SHRI GURU RAM RAI UNIVERSITY

[Estd. by Govt. of Uttarakhand, vide Shri Guru Ram Rai University Act no. 03 of 2017 & recognized by UGC u/s (2f) of UGC Act 1956]

SYLLABUS
Bachelor of Science (Chemistry)
School of Basic & Applied Sciences

(W.E.F 2022-2023)

Bachelor of Science as per
NATIONAL EDUCATION POLICY SYLLABUS

OUTCOME BASED EDUCATION

Semester-wiseTitlesofthePapers in B.Sc.(chemistry)						
Year	**Semester**	**Course Code**	**Papertitle**	**Theory/ Practical**	**Credits**	**Hours**
Certificate Course in Basic Science						
First Year	I	CHEMC101	Fundamentals ofChemistry-I	Theory	4	4
		CHEMC102	Chemical Analysis-I	Practical	2	2
	II	CHEMC201	Fundamentals ofChemistry-II	Theory	4	4
		CHEMC202	Chemical Analysis-II	Practical	2	4
DiplomaCourseinBasic Science						
Second Year	III	CHEMC301	General Chemistry-I	Theory	4	4
		CHEMC302	Analytical Procedures-I	Practical	2	4
	IV	CHEMC401	General Chemistry-II	Theory	4	4
		CHEMC402	Analytical Procedures-II	Practical	2	2
Degree in Bachelor ofScience						
Third Year	V	CHEMC501	Inorganic Chemistry	Theory	4	4
		CHEMC502	Analytical Procedures -III	Practical	2	4
		CHEMC503	Organic Chemistry	Theory	4	4
		CHEMC504	Research Project	Project	Qualifying	4
	VI	CHEMC601	Physical Chemistry	Theory	4	4
		CHEMC602	Analytical Procedures -IV	Practical	2	4
		CHEMC603	Analytical Chemistry	Theory	4	4
		CHEMC604	Research Project	Project	Qualifying	4

Year	**Semester**	**Course Code**	**Papertitle**	**Theory/ Practical**	**Credits**	**Hours**
MINOR/OPEN ELECTIVE COURSES						
First Year	I/II	CHEOE001	Basics of chemistry-I	Theory	4	4
Second Year	III/IV	CHEOE002	Basics of chemistry-II	Theory	4	4

Year	**Semester**	**Course Code**	**Papertitle**	**Theory/ Practical**	**Credits**	**Hours**
Skill Development Course						
First Year	I	CHEVC101	Basic Analytical chemistry-I	Theory	3	3
First Year	II	CHEVC201	Basics of Analytical Chemistry-II	Theory	3	3
Second Year	lll	CHEVC301	Chemistry of Soil and Water	Theory	3	3

Second Year	IV	CHEVC401	Industrial Training		3	3

Year	Semester	Course Code	Papertitle	Theory/ Practical	Credits	Hours
COMPULSORY/CO-CURRICULAR COURSES						
First Year	I	COCCR103	Communication Skills	Theory	0	4
	II	COCCR203	Environment Studies and Value Education	Theory	0	4
Second Year	III	COCCR305	Management Paradigms From Bhagvad Gita	Theory	0	4
	IV	COCCR405	Meditation	Theory	0	4
Third Year	V	COCCR506	Vedic Science	Theory	0	4
	VI	COCCR606	Essence of Indian Traditional Knowledge	Theory	0	4

Programme outcome (POs)

Students will be able to

PO 1	Bachelor of Science offers theoretical as well as practical knowledge about different subject areas.
PO2	Graduates will develop scientific temperament to solve scientific problems in emerging areas of science at National and International level.
PO3	Graduates will acquire coherent understanding of the academic field to pursue multi and interdisciplinary science careers in future.
PO4	Graduate will have clarity of thought and expression. Qualities like logical thinking and decision making will be enhanced
PO5	Graduates plan and execute experiments or investigations, analyze and interpret data information collected using appropriate methods
PO6	Graduates will be able to compete in various national and international competitive examinations.
PO7	Graduates will understand the principles of basic and applied sciences and apply them logically in environmental and socio-technological context with a systematic approach towards sustainable development.
PO8	Graduates will have critical thinking, follow innovations and developments in Science and technology
PO9	Graduates will acquire effective communication skills
PO10	Graduates will understand ethical principles and responsibilities for effective citizenship.
PO11	Graduates will develop new and enhancing conversational skills that lead to not only to good communication but also to the excellent drafting abilities linked with technical reports and presentations.
PO12	Graduates will competent enough for doing jobs in Govt. and private sectors of academia, research and industry.

Program Specific Outcome (PSOs)

PSO 1	Chemistry graduates will become familiar with the fundamental concepts in organic, inorganic, physical and analytical chemistry.
PSO2	Chemistry graduates will develop analytical skills and acquire the ability to synthesize, separate and characterize compounds using laboratory techniques.
PSO3	Chemistry graduates will be able to understand the qualitative and quantitative chemical analysis of the compounds in the laboratory.
PSO4	Skill enhancement courses like chemistry of cosmetics & perfumes, pesticide and polymer chemistry will equip students with the knowledge and skills which will help them to make a successful career in the respective industries.

Eligibility for admission:

Any candidate who has passed the Plus Two of the Higher Secondary Boardof Examinations in anystate recognized as equivalent to the Plus Two of the Higher Secondary Board in PCM/PCB with not less than 45 %-marks in aggregate is eligible for admission, However, SC/ST, OBC and other eligible communities shall be given relaxation as per University rules.

L - Lecture T – Tutorial P – Practical C – Credit

Examination Scheme:

Components	Internal	External (ESE)
Weightage (%)	25	75

Semester-I
Paper-I (Theory)
Course Title: Fundamentals of Chemistry-I

Programme/Class: Certificate in IntroductoryChemistry	Year: First	Semester: First
	Paper-I Theory Subject: Chemistry	
Course Code: CHEMC101	Course Title: Fundamentals of Chemistry-I	

L	T	P	C
4	0	0	4

Course outcomes (COs):
Upon successful completion of the course, student will be able to:

CO1	Gain knowledge of the basics of atomic structure, periodic properties, chemical bonding, fundamentals of organic chemistry and states of matter.
CO2	Understand fundamentals of atomic structure, periodic properties, chemical bonding, mechanism of organic reactions, stereochemistry and states of matter.
CO3	Develop concept of atomic structure, periodic properties, chemical bonding and, reaction mechanism and stereochemistry.
CO4	Explain structure of different inorganic, organic molecules/ions, mechanism of organic reactions and solid-state chemistry.
CO5	Predict structure of organic/inorganic molecules on the basis of VSEPR and hybridization & determine configurations of organic compounds.
CO6	Solve problems related to chemical bonding, atomic structure and states of matter.

