Curriculum Framework Syllabus
B.Sc. (Chemistry) 2023-24
L-6 (IV Semester)

Level / Semester	Nature of Course	Courses Code	Course Title	MM	L	T	P	C
L-6 IV Semester	Discipline Specific: Major	CHE-DSM-411	Inorganic and Organic Chemistry (Theory)	100	4	0	0	4
	Discipline Specific: Major	CHE-DSM-412	Inorganic and Organic Chemistry (Practical)	100	0	0	2	2
	Discipline Specific: Major	DSM-413	Other Department	100	6	0	0	6
	Multi Discipline Major	CHE-MDM-411	Inorganic and Industrial Chemicals (Theory)	100	4	0	0	4
	Multi Discipline Major	CHE-MDM-412	Inorganic and Industrial Chemicals (Practical)	100	0	0	2	2
	Skill Enhancement Course (SEC)	CHE-SEC-411	Green Methods in Chemistry (Theory)	100	2	0	0	2
	Value Enhancement Course	VEC-411	Other Department					Qualifying
Total Credits								**20**

Bachelor of Science – B.Sc.
Discipline Specific Major (DSM)
B.Sc. IV Semester
CHE-DSM-411: Inorganic and Organic Chemistry (Theory)

Credit: 04	Time: 60 Hrs

Course Learning Objectives: To impart basic and advance knowledge of Inorganic Chemistry and Organic Chemistry.

Course Learning Outcomes: Upon successful learning, students will be able to

Unit I: Understand the general principle of metallurgy

Unit II: Understand about the chemistry of compounds of s- and p-block elements

Unit III: Learn the chemistry of hydrides of nitrogen, halides and oxohalides and explore the chemistry of carboxylic acids and their derivatives.

Unit IV: Understand and explore the chemistry of amines and diazonium salts.

Unit V: Learn about the chemistry of amino acids and carbohydrates.

Unit I	**General Principles of Metallurgy:** Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent. Hydrometallurgy, Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, Kroll process, Parting process, van Arkel-de Boer process and Mond's process. s- and p-Block Elements: Periodicity in s- and p-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling, Mulliken, and Alfred-Rochow scales). Allotropy in C, S, and P. Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides), inert pair effect, diagonal relationship, and anomalous behavior of first member of each group.	12
Unit II	**Compounds of s- and p-Block Elements:** Hydrides and their classification (ionic, covalent, and interstitial), structure and properties with respect to stability of hydrides of p- block elements. Concept of multicenter bonding (diborane): Structure, bonding and their important properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial, organic, and environmental chemistry.	12
Unit III	**Hydrides of nitrogen:** (NH_3, N_2H_4, N_3H, NH_2OH) Oxoacids of P, S and Cl. Halides and oxohalides: PCl_3, PCl_5, $SOCl_2$ and SO_2Cl_2 Functional group approach for the following organic compounds (preparations & reactions) be studied in context to their structure. **Carboxylic acids and their derivatives:** Carboxylic acids (aliphatic and aromatic) Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell – Vohlard - Zelinsky (HVZ) Reaction. Carboxylic acid derivatives (aliphatic): (Upto 5 carbons) Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.	12

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Unit IV	**Amines and Diazonium Salts**: Amines (Aliphatic and Aromatic): (Upto 5 carbons) Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, reaction with HNO_2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation. Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, halogen benzene, phenol and dyes.	12
Unit V	**Amino Acids:** Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test. **Carbohydrates:** Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.	12

Reference books:

1. W. J. Huheey, Inorganic Chemistry: Principles of structure and Reactivity, Fourth Edition, Pearson.
2. B.R. Puri, L.R. Sharma, K.C. Kalia, Principle of Inorganic Chemistry, 33rd edition, Vishal Publishing Co.
3. J. D. Lee, Concise Inorganic Chemistry, 5th Edition, John-Wiley & Sons.
4. F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry,* John Wiley.
5. D. F. Shriver and P. W. Atkins: *Inorganic Chemistry*, Oxford University Press. Gary Wulfsberg: *Inorganic Chemistry,* Viva Books Pvt. Ltd.
6. Douglas, McDaniel and Alexader: Concepts and Models in Inorganic Chemistry, John Wiley.
7. T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
8. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
9. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
10. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman
11. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
12. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry,7thEd., W. H. Freeman.
13. Berg, J. M., Tymoczko, J. L. &Stryer, L. Biochemistry 7thEd., W. H. Freeman

Bachelor of Science – B.Sc.
Discipline Specific Major (DSM)
B.Sc. IV Semester
CHE-DSM-412: Inorganic and Organic Chemistry (Practical)

Credit: 02	Time: 30 Hrs

Course Learning Objectives: To impart practical knowledge including procedure and applications of experimental Inorganic and Organic chemistry.
Course Learning Outcomes: Upon successful learning, students will be able to

- Learn the separation and qualitative analysis of mixtures of acid and basic radicals.
- Understand and learn the separation of mixtures of inorganic ions by paper chromatography.
- Understand and learn the qualitative test of amino acids and sugars.
- Understand and learn the separation of mixtures of amino acids/sugars by paper chromatography.
- Learn the practical and green synthesis of organic compounds.
- Understand and learn the purification of organic compounds, determinations of melting points and chemical yields.

