Chemical Analysis of Foods – H.E. Cox and Pearson.
5. Foods: Facts and Principles. N. Shakuntala Many and S. Swamy, 4thed. New Age International (1998)
6. Physical Chemistry – P I Atkins and J. de Paula – 7thEd. 2002, Oxford University Press.
7. Handbook on Fertilizer Technology by Swaminathan and Goswamy, 6th ed. 2001, FAI.
8. Organic Chemistry by I. L. Finar, Vol. 1 & 2. 9. Polymer Science and Technology, J. R. Fried (Prentice Hall).

References

Pedagogy

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

Date

Course Co-ordinator

Subject Committee Chairperson