Total Number of Hours = 60

Unit	Content	Number of Hours
1	**Atomic Structure and Periodic Properties:** Dual nature of matter; de Broglie concept. Heisenberg uncertainty principle; its significance. Atomic orbitals, Schrödinger wave equation (no derivation); significance of ψ and ψ^2. Quantum numbers, radial and angular wave functions and probability distribution curves, shapes of s, p and d orbitals. Aufbau energy diagram, Pauli's exclusion principle. Hund's rule of maximum multiplicity. Electronic configuration of elements (s block, p block and first series of d-block elements). Effective nuclear charge, Slater's rule. The general idea of Modern periodic table, atomic and ionic radii, ionization potential, electron affinity, electronegativity-definition, trends of variation in periodic table and their application in prediction and explaining the chemical behaviour of elements and compounds thereof.	**12**
2	**Chemical Bonding-I**: Ionic bond, covalent bond-Valence Bond Theory and its limitations; various types of hybridization and shapes of different inorganic and organic molecules. Valence Shell Electron Pair Repulsion Theory (VSEPR) and shapes of NH_3, H_2O, H_3O^+, SF_4, ClF_3, ICl_2^-, TeF_5^- NH_4^+ and other simple molecules/ions (CO_2, SO_2, SO_3, Cl_2O_7, SO_4^{2-}, CO_3^{2-}, NO_3^-, PO_4^{3-}) including compounds of xenon.	**8**
3	**General Organic Chemistry and Mechanism of Organic Reactions:** Resonance, hyperconjugation, field effects- inductive, mesomeric, electromeric effect. Types of reagents- electrophiles and nucleophiles. Types of organic reactions. Energy considerations. Reactive intermediates- carbocations, carbanions, free radicals, carbenes, arynes and nitrenes (with examples).	**8**
4	**Stereochemistry of Organic Compounds:** Types of isomerism- optical isomerism- elements of symmetry, molecular chirality, enantiomers, stereogenic centers, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centre, diastereomers, threo and erythro diastereomers, meso compounds, inversion, retention and racemization. Relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclature. Geometrical isomerism: determination of configuration of geometrical isomers, E & Z system of nomenclature.	**12**

5	**States of Matter-I: Gaseous State-**Postulates of kinetic theory of gases, deviation from ideal behavior, van der Waal's equation of states, Critical phenomena – PV isotherms of real gases, relationship between critical constants and van der Waals constants. Molecular velocities: Root mean square, average and most probable velocities, qualitative discussion of the Maxwell's distribution of molecular velocities, Numerical problems. **Liquid State-**Intermolecular forces, Structural differences between solids, liquids and gases. Physical properties of liquids including their methods of determination: surface tension, viscosity, Numerical problems.	**12**
6	**States of Matter-II:** **Solid State:** Introduction to crystalline materials, Definition of space lattice, unit cell, crystal planes, Miller indices, Laws of crystallography – (i) law of constancy of interfacial angles (ii) law of rationality of indices (iii) law of symmetry. Symmetry elements in crystals, X-ray diffraction by crystals. Bragg's equation, Numerical problems. **Colloidal State:** Definition of colloids, classification of colloids. Solids in liquids (sols): properties – kinetic, optical and electrical; stability of colloids, protective action, Hardy-Schulze law, gold number.	**8**

Books Recommended:

i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.

ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.

iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. First Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.

iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010**.**

Semester-I, Paper-II (Practical)

Course Title: Chemical Analysis -I

Programme/Class: Certificate in Introductory Chemistry	**Year:** First		**Semester:** First
			Paper-2 Practical Subject: Chemistry
Course Code: CHEMC102			**Course Title:** Chemical Analysis-I
L	**T**	**P**	**C**
0	**0**	**2**	**2**

Course outcomes (COs):

Upon successful completion of the course, student will be able to:

CO1	Gain knowledge about the concepts of qualitative analysis of cation and anions in inorganic mixtures.
CO2	Understand lab hazards and safety precautions.
CO3	Determine of absolute configuration of organic molecules using ball and stick models.
CO4	Illustrate the structure of simple organic compounds showing their stereochemistry using Fischer Projection.
CO5	Evaluate surface tension of liquids using stalagmometer.
CO6	Solve problems related to configuration and surface tension.

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Laboratory hazards and safety precautions	6
2	**Salt mixture analysis:** Identification of acid radicals (three to four) including anions in combination and basic radicals upto II Group in the given salt mixture.	18
3	**Organic exercise:** Determination of absolute configuration of organic molecules using ball and stick models. Students are supposed sketch the structure of simple organic compounds showing their stereochemistry using Fischer Projection.	18
4	**Physical exercise:** Determination of relative surface tension of the given liquid using Stalagmometer.	18

Suggested Readings:

i. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
ii. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
iii. Harris, D. C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
iv. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.

Semester-II
Paper-I
(Theory)
Course Title: Fundamentals of Chemistry-II

Programme/Class: Certificate in Introductory Chemistry	**Year:** First	**Semester:** Second
		Paper-I Theory Subject: Chemistry
Course Code: CHEMC201	**Course Title:** Fundamentals of Chemistry-II	

L	**T**	**P**	**C**
4	**0**	**0**	**4**

Course outcomes (COs):

Upon successful completion of the course, student will be able to:

CO1	Gain knowledge of the basics of chemical bonding, properties of s and p block element, aliphatic & aromatic hydrocarbons, chemical kinetics, catalysis and thermodynamics.
CO2	Understand fundamentals of chemical bonding, properties of s and p block element, aliphatic & aromatic hydrocarbons, chemical kinetics, catalysis and thermodynamics.
CO3	Develop concept of chemical bonding, aliphatic & aromatic hydrocarbons, chemical kinetics and thermodynamics.
CO4	Explain MOT, properties of s and p block elements, preparation and properties of aliphatic and aromatic hydrocarbons.
CO5	Derive integrated rate equations and half-lives for first, second and zero order reactions and also evaluate heat capacities at constant volume, pressure and Kirchhoff's equation.
CO6	Solve problems related to chemical kinetics and thermodynamics.

Total Number of Hours = 60		
Units	**Content**	**Number of Hours**
1	**Chemical Bonding-II:** Molecular Orbital Theory (MOT) as applied to diatomic homonuclear/heteronuclear inorganic molecules. MO diagrams and bond order of H_2, He_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, Ne_2, CO, NO, HF difference between VB and MO theories. Polarization of covalent molecules, Percentage ionic character from dipole and electronegativity difference. Polarizing power and polarizability; Fajan's rule. Weak interactions-hydrogen bonding in inorganic and organic molecules and van der Waals interactions.	**10**

2	**Salient Features of s- and p-Block Elements:** General discussion with respect to all periodic (Occurrence, electronic configuration, atomic & ionic radii, density, ionization potential, metallic behaviour, electropositive nature, electronegativity, electron affinity, hydration energy, flame colouration, photoelectric effect, polarization power, boiling and melting point) and chemical properties (reactivity towards water, oxygen, air and moisture, hydrogen, halogens, ammonia). Diagonal relationship, catenation, inert pair effect, pπ- pπ, dπ-pπ bond. Silicates, Boron nitrogen compounds (borazene and boron nitrides), interhalogen compounds.	**10**
3	**Aliphatic Compounds:** Chemical reactions of alkanes. Mechanism of free radical halogenation of alkanes. Cycloalkanes- Baeyer's strain theory and its limitations. Chemical reactions of alkenes- mechanisms involved in hydrogenation, electrophilic and free radical additions, Markownikoff's Rule, hydroboration-oxidation, oxymercuration-reduction. Epoxidation, ozonolysis, hydration, hydroxylation and oxidation with $KMnO_4$, Polymerization of alkenes. Substitution at the allylic and vinylic positions of alkenes. Chemical reactions of alkynes, acidity of alkynes. Mechanism of electrophilic and nucleophilic addition reactions, hydroboration-oxidation, metal- ammonia reduction, oxidation and polymerization.	**10**
4	**Aromatic Compounds:** Aromaticity- the Hückel rule, aromatic ions. Aromatic electrophilic substitution- general pattern of the mechanism, role of σ and π complexes. Mechanism of nitration, halogenation, sulphonation, mercuration and Friedel- Crafts reaction. Energy profile diagrams. Activating and deactivating substituents, orientation and ortho/para ratio.	**10**
5	**Chemical Kinetics and Catalysis:** Chemical kinetics and its scope, rate of a reaction, factors influencing the rate of a reaction– concentration, temperature, pressure, solvent, light, catalyst; hetero and homocatalysis, significance. Inhibitors, poisons and promoters. Concentration dependence of rates of simple reaction, Molecularity, Order of reaction- zero order, first order, second order, pseudo-order, Radioactive decay a first order phenomenon, half-life period, Methods of determination of the order of reaction-differential method, method of integration, method of half-life period and isolation methods, Numerical problems.	**10**