Laboratory course

Inorganic Chemistry Laboratory

1. Semi-micro qualitative analysis of mixtures of acid and basic radicals - not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following radicals. Emphasis should be given to the understanding of the chemistry of different reactions.

   Cations: NH_4^+, Pb^{2+}, Ag^+, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr_3^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^+
   Anions: CO_3^{2-}, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_3^-, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-,SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$ *(Spot tests should be carried out wherever feasible)*

2. Separation of mixtures by chromatography: Measure the R_f value in each case. (Combination of two ions to be given) Paper chromatographic separation of Fe^{3+}, Al^{3+} and Cr^{3+} or Paper chromatographic separation of Ni^{2+}, Co^{2+}, Mn^{2+} and Zn^{2+}

Organic Chemistry Laboratory

1. Separation of mixture of amino acids by paper chromatography and determination of R_f value.
2. Separation of mixture of sugars by paper chromatography and determination of R_f value.
3. Qualitative tests of amino acids and sugars and their derivatives preparation.
4. Organic preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done (any four).
   a) Oxidation of ethanol/ isopropanol (Iodoform reaction).
   b) Acetylation of aniline by green procedure.
   c) Nitration of Salicylic acid by green approach.
   d) Bromination of acetanilide by green procedure (using ceric ammonium nitrate and KBr).
   e) Aldol condensation using either conventional or green method.
   f) Hydrolysis of amides/esters.

Reference Books:

1. A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
2. A. K. Nad, B. Mahapatra, A. Ghoshal, An Advanced Course In Practical Chemistry, New

Central Book Agency Pv. Ltd.
3. A.I. Vogel: Textbook of Practical Organic Chemistry, Prentice Hall, 5thEdn.
4. A.I. Vogel: Text Book of Elementary Practical Organic Chemistry: Small Scale Preparation, Pearson India; 2nd edition (1 January 2010)
5. B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.
6. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
7. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
8. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
9. Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

Bachelor of Science – B.Sc.
Multidisciplinary Major (MDM)
B.Sc. IV Semester
CHE-MDM-411: Inorganic and Industrial Chemicals (Theory)

Credit: 04	Time: 60 Hrs

Course Objectives:
To impart the basic understanding and applications of Inorganic and Industrial Chemicals among the students.

Course learning outcomes: Upon successful learning, students will be able to
Unit I- Learn about basic knowledge, properties and applications of silicates, glass, ceramics and cements.
Unit II: Understand about alloys and batteries, their manufacture, components and applications.
Unit III: Learn the fundamental knowledge on paints and pigments and their applications.
Unit IV: Learn about fertilizers and chemical explosives and their manufacture and uses.
Unit V: Learn about Soaps and detergents, their properties and manufacture processes.

Unit I	Silicate and Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Composition and properties of the different types of glasses. Ceramics: Important clays and feldspar, ceramic, their types, manufacture and their applications, superconducting and semiconducting oxides. Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.	12
Unit II	Alloys: Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel. Composition and properties of different types of steels. Batteries: Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells and Solar cell.	12
Unit III	Paints and pigments: Formulation, composition and related properties. Oil paint, Pigments, toners and lakes pigments, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, Metallic coatings, metal spraying and anodizing.	12
Unit IV	Fertilizers: Different types of fertilizers. Manufacture of fertilizers including Urea, NPK fertilizer, ammonium nitrate, ammonium phosphates; superphosphate, mixed fertilizers. Chemical explosives: Origin of explosive properties in organic compounds, preparation and explosive properties of trinitrotoluene (TNT), Nitroglycerine and dynamite, lead azide, cyclonite (RDX).	12
Unit V	Soaps and Detergents: Definitions of soaps & detergents and their classifications, Raw materials for soap industry and their selection. Cleansing action of soaps and detergents, Physico-chemical properties of soap solutions; Plants and Processes employed in soap manufacture. Saponification, Analysis of free alkali present in different soaps/detergents, Recovery of by-products, various households and industrial soaps, soap additives.	12

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.

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2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
7. B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut.

Bachelor of Science – B.Sc.
Multidisciplinary Major (MDM)
B.Sc. IV Semester
CHE-MDM-412: Inorganic and Industrial Chemicals (Practical)

Credit: 02	Time: 30 Hrs

Course Learning Objectives: To provide basic concept on experimental methodologies of Inorganic and Industrial Chemicals.