6	**Thermodynamics I:** Definition of thermodynamic terms, system, surroundings etc. Types of thermodynamic systems and thermodynamic processes. Intensive and extensive properties. Concept of heat and work, first law of thermodynamics, definition of internal energy and enthalpy. Heat capacity – heat capacities at constant volume and at constant pressure and their relationship, calculation of w, q, dU & dH for the expansion of ideal gases under isothermal and reversible conditions. Thermochemistry; standard state, Standard enthalpy of formation – Hess's law of heat summation and its application. Temperature dependence of enthalpy, Kirchoff's equation, Numerical problems.	**10**

Books Recommended:

i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.

ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", VishalPublishing Co., India, 2020, 33rd edition.

iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. First Year", S. Chand Publishing,New Delhi, India, 2011, 3rd edition.

iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S.Chand Publishing, New Delhi, India, 2010**.**

Semester-II, Paper-II (Practical)
Course Title: Chemical Analysis - II

Programme/Class: Certificate in Introductory Chemistry	**Year:** First	**Semester:** Second
Paper-2 Practical Subject: Chemistry		
Course Code: CHEMC202	Course Title: Chemical Analysis –II	

L	**T**	**P**	**C**
0	**0**	**2**	**2**

Course outcomes (COs):

Upon successful completion of the course, student will be able to:

CO1	Gain knowledge about the concepts of qualitative analysis of cation and anions in inorganic mixtures.
CO2	Understand lab hazards and safety precautions.
CO3	Determine the strength of given solution by acid-base titration method.
CO4	Differentiate between alkanes, alkenes and alkynes.
CO5	Distinguish between aliphatic and aromatic compounds using chemical and physical tests.
CO6	Calculate relative viscosity of the given liquid using Ostwald viscometer.

Total Number of Hours = 60

Unit	**Contents**	**Number of Hours**
1	Laboratory hazards and safety precautions	**6**

2	**Inorganic exercise:** Acid-base titrations; preparation of a solution in normal/molar terms, its standardization using a primary standard solution, determination of the strength of unknown solution. For example: preparation of NaOH solution (secondary standard say N/10), preparation of $(COOH)_2$ solution (primary standard say N/10), standardization of NaOH solution titrating it against $(COOH)_2$ solution using phenolphthalein (indicator) and then determination of the strength of given HCl solution.	**18**
3	**Organic exercise:** Differentiation between alkanes, alkenes and alkynes. Differentiation between aliphatic and aromatic compounds using chemical and physical tests.	**18**
4	**Physical exercise:** Determination of relative viscosity of the given liquid using Ostwald viscometer.	**18**

Suggested Readings:

i. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
ii. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth PublishingCompany, Belmont, California, USA, 1988.
iii. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
iv. Harris, D. C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.

Semester-III
Paper-I
(Theory)
Course Title: General Chemistry-I

Programme/Class: Diploma in Chemical Science	**Year:** Second	**Semester:** Third
	Paper-I Theory Subject: Chemistry	
Course Code: CHEMC301	**Course Title:** General Chemistry-I	

L	**T**	**P**	**C**
4	**0**	**0**	**4**

Course outcomes (COs):
Upon successful completion of the course, student will be able to:

CO1	Gain knowledge of transition elements, coordination chemistry, halides, alcohols, phenols, thermodynamics, chemical and phase equilibria.
CO2	Understand concepts of transition elements, coordination chemistry, halides, alcohols, phenols, thermodynamics, chemical and phase equilibria.
CO3	Explain transition elements, coordination chemistry, halides, alcohols, phenols, thermodynamics, chemical and phase equilibria.
CO4	Illustrate theories of coordination chemistry, properties of transition elements, mechanism of nucleophilic substitution and name reactions.
CO5	Predict geometry and magnetic nature of coordination compounds, mechanism of organic reactions and feasibility of reactions.
CO6	Solve numerical problems related to thermodynamics, chemical and phase equilibria.

Total No. of Hours- = 60

Unit	Contents	Number of Hours
1	**Chemistry of Transition Elements (First, second and third Transition Series):** Characteristic properties of the elements; electronic configuration, atomic & ionic radii, oxidation states and stability of uncommon oxidation states, ionization energy, boiling & melting points, complex compound formation, colour, catalytic properties and magnetic properties. coordination number and geometry. Comparative treatment of 3d, 4d and 5d elements and their analogues in respect of occurrence, atomic & ionic radii, oxidation state, ionization energy, complex formation tendency, magnetic behaviour, geometry and colour.	10
2	**Coordination Chemistry-I:** Definition, terminology (ligand, coordination number, coordination sphere, complex ion etc.), Nomenclature of coordination compounds (IUPAC system), Werner's theory for coordination compounds; its experimental verification, effective atomic number (EAN) concept, 18-electron rule, stability of complexes and factors contributing to the stability. Chelates- Introduction, factors affecting the stability of chelates, thermodynamic origin of stability, applications. Valence Bond Theory (VBT) for coordination compounds, geometry of complexes (tetrahedral, octahedral, square planar), magnetic properties of complex compounds.	10
3	**Halides:** Chemical reactions. Alkyl, aryl and vinyl halides. Mechanism of nucleophilic substitution reactions, S_N2 and S_N1 reactions with energy profile diagrams.	8
4	**Alcohols and Phenols:** Alcohols: Reactions of alcohols. Dihydric alcohols-methods of preparation, chemical reactions of vicinal glycols, oxidative cleavage [$Pb(OAc)_4$ and HIO_4] and pinacol-pinacolone rearrangement. Trihydric alcohols-methods of formation, chemical reactions of glycerol. Phenols: Physical properties and acidic character. Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols-electrophilic aromatic substitution, acylation and carboxylation. Mechanism of Fries rearrangement, Claisen condensation, Gatterman synthesis, and Reimer-Tiemann reaction.	12
5	**Thermodynamics II:** Second law of thermodynamics, need of the law, different statements of the law. Carnot cycle and its efficiency, Carnot theorem. Thermodynamic scale of temperature. Concept of entropy: entropy as a state function, entropy as a function of V and T, entropy as a function of P and T,. Clausius inequality, entropy as criteria of spontaneity and equilibrium. Entropy change in ideal gases. Gibbs free energy and Helmholtz work functions. Criteria for thermodynamic equilibrium and spontaneity, Variation of G and A with P, V and T, Gibbs-Helmholtz equation, Numerical problems.	12

6	**Chemical Equilibrium:** The law of mass action, free energy and equilibrium constant, factors influencing equilibrium constant, relationship between Kp and Kc. Le-Chatelier's principle, Numerical problems. **Phase Equilibrium:** Statement and meaning of the terms: phase, component and degree of freedom, Gibbs phase rule, phase equilibria of one component systems, Raoult's and Henry's law.	8

Books Recommended:

i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.

ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", VishalPublishing Co., India, 2020, 33rd edition.

iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. Second Year", S. ChandPublishing, New Delhi, India, 2011, 3rd edition.

iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S.Chand Publishing, New Delhi, India, 2010**.**

Semester-III Paper-II (Practical)
Course Title: Analytical Procedures-I

Programme/Class: Diploma in Chemical Science	**Year:** Second		**Semester:** Third
			Paper-II Practical Subject: Chemistry
Course Code: CHEMC302			**Course Title:** Analytical Procedures-I
L	**T**	**P**	**C**
4	**0**	**0**	**4**

Course outcomes (COs):
Upon successful completion of the course, student will be able to:

CO1	Gain knowledge of laboratory hazards and safety precautions.
CO2	Understand physical, inorganic and organic exercises.
CO3	Determine the critical solution temperature of partially miscible liquids.
CO4	Differentiate between alcohols and phenols.
CO5	Test the inorganic mixtures of acidic and basic radicals in given samples.
CO6	Solve practical problems related to physical chemistry.

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Laboratory hazards and safety precautions	**6**

2	**Inorganic exercise:** Complete analysis of inorganic mixture including both acid and basic radicals with a special emphasis on the role of common ion effect and solubility product.	**30**
3	**Organic exercise:** Functional group tests for alcohols and phenols. Differentiation between alcohols and phenols using chemical and physical tests.	**12**
4	**Physical exercise:** Determination of critical solution temperature (CST)	**12**

Suggested Readings:

i. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
ii. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wordsworth PublishingCompany, Belmont, California, USA, 1988.
iii. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
iv. Harris, D. C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.

Semester-IV
Paper-I
(Theory)
Course Title: General Chemistry-II

Programme/Class: Diploma in Chemical Science	**Year:** Second	**Semester:** Fourth
		Paper-I Theory Subject: Chemistry
Course Code: CHEMC401	**Course Title:** General Chemistry-II	

L	**T**	**P**	**C**
4	**0**	**0**	**4**

Course outcomes (COs):

Upon successful completion of the course, student will be able to:

CO1	Gain knowledge of basic concepts of acid and bases, inner transition elements, aldehydes, ketones, carboxylic acids and electrochemistry.
CO2	Understand the chemistry of acid and bases, inner transition elements, and electrochemistry.
CO3	Establish the mechanism of nucleophilic addition reactions of aldehydes, ketones, carboxylic acids.
CO4	Explain concepts of acid and bases, inner transition elements and carbonyl compounds.
CO5	Summarize the concepts of electrochemistry and its applications.
CO6	Solve numerical problems related to electrochemistry.

Total No. of Hours- = 60

Unit	Contents	Number of Hours
1	**Acids and Bases:** Arrhenius concept, Bronsted-Lowry concept, and Lewis concept of acids and bases; Hard and Soft Acid-Base Theory: Classification of acids and bases as hard and soft. Pearson's hard and soft acid base concept, acid base strength and hardness and softness. Role of the solvent and strength of acids and bases.	10
2	**Chemistry of Inner Transition Elements:** Chemistry of Lanthanides: Electronic configuration, oxidation states, atomic & ionic radii, lanthanide contraction and its consequences, complex formation, colour; Methods of separation of lanthanides **Chemistry of Actinides:** General features of actinides-electronic configuration, atomic & ionic radii, ionization potential, oxidation states and complex formation.	10
3	**Aldehydes and Ketones:** Comparative account of properties of aliphatic and aromatic aldehydes and ketones. Mechanism of nucleophilic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensation. Condensation with ammonia and its derivatives; Wittig reaction,. Use of acetals as protecting group. Oxidation of aldehydes, Baeyer-Villiger oxidation of ketones, Cannizzaro reaction, Clemmensen, Wolff-Kishner, $LiAlH_4$ and $NaBH_4$ reductions.	10
4	**Carboxylic Acids:** Reactions of carboxylic acids, Hell-Volhard-Zelinsky reaction. Synthesis of acid chlorides, esters and amides.	10
	Reduction of carboxylic acids, mechanism of decarboxylation. Methods of formation and chemical reactions of halo acids, hydroxy acids- malic, tartaric, and citric acids. Methods of preparation and chemical reactions of unsaturated monocarboxylic acids.	
5	**Electrochemistry I:** Electrical transport-conduction in metals and electrolytic solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution. Arrhenius theory of electrolytic dissociation and its limitations, weak and strong electrolytes, Ostwald's dilution law, its uses and limitations, Numerical Problems.	8

6	**Electrochemistry II:** Oxidation state, types of redox reactions, Types of reversible electrodes-gas-metal ion, metal-metal ion, metal-insoluble salt anion and redox electrodes. Electrode reactions, Nernst equation, derivation of cell EMF and single electrode potential, standard hydrogen electrode-reference electrode, standard electrode potential, sign conventions, electrochemical series and its significance. Electrolytic and Galvanic cells-reversible andirreversible cells, conventional representation of electrochemical cells. EMF of a cell and its measurements. Calculation of thermodynamic quantities of cell reactions (ΔG, ΔH and K), Numerical Problems.	12

Books Recommended:

i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.

ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", VishalPublishing Co., India, 2020, 33rd edition.

iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. Second Year", S. ChandPublishing, New Delhi, India, 2011, 3rd edition.

iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S.Chand Publishing, New Delhi, India, 2010**.**

Semester-IV Paper-II (Practical)
Course Title: Analytical Procedures-II

Programme/Class: Diploma in Chemical Science	**Year:** Second		**Semester:** Fourth
			Paper-II Practical Subject: Chemistry
Course Code:CHEMC402		**Course Title:** Analytical Procedures-II	
L	**T**	**P**	**C**
4	**0**	**0**	**4**

Course outcomes (COs):
Upon successful completion of the course, student will be able to:

CO1	Gain knowledge of laboratory hazards and safety precautions.
CO2	Understand physical, inorganic and organic exercises.
CO3	Determine the concentrations of oxidising and reducing agents through double titration
CO4	Differentiate between aldehydes, ketones and carboxylic acids
CO5	Test the solubility of salts
CO6	Solve practical problems related to physical chemistry.

Total Number of Hours = 60

Unit	**Contents**	**Number of Hours**

1	Laboratory hazards and safety precautions	**6**
2	**Inorganic exercise:** Volumetric exercises (double titration) based on redox reactions involving internal as well as external indicators.	**18**
3	**Organic exercise:** Preliminary and Functional group tests for aldehydes, ketones and carboxylic acids (both aliphatic and aromatic).	**18**
4	**Physical exercise:** Determination of solubility of salts.	**18**

Semester-V
Paper-I
(Theory)
Course Title: Inorganic Chemistry

Programme/Class: Degree in Bachelor of Science	**Year:** Third	**Semester:** Fifth
Paper-1 Theory Subject: Chemistry		
Course Code: CHEMC501	**Course Title:** Inorganic Chemistry	

L	**T**	**P**	**C**
4	**0**	**0**	**4**

Course outcomes (COs):
Upon successful completion of the course, student will be able to:

CO1	Gain knowledge of basic concepts of metal ligand bonding, coordination compounds, organometallic chemistry, electronic spectra and magnetic properties of transition elements.
CO2	describe the stability, crystal field theory, electronic spectra and magnetic properties of coordination compounds
CO3	Explain metal-ligand bonding, thermodynamic and kinetic aspects of transition metal complexes.
CO4	Explain properties and applications of industrially important inorganic materials and organometallic chemistry.
CO5	Summarize the applications and limitations of CFT, chelate effect and its thermodynamic origin.
CO6	Calculate ground state term and magnetic moments of octahedral and tetrahedral complexes.

Total Number of Hours = 60

Unit	**Contents**	**Number of Hours**

1	**Metal-Ligand Bonding in Transition Metal Complexes:** Limitations of valence bond theory, an elementary idea about crystal field theory (CFT); crystal field splitting of octahedral and tetrahedral complexes, tetragonal distortion (Jahn-Teller distortion, factors affecting the crystal-field parameters, calculation of crystal field stabilization energy (CFSE), spectrochemical series, limitations of CFT. Comparison between VBT and CFT.	10
2	**Thermodynamic and Kinetic Aspects of Coordination Compounds:** Stability of metal complexes- thermodynamic and kinetic stability, stable and unstable complexes, inert and labile complexes, stepwise and overall stability constants, relationship between the stepwise and overall stability constants, Chelate effect and its thermodynamic origin.	10
3	**Electronic Spectra of Transition Metal Complexes:** Types of electronic transitions, selection rules for d-d transitions, calculations of spectroscopic ground states (Russell Saunders/L-S coupling), Orgel energy level diagram for d^1, d^4 and d^6, d^9 tetrahedral and octahedral complexes, discussion of the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ion.	8
4	**Magnetic Properties of Transition Metal Complexes:** Origin of magnetic behavior, concept of magnetic susceptibility, diamagnetism, paramagnetism, ferromagnetism, ferrimagnetism and antiferromagnetism, magnetic moments, quenching of orbital magnetic moment by crystal field, magnetic susceptibility-definition relationship with temperature, Curie law and Curie Weiss law ,magnetic moment, spin only formula, correlation of μ_s and μ_{eff} values, orbital contribution to magnetic moments, application of magnetic moment data for 3d metal complexes.	10
5	**Organometallic Chemistry:** Definition, nomenclature and classification based on nature of metal-carbon bond. EAN and 18-electron rule. Definition, nomenclature, classification, general methods of preparation of organometallic compounds Applications of organometallic compounds-Ziegler-Natta catalyst, Wilkinson catalyst (No mechanism).	8
6	**Some Industrially Important Inorganic Materials:** Silicones, siloxanes, polymethylhydrosiloxanes, their applications. Phosphazenes, nature of bonding in triphosphazenes. Aluminosilicates- Feldspars, Ultramarines, Zeolites. Clays and Pillared Clays. Cement- manufacture, composition and setting. Glass-manufacture, annealing, types and uses. Ceramics-definition, traditional and new ceramics, structure of ceramics. Inorganic fertilizers-essential nutrients for plants, nitrogenous, phosphatic and potash fertilizers.	14

Books Recommended:

i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India,

5th edition.

ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", VishalPublishing Co., India, 2020, 33rd edition.

iii. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S.Chand Publishing, New Delhi, India, 2010**.**

iv. Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers,India, 2018, 1st edition.

Semester-V, Paper-III (Practical)

Course Title: Analytical Procedures-III

Programme/Class: Certificate in Introductory/General Chemistry	**Year:** Third	**Semester:** Fifth
Paper-III Practical Subject: Chemistry		
Course Code: CHEMC502	**Course Title:** Analytical Procedures-III	

L	**T**	**P**	**C**
0	**0**	**2**	**2**

Course outcomes (COs):

Upon successful completion of the course, student will be able to:

CO1	Gain knowledge of laboratory hazards and safety precautions.
CO2	Understand the inorganic and organic exercises.
CO3	Determine the yield of synthesized organic and inorganic compounds.
CO4	Analyze the nitrogen containing compounds.
CO5	Separate the binary organic mixture.
CO6	Prepare organic and inorganic compounds.

Total Number of Hours = 60

Unit	**Contents**	**Number of Hours**
1	Laboratory hazards and safety precautions	**6**
2	**Inorganic exercise:** Inorganic synthesis – cuprous chloride, potash alum, chrome alum, ferrous oxalate, ferrous ammonium sulphate, tetraamminecopper(II) sulphate and hexaamminenickel(II) chloride. Crystallization of compounds.	**14**

3	**Organic exercise:** **Organic qualitative analysis:** Analysis of Nitrogen containing organic compounds (detection of elements, amines, nitro, amides and anilides) Binary mixture of organic compounds separable by water **Organic synthesis:** through nitration, halogenation, acetylation, sulphonation and simple oxidation	**40**

Semester-V
Paper-II
(Theory)
Course Title: Organic Chemistry

Programme/Class: Degreein Bachelor of Science	**Year:** Third	**Semester:** Fifth
	Paper-II Theory Subject: Chemistry	
Course Code: CHEMC503	**Course Title:** Organic Chemistry	

L	**T**	**P**	**C**
4	**0**	**0**	**4**

Course outcomes (COs):
Uponsuccessfulcompletionofthecourse, studentwillbeableto:

CO1	Gain knowledge of the basics of Lipid and fats,,Reagents in organic synthesis ,nitrogen containg organic compound,Organometallic CompoundsDyes and PaintsCarbohydrates and Proteins.
CO2	Understand fundamentals of Lipids and Fats,types of reagents, Chemical reactions of nitroalkanesnitroarenes&Halo nitroarenesOrgano magnesium&Organozinc compounds.
CO3	Develop concept of types of dyes**.**Paints and Varnisheschemistry, applications.General study of disaccharides.
CO4	Explain Reagents in Organic Synthesi,Lipids-FatsDefinition ,nutrition and health,**.**Soaps, Detergents and their action mechanism,Mechanism of nucleophilic substitution in nitroareneselectrophilic aromatic substitution in aryl amines
CO5	considertheClassification, nomenclature.and mechanism ofMonosaccharidesstructure and chemical reactions of organo metallic compound, structure and nomenclature of aminesPreparation of alkyl and aryl amines .
CO6	Solve problems related to Reagents in Organic SynthesisNitrogen Containing Organic CompoundsOrganometallic CompoundCarbohydrates and Proteinsand .

Total Number of Hours = 60

Unit	**Contents**	**Number of Hours**
1	Introduction to lipids, classification, oils and fats, common fattyacids present in oils and fats, omega fatty acids, trans fats,hydrogenation, saponification value, iodine number.	12

2	**Reagents in Organic Synthesis:** Reagent compounds, types of reagents, acetylene, ammonia, Bayer's reagent, NBS, n-butyl lithium, CAN, chromic acid, chromium trioxide, diborane, DMSO, dioxane, Fehling reagent, Grignard reagent, hydrazide, hydrogen peroxide, LAH, OsO_4, PCl_5, potassium dichromate, potassium permanganate, Raney Ni, silver nitrate, sodium borohydride, NaH, THF, TMS, $SOCl_2$, Tollen's reagent.	12
3	**Nitrogen Containing Organic Compounds:** Chemical reactions of nitroalkanes. Mechanism of nucleophilic substitution in nitroarenes and their reduction in acidic, neutral and alkaline medium. Picric acid. Halo nitroarenes-reactivity, structure and nomenclature of amines. Physical properties. Separation of mixture of primary, secondary and tertiary amines. Structural features affecting basicity of amines. Preparation of alkyl and aryl amines (reduction of nitro compounds, nitriles), reductive amination of aldehydic and ketonic compounds. Gabriel- phthalimide reaction, Hofmann bromamide reaction. Reaction of amines, electrophilic aromatic substitution in aryl amines, reactionof amines with nitrous acid.	14
4	**Organometallic Compounds:** the Grignard reagent-formation, structure and chemical reactions. Organozinc compounds; formation and chemical reactions.	10
5	**Dyes and Paints:** Color and constitution, types of dyes, Alizarin, Indigo, Congo red, Malachite green, Methylene blue, Phenolphthalein, Methyl orange. Paints and Varnishes: Definition, components, chemistry, applications.	10
6	**Carbohydrates and Proteins:** Carbohydrates: Classification and nomenclature. Monosaccharides, mechanism of osazone formation, interconversion of glucose and fructose, chain lengthening and chain shortening of aldoses. Configuration of monosaccharides. Erythro and threo diastereomers. Formation of glycosides. Cyclic structure of D(+)-glucose. Mechanism of mutarotation. General study of disaccharides. **Proteins**: Classification, structure and stereochemistry of amino acids. Acid-base behavior, isoelectric point and electrophoresis. Classification of proteins.	12

Books Recommended:

i. Finar, I.L., "Organic Chemistry", Pearson Education India, 2002, 6th edition.

ii. Eliel, E.L. and Wilen, S.H., "Stereochemistry of Organic Compounds", Willey, 1994,1st edition.

iii. Boyd, Morrison and Bhattacharjee, "Organic Chemistry", Pearson Education India,2010, 7th edition.

iv. Mukerji, S.M., "Reaction mechanism in Organic Chemistry", Laxmi Publications,2007, 3rd edition.