Course Learning Outcomes: Upon successful learning, students will be able to

- Understand the analysis of Cu, Zn, Ni in alloy samples.
- Learn the qualitative estimation of manganese in steel sample.
- Learn the quantitative estimation of iron, calcium in industrial samples.
- Understand the preparation of pigments
- Learn the quantitative estimation
- Learn to determine free alkali contents of soap.
- Learn to determine the saponification value of an oil/fat.

Laboratory course

1. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
2. Estimation of copper/zinc in brass alloy or synthetic samples
3. Estimation of manganese in cast iron/steel or synthetic samples using standard $KMnO_4$ solution.
4. Determination of free acidity in ammonium sulphate fertilizer.
5. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
6. Estimation of phosphoric acid in superphosphate fertilizer.
7. Estimation of iron/CaO in Portland cement.
8. Preparation of pigment (zinc oxide).
9. Determination of free alkali present in soap/detergent.
10. To determine the saponification value of an oil/fat.

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
7. A. K. Nad, B. Mahapatra, A. Ghoshal, An Advanced Course In Practical Chemistry, New Central Book Agency Pv. Ltd.
8. B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut.

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Bachelor of Science – B.Sc.
Skill Enhancement Course (SEC)
B.Sc. IV Semester
CHE-SEC-411: Green Methods in Chemistry (Theory)

Credit: 02	Time: 30 Hrs

Course Objectives:
To impart the basic understanding of green chemistry and its interdisciplinary applications among the students.

Course learning outcomes: Upon successful learning, students will be able to
Unit I- Learn the basic concept, background and significance of green chemistry, various tools and twelve principles of green chemistry.
Unit II: Understand the design of green synthetic methods for drugs by using principles of green chemistry and the developments of some real-world cases in green chemistry.
Unit III: Learn the fundamental concept of catalyst, catalytic reactions, and use of catalyst to improve the bleaching activity of hydrogen peroxide.
Unit IV: Understand the concept of green chemistry for production of environmentally advanced preservative, use of green solvent and energy efficient reactions.
Unit V: Learn the design of safer chemicals such as environmentally benign pigments, plastic, recyclable carpet by replacing toxic chemicals.

Unit I	Introduction to Green Chemistry: Goals of Green Chemistry. Limitations of Green Chemistry, Tools of Green chemistry, green chemistry metrics, Twelve principles of Green Chemistry, with examples. Designing a Green Synthesis using these principles; Prevention of Waste/byproducts; Atom Economy; prevention of hazardous/ toxic products; designing safer chemicals –selection of appropriate auxiliary substances (solvents, separation agents), green solvents, solventless processes, ionic liquids; energy efficient reactions - use of microwaves, ultrasonic energy; selection of starting materials; avoidance of derivatization, use of catalytic reagents, designing of biodegradable products; prevention of chemical accidents; development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.	06
Unit II	The following Real-world Cases in Green Chemistry should be discussed: A green synthesis of adipic acid, ibuprofen, paracetamol, catechol etc. which creates less waste and fewer byproducts (Atom economy). Surfactants for Carbon Dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments. CO_2 as an environmentally friendly blowing agent for the polystyrene foam sheet packaging market.	06
Unit III	Catalysis and green chemistry: Applications of different types of green catalysts, different catalytic transformations using metal catalysis, organocatalysis, photocatalysis, nano catalysis, phase-transfer catalysis, biocatalysis by following green chemistry principles. Comparison of homogeneous and heterogeneous catalysis. Using a catalyst to improve the delignifying (bleaching) activity of hydrogen peroxide.	06
Unit IV	Green solvents: Use of water, ionic liquid, and supercritical fluids for green synthesis of various compounds.	06

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	Energy efficient reactions - alternative source of energy, Microwave assisted reactions and Ultrasound assisted reactions. Green Preservatives: A new generation of environmentally advanced preservative: getting the chromium and arsenic out of pressure treated wood.	
Unit V	Green pigments: Rightfit pigment, synthetic azopigments to replace toxic organic and inorganic pigments. Development of a fully recyclable carpet: cradle to cradle carpeting. An efficient and green synthesis of compostable and widely applicable plastic (poly lactic acid)	06

Reference Books:

1. Manahan S.E. (2005) Environmental Chemistry, CRC Press
2. Miller, G.T. (2006) Environmental Science 11th edition. Brooks/Cole
3. Anastas, P.T & Warner, J.C. Green Chemistry: Theory and Practice, Oxford University Press (1998).
4. Lancaster, M. Green Chemistry: An Introductory Text RSC publishing, 2nd Edition, 2010.
5. Mishra, A. (2005) Environmental Studies. Selective and Scientific Books, New
6. V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry, Anamalaya Publishers (2005).
7. A.S. Matlack: Introduction to Green Chemistry, Marcel Dekker (2001).
8. M.C. Cann & M.E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
9. M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington (2002)
10. M.C. Cann & M.E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).