Semester-VI
Paper-I
(Theory)
Course Title: Physical Chemistry

Programme/Class: Degreein Bachelor of Science	**Year:** Third	**Semester:** Sixth
		Paper-I Theory Subject: Chemistry
Course Code: CHEMC601		**Course Title:** Physical Chemistry

L	**T**	**P**	**C**
4	**0**	**0**	**4**

Course outcomes (COs):
Upon successful completion of the course, student will be able to:

CO1	Gain knowledge of basic concepts of surface chemistry, photochemistry, quantum mechanics, solutions, radioactivity and thermodynamics
CO2	Understand the basics of surface chemistry, quantum mechanics and photochemistry.
CO3	Explain chemistry of solutions, radioactivity and thermodynamics.
CO4	Explain adsorption models, laws of photochemistry, Jablonski diagram, colligative properties, applications of radioactivity and third law of thermodynamics.
CO5	Summarize the applications of adsorption models, radioactivity and elementary quantum mechanics.
CO6	Solve numerical problems related to surface chemistry, photochemistry, quantum mechanics, solutions, radioactivity and thermodynamics

Total Number of Hours = 60

Unit	**Contents**	**Number of Hours**
1	**Surface Chemistry:** Definition of surface phenomenon-Adsorption. Chemical and physical adsorption, Factors affecting adsorption. Isotherm and Isobar. Free energy of adsorption. Quantitative treatment of adsorption, Freundlich's and Langmuir's adsorption model and their applications. Limitation of Langmuir adsorption model. Adsorption in catalysis, characteristics of catalyzed reactions.	10
2	**Elementary Quantum Mechanics:** Black-body radiation, Plank's radiation law, photoelectric effect, Bohr's model of hydrogen atom (no derivation) and its defects. Compton effect, de Broglie hypothesis, Heisenberg's uncertainty principle, operator concept, , Schrödinger wave equation and its importance, physical interpretation of the wave function, Numerical Problems.	12

3	**Photochemistry:** Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry; Grothuss-Drapper law, Lambert's law, Lambert-Beer's law, Stark-Einstein law, Jablonski diagram depicting various processes occurring in the excited state, fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, Numerical Problems.	10
4	**Solutions and Colligative Properties:** Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient. Dilute solutions, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular mass determination. Osmosis, law of osmotic pressure, determination of molecular mass from osmotic pressure. Elevation of boiling point and depression in freezing point, Numerical Problems.	10
5	**Thermodynamics III:** Statement and concept of residual entropy, third law of thermodynamics, unattainability of absolute zero, Nernst heat theorem. Evaluation of absolute entropy from heat capacity data, Numerical Problems	8
6	**Radioactivity:** Definition, nature of radioactivity, emission, types of radioactively, occurrence, Energetics and kinetics radioactivity, rates of radioactive transitions, Applications of radioactivity, Numerical Problems.	10

Books Recommended:

i. Madan, R.L., "Chemistry for Degree Students, B. Sc. Third Year", S. ChandPublishing, New Delhi, India, 2011, 3rd edition.

ii. Atkins P.W., "Atkin's Physical Chemistry: International", Oxford University Press,2018, 11th edition.

iii. Ball D.W., "Physical Chemistry", Cengage India Private Limited, 2017, 2nd edition.

iv. Puri, B.R., Pathania, M.S. and Sharma, L.R., "Principles of Physical Chemistry",Vishal Publishing, India, 2020, 47th edition.

Semester-VI
Paper-II
(Theory)
Course Title: Analytical Chemistry

Programme/Class: Degreein Bachelor of Science	**Year:** Third	**Semester:** Sixth
	Paper-II Theory Subject: Chemistry	
Course Code: CHEMC603	**Course Title:** Analytical Chemistry	

L	**T**	**P**	**C**
4	**0**	**0**	**4**

Course outcomes (COs):

Upon successful completion of the course, student will be able to:

CO1	Gain knowledge of basic concepts of biochemistry, nanochemistry, spectroscopy,green chemistry, data analysis and analytical techniques.
CO2	Understand concepts of biochemistry, nanochemistry, and spectroscopy.
CO3	Explain green chemistry, data analysis and analytical techniques.
CO4	Explain principle, applications and instrumentation of spectroscopic techniques.
CO5	Summarize concepts of green, nano and biochemistry.
CO6	Interpret spectroscopic data.

Total Number of Hours = 60

Unit	**Contents**	**Number of Hours**
1	**General Biochemistry:** Introduction to biomolecules, Enzymes; Definition, classification, role in physiology. General introduction to hormones. Nucleic acids; Nitrogen bases, purines, pyrimidines, nucleosides, nucleotides, structure of RNA and DNA molecule.	12
2	**Data Analysis:** Errors; Definition, types of errors, precision, accuracy, absolute, Significant Figures; significant figures in Arithmatics-addition, subtraction, multiplication and division, Mean and Standard deviation, Standard deviation and probability.	10
3	**Fundamentals of Nanochemistry:** Definition, brief history, classification, general approach of nano synthesis, general methods of characterization, general applications.	9
4	**Basics of Green Chemistry:** Introduction, role of green chemistry in sustainable development, principles of green chemistry.	8
5	**Analytical Techniques:** Basic concepts of electro-gravimetric and coulometric analysis. Thermogravimetric analysis. Chromatography: Introduction, Types, paper and column chromatography	9
6	**Spectroscopy:** Ultraviolet (UV) absorption spectroscopy-absorption laws (Beer-Lambert law), molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of conjugation, concept of chromophore and auxochrome. Bathochromic, hypsochromic, hyperchromic and hypochromic shifts.	12
	Infra-Red (IR) absorption spectroscopy- molecular vibrations, Hooke's Law, selection rules, intensity and position of IR bands, measurement of IR spectrum, finger print region, characteristic absorptions of various functional groups and interpretation of IR spectra of simple organic compounds.	

Books Recommended:

i. Clark, J. H., and Macquarrie, D.J., Handbook of Green Chemistry and Technology,Wiley-Blackwell, 2002.

ii. Anastas, P.T., and Williamson, T.C. Green Chemistry: Frontiers in Benign ChemicalSyntheses and Processes, Oxford University Press, New York, 1999.

iii. Ozin, G.A., Arsenault, A.C. and L. Cademartiri, Nanochemistry: A ChemicalApproach to Nanomaterials, Royal Society of Chemistry, 2008, 2nd

edition.

iv. P. H. Raven, Biology, Tata MacGraw Hill.

Semester-VI, Paper-III (Practical)

Course Title: Analytical Procedures-IV

Programme/Class: Certificate in Introductory/General Chemistry	**Year:** Third		**Semester:** Sixth
Paper-III Practical Subject: Chemistry			
Course Code: CHEMC602	**Course Title:** Analytical Procedures-IV		
L	**T**	**P**	**C**
0	**0**	**2**	**2**

Course outcomes (COs):

Upon successful completion of the course, student will be able to:

CO1	Gain knowledge of laboratory hazards and safety precautions.
CO2	Understand the physical and inorganic exercises.
CO3	Determine the solubility of organic compounds by titration method.
CO4	Analyze organic compounds by spectrophotometer.
CO5	Estimate different metal ions through gravimetric exercise.
CO6	Interpret the spectral data and chromatograms of organic compounds.

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Laboratory hazards and safety precautions	**6**
2	**Physical exercise:** Determination of solubility of organic compound (viz. oxalic acid) in water by titration method.	**18**
3	**Spectroscopic exercise:** Functional Group determination by UV and IR Spectroscopy; analysis of organic compounds including alcohols, phenols, carboxylic acids, carbonyl compounds, nitrogen containing compounds.	**18**
4	**Inorganic Exercise:** Gravimetric analysis of any one or two metal ions; Ba^{2+}, Fe^{3+}, Ni^{2+}, Cu^{2+}, Zn^{2+} etc.	**10**
5	**Chromatographic technique:** Demonstrative Chromatography- paper chromatography (Analytical separation of organic compounds- Amino acids/ dyes)	**8**

SKILL ENHANCEMENT COURSE

Semester-I
Paper I (Theory)
Course Title: Basics of Analytical Chemistry-I

Programme / Class: Certificate in Introductory Chemistry	**Year:** First	**Semester:** First
Paper-I Theory Subject :Chemistry		
Course Code : CHEVC101	**CourseTitle:** Basics of Analytical Chemistry-I	

L	**T**	**P**	**C**
3	**0**	**0**	**3**

Course outcomes (COs):

Upon successful completion of the course, student will be able to:

CO1	Gain knowledge about the basic concepts of analytical chemistry.
CO2	Understand analytical approaches, lab equipment and concentrations of solutions.
CO3	Explain lab equipment, concentrations of solutions and various types of titrations.
CO4	Explain errors, precision, accuracy, sampling, measuring equipment and strength of solutions.
CO5	Summarize the concepts of analytical chemistry.
CO6	Solve numerical problems based on analytical chemistry

Unit	**Contents**	**Number of Hours**
1	**Analyticalapproaches:**Typesoferrors,precision&accuracy,absoluteandrelativeuncertainty.Significantfigures;significant figuresinArithmatics-addition,subtraction,multiplicationanddivision. Meanandstandarddeviation.	8
2	**LaboratoryApparatus:**Laboratoryburner;Bunsenburner,airflowregulation,obtainingwarmgentleflamewiththeburner, hottestflameoftheburner.Cuttingandbendingofglasstubing/glassrod,firepolishingofglasstubingor rod.	8
3	**StepsinChemicalAnalysis:**Sampling, sample preparation, analysis,interpretationandpreparationofreport.	8
4	**UseofMeasuring Equipments:** Pipette, burette, chemical balance,leastcount.	7
5	**ChemicalConcentration:**Normality,morality,preparationofsolutionofdefinednormality/molarityofagivencompoundand fromagivensolutionofdifferentstrength,percentcomposition,partpermillion(ppm),partperbillion(ppb),calculations.	8
6	**Titration:**Typesoftitrations,endpoint, equivalencepoint, Indicators-typesandtheory.	6

Recommended Texts:

i. Nivaldo,J.andTro,HoYuAu-Yeung,IntroductoryChemistry,PearsonIndiaEducation,2017,5th edition.

ii. Timberlake,K.C.,andTimberlake,W.,BasicChemistry,PearsonIndiaEducation,2017,4th edition.
iii. Pavia,D.L.,Lampman,G.M.,Kriz,G.S,andEngel,R.G.,MicroscaleandMacroscaleTechniquesintheOrganicLaboratory,HarcourtCollegePublishers,2001,1st edition.
iv. Harris,D.C.,Exploring ChemicalAnalysis, W. H.FreemanandCompany,NewYork,1993,4th edition.

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Semester-II
PaperII(Theory)
CourseTitle:Basics of Analytical Chemistry-II

Programme/Class: CertificateinIntroductoryChemistry	**Year:**First		**Semester:Second**
Paper-II Theory Subject: Chemistry			
CourseCode: CHEVC201	**CourseTitle:** Basics of Analytical Chemistry-II		
L	**T**	**P**	**C**
3	**0**	**0**	**3**

Course outcomes (COs):

Upon successful completion of the course, student will be able to:

CO1	Gain knowledge about the basic concepts of analytical chemistry.
CO2	Understand concepts of physical constants, polarimeter, refractometer and electromagnetic radiation.
CO3	Explain distillation, crystallization, filtration, solubility and extraction.
CO4	Illustrate instrumentation of polarimeter, refractometer, spectrophotometer and distillation assemblies.
CO5	Summarize the concepts of analytical chemistry.
CO6	Solve numerical problems related to polarimetry, refractometry, electromagnetic radiation and solubility.

S.No.	**Contents**	**Total No. of Hours**
1	**Physical Constants:** Melting points, melting point theory, mixturemeltingpoint,packingofmeltingpointtube,Determinationofmeltingpoint;decomposition,discoloration,softening,shrinking andsublimation.Boilingpoint,determinationofboilingpoint,useofboilingchips,calibrationofthermometer.	8
2	**Polarimetry and Refractometry:** Polarimetry: Nature of polarizedlight,polarimeter,samplecells,operationofthe polarimeter,opticalpurity.Refractometry:Refractometry;Therefractiveindex, Refractometer.	8
3	**ElectromagneticRadiation:**Properties,absorptionoflight, transmittance,absorbanceandBeer'sLaw.Spectrophotometer-Singlebeamanddoublebeaminstruments.	8
4	**Distillation:**Simpledistillation,distillationtheory,fractionaldistillation,differencebetweensimpleandfractionaldistillation, vapour-liquidcompositiondiagram,Raoult'sLaw,typesoffractionatingcolumns,columnefficiency,azeotropes.	8

5	**Crystallization andFiltration:**Filtration-Selectionofsuitablesolvent/s,purificationofcompounds.Filtration-Gravityfiltration, filterpapers,vacuumfiltration,aspirator,workingofaspirator.	7
6	**Solubility and Extraction:** Solubility-Definition, predicting solubility behaviour, water as a solvent,organicsolvents. ExtractionTheory,distributioncoefficient,separationanddryingagents.	6

Recommended Texts:

i. Nivaldo,J.andTro,HoYuAu-Yeung,IntroductoryChemistry,PearsonIndiaEducation,2017,5th edition.
ii. Timberlake,K.C.,andTimberlake,W.,BasicChemistry,PearsonIndiaEducation,2017,4th edition.
iii. Pavia,D.L.,Lampman,G. M., Kriz, G. S,and Engel,R.G., Microscaleand MacroscaleTechniquesintheOrganicLaboratory,HarcourtCollegePublishers,2001,1st edition.
iv. Harris,D.C.,ExploringChemicalAnalysis,W.H.FreemanandCompany,NewYork,1993,4th edition.

Programme/Class: Certificate in Introductory Chemistry	**Year:** Second	**Semester:** Third
Paper-III Theory Subject :Chemistry		
CourseCode: CHEVC301	**CourseTitle: Chemistry of Soil and Water**	

L	**T**	**P**	**C**
3	**0**	**0**	**3**

Course outcomes (COs):

Upon successful completion of the course, students will be able to

CO1	Gain knowledge about basic composition of soil and water.
CO2	Describe about the chemistry ofsoil and water
CO3	Explain physical, chemical and biological parameters of soil.
CO4	Analyze physical, chemical and biological parameters of water
CO5	Evaluate pH of soil and water samples
CO6	Test the quality of soil and water samples

S.No.	**Contents**	**Total No. of Hours**
1	Analysis of soil: Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators. Determination of pH of soil samples. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.	23

2	Analysis of water: Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods. Determination of pH, acidity and alkalinity of a water sample. Determination of dissolved oxygen (DO) of a water sample.	22

Text Books:

TB1. Srilakshmi, B., Food Science, 7th Ed., New Age International, New Delhi (2018)
TB2. Biswas, T. D.; Mukherjee, S. K., Text Book of Soil Science, 2nd Ed., McGraw Hill Publishing Company, New Delhi (2017).

Reference Books:

RB1. Srivastava, A., Waste Water Treatment and Water Management: Water Treatment and Management, Notion Press (2018).
RB2. Sharma, B. K., Industrial Chemistry (Including Chemical Engineering), Goel Publishing House, Meerut (2016).

Programme/Class: Certificate in Introductory Chemistry	**Year:** Second		**Semester:** Fourth
Paper-IV Industrial Training			
CourseCode: CHEVC401	**CourseTitle:** Industrial Training		
L	**T**	**P**	**C**
0	**0**	**3**	**3**

Minor/Open Elective courses -I

Semester-I/II
Paper-I (Theory)
Course Title: Basics of Chemistry-I

Programme/Class: Certificate in Introductory Chemistry	**Year:** First		**Semester:** First/second
Paper :Theory Subject :Chemistry			
CourseCode: CHEOE001	**CourseTitle: Basics of Chemistry-I**		
L	**T**	**P**	**C**
4	**0**	**0**	**4**

Course outcomes (COs):

Upon successful completion of the course, students will be able to

CO1	Gain knowledge about basics of inorganic, physical and organic chemistry
CO2	Describe about atomic structure, bonding, chemical reactions, periodic properties

CO3	Explain gaseous state, thermochemistry and general organic chemistry
CO4	Illustrate the concepts of inorganic, physical and organic chemistry
CO5	Summarize atomic structure, VSEPR, VBT, periodic properties and characteristics of reactive intermediates
CO6	Solve numerical related to gaseous state and thermochemistry

Unit	Content	Number of Hours
1	**Atom and Molecules:** Bohr's Atomic theory (only postulates), structure of an atom; nuclear particles, atomic number, mass number and Isotopes, Atomic orbitals, filling of electrons in various orbitals-Aufbau energy diagram, Pauli's Exclusion Principle, Hund's rule of maximum multiplicity	**10**
2	**Ions, Molecules, Bonding and Chemical Reactions** Ions, ionic bond and ionic compounds, Chemical equations, Reactions in aqueous medium- Arrhenius theory of acids and bases, Acid-Base reaction, definition of acid and base, neutralization, Oxidation Reduction reactions-oxidation number Covalent compounds-bonding, VSEPR: concept and geometry, Valence Bond theory, Hybridization, geometry of covalent molecules, Hydrogen bonding	**12**

3	**Periodic Properties** Periodic table and periodic law, periodic classification of the elements, Periodic relationship among the elements, periodic properties-atomic size, ionization energy, electron affinity, electronegativity	**10**
4	**Gaseous State** Pressure of a gas, pressure volume relationship-Boyle's law, the temperature volume relationship-Charle's law, Ideal gas equation	**8**
5	**Thermochemistry** Energy changes in chemical reactions, Enthalpy, specific heat, heat capacity- constant volume and constant pressure, Standard enthalpy of formation and reactions	**8**
6	**General organic Chemistry** Inductive, mesomeric, electromeric effect, hydrogen bonding and its significance Reactive intermediates: carbocation, carbanion and free radicals Alkanes, alkenes, alkynes, aromatic hydrocarbons. Homologous series, Preparation and properties of ethene and ethyne.	**12**

Books Recommended:

i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.

ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.

iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. First Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.

iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010**.**

Semester-III/IV
Paper-I (Theory)
Course Title: Basics of Chemistry-II

Programme/Class: Certificate in Introductory Chemistry	**Year:** Second	**Semester:** Third/Fourth
Paper :Theory Subject :Chemistry		
CourseCode: CHEOE002	**CourseTitle: Basics of Chemistr-II**	

L	**T**	**P**	**C**
4	**0**	**0**	**4**

Course outcomes (COs):

Upon successful completion of the course, student will be able to:

CO1	Gain knowledge of the basics of chemical bonding, properties of s and p block element, aliphatic & aromatic hydrocarbons, chemical kinetics and thermodynamics.
CO2	Understand fundamentals of chemical bonding, properties of s and p block element, aliphatic & aromatic hydrocarbons, chemical kinetics and thermodynamics.
CO3	Develop concept of chemical bonding, aliphatic & aromatic hydrocarbons, chemical kinetics and thermodynamics.
CO4	Explain MOT, properties of s and p block elements, properties of aliphatic and aromatic hydrocarbons.
CO5	Derive integrated rate equations and half-lives for zero and first order reactions and also evaluate heat capacities at constant volume, pressure and Kirchhoff's equation.
CO6	Solve numerical problems related to chemical kinetics and thermodynamics.

Unit	**Content**	**Number of Hours**
1	**Chemical Bonding** Molecular Orbital Theory (MOT) as applied to diatomic inorganic molecules. MO diagrams and bond order of H_2, He_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, Ne_2. Polarization of covalent molecules, Percentage ionic character from dipole and electronegativity difference. Polarizing power and polarizability; Fajan's rule.	**10**
2	**s- and p-Block Elements** General discussion with respect to all periodic: Occurrence, electronic configuration, atomic & ionic radii, density, ionization potential, metallic behaviour, electropositive nature, electronegativity, electron affinity, and chemical properties (reactivity towards water, oxygen, air and moisture, hydrogen, halogens, ammonia)	**10**

3	**Aliphatic Compounds:** Chemical reactions of alkanes: Mechanism of free radical halogenation of alkanes. Chemical reactions of alkenes: mechanisms involved in hydrogenation, electrophilic and free radical additions, Markownikoff's Rule Chemical reactions of alkynes: Mechanism of electrophilic and nucleophilic addition reactions	10
4	**Aromatic Compounds:** Aromaticity- the Hückel rule, aromatic ions. Aromatic electrophilic substitution- general pattern of the mechanism Mechanism of nitration, halogenation, sulphonation	10
5	**Chemical Kinetics** Rate of a reaction, factors influencing the rate of a reaction– concentration, temperature, pressure, solvent, light, catalyst; hetero and homocatalysis, significance. Molecularity, Order of reaction- zero order and first order half-life period, Numerical problems.	10
6	**Thermodynamics** Definition of thermodynamic terms, system, surroundings etc. Types of thermodynamic systems and thermodynamic processes. Intensive and extensive properties. Concept of heat and work, first law of thermodynamics, Thermochemistry; standard state, Standard enthalpy of formation – Hess's law of heat summation and its application. Temperature dependence of enthalpy, Kirchoff's equation, Numerical problems.	10

Books Recommended:

v. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.

vi. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.

vii. Madan, R.L., "Chemistry for Degree Students, B. Sc. First Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.

viii. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010**.**